PXIe-5841 Calibration Procedure

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Contents

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This document contains the verification procedures for the PXIe-5841 vector signal transceiver.

Refer to ni.com/calibration for more information about calibration solutions.

Revision History

Part Number	Edition Date	Changes
378130C-01	November 2022	Updated the recommended test equipment.
378130B-01	September 2022	Updated the recommended test equipment. Revised measurement setup, procedures, and figures.

Table 1.

Required Software

Calibrating the PXIe-5841 requires you to install the following software on the calibration system:

- LabVIEW 2016 SP1 Base/Full/Pro or later
- NI-RFSA 20.7.2 or later
- NI-RFSG 20.7.2 or later
- Spectral Measurements Toolkit 17.0 or later

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:

- LabVIEW 2016 SP1 Base/Full/Pro or later
- NI-RFSA 20.7.2
- NI-RFSG 20.7.2
- Spectral Measurements Toolkit 17.0 or later

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

Test Equipment

The following table lists the equipment NI recommends for the performance verification procedures.

If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

Equipment	Recommended Model	Where Used	Minimum Requirements
Frequency reference	Symmetricom 8040 Rubidium Frequency Standard	Verifications: - Internal frequency reference - Spectral purity	Frequency: 10 MHz Frequency accuracy: ≤±1E-9 Output mode: sinusoid
Power sensor	Rohde & Schwarz NRP18A	Test system characterization Verifications: - Input absolute amplitude accuracy - Frequency response - Output power level accuracy	Range: -60 dBm to +20 dBm Frequency range: 10 MHz to 6.5 GHz Absolute uncertainty: <0.097 dB Power linearity: <0.097 dB

Equipment	Recommended Model	Where Used	Minimum Requirements
			VSWR: <1.20:1 up to 6.5 GHz
Vector signal analyzer	PXIe-5668R	Test system characterization RF output IMD3 functional performance test Adjustments: - RF internal frequency reference - LO gain	Frequency range: 10 MHz to 6.5 GHz Instantaneous bandwidth: 50 MHz Phase noise at 20 kHz offset: <-125 dBc/Hz
RF Signal Generator #1	PXIe-5654 with PXIe-5696	RF input IMD3 functional performance test Adjustment: LO Gain	Output amplitude range: +5 dBm to -55 dBm Frequency range: 70 MHz to 6.5 GHz
RF Signal Generator #2	PXIe-5654 with PXIe-5696 OR Anritsu MG3692C with: Option 2: Adds a 10 dB/step attenuator; 110 dB range on models ≤40 GHz. Option 4: 8 MHz to 2.2 GHz RF coverage, ultra-low phase noise version. Uses a digital down converter to significantly	RF input IMD3 functional performance test	Output amplitude range: +5 dBm to -55 dBm Frequency range: 70 MHz to 6.5 GHz

Equipment	Recommended Model	Where Used	Minimum Requirements
	reduce SSB phase noise. All specifications apply≥10 MHz. Option 28A: Adds Analog Modulation Suite. **Note** Option 15 is not needed and should be avoided since it significantly degrades harmonic and harmonic-related spurs that can impact the IMD3 test results.		
Power splitter (x3)	Aeroflex/Weinschel 1593	Test system characterization Verifications: - Frequency response - Input absolute amplitude accuracy - Output power level accuracy Adjustments: - Input absolute amplitude accuracy	VSWR: ≤1.25:1 up to 18 GHz Amplitude tracking: <0.25 dB

Equipment	Recommended Model	Where Used	Minimum Requirements
		▪ Output power level accuracy ▪ LO gain	
Power Combiner	Mini Circuits ZFRSC-123-S+	Input/Output IMD3 functional performance test	Impedance: 50 Ω Frequency: DC to 12 GHz Isolation: 19.5 dB Insertion loss: ≤10 dB
6 dB attenuator (x3)	Anritsu 41KB-6 or Mini-Circuits BW-S6-2W263+	Test system characterization Adjustments: ▪ Input absolute amplitude accuracy ▪ Output power level accuracy	Frequency range: DC to 6.5 GHz VSWR: ≤1.1:1
50 Ω SMA (m) terminator	—	Test system characterization	Frequency range: DC to 6.5 GHz VSWR: ≤1.1:1
SMA (m)-to-SMA (m) cable (x7)	—	All procedures	Frequency: DC to 6.5 GHz Impedance: 50 Ω

Equipment	Recommended Model	Where Used	Minimum Requirements
SMA (m)-to-MMPX (m) cable (x3)	—	Verifications: ▪ RF input spectral purity ▪ RF output spectral purity Adjustments: ▪ Adjusting LO gain (RF IN and RF OUT)	Frequency range: DC to 6.5 GHz Impedance: 50 Ω
MMCX (f)-to-SMA (f) adapter	Huber+Suhner 31_MMCX-SMA-50-2/111_NE or Johnson/Cinch 134-1019-171	Test system characterization	Frequency range: DC to 6.5 GHz[1] Impedance: 50 Ω VSWR: ≤1.2
SMA (f)-to- N (f) adapter	Huber+Suhner 31_N-SMA-50-1/1-_UE	Test system characterization	Frequency range: DC to 6.5 GHz Impedance: 50 Ω Return loss: ≥23 dB
SMA (m)-to- N (f) adapter (x4)	33_SMA_N-50-1/1-_UE	Test system characterization	Frequency range: DC to 6 GHz Impedance: 50 Ω Return loss: ≥23 dB
3.5 mm (m)-to-3.5 mm (m) adapter (x2)	Huber+Suhner 32_PC35-50-0-2/199_NE	Test system characterization	Frequency range: DC to 6 GHz

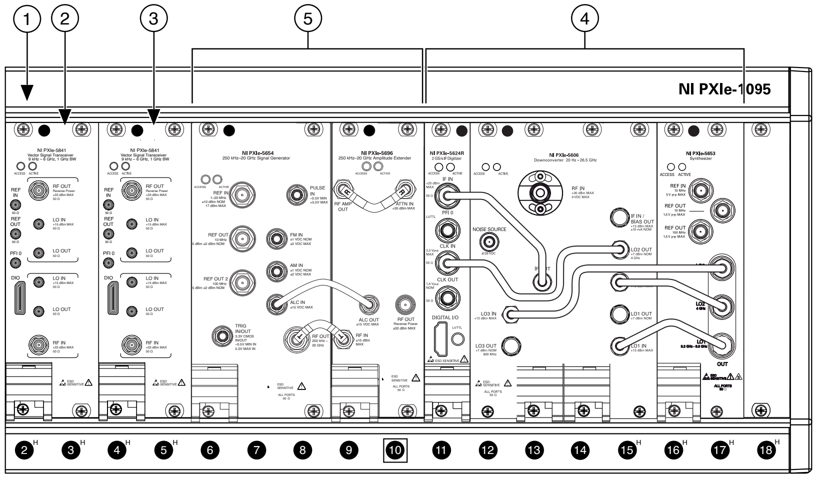
Equipment	Recommended Model	Where Used	Minimum Requirements
		Verifications: ▪ Frequency response ▪ Input absolute amplitude accuracy ▪ Output power level accuracy	Impedance: 50 Ω Return loss: ≥30 dB
3.5 mm (f)-to-3.5 mm (f) adapter	Huber+Suhner 31_PC35-50-0-1/199_UE	Test system characterization	Frequency range: DC to 6 GHz Impedance: 50 Ω Return loss: ≥30 dB
External Transceiver	PXIe-5841	Test system characterization Verifications: ▪ Input absolute amplitude accuracy ▪ Frequency response ▪ Power level accuracy	Frequency range: 10 MHz to 6 GHz -50 dBm to 10 dBm Digital gain linearity: <0.054 dB Digital tone control (amplitude and frequency)
20 dB attenuator	Anritsu 41KC-20	Used in the following fixture: ▪ LO MMPX cable loss assembly Adjustment:	VSWR: ≤ 1.1:1 Frequency range: DC to 6.5 GHz

Equipment	Recommended Model	Where Used	Minimum Requirements
		▪ LO gain	
12 dB attenuator	Mini Circuits BW-S12W2+	Used in the following fixtures for test system characterization: ▪ RF output power splitter assembly Verification: ▪ Output power level accuracy Adjustment: ▪ LO gain	VSWR: ≤ 1.1:1 Frequency range: DC to 6.5 GHz
MMPX (m)-to-BNC (m) cable (x3)	NI part number: 763771-01	All procedures	—

Table 2. Required Equipment Specifications for PXIe-5841 Calibration

The following figure shows a recommended calibration system configuration for the PXIe-5841 .

Figure 1. Recommended PXIe-5841 Calibration System



1. PXIe-1095 Chassis
2. Slot 2: PXIe-5841 (Device Under Test)
3. Slot 4: External Transceiver
4. Slot 11: PXIe-5668R
5. Slot 6: PXIe-5654 with PXIe-5696

Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-5841 meets published specifications.

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the PXIe-5841 , including front panel connections and screws, are secure.
- Maintain an ambient temperature of 23 °C ± 5 °C.
- Keep relative humidity between 10% and 90%, noncondensing.
- Allow a warm-up time of at least 30 minutes after the chassis is powered on and NI-RFSA and NI-RFSG instrument driver is loaded and recognizes the PXIe-5841 . The warm-up time ensures that the PXIe-5841 and test instrumentation are at a stable operating temperature.

- In each verification procedure, insert a delay between configuring all instruments and acquiring the measurement. This delay may need to be adjusted depending on the instruments used but should always be at least 10 ms for the first iteration, 10 ms when the power level changes, and 10 ms for each other iteration.
- Ensure that the PXI chassis fan mode is set to Auto when used in a chassis with ≥58 W slot-cooling capability or the fan mode is set to High when used in any other chassis.
- Ensure that 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 Not to Users** document available at ni.com/manuals.

Initial Setup

Refer to the **PXIe-5841 Getting Started Guide** for information about how to install the software and the hardware and how to configure the device in Measurement & Automation Explorer (MAX).

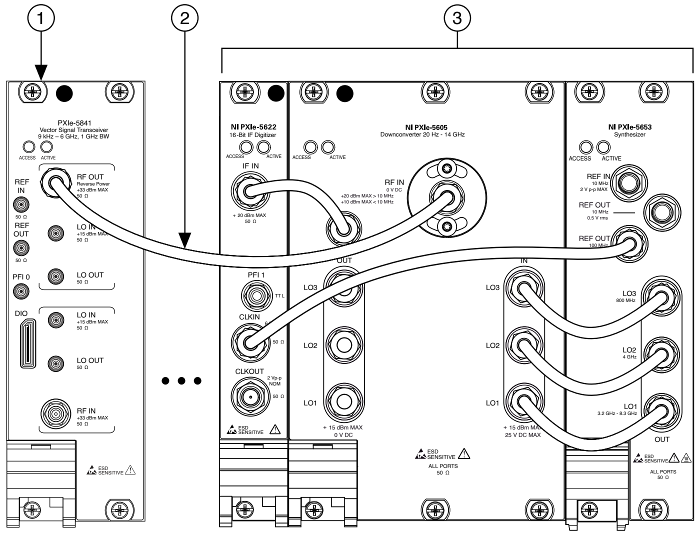
External Transceiver IMD3 Functional Performance Test

RF Output IMD3 Functional Performance Test

This procedure measures the IMD3 performance of the PXIe-5841 . This is not a warranted specification, but the limits of this test ensure that the PXIe-5841 meets the linearity requirement when it is used as the external transceiver for a different PXIe-5841 (DUT).

1. Connect the external transceiver front panel connector to the vector signal analyzer RF IN front panel connector.
   The following figure illustrates the complete hardware setup.

Figure 2. RF Output IMD3 Characterization Cabling Diagram



1. External Transceiver
2. SMA (m)-to-SMA (m) Cable
3. Vector Signal Analyzer

2. Connect an available 10 MHz rubidium frequency reference output to the spectrum analyzer REF IN front panel connector.
3. Connect an available 10 MHz rubidium frequency reference output to the external transceiver REF IN front panel connector.
4. Configure the external transceiver to generate two single sideband tones simultaneously at 1.6 MHz (f_1) and 2.3 MHz (f_2) offset from the carrier, using the following settings:
   - Center frequency: 120 MHz
   - Power level: 10 dBm
   - Pre-filter gain: -3 dB
   - Power level type: peak power
   - I/Q rate: 10 MS/s
   - Reference Clock source: REF IN
   - Relative tone power (dB): -12 dB

5. Use the vector signal analyzer to measure the generated signal using the following settings:
   - Center frequency: (**Center frequency** from step 5 + (f_1 + f_2)/2)
   - Reference level: **Power level** from step 5 - 10 dB
   - Span: 2.3 MHz
   - Resolution bandwidth: 500 Hz
   - Averaging type: RMS
   - Number of averages: 10
   - FFT window: Hanning
   - Preamplifier enabled: Disabled
   - Preselector enabled: Enabled when in signal path
6. Measure and record the peak power of the following tones and distortion locations:
   1. Center frequency + f_1, record as **fundamental tone**$_1$
   2. Center frequency + f_2, record as **fundamental tone**$_2$
   3. Center frequency + ($2f_2$-f_1), record as **IMD tone**$_1$
   4. Center frequency + ($2f_1$-f_2), record as **IMD tone**$_2$
7. Calculate the output IMD3 using the following equation:
   Output IMD3= **maximum** (**IMD3 tone**$_1$, **IMD3 tone**$_2$) - **minimum** (**fundamental tone**$_1$, **fundamental tone**$_2$)
8. Repeat steps 4 through 8 for the remaining frequencies from 120 MHz to 6 GHz in 10 MHz steps.
9. Repeat steps 4 through 9 for all output power levels in the following **IMD3 (dBc) -6 dB Relative Power** table.
10. Compare the output IMD3 values calculated in steps 8 through 10 to the corresponding limits in the following table.

