CALIBRATION PROCEDURE

NI PXIe-5611

This document describes processes to calibrate the NI PXIe-5611 I/Q modulator. This document provides performance tests to verify if the instrument is performing within the published specifications. For more information about calibration, visit `ni.com/calibration`.

Contents

NATIONAL INSTRUMENTS™

Conventions

The following conventions are used in this document:

»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.
	This icon denotes a tip, which alerts you to advisory information.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
bold	Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
italic	Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.
`monospace bold`	Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.
`monospace italic`	Italic text in this font denotes text that is a placeholder for a word or value that you must supply.

Software Requirements

To calibrate the NI PXIe-5611, you must install NI-RFSG version 1.6 or later on the calibration system. NI-RFSG includes all the VIs necessary for calibration. You can download the latest version of NI-RFSG at `ni.com/idnet`.

NI-RFSG supports programming the calibration procedures in LabVIEW. Calibration VIs are accessible in LabVIEW from the Functions palette. Refer to Table 1 for file locations.

For more information about calibration VIs, refer to the *NI RF Signal Generators Help*, accessible at **Start»All Programs»National Instruments»NI-RFSG»Documentation»NI RF Signal Generators Help**.

Table 1. Calibration File Locations (NI-RFSG 1.6 or Later)

File Name and Location	Description
`IVI\Bin\niRFSG.dll`	NI-RFSG driver containing the entire NI-RFSG API, including calibration functions.
<*LabVIEW* >`\instr.lib\niRFSG\niRFSG5611Calibration`	Folder containing NI-RFSG calibration API VIs. You can access calibration functions from the NI-RFSG calibration section of the LabVIEW function palette.

Documentation Requirements

You might find the following documentation helpful as you write the calibration procedure:

- *NI PXIe-5673 Specifications*
- *NI PXIe-5673E Specifications*
- *NI PXIe-5673 Calibration Procedure*
- *NI PXIe-5673E Calibration Procedure*
- *NI 5450 Calibration Procedure*
- *NI PXI-5650/5651/5652 Calibration Procedure*
- *NI PXIe-5650/5651/5652 Calibration Procedure*
- *NI RF Signal Generators Getting Started Guide*
- *NI RF Signal Generators Help,* including LabVIEW VI programming references

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

This calibration procedure calibrates the NI PXIe-5611 I/Q modulator as a stand-alone device. To calibrate the NI PXIe-5673 or NI PXIe-5673E, refer to their calibration procedures at `ni.com/manuals`.

Password

The default password for password-protected operations is `NI`.

Calibration Interval

The measurement accuracy requirements of your application determine how often you should calibrate your device. NI recommends that you perform a complete calibration for the NI 5611 at least once a year. You can shorten this calibration interval based on the accuracy demands of your application.

Calibration Overview

Calibration involves verification, and, if necessary, adjustment, and reverification of the NI 5611.

Verification is the process of testing to ensure that the accuracy of the device. Perform verification post-adjustment to determine if the adjustment was successful.

Adjustment is the process of measuring and compensating for device performance to improve the measurement accuracy. Performing an adjustment updates the calibration date.

Perform a complete calibration to guarantee successful adjustment and performance of the NI 5611 for a one-year calibration interval. After adjustment, repeat verification to ensure that the device meets the calibration test limits.

After calibrating the NI 5611 as a stand-alone device, NI strongly recommends that you calibrate the NI 5673, which includes the NI 5611. To calibrate the NI PXIe-5673 or NI PXIe-5673E, refer to their calibration procedures at `ni.com/manuals`.

Figure 1 shows the programming flow for a complete calibration.