Frequency	Output Power Level	Characterization Limit (dBc)
120 MHz to 5.95 GHz	10	-50
120 MHz to 5.95 GHz	-10	-50

Frequency	Output Power Level	Characterization Limit (dBc)
120 MHz to 5.95 GHz	-20	-50

Table 3. IMD3 (dBc) -6 dB Relative Power

Note
The external transceiver requirements are <0.054 dB gain linearity. The relationship between IMD3 distortion and gain linearity can be described in the following formula:

$$\text{Gain Linearity} = 20 * \log\left(1 - \frac{1}{10\left(-\frac{\text{IMD3}+6}{20}\right)+3}\right)$$

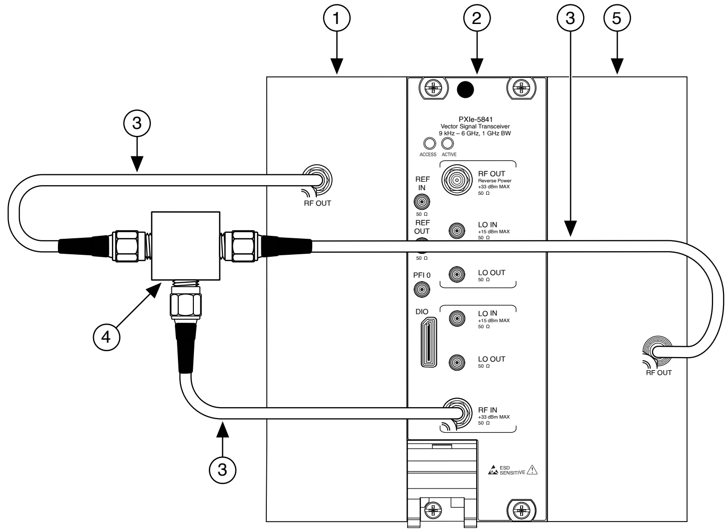
Note If the external transceiver meets the specified limits in the table above, it meets all performance requirements to be used as the measurement module in subsequent verification procedures.

RF Input IMD3 Functional Performance Test

This procedure measures the IMD3 performance of the PXIe-5841 . This is not a warranted specification, but the limits of this test ensure that the PXIe-5841 meets the linearity requirement when it is used as the external transceiver for a different PXIe-5841 (DUT).

1. Connect the RF OUT ports of the RF signal generators to the input ports of the power combiner.
2. Connect the output of the power combiner to the external transceiver RF IN front panel connector.
   The following figure illustrates the complete hardware setup.

Figure 3. RF Input IMD3 Characterization Cabling Diagram



1. RF Signal Generator 1
2. External Transceiver
3. SMA (m)-to-SMA (m) Cable
4. Power Combiner
5. RF Signal Generator 2

3. Connect an available 10 MHz rubidium frequency reference output to the external transceiver REF IN connector.
4. Connect an available 10 MHz rubidium frequency reference output to both of the RF signal generators REF IN front panel connectors.
5. Configure the external transceiver input for a center frequency of 70 MHz, using the following settings:
   - Center frequency: 70 MHz
   - Reference level: Configured reference level from the **IMD3 Test Limits** table that corresponds to the **center frequency**
   - Span: 20 MHz
   - Resolution bandwidth: 1 kHz
   - Averaging mode: RMS
   - Number of averages: 10

- Window type: Flat Top
- Downconverter center frequency: Center frequency + 3.75 MHz
- Reference Clock source: REF IN
- Reference Clock frequency: 10 MHz

> **Note** Steps 6 and 7 configure the RF signal generator 1 at a 1.6 MHz (f_1) offset and the RF signal generator 2 at a 2.3 MHz (f_2) offset from the center frequency. The spacing of the two tones is the same for all iterations of this procedure.

6. Configure the RF signal generator 1 output for a frequency offset of f_1 from the **center frequency** in step 5, using the following settings:
   - Center frequency: **Center frequency** from step 5 + f_1
   - Power level: **Reference level** from step 5 5 dB
   - Reference clock source: REF IN
   - Reference clock frequency: 10 MHz
7. Configure the RF signal generator 2 output for a frequency offset of f_2 from the **center frequency** in step 5, using the following settings:
   - Center frequency: **Center frequency** from step 5 + f_2
   - Power level: **Reference level** from step 5 + 5 dB
   - Reference clock source: REF IN
   - Reference clock frequency: 10 MHz
8. Acquire a spectrum of the combined signal from steps 6 and 7 using the external transceiver.
9. Measure the power at the expected distortion frequencies using the following settings:
   - **Center frequency** from step 5 + f_1, record as **fundamental tone**$_1$
   - **Center frequency** from step 5 + f_2, record as **fundamental tone**$_2$.
   - Center frequency + ($2f_1$-f_2). Record as **IMD3** tone$_1$.
   - Center frequency + ($2f_2$-f_1). Record as **IMD3** tone$_2$.

10. Calculate **input IMD3** using the following equation:
    Input IMD3= **maximum** (**IMD3 tone**$_1$, **IMD3 tone**$_2$) - **minimum** (**fundamental tone**$_1$, **fundamental tone**$_2$)
11. Record the **input IMD3** value.
12. Repeat steps 5 through 11 for the remaining frequencies from 70 MHz to 5.95 GHz in 25 MHz steps.
13. Repeat steps 5 through 12 for the remaining configured reference levels in the **IMD3 Test Limits** table.
14. Compare the calculated input IMD3 with the specified limits in the following table.

Frequency	Configured Reference Level (dBm)	Characterization Limit (dBc)
70 MHz to 5.95 GHz	0	-50
70 MHz to 5.95 GHz	-20	-50
70 MHz to 5.95 GHz	-40	-50

Table 4. IMD3 Test Limits

Note The PXIe-5841 requirements are <0.054 dB gain linearity. The relationship between IMD3 distortion and gain linearity can be described in the following formula:

$$\text{Gain Linearity} = 20 * \log\left(1 - \frac{1}{10\left(-\frac{\text{IMD3}+6}{20}\right)+3}\right)$$

Note If the external transceiver meets the specified limits in the table above, it meets all performance requirements to be used as the external transceiver in subsequent verification procedures.

15. Repeat steps 6 through 13 for the remaining configured reference levels in the **IMD3 Test Limits** table.

Self-Calibrating the PXIe-5841

Allow a 30-minute warm-up time before you begin self-calibration.

Note The warm-up time begins after the PXI Express chassis is powered on and the operating system completely loads.

Note No signal connections are needed for self-calibration.

The PXIe-5841 includes precise internal circuits and references used during self-calibration to adjust for any errors caused by short-term fluctuations in the environment. You must call the self-calibration function to validate the specifications in the **Verification** section. You must perform self-calibration on both the external transceiver and DUT.

1. Perform self-calibration using the NI-RFSA or NI-RFSG installed Self Calibrate VI. Open one of the following self-calibration tools:
   - Add the niRFSG Self Cal VI, located on the Functions » Measurement I/O » NI-RFSG » Calibration » Self Calibration palette, to a block diagram. You must call the niRFSG Initialize VI before and niRFSG Close VI after the niRFSG Self Cal VI.
   - Add the niRFSA Self Cal VI, located on the Functions » Measurement I/O » NI-RFSA » Calibration palette, to a block diagram. You must call the niRFSA Initialize VI before and niRFSA Close VI after the niRFSA Self Cal VI.
2. Run the self-calibration VI.

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 RF Input Power Splitter Assembly

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

This procedure characterizes the balance between the two output terminals of the splitter, where the second terminal is terminated into an attenuator. The following procedures require the power splitter balance data:

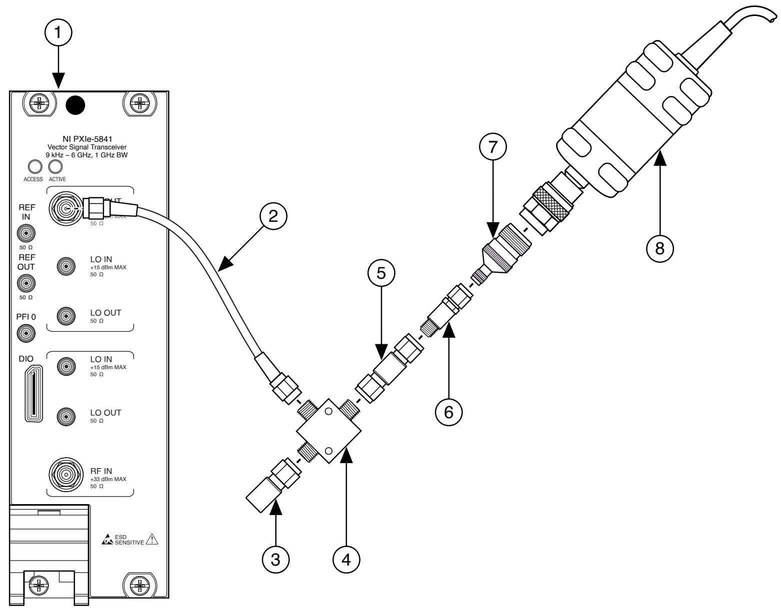
- **Verifying Input Absolute Amplitude Accuracy**
- **Verifying Input Frequency Response**
- **Adjusting Input Absolute Amplitude Accuracy**

For characterization used only in a verification procedure, use the test points in the below **Characterization Test Points for RF Input Verification Procedures** table. If characterizing for adjustment only or for verification and adjustment, use the test points in the **Characterization Test Points for RF Input Adjustment Procedures** table.

1. Connect one end of the SMA (m)-to-SMA (m) cable to the RF OUT front panel connector of the external transceiver.
2. Connect the other end of the SMA (m)-to-SMA (m) cable to the input port of the power splitter.
3. Connect the 50 Ω (m) terminator to one of the power splitter output ports. Refer to this port as **splitter output 1**.
4. Connect the power splitter output to the SMA (f) connector of the 6 dB attenuator using a 3.5 mm (m)-to-3.5 mm (m) adapter. Refer to the combined power splitter output and 6 dB attenuator as **splitter output 2**.

5. Connect the power sensor to splitter output 2 using the SMA (f)-to-N (f) adapter.
   The following figure illustrates the hardware setup.

   Figure 4. Connection Diagram for Measuring at Splitter Output 2



   1. External Transceiver
   2. SMA (m)-to-SMA (m) Cable
   3. 50 Ω Terminator
   4. Power Splitter
   5. 3.5 mm (m)-to-3.5 mm (m) Adapter
   6. 6 dB Attenuator
   7. SMA (f)-to-N (f) Adapter
   8. Power Sensor

6. Configure the RF signal source (Vector Signal Transceiver) to generate a tone using the following settings:
   - RF frequency: Whether characterizing for verification, adjustment, or verification and adjustment, use the test points in the following**Characterization Test Points for RF Input** table. Store as **frequency**.

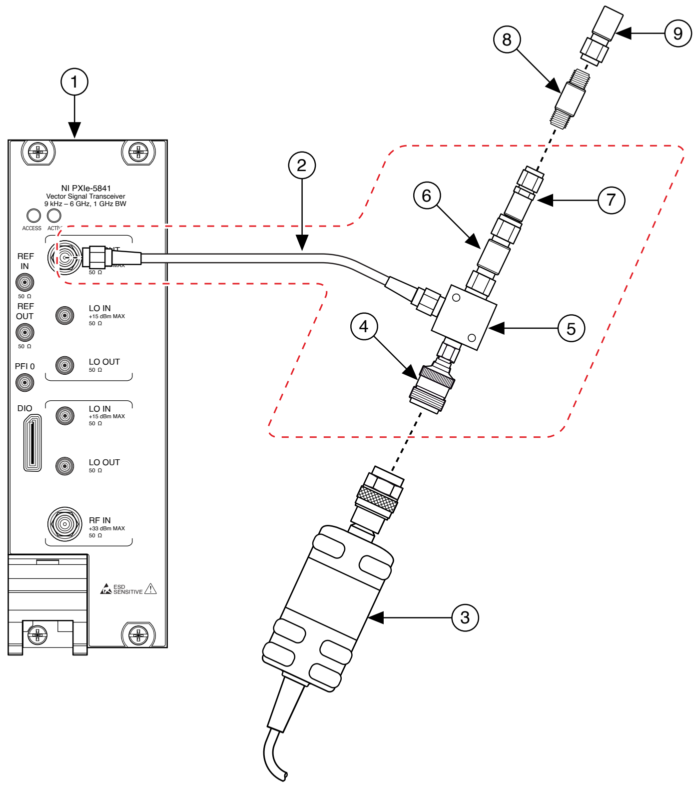
- Power level: 0 dBm
- Allow out of specification user settings: Enabled

Test Points	Step Size (MHz)
8 MHz to 6.5 GHz	2
235 MHz	—
275 MHz	—
295 MHz	—
375 MHz	—

Table 5. Characterization Test Points for RF Input

7. Configure the power sensor to correct for **frequency** using the power sensor frequency correction function.
8. Use the power sensor to measure the power at the **frequency** from step 6.
9. Repeat steps 6 through 8 by updating **frequency**. For characterization used only in a verification procedure, only for adjustment, or for verification and adjustment, use the test points in the **Characterization Test Points for RF Input** table.
   Record the resulting measurements as **splitter output 2 power**. Each frequency should have a corresponding value.
10. Disconnect the power sensor and SMA (f)-to-N (f) adapter.
11. Switch the power sensor and 50 Ω terminator.
    The following figure illustrates the hardware setup.

Figure 5. Connection Diagram for Measuring at Splitter Output 1



1. External Transceiver
2. SMA (m)-to-SMA (m) Cable
3. Power Sensor
4. SMA (m)-to-N (f) Adapter
5. Power Splitter
6. 3.5 mm (m)-to-3.5 mm (m) Adapter
7. 6 dB Attenuator
8. 3.5 mm (f)-to-3.5 mm (f) Adapter
9. 50 Ω Terminator

12. Configure the external transceiver using the following settings:
    - RF frequency: Whether characterizing for verification, adjustment, or verification and adjustment, use the test points in the previous **Characterization Test Points for RF Input** table. Store as **frequency**.