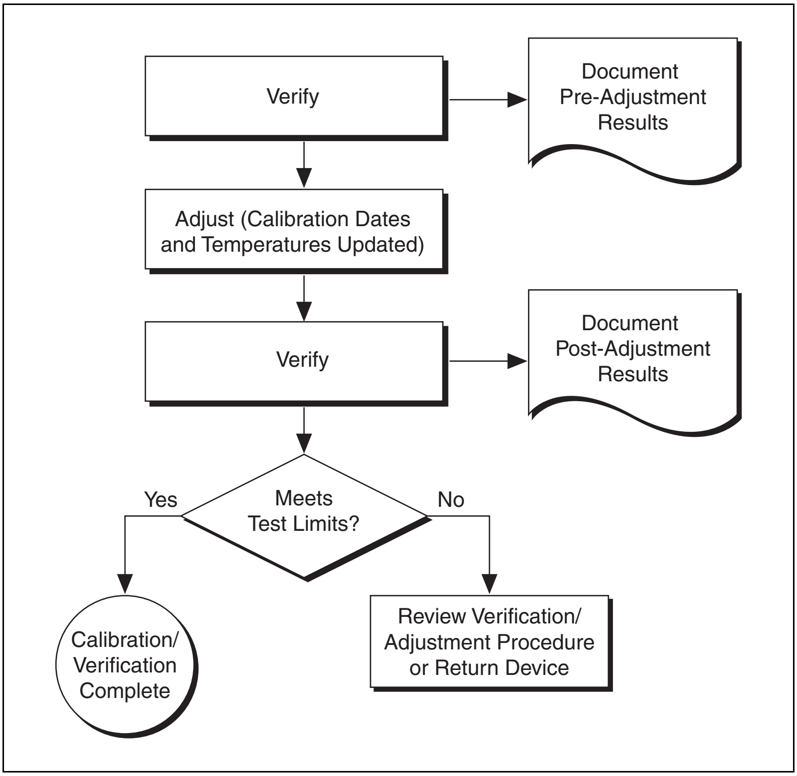


Figure 1. Complete Calibration Programming Flow

Test Equipment

Table 2 lists the equipment required to calibrate the NI 5611. If you do not have the recommended equipment, select a substitute calibration standard using the specifications listed in Table 2.

Table 2. Required Equipment Specifications for NI 5611 Calibration

Required Equipment	Recommended Equipment	Specifications
Spectrum analyzer	Rohde & Schwarz (R&S) FSU Spectrum Analyzer with high-frequency preamplifier option (B23)	Frequency range: 50 MHz to 6.6 GHz Noise floor: <–152 dBm/Hz to 6.6 GHz
Power meter	Anritsu ML2438A and a MA2472 diode sensor	Range: –50 dBm to +10 dBm Frequency range: 50 MHz to 6.6 GHz Accuracy: 0.5%
Power splitter	Aeroflex/Weinschel 1593	SWR: 1.25 Amplitude tracking: <0.25 dB
NI PXIe-5450 arbitrary waveform generator	NI PXIe-5450	This device must be fully calibrated before calibrating the NI 5611.
NI PXI-5652 RF signal generator	NI PXI-5652	This device must be fully calibrated before calibrating the NI 5611.
6 dB attenuator	Anritsu 41KB-6	Frequency range: DC to 12 GHz SWR: 1.1
50 Ω terminator (included in the NI 5673 kit)	NI 778353-01	—
Adapter SMA(m)-to-N(f)	S.M. Electronics SM4241	VSWR: 1.15 : 1
SMA torque wrench	NI 187106-01	1 N · m
NI PXIe-5673 Cable Accessory Kit	NI 780567-01	Matched-length I/Q semi rigid SMA cable (4) LO semi-rigid SMA cable (1) RF flexible SMA cable (1)
SMA adapter plug/plug	Huber+Suhner 32_N-SMA-50-1/11-_NE	VSWR: 1.05 : 1
BNC (m) to BNC (m) cable (36 inches)	—	—

Test Conditions

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

- Verify that the NI 5611, NI 5450, and NI 5652 are properly connected as indicated in *Chapter 5, NI 5673 RF Vector Signal Generator* or *Chapter 6, NI 5673E RF Vector Signal Generator* in the *NI RF Signal Generators Getting Started Guide*.
- Verification limits are defined assuming the same NI 5611, NI 5450, and NI 5652 is used during adjustment and verification.
- Keep cabling as short as possible. Long cables act as antennae, picking up extra noise that can affect measurements.
- Verify that all connections, including front panel connections and screws, are secure.
- Ensure that the PXI Express chassis fan speed is set to HI, the fan filters are clean, and the empty slots contain filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.
- Keep relative humidity between 10% and 90%, noncondensing.
- Maintain an ambient temperature of 23 °C ±5 °C.
- Allow a warm-up time of at least 30 minutes after the chassis is powered on. The warm-up time ensures that the NI 5611 is at a stable operating temperature.
- Perform a self-calibration on the NI PXIe-5450 signal generator.
- Each verification procedure requires a delay to be inserted in between configuring all devices and acquiring the measurement. This delay may need to be adjusted depending on the instruments used but should always be at least 1,000 ms for the first iteration, 1,000 ms when the power level changes, and 100 ms for each other iteration.

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX). Refer to *Chapter 5, NI 5673 RF Vector Signal Generator* or *Chapter 6, NI 5673E RF Vector Signal Generator* in the *NI RF Signal Generators Getting Started Guide* for more information about how to configure your device.
2. *Verification*—Verify the existing operation of the device. This step confirms whether the device is operating within its specified range prior to adjustment.

3. *Adjustment*—Perform an external adjustment of the device that adjusts the calibration constants of the device. The adjustment procedure automatically stores the calibration date on the EEPROM to allow traceability.
4. *Reverification*—Repeat the verification procedure to ensure that the device is operating within its specifications after adjustment.

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

Initial Setup

Refer to the *NI RF Signal Generators Getting Started Guide* for information about how to install the software and hardware and how to configure the device in MAX.

Characterizing the Power Splitter

Several procedures in this document require using a splitter that has been characterized to remove error from future measurements. Complete the following steps to characterize a splitter using an NI 5652, power meter, and spectrum analyzer, as shown in Figure 2.

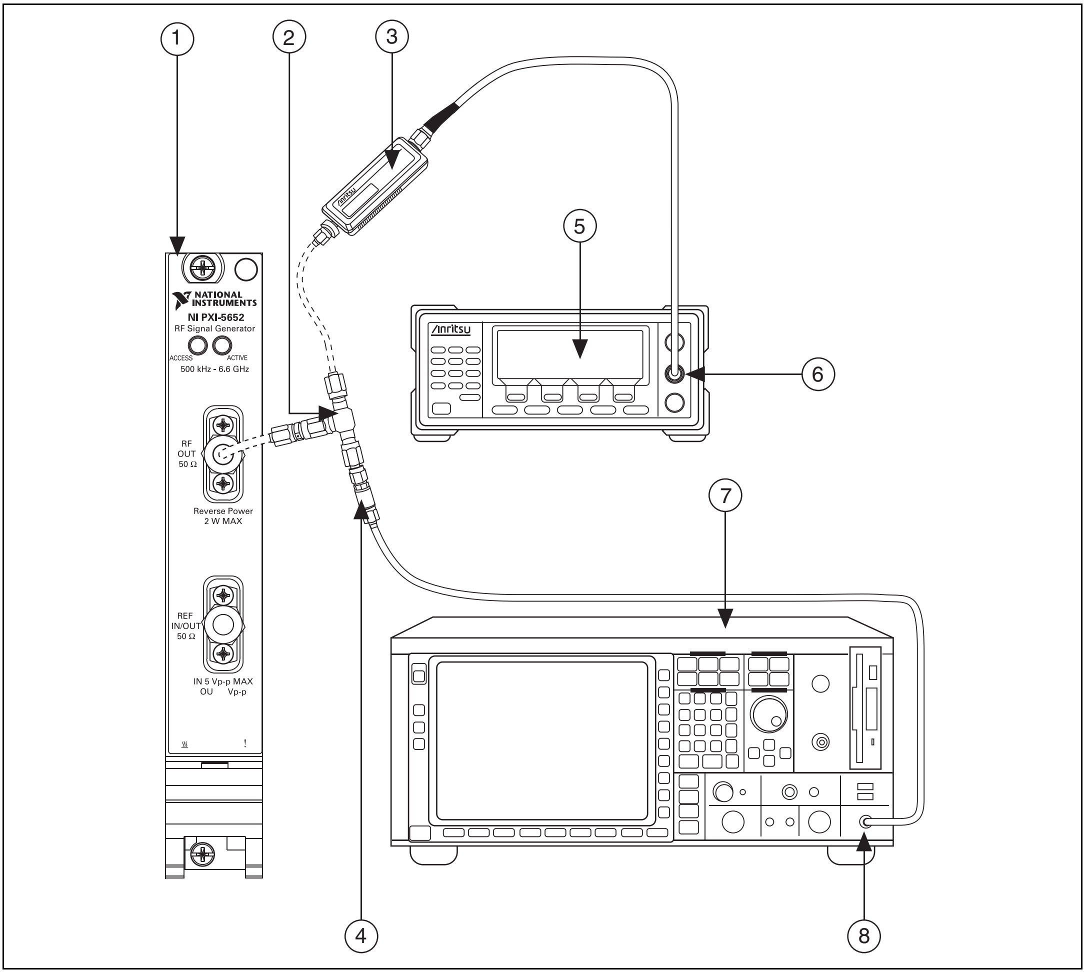
1. Disconnect the NI 5611 LO IN front panel connector from the NI 5652 RF OUT front panel connector.
2. Connect the power meter power sensor to the NI 5652 RF OUT front panel connector.
3. Generate a tone with the NI 5652 with the following NI-RFSG property settings:
    - Frequency (Hz): 50 MHz
    - Power Level (dBm): –10 dBm
4. Use the power meter to measure the output power.
5. Repeat steps 3 through 4 for every frequency from 50 MHz to 6.6 GHz in 5 MHz increments, including endpoints. Store the resulting measurements.
6. Disconnect the power sensor from the NI 5652 RF OUT front panel connector.