- Power level: 0 dBm
- Allow out of specification user settings: Enabled

13. Configure the power sensor to correct for **frequency** using the power sensor frequency correction function.
14. Use the power sensor to measure the power.
15. Repeat steps 13 through 15 by updating **frequency**. Use the test points in the **Characterization Test Points for RF Input** table.
    Record the resulting measurements as **splitter output 1 power**. Each frequency should have a corresponding value.
16. Calculate the splitter balance for each frequency point using the following equation:
    splitter balance = **splitter output 2 power** - **splitter output 1 power**
17. Remove the SMA (m)-to-SMA (m) cable from the RF OUT port of the external transceiver.
18. Remove the 50 Ω terminator and SMA (f)-to-SMA (f) adapter.
19. Remove the power sensor from the SMA (m)-to-N (m) adapter.
20. Do not disassemble any other components, and set the assembly (indicated by the previous figure's red dashed line) aside for use in the procedures mentioned at the beginning of this section.

> Note If any other portions of this splitter assembly are disconnected at any point, the **RF Input Power Splitter Assembly** procedure must be repeated.

Characterizing RF Output Power Splitter Assembly

This procedure characterizes the loss through the power splitter.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

The following procedures require the power splitter loss data:

- **Verifying Output Power Level Accuracy**
- **Verifying Output Frequency Response**

- **Adjusting Output Power Level Accuracy**

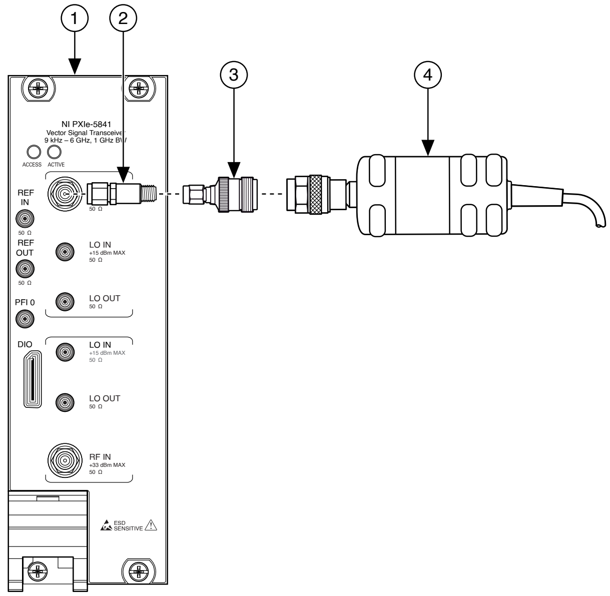
For characterization used only in a verification procedure, use the test points in the following **Characterization Test Points for RF Output Verification Procedures** table. If characterizing for adjustment only or for verification and adjustment, use the test points in the **Characterization Test Points for RF Output Adjustment Procedures** table.

Test Points	Step Size (MHz)
8 MHz to 6.5 GHz	2
235 MHz	—
275 MHz	—
295 MHz	—
375 MHz	—

Table 6. Characterization Test Points for RF Output

1. Connect the SMA (m) connector of the 6 dB attenuator to the RF OUT front panel connector of the vector signal generator.
2. Connect the SMA (f) connector of the 6 dB attenuator to the power sensor using an SMA (m)-to-N (f) adapter.
   The following figure illustrates the hardware setup.

Figure 6. Connection Diagram for Measuring Splitter Input Power



1. External Transceiver
2. 6 dB Attenuator
3. SMA (m)-to-N (f) Adapter
4. Power Sensor

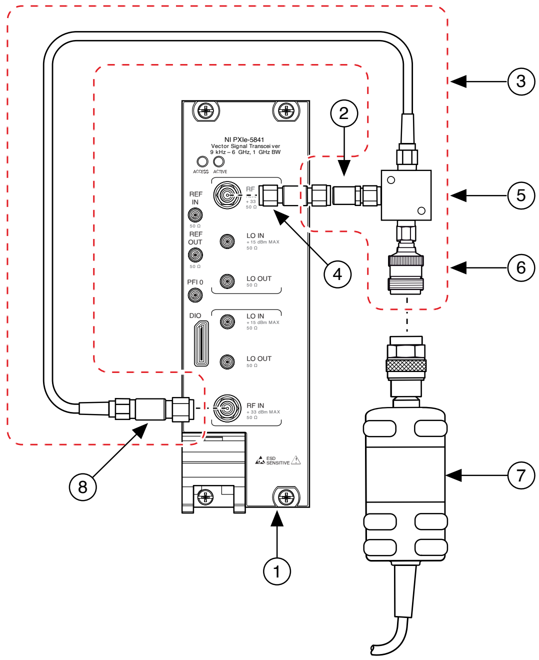
3. Configure the external transceiver to generate a tone using the following settings:
   - RF frequency: Frequency from verification or adjustment table
   - Upconverter center frequency: **RF frequency** - 3.75 MHz
   - Power level: 0
   - Allow out of specification user settings: Enabled
4. Configure the power sensor to correct for the **RF frequency** from step 3 using the power sensor frequency correction function.
5. Use the power sensor to measure the output power.
6. Repeat steps 3 through 5 for the remaining frequencies. For characterization used only in a verification procedure, use the test points in the **Characterization Test Points for RF Output Verification Procedures** table. If characterizing for adjustment only or for verification and adjustment, use the

test points in the **Characterization Test Points for RF Output Verification Procedures** table.
Record the resulting measurements as **splitter input power**. Each frequency should have a corresponding value.

7. Disconnect the power sensor and SMA (m)-to N (f) adapter from the 6 dB attenuator.
8. Connect the power splitter input port to the SMA (f) port of the 6 dB attenuator using an SMA (m)-to-SMA (m) adapter.
9. Connect the power sensor to one of the splitter output ports using the SMA (m)-to-N (f) adapter.
Refer to this port as **splitter output 1** for the remainder of this procedure and all tests that use the resulting characterization data.
10. Connect the other output of the power splitter to the SMA (f) connector of a second 6 dB attenuator using an SMA (m)-to-SMA (m) cable.
11. Connect the SMA (m) connector of the second 6 dB attenuator to the RF IN front panel port of the external transceiver.
Refer to this port as **splitter output 2** for the remainder of this procedure and all tests that use the resulting characterization data.

The following figure illustrates the hardware setup.

Figure 7. Connection Diagram for Measuring Splitter Output 1 Power



1. External Transceiver
2. SMA (m)-to-SMA (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. 6 dB Attenuator
5. Power Splitter
6. SMA (m)-to-N (f) Adapter
7. Power Sensor
8. 12 dB Attenuator

12. Configure the external transceiver to generate a tone using the following settings:
    - RF frequency: Frequency from verification or adjustment table
    - Upconverter center frequency: **RF frequency** - 3.75 MHz
    - Power level: 0 dBm
13. Configure the external transceiver using the following settings:
    - RF frequency: **RF frequency** from step 12

- Reference level: 10 dBm
- Downconverter center frequency: **Upconverter center frequency** from step 12
- Span: 10 MHz
- Resolution bandwidth: 4 kHz
- Averaging mode: RMS
- Number of averages: 10

14. Configure the power sensor to correct for the frequency from step 12 using the power sensor frequency correction function.
15. Use the power sensor to measure the output power. Store this value as **splitter output 1 power**.
16. Repeat steps 12 through 15 for the remaining frequencies. For characterization used only in a verification procedure, use the test points in the **Characterization Test Points for RF Output** table.
17. Calculate a table of splitter loss values for each frequency of each transfer function using the following equation:
    splitter loss = **splitter output 1 power** - **splitter input power**
    Store the results in a **Splitter Loss** table.
18. Remove the SMA (m)-to-SMA (m) adapter from the 6 dB attenuator connected to the RF OUT port of the PXIe-5841 . Leave it connected to the splitter.
19. Remove the 12 dB attenuator from the RF IN port of the PXIe-5841 .
20. Remove the power sensor from the SMA (m)-to-N (m) adapter.
21. Do not disassemble any other components, and set the assembly (indicated by the previous figure's red dashed line) aside for use in the procedures mentioned at the beginning of this section.

> **Note** If any other portions of this splitter assembly are disconnected at any point, the **Characterizing Splitter Loss** procedure must be repeated.

Characterizing LO Splitter Assembly

This procedure characterizes the loss through the LO splitter.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

The following procedure requires the power splitter loss data:

- **Adjusting LO Gain (RF IN and RF OUT)**

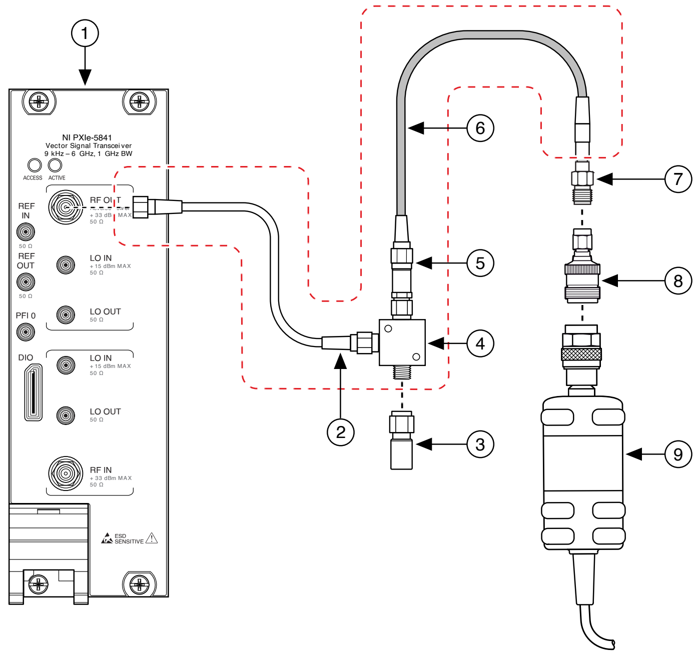
Use the test points in the following **Characterization Test Points for LO Gain Adjustment Procedures** table.

Test Points	Step Size (MHz)
20 MHz to 6.5 GHz	50

Table 7. Characterization Test Points for LO Gain Adjustment Procedures

1. Connect the SMA (m) connector of the SMA (m)-to-MMPX (m) cable to the RF OUT front panel connector of the vector signal transciever.
2. Connect the 50 Ω (m) terminator to splitter output 1.
3. Connect splitter output 2 to the SMA (m) connector the 6 dB attenuator.
4. Connect the SMA (m)-to-MMPX (m) cable to the SMA (f) connector of the 6 dB attenuator.
5. Connect the power sensor to the end of the MMPX cable using the N (f)-to-SMA (m) adapter and an MMCX (f)-to-SMA (f) adapter.
   The following figure illustrates the hardware setup.

Figure 8. Connection Diagram for Measuring Splitter Input Power

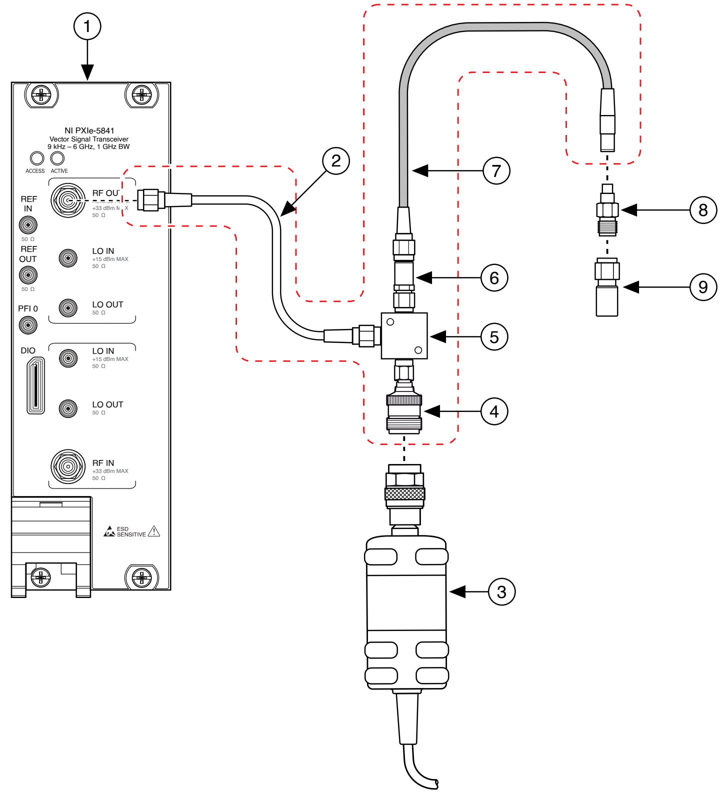


1. External Transceiver
2. SMA (m)-to-SMA (m) Cable
3. 50 Ω Terminator
4. Power Splitter
5. 6 dB Attenuator
6. SMA (m)-to-MMPX (m) Cable
7. MMCX (f)-to-SMA (f) Adapter
8. SMA (m)-to-N (f) Adapter
9. Power Sensor

6. Configure the external transceiver to generate a tone using the following settings:
   - RF frequency: Frequency from the **Characterization Test Points for LO Gain Adjustment** table
   - Upconverter center frequency: **RF frequency** - 3.75 MHz
   - Power level: 0
   - Allow out of specification user settings: Enabled

7. Configure the power sensor to correct for the **RF frequency** from step 3 using the power sensor frequency correction function.
8. Use the power sensor to measure the output power.
9. Repeat steps 7 through 8 for the remaining frequencies. Use the test points in the **Characteriation Test Points for LO Gain Adjustment Procedures** table. Record the resulting measurements as **LO splitter output 2 power**. Each frequency should have a corresponding value.
10. Disconnect the power sensor and 50 Ω terminator from the power splitter. Do not disconnect any component in the previous figure within the red dashed line.
11. Connect the power sensor to splitter output 1 using an SMA (m)-to-N (f) adapter.
12. Switch the 50 Ω terminator and power sensor.
    The following figure illustrates the hardware setup.