Caution If you use a cable, it should be as short as possible. The cable should always be used with the splitter for subsequent verification procedures in this document that require a splitter.

7. Connect the power splitter input port to the NI 5652 RF OUT front panel connector without a cable, if possible.

Caution Remember the port to which the power sensor is connected. The power sensor must be connected to the same port for subsequent procedures in this document.

8. Connect one available port of the power splitter to the power sensor without a cable, if possible.
9. Connect one available end of the power splitter to the 6 dB attenuator.
10. Connect the other available port of the 6 dB attenuator to the spectrum analyzer RF INPUT front panel connector as shown in Figure 2.
11. Configure the reference level of the spectrum analyzer to –30 dBm. The spectrum analyzer is used only for termination.



1	NI 5652 RF Signal Generator	5	Power Meter
2	Splitter	6	CH A Connector
3	Power Sensor	7	Spectrum Analyzer
4	Attenuator	8	RF INPUT Connector

Figure 2. Power Splitter Characterization Setup

12. Repeat steps 3 through 4 for every frequency from 50 MHz to 6.6 GHz in 5 MHz increments, including endpoints. Store the resulting measurements.

13. Subtract the power measurements from step 5 from the measurements in step 12 for each corresponding frequency. Store the resulting calculations. The result is an array representing the loss through the splitter for the entire needed frequency range in 5 MHz increments.

Note This array is later used to compensate measurements and correct for splitter loss. If you do not find the exact frequency needed in the splitter correction array, use the loss corresponding to the next closest frequency.

You have successfully characterized your splitter.

Verification

This section describes the steps you must follow to verify successful adjustment of the NI 5611.

Verification tests the following NI 5611 specifications:

- LO filter response
- LO path gain
- Modulation impairments
- Modulation bandwidth and impairments
- RF path gain
- Intermodulation products

Verification of the NI 5611 is complete only after you have successfully completed all tests in this section.

Verifying LO Filter Response

Complete the following steps to verify the LO filter response of an NI 5611 module using a spectrum analyzer.

1. Connect the NI 5611 LO OUT front panel connector to the spectrum analyzer RF INPUT front panel connector.
2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer REF OUT rear panel connector.
3. Generate a signal with the following NI-RFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: CW
   - LO OUT Enabled: Enabled
4. Use the spectrum analyzer to measure the mean fundamental tone power using the following spectrum analyzer parameter settings:
   - Center Frequency: Frequency from step 3
   - Reference level: +5 dBm
   - Frequency span: 0 Hz

- Resolution bandwidth: 500 Hz
- Sweep time: 5 ms

5. Use the spectrum analyzer to measure the mean tone power at the 2nd harmonic frequency using the following spectrum analyzer parameter settings:
   - Center Frequency: Frequency from step 3 × 2
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
6. Calculate the power level of the harmonic in dBc by subtracting the measured fundamental power from step 4 from the measured harmonic power from step 5.
7. Compare the calculated power level from step 6 to the corresponding limit in Table 1.
8. Repeat steps 3 through 7 for every frequency from 85 MHz to 2.2 GHz in 5 MHz increments, including endpoints.

Table 3. LO Filter Response Verification Test Parameters

Harmonic	2nd Harmonic Upper Limits (dBc)	
	F ≤ 100 MHz	**100 MHz < F ≤ 2.2 GHz**
2nd (2F)	–21	–31

If the results are within the selected test limit, the device has passed this portion of the verification.

Verifying LO Path Gain

Complete the following steps to verify the LO path gain of the NI 5611 module using a power meter.

1. Connect the NI 5611 LO OUT front panel connector to the power meter.
2. Generate a signal with the following NI-RFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: CW
   - LO OUT Enabled: Enabled
3. Use the power meter to measure the LO OUT power.

4. Compare the measured LO OUT output power to the limit in Table 4.
5. Repeat steps 2 through 4 for every frequency from 85 MHz to 6.6 GHz in 10 MHz increments, including endpoints.

Table 4. LO Path Gain Verification Upper Test Limits

LO OUT Power (dBm)	As Found LO OUT Power Accuracy Test Limits (dB)	As Left LO OUT Power Accuracy Test Limits (dB)
0	±2.0	±1.0

If the results are within the selected test limit, the device has passed this portion of the verification.

Verifying Modulation Impairments

Complete the following steps to verify the modulation impairments of the NI 5611 using a spectrum analyzer.

1. Connect the NI 5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector.
2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer 10 MHz REF OUT rear panel connector on the spectrum analyzer.
3. Generate a single-sideband tone with a +1 MHz offset from the carrier signal with the following NI-RFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn

   The image appears at 84 MHz, and the carrier leakage at 85 MHz.
4. Use the spectrum analyzer to measure the mean power of the RF output using the following spectrum analyzer parameter settings:
   - Center frequency: Frequency in step 3 + 1 MHz
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External

Note Zero-span mode shortens test time by avoiding unnecessary frequency sweeping. To obtain the average power, convert the zero-span trace data to linear volts, perform a mean calculation, and then convert the linear volts back to dBm.

5. Use the spectrum analyzer to measure the mean power of the image using the following spectrum analyzer parameter settings:
   - Center frequency: Frequency in step 3 – 1 MHz
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
6. Use the spectrum analyzer to measure the mean power of the carrier using the following spectrum analyzer parameter settings:
   - Center frequency: Equivalent to the frequency in step 3
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
7. Calculate the image suppression ratio (ISR) and carrier suppression ratio (CSR) according to the following formulas and save the values:

   ISR = Measured Image Power – Measured RF Output Power

   CSR = Measured Carrier Leakage Power – Measured RF Output Power
8. Repeat steps 3 though 7 for each LO frequency from 85 MHz to 6.6 GHz in 10 MHz steps, including endpoints.

Note With the baseband set to 1 MHz, 0 dBm single-sideband tone, the RF output is always 1 MHz above the LO frequency, the image is 1 MHz below LO, and the carrier leakage is at LO frequency.

9. Use Table 5 to compare the ISR and CSR from step 7 for each LO frequency.

Table 5. Modulation Impairments Verification Upper Test Limits

LO Frequency (MHz)	ISR (dBc) Test Limit	CSR (dBc) Test Limit
85 to 400	–43	–44
400 to 2,500	–50	–44

Table 5. Modulation Impairments Verification Upper Test Limits

LO Frequency (MHz)	ISR (dBc) Test Limit	CSR (dBc) Test Limit
2,500 to 5,500	–46	–44
5,500 to 6,600	–43	–41

If the results are within the selected test limit, the device has passed this portion of the verification.