Figure 9. Connection Diagram for Measuring Splitter Output 1 Power



1. External Transceiver
2. SMA (m)-to-SMA (m) Cable
3. Power Sensor
4. SMA (m)-to-N (f) Adapter
5. Power Splitter
6. 6 dB Attenuator
7. SMA (m)-to-MMPX (m) Cable
8. MMCX (f)-to-SMA (f) Adapter
9. 50 Ω Terminator

13. Configure the external transceiver to generate a tone using the following settings:
    - RF frequency: Frequency from the **Characterization Test Points for LO Gain Adjustment** table

- Upconverter center frequency: **RF frequency** - 3.75 MHz
- Power level: 0 dBm
- Allow out of specification user settings: Enabled

14. Configure the power sensor to correct for the frequency from step 13 using the power sensor frequency correction function.
15. Use the power sensor to measure the output power.
16. Repeat steps 13 through 15 for the remaining frequencies. Use the test points in the **Characterization Test Points for LO Gain Adjustment Procedures** table.
    Store this value as **LO splitter output 1 power**. Each frequency should have a corresponding value
17. Calculate the splitter balance for each frequency point using the following equation:
    LO splitter balance = **LO splitter output 2 power** - **LO splitter output 1 power**
    Store the results in an **LO Splitter Balance** table.
18. Disconnect the SMA (m)-to-SMA (m) cable connected to the RF OUT port of the external transceiver. Leave it connected to the splitter.
19. Disconnect the MMCX (f)-to-SMA (f) adapter from the SMA (m)-to-MMPX (m) cable.
20. Disconnect the power sensor from the SMA (m)-to-N (m) adapter.
21. Do not disassemble any other components, and set the assembly (indicated by the previous figure's red dashed line) aside for use in the procedures mentioned at the beginning of the section.

> Note If any portions of this splitter assembly are discontinued at any point, the **Characterizing LO Splitter Assembly** procedure must be repeated.

Characterizing LO MMPX Cable Loss

This procedure characterizes the loss through the MMPX (m)-to-SMA (m) cable.

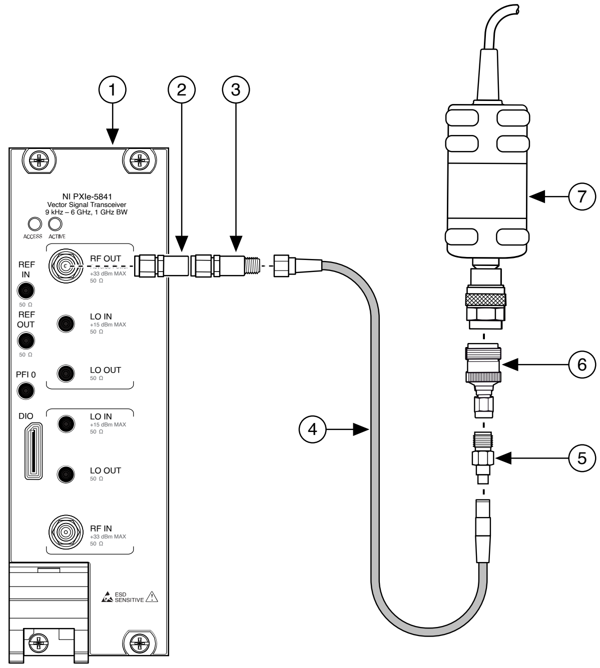
You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

The following procedure requires the power splitter loss data:

- **Adjusting LO Gain (RF IN and RF OUT)**

1. Connect the 20 dB attenuator to the 6 dB attenuator.
2. Connect the SMA (m) connector of the 6 dB attenuator to the RF OUT front panel connector of the external transceiver.
3. Connect the SMA (m)-to-MMPX (m) cable to the SMA (f) connector of the 20 dB attenuator.
4. Connect the power sensor to the SMA (m)-to-MMPX (m) cable using an N (f)-to-SMA (m) adapter and an MMCX (f)-to-SMA (f) adapter.
   The following figure illustrates the hardware setup.

Figure 10. Connection Diagram for Measuring LO MMPX Cable Loss



1. External Transceiver
2. 6 dB Attenuator
3. 20 dB Attenuator
4. SMA (m)-to-MMPX (m) Cable
5. MMCX (f)-to-SMA (f) Adapter
6. SMA (m)-to-N (f) Adapter
7. Power Sensor

5. Configure the external transceiver to generate a tone using the following settings:
   - RF frequency: Same test points as used in LO gain characterization
   - Upconverter center frequency: **RF frequency** - 3.75 MHz
   - Power level: 0
   - Allow out of specification user settings: Enabled
6. Configure the power sensor to correct for the **RF frequency** from step 4 using the power sensor frequency correction function.

7. Use the power sensor to measure the output power.
8. Repeat steps 4 through 6 for the remaining frequencies in the **Characterization Test Points for LO Gain Adjustment Procedures** table. Record the resulting measurements as **mmpx output power**. Each frequency should have a corresponding value.
9. Calculate the MMPX cable loss for each frequency using the following equation:
   MMPX cable loss = mmpx output power - splitter input power

> Note **Splitter input power** is obtained from step 6 of the **Characterizing RF Output Power Splitter Assembly** section. If the attenuator has not been removed from the external transceiver, that data should be used.

As-Found and As-Left Limits

The as-found limits are the published specifications for the PXIe-5841 . NI uses these limits to determine whether the PXIe-5841 meets the specifications when it is received for calibration.

The as-left calibration limits are equal to the published NI specifications for the PXIe-5841 , less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to determine whether the PXIe-5841 meets the device specifications over its calibration interval.

Verification

This section provides instructions for verifying the PXIe-5841 specifications.

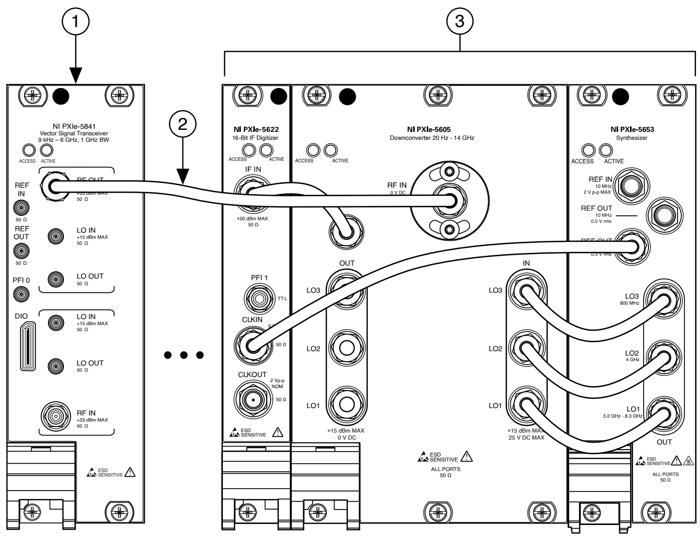
> Note The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

Verifying Internal Frequency Reference

This procedure verifies the frequency accuracy of the PXIe-5841 onboard frequency reference using a vector signal analyzer.

1. Connect the vector signal analyzer RF IN front panel connector to the PXIe-5841 RF OUT front panel connector.
   The following figure illustrates the hardware setup.

   Figure 11. Internal Frequency Reference Verification Cabling Diagram

   1. PXIe-5841
   2. SMA (m)-to-SMA (m) Cable
   3. Vector Signal Analyzer
2. Connect an available 10 MHz rubidium frequency reference output to the vector signal analyzer REF IN front panel connector.
3. Configure the signal analyzer to acquire a 2.22 GHz signal using the following settings:
   - Center frequency: 2.22 GHz
   - Reference Level: 10 dBm
   - Reference Clock source: External
   - Resolution bandwidth: 100 Hz

- Span: 100 kHz
- FFT window: Hanning
- Averaging type: RMS
- Number of averages: 20

4. Configure the PXIe-5841 to generate a signal at 2.22 GHz, using the following settings:
   - Center frequency: 2.22 GHz
   - Power level: -10 dBm
   - Reference Clock source: Onboard
5. Measure the frequency of the peak acquired tone.
6. Calculate the deviation using the following equation:
   $\Delta f = \frac{f_{measured} - 2.22\ \text{GHz}}{2.22\ \text{GHz}}$ $\Delta f = \frac{f_{measured} - 2.22\ \text{GHz}}{2.22\ \text{GHz}}$
7. Refer to the table below for the limits from step 6:

As-Found Limit (2 years)	3.2E-6 Hz/Hz
As-Found Limit (1 year)	2.2E- 6 Hz/Hz
As-Left Limit	1.2E- 6 Hz/Hz

Table 8. Internal Frequency Reference Verification Limits

The following equation can be used to calculate the limits:
initial accuracy + **aging** + **temperature stability**
where

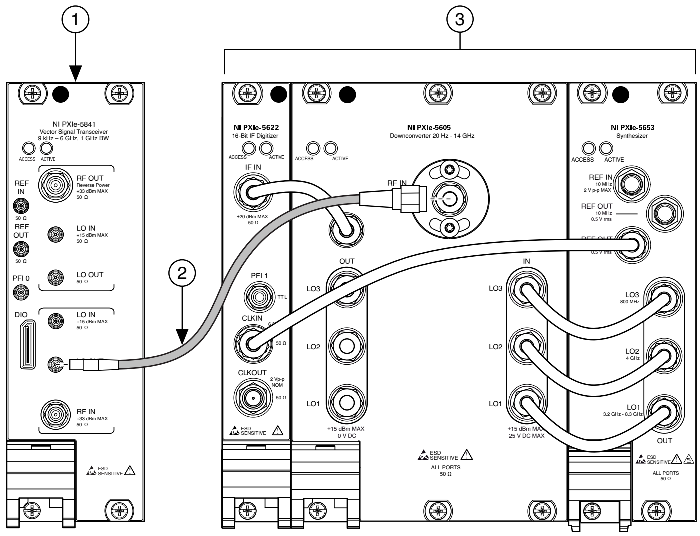
- **initial accuracy** = ±200 * 10^{-9}
- **aging** = ±1 * 10^{-6} /**year** * **desired calibration interval in years**
- **temperature stability** = ±1 * 10^{-6}

Verifying RF Input Spectral Purity

This procedure verifies the RF input spectral purity of the PXIe-5841 .

1. Connect the PXIe-5841 LO OUT(RF IN) front panel connector to the RF IN front panel connector of the vector signal analyzer using the SMA (m)-to-MMPX (m) cable.
   The following figure illustrates the hardware setup.

   Figure 12. RF Input Spectral Purity Verification Cabling Diagram



   1. PXIe-5841
   2. MMPX (m)-to-SMA (m)
   3. Vector Signal Analyzer

2. Connect an available 10 MHz rubidium frequency reference output to the PXIe-5841 REF IN front panel connector.
3. Connect the same 10 MHz rubidium frequency reference output to the vector signal analyzer REF IN front panel connector.
4. Configure the PXIe-5841 to export the LO using the following settings:
   - Center frequency: 900 MHz
   - LO OUT: Enabled
   - Reference Clock source: REF IN
5. Configure the vector signal analyzer to acquire a spectrum using the following settings:

- Center frequency: 900 MHz
- Reference level: 0 dBm
- Span: 100 Hz
- Window: 7-term Blackman-Harris
- Resolution bandwidth (RBW): 10 Hz
- Reference Clock source: External
- Averaging type: RMS
- Number of averages: 3

6. Measure the peak power at the center frequency.
   The measured value is the power, in dBm, of the generated tone.
7. Configure the vector signal analyzer to acquire a spectrum using the following settings:
   - Center frequency: **Center frequency** from step 5 + 20 kHz
   - Number of averages: 50
8. Measure the power at a 20 kHz offset by averaging all measurements across the 100 Hz span. Normalize the result to 1 Hz bin width by subtracting 10 * log (RBW), where RBW is the setting specified in step 5.
   The result of this step is in dBm/Hz.
9. Calculate the relative difference between the signal and noise using the following equation:
   SSB Phase Noise at 20 kHz (dBc/Hz) = **step 8 measurement** (dBm/Hz) - **step 6 measurement** (dBm)
   The result of this step is in dBc/Hz.
10. Compare the results of step 9 to the specified limits in the following table.

Frequency	As-Found Limit (dBc/Hz)	As-Left Limit (dBc/Hz)
<3 GHz	-102	-103.5
3 GHz to 4 GHz	-102	-103.5
>4 GHz to 6 GHz	-96	-97.8

Table 9. SSB Phase Noise at 20 kHz Offset

11. Repeat steps 4 through 10 for the center frequencies listed in the following table.

Center Frequency (MHz)	Step Size (MHz)
900	—
2,400	—
3,300 to 3,500	100
4,100 to 4,300	100
4,700 to 4,900	100
5,700 to 5,900	100

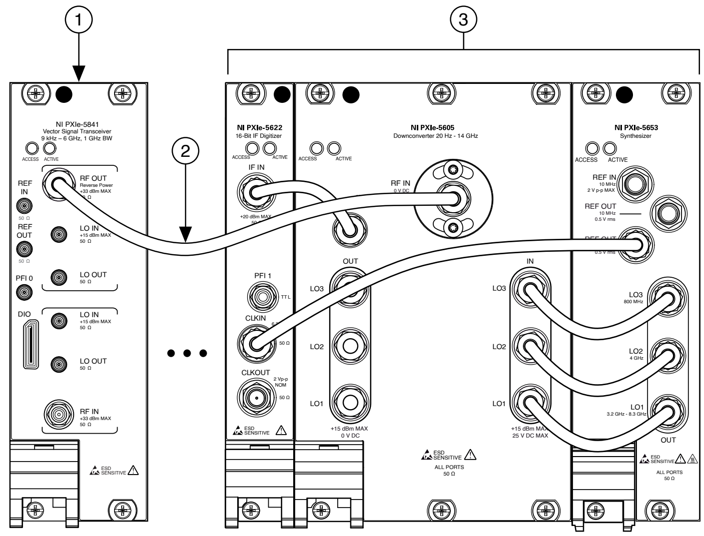
Table 10. Spectral Purity Test Points

Verifying RF Output Spectral Purity

This procedure verifies the RF output spectral purity of the PXIe-5841 .