Verifying Modulation Bandwidth and Impairments

Complete the following steps to verify the modulation bandwidth performance and modulation impairments of the NI 5611 using a spectrum analyzer.

1. Connect the NI 5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector.
2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer 10 MHz REF OUT rear panel connector on the spectrum analyzer.
3. Generate an I/Q tone at –50 MHz offset from the carrier with the following NI-RFSG property settings:
   - Frequency (Hz): 200 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn
4. Use the spectrum analyzer to measure the mean output power of the RF output using the following spectrum analyzer parameter settings:
   - Center frequency: frequency in step 3 + offset in step 3
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
5. Use the spectrum analyzer to measure the mean output power of image using the following spectrum analyzer parameter settings:
   - Center frequency: frequency in step 3 – offset in step 3
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz

- Sweep time: 5 ms
- Reference clock source: External

6. Calculate the ISR according to the following formula and save the values:

   ISR = Measured Image Power – Measured RF Output Power

7. Repeat steps 3 through 6 for every offset frequency from –50 MHz to +50 MHz in 5 MHz increments while keeping the LO frequency fixed.

Tip Set the NI-RFSG Generation Mode property to **CW** to generate a 0 Hz offset. The ISR with a 0 Hz frequency offset cannot be measured, and the 0 Hz data point can be ignored.

8. Calculate the relative modulation bandwidth flatness by subtracting the RF output power measured at 0 Hz offset from the RF output powers measured at each of the other offset frequencies.
9. Compare each value calculated in step 8 to the limits in Table 6 and compare only the ISR values calculated for offset frequencies between –10 MHz and 10 MHz in step 5 to the limits in Table 7.

Note Values calculated for offset frequencies less than –10 MHz and greater than 10 MHz are not specified and do not have test limits.

10. Repeat steps 3 through 9 for each LO frequency in Table 6.

Table 6. Modulation Bandwidth Impairment Verification Test Limits

LO Frequency (GHz)	Modulation Bandwidth Test Limits (dB)	
	Maximum	Minimum
0.2	3	–3
2.4	3	–3
4.0	3	–3
5.8	3	–3

Table 7. Modulation Bandwidth Impairment Verification Test Limits for Offset Frequencies Between –10 MHz and +10 MHz

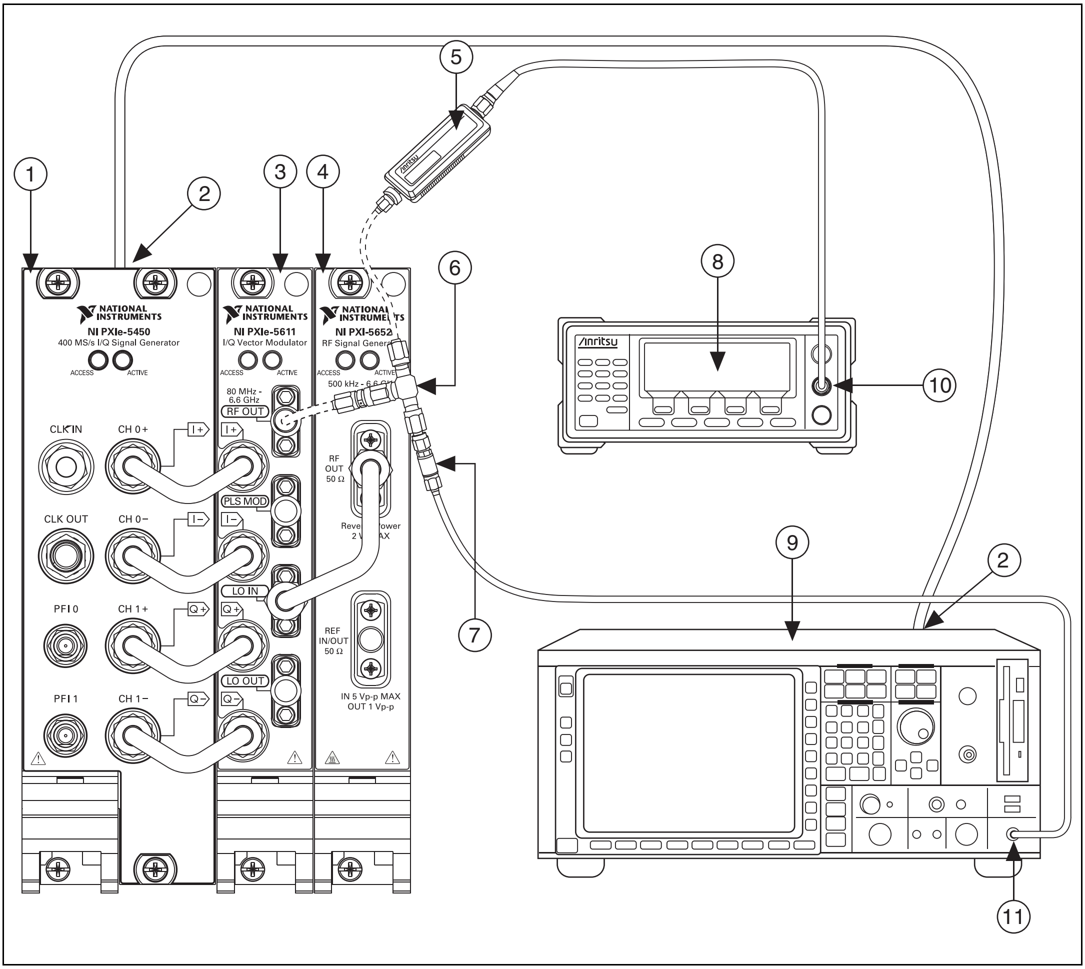
LO Frequency (GHz)	Test Limits ISR (dBc)
0.2	–41
2.4	–48
4.0	–45
5.8	–41

If the results are within the selected test limit, the device has passed this portion of the verification.

Verifying RF Path Gain

Complete the following steps to verify the RF path gain of the NI 5611 using a power meter, rubidium frequency standard, spectrum analyzer, power splitter, and 6 dB attenuator.

Note The attenuator is placed in front of the spectrum analyzer to improve the spectrum analyzer return loss. The power splitter must be characterized so that you can account for its loss. Refer to the *Characterizing the Power Splitter* section for more information about how to characterize your power splitter.



1	NI 5450 Arbitrary Waveform Generator	6	Power Splitter
2	Connection from NI PXI Express REF IN Rear Panel Connector to Spectrum Analyzer REF OUT Rear Panel Connector	7	Attenuator
3	NI 5611 I/Q Modulator	8	Power Meter
4	NI 5652 RF Signal Generator	9	Spectrum Analyzer
5	Power Sensor	10	CH A Connector
		11	RF INPUT Connector

Figure 3. Connecting Hardware to Verify RF Path Gain

1. Connect the input port of the power splitter to the NI 5611 RF OUT front panel connector.
2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer 10 MHz REF OUT rear panel connector.

Caution The port used to connect the power splitter to the power sensor in step 8 of the *Characterizing the Power Splitter* section must be the same port used to connect the power splitter to the power meter in step 3 of this section.

3. Connect one available port of the power splitter to the power meter.

Caution The port used to connect the power splitter to the 6 dB attenuator in step 9 of the *Characterizing the Power Splitter* section must be the same port used to connect the power splitter to the power meter in step 4 of this section.

4. Connect one available port of the power splitter to the 6 dB attenuator.
5. Connect one available port of the 6 dB attenuator to the spectrum analyzer RF INPUT front panel connector.
6. Disconnect the NI 5450 CLK IN front panel connector from the NI 5652 REF IN/OUT front panel connector.
7. Generate a single-sideband tone with a +1 MHz offset from the carrier with the following NI-RFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 5 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn
8. Use the power meter to measure power splitter-compensated output power.
9. Repeat steps 7 through 8 for every frequency from 85 MHz to 6.6 GHz in 20 MHz increments, including endpoints.
10. Set the NI-RFSG Power Level property to `0` dBm, and repeat steps 7 through 9.
11. Set the NI-RFSG Power Level property to `–30` dBm, and repeat steps 7 through 9, measuring the power using both the power meter and spectrum analyzer. Use the following parameter settings for the spectrum analyzer:
    - Center frequency: frequency in step 7 + 1 MHz
    - Reference level: –30 dBm
    - Frequency span: 0 Hz
    - Resolution bandwidth: 500 Hz
    - Sweep time: 20 ms
    - Reference clock source: External
    - Attenuation: 5 dB
    - Preamplifier: On
12. Use the power meter measurements to calculate a correction for the spectrum analyzer inaccuracies and attenuator loss.