1. Connect the PXIe-5841 RF OUT front panel connector to the RF IN front panel connector of the vector signal analyzer.
   The following figure illustrates the hardware setup.

Figure 13. RF Output Spectral Purity Verification Cabling Diagram



1. PXIe-5841
2. SMA (m)-to-SMA (m) Cable
3. Vector Signal Analyzer

2. Connect an available 10 MHz rubidium frequency reference output to the PXIe-5841 REF IN front panel connector.
3. Connect the same 10 MHz rubidium frequency reference output to the vector signal analyzer REF IN front panel connector.
4. Configure the PXIe-5841 to generate an offset CW tone using the following settings:
   - Center frequency: 900 MHz
   - Output power: 0 dBm
   - Tone offset: 3.75 MHz
   - I/Q rate: 10 MS/s
   - Reference Clock source: REF IN
5. Configure the vector signal analyzer to acquire a spectrum using the following settings:
   - Center frequency: 900 MHz
   - Reference level: 10 dBm

- Span: 100 Hz
- Window: 7-term Blackman-Harris
- Resolution bandwidth: 10 Hz
- Reference Clock source: External
- Averaging type: RMS
- Number of averages: 3

6. Measure the peak power at the center frequency.
   The measured power should match the power, in dBm, of the generated tone.
7. Configure the vector signal analyzer to acquire a spectrum using the following settings:
   - Center frequency: **Center frequency** from step 5 + 20 kHz
   - Reference level: 10 dBm
   - Span: 100 Hz
   - Resolution bandwidth: 10 Hz
   - Reference Clock source: External
   - Averaging type: RMS
   - Number of averages: 50
8. Measure the power at a 20 kHz offset by averaging all measurements across the 100 Hz span. Normalize the result to 1 Hz bin width by subtracting 10 * log (RBW), where RBW is the setting specified in step 7.
   The result of this step is in dBm/Hz.
9. Calculate the relative difference between the signal and noise using the following equation:
   SSB Phase Noise at 20 kHz (dBc/Hz) = **step 8 measurement** (dBm/Hz) - **step 6 measurement** (dBm)
   The result of this step is in dBc/Hz.
10. Compare the results of step 9 to the specified limits in the following table.

Frequency	As-Found Limit (dBc/Hz)	As-Left Limit (dBc/Hz)
<3 GHz	-102	-103.5
3 GHz to 4 GHz	-102	-103.5

Frequency	As-Found Limit (dBc/Hz)	As-Left Limit (dBc/Hz)
>4 GHz to 6 GHz	-96	-97.8

Table 11. SSB Phase Noise at 20 kHz Offset

11. Repeat steps 4 through 10 for the frequencies listed in the Spectral Purity Test Points table.

Verifying Input Absolute Amplitude Accuracy

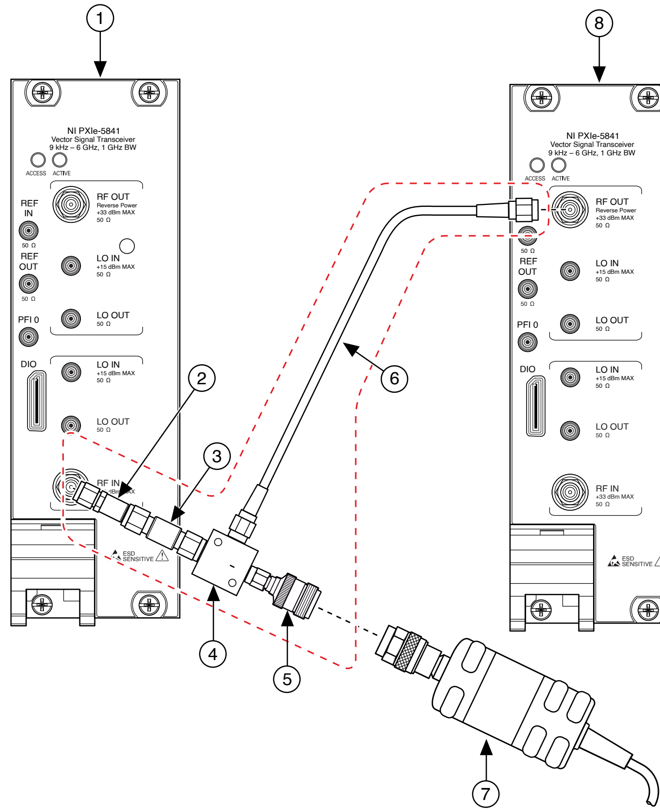
This procedure verifies the absolute amplitude accuracy of the PXIe-5841 input channels.

This procedure requires the same attenuator, splitter assembly, and data collected in the Characterizing RF Input Power Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing RF Input Power Splitter Assembly** section must be redone.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

1. Connect the external transceiver RF OUT front panel connector to the SMA (m)-to-SMA (m) cable of the RF input splitter assembly.
2. Connect the PXIe-5841 (DUT) RF IN front panel connector to the 6 dB attenuator (splitter output) of the RF input splitter assembly.
3. Connect the SMA (m)-to-N (f) adapter of the RF input splitter assembly to the power sensor.
   The following figure illustrates the complete hardware setup.

Figure 14. Input Absolute Amplitude Accuracy Verification Cabling Diagram



1. PXIe-5841 (DUT)
2. 6 dB Attenuator
3. 3.5 mm (m)-to-3.5 mm (m) Adapter
4. Power Splitter
5. SMA (m)-to-N (f) Adapter
6. SMA (m)-to-SMA (m) Cable
7. Power Sensor
8. External Transceiver

Transfer	Supported Reference Levels (dBm)	Configured Output Power (dBm)
A	30 to -10	0
B	<-10 to -30	-20

Table 12. Supported Reference Levels for Given Output Power Levels

Start Frequency (MHz)	Stop Frequency (MHz)	Frequency Step Size (MHz)
150	950	50
78.7	—	—
1,000	6,000	200

Table 13. RF Input Accuracy Center Frequency Settings

4. Configure the PXIe-5841 to acquire a signal at the center frequency specified in the previous table, using the following settings:
    - Center frequency: **Center frequency** from the **RF Input Accuracy Center Frequency Settings** table
    - Preamp: Automatic
    - Downconverter center frequency: **Center frequency** - 3.75 MHz
    - Reference level: 30 dBm
    - Span: 10 MHz
    - Resolution bandwidth: 1 kHz
    - Averaging type: RMS
    - Number of averages: 10
    - FFT window: Flat Top
5. Configure the external transceiver to generate a signal at the **center frequency** specified in step 4, using the following settings:
    - Upconverter center frequency: **Center frequency** from step 4 - 3.75 MHz
    - RF frequency: **Center frequency** from step 4
    - Power level: **Configured output power** from the transfer row in the **Supported Reference Levels for Given Output Power Levels** table that supports the **reference level** from step 4.
    - Prefilter gain: -3 dB
    - Digital gain: (**Reference level** from step 4 - **power level** from step 5) or 0 dB, whichever is less.
6. Configure the power sensor to correct for the **center frequency** from step 4 using the power sensor frequency correction function.

7. If this is the first measurement at the **upconverter center frequency** and **power level** from step 5, follow the steps below to create a new RF input accuracy transfer result and transferred digital gain. Otherwise, proceed to step 8 and use the existing RF input accuracy transfer result and transferred digital gain.
    1. Measure the power of the signal present at the reference output of the power splitter using the power sensor. Record the results from this step as **RF input accuracy transfer result**.
    2. Record the **digital gain** used in step 5 as **transferred digital gain**
8. Calculate the transfer input power using the following equation: **transfer input power** = **RF input accuracy transfer result** + (**transferred digital gain** - **digital gain** from step 5)
9. Calculate the **corrected input power** using the following equation: **corrected input power** = **transfer input power** + **splitter balance**

> Note Determine the **splitter balance** by interpolating between data points derived using test points in the Characterization Test Points for RF Input Verification Procedures table.

10. Using the settings from step 4, perform an acquisition with the PXIe-5841 , and measure the tone present at the center frequency. Record this measurement as **PXIe-5841 input power**.
11. Repeat steps 4 through 10 for the remaining reference levels from 30 dBm to -30 dBm in 10 dB increments.
12. Repeat steps 4 through 11 for the remaining frequencies in the previous table.
13. Compare the **absolute amplitude accuracy** values measured to the verification test limits in the following table.

Center Frequency	As-Found Limit (2 Years) (dB)	As-Found Limit (1 Year) (dB)	As-Left Limit (dB)
10 MHz to <120 MHz	—	—	±0.4[2]
120 MHz to 2.2 GHz	±0.90	±0.70	±0.30
>2.2 GHz to 4.4 GHz	±0.85	±0.65	±0.30
>4.4 GHz to 5 GHz	±0.90	±0.70	±0.30

Center Frequency	As-Found Limit (2 Years) (dB)	As-Found Limit (1 Year) (dB)	As-Left Limit (dB)
>5 GHz to 6 GHz	±0.95	±0.75	±0.30

Table 14. Input Absolute Amplitude Accuracy Verification Test Limits

Verifying Input Frequency Response

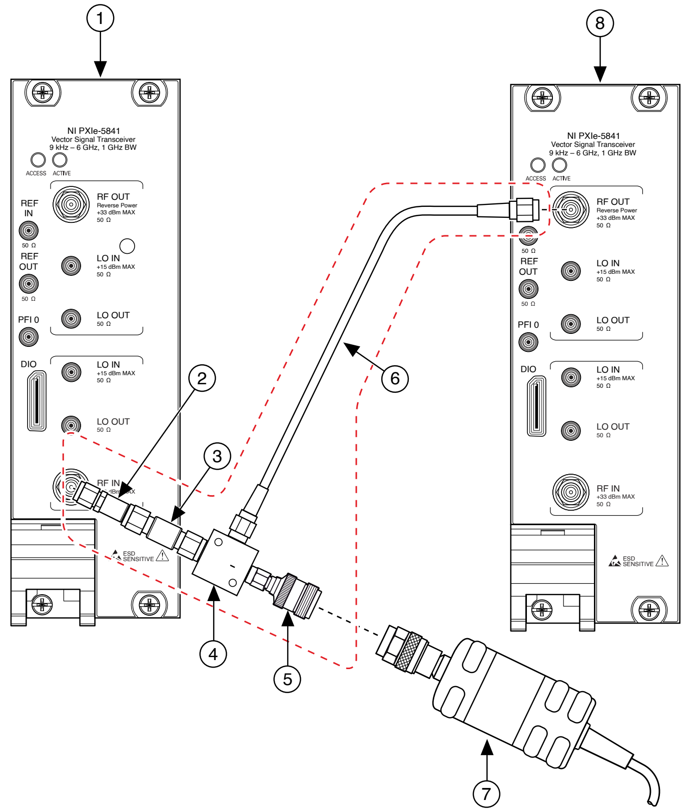
This procedure verifies the frequency response of the PXIe-5841 RF input channels.

This procedure requires the same attenuator, splitter assembly, and data collected in the Characterizing RF Input Power Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing RF Input Power Splitter Assembly** section must be redone.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

1. Connect the external transceiver RF OUT front panel connector to the SMA (m)-to-SMA (m) cable of the RF input splitter assembly.
2. Connect the PXIe-5841 (DUT) RF IN front panel connector to the 6 dB attenuator (splitter output) of the RF input splitter assembly.
3. Connect the SMA (m)-to-N (f) adapter of the RF input splitter assembly to the power sensor.
   The following figure illustrates the complete hardware setup.

Figure 15. Input Frequency Response Verification Cabling Diagram



1. PXIe-5841 (DUT)
2. 6 dB Attenuator
3. 3.5 mm (m)-to-3.5 mm (m) Adapter
4. Power Splitter
5. SMA (m)-to-N (f) Adapter
6. SMA (m)-to-SMA (m) Cable
7. Power Sensor
8. External Transceiver

Given Reference Levels (dBm)	Supported Output Power Levels (dBm)
30 to -10	0
<-10 to -30	-20

Table 15. Supported Output Power Levels for Given Reference Levels

Test Bandwidth (MHz)	Test Points (MHz)				
50	260	300	320	400	—
100	420	630	—	—	—
200	700	900	950	1,250	1,350
	1,550	1,650	2,150	2,250	2,650
	2,750	3,350	3,450	4,450	4,550
	5,250	5,350	5,900	—	—
1,000	—	—	—	—	—
	—	—	—	2,250	2,650
	2,750	3,350	3,450	4,450	4,550
	5,250	5,350	5,500	—	—

Table 16. Input Frequency Response Test Points

4. Configure the PXIe-5841 to acquire a signal at 260 MHz, using the following settings:
   - Center frequency: Test point from the **Input Frequency Response Test Points** table
   - Downconverter center frequency: Same as **center frequency**
   - Reference level: 30 dBm
   - Span: **Test bandwidth** from the **Input Frequency Response Test Points** table
   - Resolution bandwidth: 10 kHz
   - Averaging type: RMS
   - Number of averages: 10
   - FFT window: Flat Top
5. Configure the external transceiver to generate a signal at the **center frequency** specified in step 4 - (**test bandwidth**/2) MHz, where **test bandwidth** is the value specified in the previous table, using the following settings:
   - Upconverter center frequency: **Center frequency** from step 4
   - RF frequency: **Upconverter center frequency** - (**test bandwidth**/2) MHz

- Power level: **Configured output power** from the transfer row in the **Supported Output Power Levels for Given Reference Levels** table that supports the **reference level** from step 4.
- Prefilter gain: -3 dB
- Digital gain: (**reference level** from step 4 - **power level**) or 0 dB, whichever is less.

6. Configure the power sensor to correct for the RF frequency from the previous step using the power sensor frequency correction function.
7. If this is the first measurement at the **RF frequency** and **power level** from step 5, follow the steps below to create a new RF input accuracy transfer result and transferred digital gain. Otherwise, proceed to step 8, and use the existing RF input accuracy transfer result and transferred digital gain.
    1. Measure the power of the signal present at the reference output of the power splitter using the power sensor. Record the results from this step as **RF input accuracy transfer result**.
    2. Record the digital gain used in step 5 as **transferred digital gain**.
8. Calculate the **transfer input power** using the following equation: **transfer input power** = **RF input accuracy transfer result** + (**transferred digital gain** - **digital gain** from step 6)
9. Calculate the **corrected input power** using the following equation: **corrected input power** = **transfer input power** + **splitter balance**

> Note Determine the **splitter balance** by interpolating between data points derived using test points in the Characterization Test Points for RF Input Verification Procedures table.

10. Configure the PXIe-5841 using the settings from step 4, perform acquisition, and measure the tone present at the **RF frequency** from step 5.
11. Calculate the absolute amplitude accuracy using the following equation: **absolute amplitude accuracy** = PXIe-5841 **input power** - **corrected input power**
12. Repeat steps 4 through 11 by sweeping the external transceiver's tone around the test point from -(**test bandwidth**/2) to +(**test bandwidth**/2) in 10 MHz

steps where **test bandwidth** is the value specified in the **Input Frequency Response Test Points** table.
When the tone is at an offset of 0 MHz, use an offset of 3.75 MHz instead.
Record this point as **reference point**.

13. Determine the positive and negative frequency response results for the **center frequency** from step 4 by completing the following steps.
    1. Subtract the **reference point** from the maximum **absolute amplitude accuracy** to determine the positive (+) **frequency response**.
    2. Subtract the minimum **absolute amplitude accuracy** from **reference point** to determine the negative (-) **frequency response**.
14. Repeat steps 4 through 13 for the remaining frequencies in the **Input Frequency Response Test Points** table.
15. Repeat steps 4 through 13 for the remaining reference levels between 20 dBm and -30 dBm in 10 dB steps.
16. Compare the **± frequency response** values measured to the verification test limits in the following table.

Frequency	Equalized Bandwidth	As-Found Limit (2 Years) (dB)	As-Found Limit (1 Year) (dB)	As-Left Limit (dB)
>250 MHz to 410 MHz	50 MHz	±0.65	±0.45	±0.35
>410 MHz to 650 MHz	100 MHz	±0.80	±0.60	±0.45
>650 MHz to 1.5 GHz	200 MHz	±0.75	±0.55	±0.40
>1.5 GHz to 2.2 GHz	200 MHz	±0.70	±0.50	±0.35
>2.2 GHz to 2.9 GHz	200 MHz	±0.70	±0.50	±0.30
	1 GHz	±1.3	±1.1	±0.75
>2.9 GHz to 4.8 GHz	200 MHz	±0.70	±0.50	±0.35
	1 GHz	±1.35	±1.15	±0.75
>4.8 GHz to 6 GHz	200 MHz	±0.70	±0.50	±0.35
	1 GHz	±1.5	±1.3	±0.85

Table 17. Input Frequency Response Test Limits

Verifying Output Power Level Accuracy

This procedure verifies the power level accuracy of the PXIe-5841 RF Output.

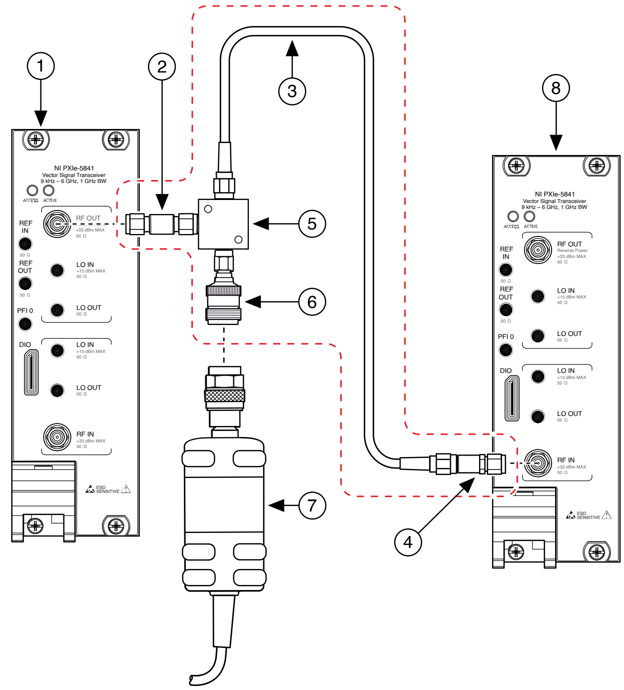
This procedure requires the test setup, splitter assembly, and data collected in the Characterizing RF Output Power Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing RF Output Power Splitter Assembly** section must be redone.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

This procedure references the following tables you created when you characterized the power splitter loss:

1. Connect the PXIe-5841 (DUT) RF OUT front panel connector to the 3.5 mm (m)-to-3.5 mm adapter of the RF Output Power Splitter assembly.
2. Connect the external transceiver to the SMA (m)-to-SMA (m) cable of the RF Output Power Splitter Assembly.
3. Connect the power sensor to the SMA (m)-to-N (f) adapter of the RF Output Power Splitter Assembly.
   The following figure illustrates the complete hardware setup.

Figure 16. Output Power Level Accuracy Verification Cabling Diagram



1. PXIe-5841 (DUT)
2. 3.5 mm (m)-to-3.5 mm (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. 12 dB Attenuator
5. Power Splitter
6. SMA (m)-to-N (f) Adapter
7. Power Sensor
8. External Transceiver

4. Configure the PXIe-5841 to generate a 150 MHz tone using the following settings:

   - Upconverter center frequency: RF frequency - 3.75 MHz
   - RF frequency: 150 MHz (from the **Output Power Level Accuracy Test Points** table)
   - Output power: -10 dBm
   - I/Q rate: 260 MS/s

Note For center frequencies greater than 2.3 GHz, configure the signal bandwidth to 200 MHz.

Reference Level	Power	Output Transfer Level (dBm)
10	15 to 0	0
-20	<0	-10

Table 18. Supported Reference Levels for Given Output Power Levels

5. Configure the external transceiver to acquire a signal at the **center frequency** specified in step 4 using the following settings:
   - Center frequency: **RF frequency** from step 4
   - Downconverter center frequency: **Upconverter center frequency** from step 4
   - Reference level: **Reference level** from the **Supported Reference Levels for Given Output Power Levels** table
   - Span: 250 kHz
   - Resolution bandwidth: 4 kHz
   - Averaging type: RMS
   - Number of averages: 10
6. Configure the power sensor to correct for the **center frequency** from step 5 using the power sensor frequency correction function.
7. If this is the first measurement at the **downconverter center frequency** and **reference level** from step 5, follow the steps below to create a new RF output accuracy transfer result. Otherwise, proceed to step 8 and use the existing RF output accuracy transfer result.
   Measure the power of the signal present at the reference output of the power splitter using the power sensor. Record the results from this step as **RF output accuracy transfer result**.
8. Acquire the signal with the external transceiver and measure the tone power located at the value of **RF frequency** from step 4. This value is the **measured tone power**.
9. Calculate the **transferred output power** using the following equation:

transferred output power = **RF output accuracy transfer result** + **measured tone power**

10. Calculate the **corrected output power** using the following equation:
corrected output power = **transferred output power** + **splitter loss**

> Note Determine the **splitter loss** by interpolating between the data points in the **Splitter Loss** table you created in step 21 of the Characterizing RF Output Power Splitter Assembly section. Ensure you use the characterization data derived from test points in the **Characterization Test Points for RF Output** table.

11. Calculate the **absolute power level accuracy** using the following equation:
absolute power level accuracy = **corrected output power** - **device output power**
where **device output power** is the configured output power of the PXIe-5841 RF output path.

12. Repeat steps 4 through 11 for the remaining power levels in the following table.

Frequency Range	Start Power Level (dBm)	Stop Power Level (dBm)	Power Level Step Size (dB)
<120 MHz	+5	0	-5
	-10	-30	-10
>120 MHz to 6 GHz	+15	0	-5
	-10	-30	-10

Table 19. Output Power Level Test Points

> Note In the preceding table, the order of power levels must be -10 dBm to -30 dBm in 10 dB steps then 0 dBm to 15 dBm in 5 dB steps.

13. Repeat steps 4 through 12 for the remaining frequencies listed in the following table.

Start Frequency (MHz)	Stop Frequency (MHz)	Frequency Step Size (MHz)
76.5	—	—
150	950	50
1,000	6,000	200

Table 20. Output Power Level Accuracy Test Points

14. Compare the **absolute power level accuracy** values measured to the test limits in the following table.

Center Frequency	As-Found Limit (2 Years) (dB)	As-Found Limit (1 Year) (dB)	As-Left Limit (dB)
10 MHz to <120 MHz	—	—	±0.8[3]
>120 MHz to 200 MHz	±1.0	±0.80	±0.30
>200 GHz to 500 MHz	±0.90	±0.70	±0.30
>500 MHz to 2.2 GHz	±0.85	±0.65	±0.30
>2.2 GHz to 6 GHz	±0.90	±0.70	±0.30

Table 21. Output Power Level Accuracy Test Limits

Verifying Output Frequency Response

This procedure verifies the frequency response of the PXIe-5841 outputs.

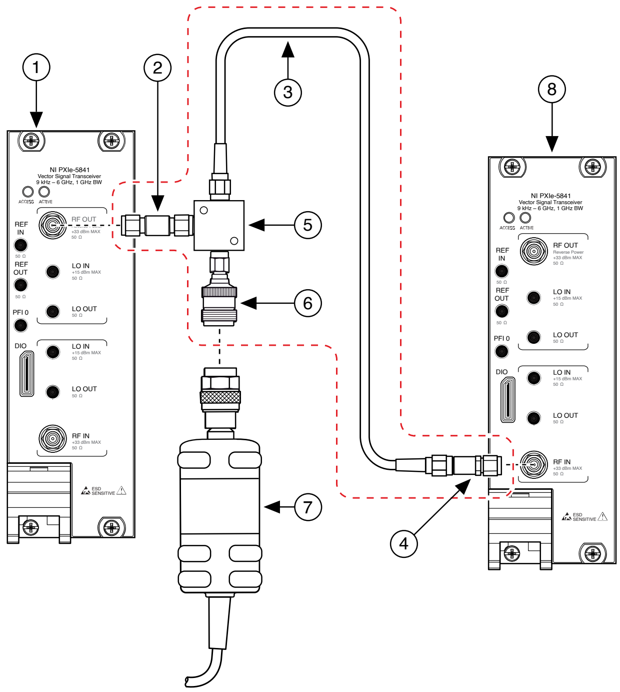
This procedure requires the test setup, splitter assembly, and data collected in the Characterizing RF Output Power Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing RF Output Power Splitter Assembly** section must be redone.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

1. Connect the PXIe-5841 RF OUT front panel connector to the input terminal of the power splitter using a 3.5 mm (m)-to-3.5 mm (m) adapter.
2. Connect splitter output 1 directly to the power sensor using the SMA (m)-to-N (f) adapter.

3. Connect the remaining power splitter output to one end of the 6 dB attenuator using an SMA (m)-to-SMA (m) cable.
4. Connect the other port of the 12 dB attenuator directly to the external transceiver RF IN front panel connector.
   The following figure illustrates the complete hardware setup.

Figure 17. Output Frequency Response Verification Cabling Diagram



1. PXIe-5841 (DUT)
2. 3.5 mm (m)-to-3.5 mm (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. 12 dB Attenuator
5. Power Splitter
6. SMA (m)-to-N (f) Adapter
7. Power Sensor
8. External Transceiver

5. Configure the PXIe-5841 (DUT) to generate a signal at 260 MHz with a tone at -(**test bandwidth**/2) MHz offset, where **test bandwidth** is the value specified in the following table using the following settings:

- Upconverter center frequency: 260 MHz
- RF frequency: **Upconverter center frequency** - (**test bandwidth**/2) MHz
- I/Q rate: 1.25 GS/s
- Output power: -10 dBm

Test Bandwidth (MHz)	Test Points (MHz)				
50	260	300	320	400	—
100	420	630	—	—	—
200	700	900	950	1,250	1,350
	1,550	1,650	2,150	2,250	2,650
	2,750	3,350	3,450	4,450	4,550
	5,250	5,350	5,900	—	—
1000	—	—	—	—	—
	—	—	—	2,250	2,650
	2,750	3,350	3,450	4,450	4,550
	5,250	5,350	5,500	—	—

Table 22. Output Frequency Response Test Points

Reference Level	Power Level	Output Transfer Level (dBm)
10	15 to 0	0
-20	<0	-10

Table 23. Supported Reference Levels for Given Output Power Levels

6. Configure the external transceiver to acquire a signal at the RF frequency of step 5, using the following settings:
   - Center frequency: **RF frequency** from step 5
   - Reference level: Configured reference level (dBm) from the **Supported Reference Levels for Given Output Power Levels** table that supports the **output power** from step 5.
   - Span: 250 kHz
   - Downconverter center frequency: **RF frequency** from step 5 - 3.75 MHz
   - Resolution bandwidth: 4 kHz
   - Averaging type: RMS

- Number of averages: 10

7. Configure the power sensor to correct for the **center frequency** from step 6 using the power sensor frequency correction function.
8. If this is the first measurement at the **downconverter center frequency** and **reference level** from step 6, follow the steps below to create a new RF output accuracy transfer result. Otherwise, proceed to step 9 and use the existing RF output accuracy transfer result.
   Measure the power of the signal present at the reference output of the power splitter using the power sensor. Record the results from this step as **RF output accuracy transfer result**.
9. Acquire the signal with the external transceiver and measure the tone power located at the value of the **RF frequency** from step 5. This value is the **measured tone power**.
10. Calculate the **transferred output power** using the following equation:
    transferred output power = **RF output accuracy transfer result** + **measured tone power**
11. Calculate the **corrected output power** using the following equation:
    corrected output power = **transferred output power** + **splitter loss**

> Note Find the **splitter loss** by interpolating between the data points in the **Splitter Loss** table you created in step 21 of the Characterizing RF Output Power Splitter Assembly section. Ensure you use the characterization data derived from test points in the **Characterization Test Points for RF Output** table.

12. Calculate the **absolute power level accuracy** using the following equation:
    absolute power level accuracy = **device output power** - **corrected output power**
    Where **device output power** is the configured output power of the PXIe-5841 RF output path.

13. Repeat steps 5 through 10 by skipping the 0 MHz offset tone and sweeping the tone offset from -(**test bandwidth**/2) to +(**test bandwidth**/2) in 5 MHz steps, where **test bandwidth** is the value specified in the **Output Frequency Response Test Points** table.

14. Repeat steps 5 through 10 by using the **RF Frequency of Upconverter Center Frequency** + 3.75 MHz in step 5. Record the result from step 10 as **reference point**.
15. Determine the positive and negative frequency response results for the **center frequency** from step 5 by completing the following steps.
    1. positive (+) **frequency response** = maximum **absolute power level accuracy** - **reference point**
    2. negative (-) **frequency response** = **reference point** - minimum **absolute power level accuracy**
16. Repeat steps 5 through 15 for power levels -10 dBm, -20 dBm, -30 dBm, 0 dBm, 10 dBm.
17. Repeat steps 5 through 16 for the remaining center frequencies listed in the **Output Frequency Response Test Points** table.
18. Compare the **± frequency response** values measured to the test limits in the following table.

Frequency	Equalized Bandwidth	As-Found Limit (2 Years) (dB)	As-Found Limit (1 Year) (dB)	As-Left Limit (dB)
≥250 MHz to 410 MHz	50 MHz	±0.75	±0.55	±0.45
>410 MHz to 650 MHz	100 MHz	±0.80	±0.60	±0.45
>650 MHz to 1.5 GHz	200 MHz	±0.75	±0.55	±0.40
>1.5 GHz to 2.2 GHz	200 MHz	±0.60	±0.40	±0.30
>2.2 GHz to 2.9 GHz	200 MHz	±0.60	±0.40	±0.30
	1 GHz	±1.40	±1.20	±0.80
>2.9 GHz to 4.8 GHz	200 MHz	±0.80	±0.60	±0.45
	1 GHz	±1.45	±1.25	±0.85
>4.8 GHz to 6 GHz	200 MHz	±0.75	±0.55	±0.40
	1 GHz	±2.10	±1.90	±1.35

Table 24. Output Frequency Response Test Limits

Adjustment

This section describes the steps needed to adjust the PXIe-5841 to meet published specifications.

Reset External Calibration

Prior to performing external calibration, the previous calibration should be removed.

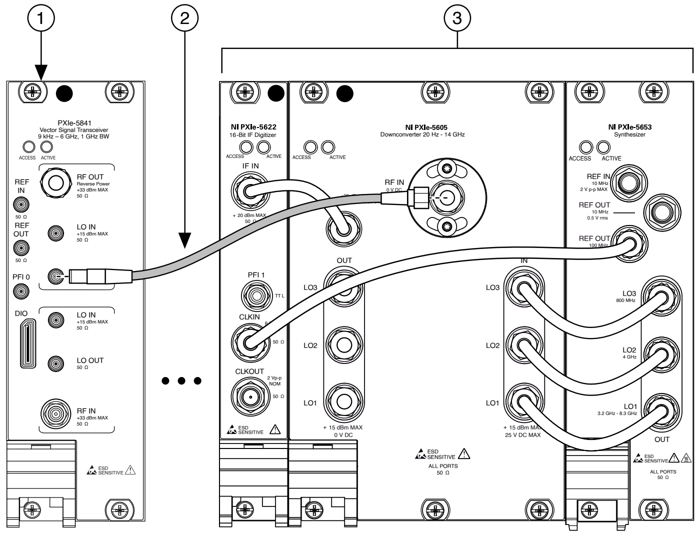
1. Wire password and calibration options into the Reset Cal Data and Settings 2 VI.
   Password is NI. Calibration options should be an empty string.
2. Call the Reset Cal Data and Settings 2 VI from Instrument I/O » Instr Drivers » NI VST Calibration » NI-5841 External Calibration » Procedure.

Adjusting RF Internal Frequency Reference

This procedure measures the accuracy of the internal frequency reference, which you use to realign the internal frequency reference to a value within warranted specifications.

1. Run Procedure 1 in the External Cal API.
   1. Call the Initialize External Calibration VI from Instrument I/O » Instr Drivers » NI VST Calibration.
   2. Call the Procedure 1 VI from Instrument I/O » Instr Drivers » NI VST Calibration » NI-5841 External Calibration » Procedure.
   3. Call the Close External Calibration VI from Instrument I/O » Instr Drivers » NI VST Calibration.
2. Connect the vector signal analyzer RF IN front panel connector to the PXIe-5841 LO OUT connector on the RF OUT part of the DUT.
   The following figure illustrates the complete hardware setup.

Figure 18. Internal Frequency Reference Adjustment Cabling Diagram



1. PXIe-5841 (DUT)
2. SMA (m)-to-SMA (m) Cable
3. Vector Signal Analyzer

3. Connect an available 10 MHz rubidium frequency reference output to the vector signal analyzer REF IN front panel connector.
4. Configure the vector signal analyzer with the following settings:
   - Reference Clock source: External
   - Mode: Spectrum
5. Call the Initialize External Calibration VI from Instrument I/O » Instr Drivers » NI VST Calibration.
6. Call the niVST Reference Clock Cal Initialize VI from Instrument I/O » Instr Drivers » NI VST Calibration » NI-5841 External Calibration » Ref Clock.
7. Call the niVST Reference Clock Cal Configure 2 VI from Instrument I/O » Instr Drivers » NI VST Calibration » NI-5841 External Calibration » Ref Clock.
8. Configure the vector signal analyzer settings to the corresponding outputs of the Configure VI:
   - Center frequency: frequency to measure (Hz)
   - Reference level: ref level (dBm)

- Span: span (Hz)
- RBW: resolution bandwidth (Hz)
- Averages: 20
- Window: Hanning

9. Measure the peak frequency and amplitude of the LO signal with the vector signal analyzer.
10. Call the niVST Reference Clock Adjust VI. Wire the peak frequency and amplitude to the Adjust VI.
11. Repeat steps 7 through 10 until the calibration complete? output of the niVST Reference Clock Adjustment VI returns a value of TRUE.
12. Call the niVST Reference Clock Cal Finalize VI.
13. Call the niVST Close External Calibration VI. Set the write calibration to hardware? input to TRUE to store the results to the EEPROM on the PXIe-5841 .

Adjusting LO Gain (RF IN and RF OUT)

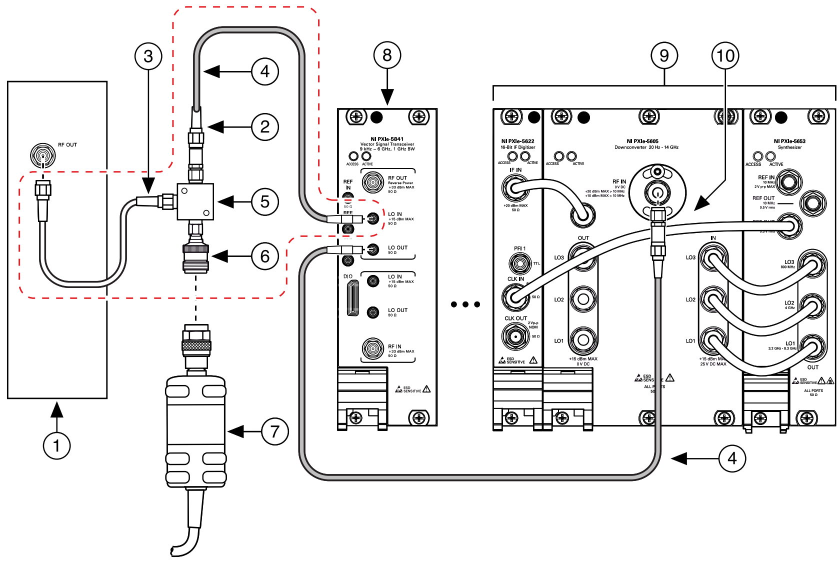
This procedure measures the PXIe-5841 LO power sensor response. The internal power sensor ensures that the internal LO power level is correct at the mixing stages for the RF IN and RF OUT channels.

This procedure requires the test setup, splitter assembly, and data collected in the Characterizing LO Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing LO Splitter Assembly** section must be redone. You must characterize the power splitter balance before running this procedure. Ensure you use the characterization data derived from test points in the **Characterization Test Points for LO Gain Adjustment Procedures** table.

1. Connect the power sensor to splitter output 1 with the SMA (m)-to-N (f) adapter.
2. Connect the RF signal generator RF OUT front panel connector to the input port of the splitter.
3. Connect the 6 dB attenuator to splitter output 2.
4. Connect an SMA (m)-to-MMPX (m) cable to the 6 dB attenuator on splitter output 2 and connect it to RF OUT LO IN.

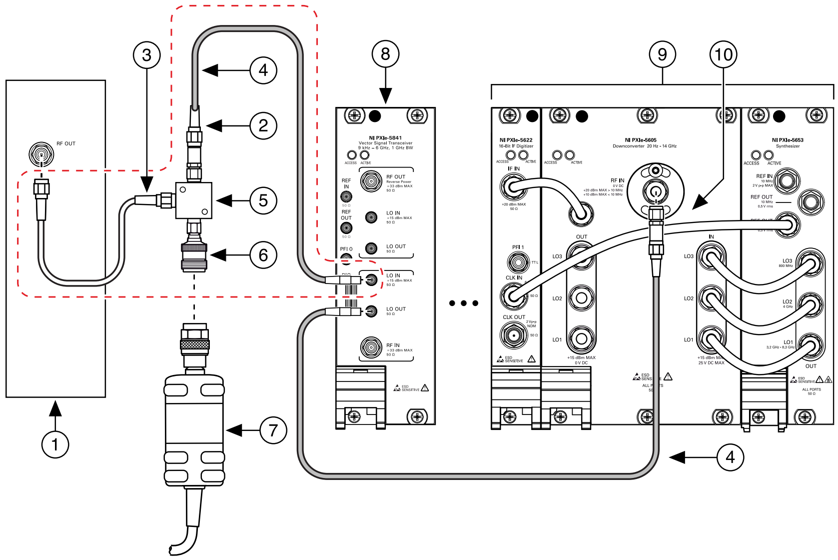
5. Connect another SMA (m)-to-MMPX (m) cable from the RF OUT LO OUT front panel connector on the PXIe-5841 to the 20 dB attenuator and connect the 20 dB to the RF IN port on the vector signal analyzer.
The following figures illustrate the complete hardware setup.

Figure 19. RF OUT LO Gain Adjustment Cabling Diagram



1. RF Signal Generator
2. 6 dB Attenuator
3. SMA (m)-to-SMA (m) Cable
4. SMA (m)-to-MMPX (m) Cable
5. Power Splitter
6. SMA (m)-to-N (f) Adapter
7. Power Sensor
8. PXIe-5841
9. Vector Signal Analyzer
10. 20 dB Attenuator

Figure 20. RF IN LO Gain Adjustment Cabling Diagram



    1. RF Signal Generator
    2. 6 dB Attenuator
    3. SMA (m)-to-SMA (m) Cable
    4. SMA (m)-to-MMPX (m) Cable
    5. Power Splitter
    6. SMA (m)-to-N (f) Adapter
    7. Power Sensor
    8. PXIe-5841
    9. Vector Signal Analyzer
    10. 20 dB Attenuator

6. Call the niVST External Calibration VI.
7. Call the niVST LO Cal Initialize VI. Wire an RF OUT constant to the Port Type input.
8. Call the niVST LO Cal Configure 2 VI.
9. Check the Generate? output from the previous step. If true, proceed to step 10. If false, disable the output and skip to step 11.
10. Configure the RF signal generator to generate a tone with the following settings:

- Center frequency: frequency (Hz) output specified by the niVST LO Cal Configure VI
- Power level: input power (dBm) output specified by the niVST LO Cal Configure VI
- Reference Clock source: Onboard

11. Check the Acquire? output from step 8. If true, proceed to step 12. If false, skip to step 13.
12. Configure the vector signal analyzer to acquire a signal at a center frequency with the following settings:
    - Center frequency: frequency (Hz) output specified by the niVST LO Cal Configure VI
    - Reference level: ref level (dBm) output specified by the niVST LO Cal Configure VI
    - Span: 20 MHz
    - Resolution bandwidth: 10 kHz
    - Averaging type: RMS
    - Number of averages: 10
13. If Generate? from step 9 was true, proceed to step 14. If false, skip to step 17.
14. Configure the power sensor to correct for the frequency (Hz) output specified by the niVST LO Cal Configure VI.
15. Measure the power of the signal present at the reference output of the power splitter using the power sensor. Record the results from this step as **LO accuracy transfer result**.
16. Calculate the actual power at the LO IN port using the following equation: **Actual LO input power** = **LO accuracy transfer result** + **LO splitter balance**
17. If Acquire? from step 9 was true, proceed to step 18. If not, skip to step 20.
18. Measure the peak power of the signal present at the input of the vector signal analyzer using the power sensor. Record the results from this step as **LO measured power**.
19. Calculate the correct LO Out power using the following equation: **Actual LO power** = **LO measured power** - **MMPX cable loss**

20. Call the niVST LO Cal Adjust 2 VI.
    1. Wire **Actual LO input power** to the actual input power (dBm) input.
    2. Wire **Actual LO power** to the measured power (dBm) input.
    3. Wire the actual tone frequency of the vector signal generator to the actual input frequency (Hz) input.
21. Repeat steps 8 through 16 until the calibration complete? output of the niVST LO Cal Adjust VI returns a value of TRUE.
22. Call the niVST LO Cal Finalize VI.
23. Call the niVST Close External Calibration VI. Set the write calibration? input to TRUE to store the results to the EEPROM on the PXIe-5841 .
24. For RF OUT LO Gain Adjustment, run Procedure 2 in the External Cal API. For RF IN LO Gain Adjustment, skip to step 27.
    1. Call the niVST Initialize External Calibration VI.
    2. Call the Procedure 2 VI.
    3. Call the niVST Close External Calibration VI.
25. Repeat steps 1 through 24 for RF IN LO OUT to adjust the LO power sensor of the PXIe-5841 RF IN channel (see figure **RF IN LO Gain Adjustment Cabling Diagram**). For the Port Type inputs in steps 7 and 19, change the constants to RF IN when repeating the steps.
26. For RF IN LO Gain Adjustment, run Procedure 3 in the External Cal API.
    1. Call the niVST Initialize External Calibration VI.
    2. Call the Procedure 3 VI.
    3. Call the niVST Close External Calibration VI.

Adjusting Input Absolute Amplitude Accuracy

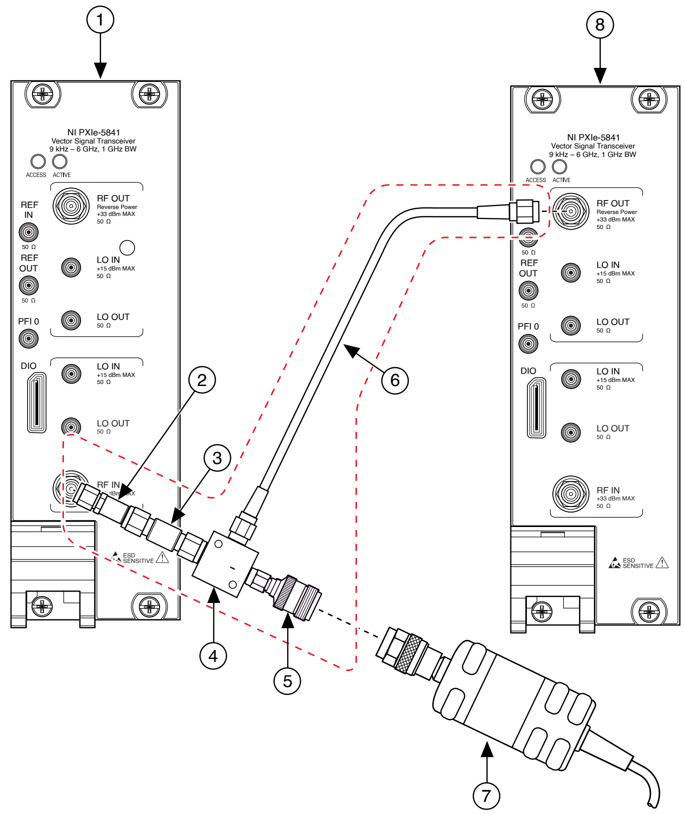
This procedure measures the response of the RF IN signal path of the PXIe-5841 . The response receives external signals at the RF IN front panel connector at a higher accuracy and optimized dynamic range.

This procedure requires the test setup, splitter assembly, and data collected in the Characterizing the RF Input Power Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing the RF Input Power Splitter Assembly** section must be redone. You must characterize the power splitter balance before running this procedure.

You must zero the power sensor as described in the Zeroing the Power Sensor section prior to starting this procedure.

1. Connect the external transceiver RF OUT front panel connector to the input SMA (m) cable of the RF input power splitter assembly.
2. Connect power splitter assembly output 1 directly to the power sensor input connector.
3. Connect the RF input power splitter assembly output 2 directly to the PXIe-5841 RF IN front panel connector.
   The following figure illustrates the complete hardware setup.

Figure 21. Absolute Amplitude Accuracy Adjustment Cabling Diagram



1. PXIe-5841 (DUT)
2. 6 dB Attenuator
3. 3.5 mm (m)-to-3.5 mm (m) Adapter
4. Power Splitter
5. SMA (m)-to-N (f) Adapter
6. SMA (m)-to-SMA (m) Cable
7. Power Sensor
8. External Transceiver

4. Connect an available 10 MHz rubidium frequency reference output to the PXIe-5841 REF IN front panel connector.
5. Connect an available 10 MHz rubidium frequency reference output to the external transceiver REF IN front panel connector.
6. Call the niVST Initialize External Calibration VI.

7. Call the niVST RF Input Gain Cal Initialize VI. Wire a REF IN constant to the reference clock source input.
8. Call the niVST RF Input Gain Cal Configure 2 VI. Make note of the Power to Generate, Frequency to Generate, and Amp State outputs from the VI. Store the calculation (Power to Generate from the VI + **splitter output 2 power** from the **Characterizing RF Input Power Splitter Assembly Test** +20) as **calculated power at input**.

Power Level (dBm)	Calculated Power at Input (dBm)
4	≤-6
-20	>-6

Table 25. Supported Power Levels from Power at RF IN

9. Configure the external transceiver to generate a tone using the following settings:
   - Center frequency: frequency to generate (Hz) output from step 8 - 5 MHz
   - Tone offset: 5 MHz
   - Power level: Selected **power level** from the **Supported Power Levels from Power at RF IN** table.
   - Digital gain: Selected **power level** from the **Supported Power Levels from Power at RF IN** table or -6 dB , whichever is less.
   - Reference clock source: REF IN
10. Obtain the following values:
    - Frequency: frequency to generate (Hz) from the RF Input Gain Cal Configure VI
    - Power level: From step 9
    - Amp state: amp state from the RF Input Gain Cal Configure VI
11. Check the values from step 10 to determine if a new **accuracy transfer result** should be measured, and perform the following steps if applicable:
    - If this is the first adjustment iteration, skip to step 12 to record a new **accuracy transfer result**.

- If the frequency, reference level, and amp state are the same as the previous iteration, use the previous **accuracy transfer result** in step 13. Skip to step 13.
- Otherwise, record a new **accuracy transfer result** in the next step.

12. Record the power measurement as the **accuracy transfer result**:
    1. Configure the power sensor to correct for the **center frequency** from step 9 using the power sensor frequency correction function.
    2. Configure the power sensor to use 5 averages if the signal generator is <-20 dBm. If not, use 1 average.
    3. Use the power sensor to measure the output power, and record as **power sensor reading**.
    4. Calculate the **accuracy transfer result** as follows:
       accuracy transfer result = **power sensor reading**
13. Calculate the corrected input power using the following equation:
    corrected input power +6

> **Note** Determine the **splitter balance** by interpolating between data points from the the Characterizing RF Input Power Splitter Assembly section. Ensure you use the characterization data derived from the test points in the **Supported Power Levels from Power at RF IN** table.

14. Call the niVST RF Input Gain Cal Adjust VI.
    1. Wire the corrected input power from step 13 to the measured power (dBm) input.
    2. Wire the value of the **center frequency** of the vector signal generator from step 9 + 5 MHz) to the measured frequency (Hz) input.

    > **Note** If the frequency value was coerced from the requested frequency, wire the coerced frequency to the measured frequency (Hz) input.

15. Repeat steps 8 through 14 until the RF input gain calibration complete output of the niVST RF Input Gain Cal Adjust VI returns a value of TRUE.
16. Call the niVST RF In Gain Cal Finalize VI.
17. Call the niVST Close External Calibration VI. Set the write calibration? input to TRUE to store the results to the EEPROM on the PXIe-5841 .
18. Run Procedure 4 in the External Cal API.
    1. Call the niVST Initialize External Calibration VI.
    2. Call the Procedure 4 VI.
    3. Call the niVST Close External Calibration VI.

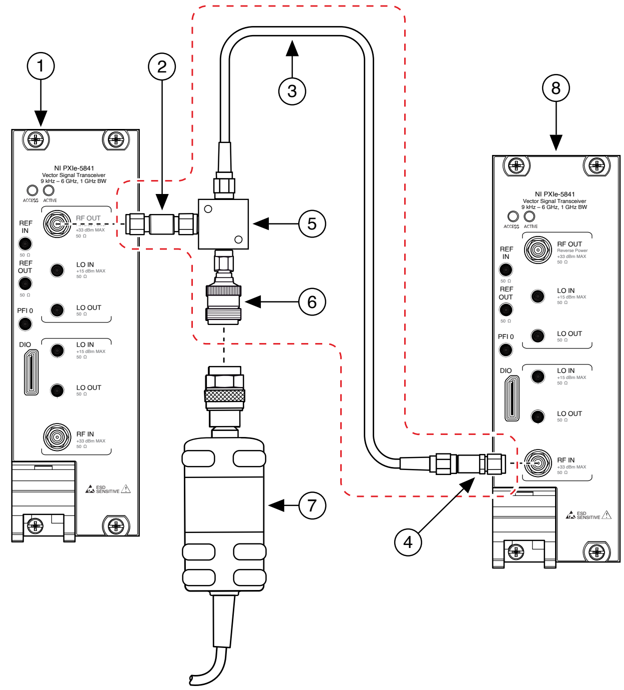
Adjusting Output Power Level Accuracy

This procedure measures the response of the RF OUT signal path of the PXIe-5841 . The response receives external signals at the RF OUT front panel connector at a higher accuracy and optimized dynamic range.

This procedure requires the test setup, splitter assembly, and data collected in the Characterizing RF Output Power Splitter Assembly section. If the splitter assembly has been modified in any way, the **Characterizing RF Output Power Splitter Assembly** section must be redone. You must characterize the power splitter balance before running this procedure. Ensure you use the characterization data derived from test points in the Characterization Test Points for RF Output Adjustment Procedures table.

1. Connect splitter output 1 directly to the power sensor using the SMA (m)-to-N (f) adapter.
2. Connect the remaining power splitter output to one end of the 6 dB attenuator using an SMA (m)-to-SMA (m) cable.
3. Connect the other port of the 6 dB attenuator directly to the vector signal analyzer RF front panel connector.
   The following figure illustrates the hardware setup.

Figure 22. Output Power Level Accuracy Adjustment Cabling Diagram



1. PXIe-5841 (DUT)
2. 3.5 mm (m)-to-3.5 mm (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. 12 dB attenuator
5. Power Splitter
6. SMA (m)-to-N (f) Adapter
7. Power Sensor
8. External Transceiver

4. Connect an available 10 MHz rubidium frequency reference output to the PXIe-5841 REF IN front panel connector.
5. Connect an available 10 MHz rubidium frequency reference output to the vector signal analyzer REF IN front panel connector.
6. Call the niVST Initialize External Calibration VI.
7. Call the niVST RF Output Gain Cal Initialize VI. Wire a REF IN constant to the reference clock source input.
8. Call the niVST RF Output Gain Cal Configure 2 VI.

Power Level in RF IN (dBm) [4]	Reference Level
> -10	20
-34 < X ≤ -10	-10
≤ 35	-35

Table 26. Supported Reference Levels from Given Expected Power

9. Obtain the following values:
   - Frequency: Frequency to Measure from the RF Output Gain Cal Configure VI
   - Reference level: Configured reference level specified in the preceding **Supported Reference Levels from Given Power Level in RF IN** table that supports the result of the calculation of the power level in RF IN.
   - Amp state: Amp State from the RF Output Gain Cal Configure VI
10. Configure the external transceiver to acquire a signal with the following settings:
    - Center frequency: Frequency to Measure from previous step
    - Downconverter center frequency: **Center frequency** - 5 MHz
    - Reference level: From previous step
    - Span: 1 MHz
    - Resolution bandwidth: 500 Hz
    - Averaging mode: RMS
    - Number of averages: 4
11. Check the values from step 10 to determine if a new **accuracy transfer result** should be measured:
    1. If this is the first adjustment iteration, skip to step 12 to record a new **accuracy transfer result**.
    2. Calculate the expected power sensor level as expected power (dBm) + **splitter loss**, and if it is below -40 dBm, use the previous accuracy transfer result in step 14. Skip to step 13.

3. If the frequency, reference level, and amp state are the same as the previous iteration, use the previous accuracy transfer result in step 14. Skip to step 13.
4. Otherwise, record a new **accuracy transfer result** in the next step.

12. Record the power sensor reading:
    1. Configure the power sensor to correct for the Frequency to Measure using the power sensor frequency correction function.
    2. Use the power sensor to measure the output power (**power sensor reading**).
13. Acquire the signal with the external transceiver and measure the peak tone power (**measured tone power**).
14. Calculate the **transferred output power** using the following equation:
    transferred output power = **power sensor reading** - **measured tone power**
15. Calculate the **corrected output power** using the following equation:
    corrected output power = **transferred output power** + **measured tone power** - **splitter loss**

> Note Determine the **splitter loss** by interpolating between the data points in the **Splitter Loss** table you created in step 20 of the Characterizing RF Output Power Splitter Assembly section. Choose the value that corresponds to the transfer used.

16. Call the niVST RF Output Gain Cal Adjust VI. Wire the corrected output power from step 15 to the measured power input.
17. Repeat steps 9 through 17 until the RF output gain calibration complete output of the niVST RF Output Gain Cal Adjust VI returns a value of TRUE.
18. Call the niVST RF Out Gain Cal Finalize VI.
19. Call the niVST External Calibration Close VI. Set the write calibration? input to TRUE to store the results to the EEPROM on the PXIe-5841 .
20. Run Procedure 5 in the External Cal API.
    1. Call the niVST Initialize External Calibration VI.
    2. Call the Procedure 5 VI.

3. Call the niVST Close External Calibration VI.

Reverification

Repeat the Verification procedures to determine the as-left status of the PXIe-5841 .

> **Note** If any test fails reverification after performing an adjustment, verify that you have met the test conditions before returning your PXIe-5841 to NI. Refer to the NI Services section for information about support resources or service requests.

Setting Calibration Date and Due Date

After completing all verifications or reverifications, set the calibration date and a calibration due date for the PXIe-5841 using either Measurement Automation Explorer (MAX) or the LabVIEW NI System Configuration API.

NI recommends a calibration due date of the date of external calibration plus the external calibration interval for the PXIe-5841.

1. MAX—Navigate to the External Calibration section of the Settings tab and update the Calibration Date and Calibration Due Date entries. Click Save.
2. LabVIEW NI System Configuration API—Use the Update Calibration VI to set the calibration date and calibration due date.
   The calibration due date can be either a specific date or an interval in months.

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.

378130C-01 2022-11-03