13. Set the NI-RFSG Power Level property to `–60` dBm, and repeat steps 7 through 9 using only the spectrum analyzer and its measured correction to measure the power accuracy using the following spectrum analyzer parameter settings:
    - Center frequency: frequency in step 7 + 1 MHz
    - Reference level: –30 dBm
    - Frequency span: 0 Hz
    - Resolution bandwidth: 500 Hz
    - Sweep time: 20 ms
    - Reference clock source: External
    - Attenuation: 5 dB
    - Preamplifier: On
14. Set the NI-RFSG Power Level property to `–90` dBm and repeat steps 7 through 9 using only the spectrum analyzer and its measured correction to measure the power accuracy using the following spectrum analyzer parameter settings:
    - Center frequency: frequency in step 7 + 1 MHz
    - Reference level: –30 dBm
    - Frequency span: 0 Hz
    - Resolution bandwidth: 500 Hz
    - Sweep time: 200 ms
    - Reference clock source: External
    - Attenuation: 5 dB
    - Preamplifier: On
15. Compare the measured values from steps 7 through 14 to the corresponding limits in Table 8.

Table 8. RF Path Gain Verification Test Limits

Output Power (dBm)	Power Accuracy Test Limits (dB)
5	±0.75
0	±0.75
–30	±0.75
–60	±0.75
–90	±0.75

If the results are within the selected test limit, the device has passed this portion of the verification.

Adjustment

Following the adjustment procedure automatically updates the calibration date and temperature in the EEPROM of the NI 5611. The calibration date is also updated when you call the niRFSG Initialize External Calibration and niRFSG Close External Calibration VIs.

Adjustment involves the following NI 5611 procedures:

- LO filter response
- LO path gain
- Modulation impairments
- RF path gain

Adjusting LO Filter Response

This adjustment yields a reduced LO second harmonic. Complete the following steps to adjust the LO filter response of the NI 5611 using a spectrum analyzer.

1. Connect the NI 5611 LO OUT front panel connector to the spectrum analyzer RF INPUT front panel connector.
2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer 10 MHz REF OUT rear panel connector on the spectrum analyzer.
3. Call the niRFSG Initialize External Calibration VI.
4. Call the niRFSG Initialize LO Filter Calibration VI.

Note The **Filter to Calibrate** parameter on the niRFSG Initialize LO Filter Calibration VI is by default set to **All Filters**. If you set the **Filter to Calibrate** parameter to another filter setting, you must repeat steps 4 through 8 for each filter.

5. Call the niRFSG 5611 Configure LO Filter Calibration VI.
6. Use the spectrum analyzer to measure the mean output power using the following spectrum analyzer parameter settings:
   - Center frequency: frequency specified by the **Frequency to Measure (Hz)** parameter of the niRFSG 5611 Configure LO Filter Calibration VI
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms

7. Call the niRFSG 5611 Adjust LO Filter Calibration VI, and pass the value measured in step 6 to the **Measured LO OUT Power (dBm)** parameter.
8. Repeat steps 5 through 7 in a loop until the **LO Filter Calibration Complete** parameter returns a value of TRUE.
9. Call the niRFSG Close External Calibration VI to close the session and store the results to the EEPROM on the NI 5611.

Adjusting LO Path Gain

This adjustment yields accurate power levels reaching both the internal modulators and the LO OUT connector on the NI 5611. Complete the following steps to calibrate the LO path gain on the NI 5611 using a power meter.

1. Connect the NI 5611 LO OUT front panel connector to the power meter.
2. Call the niRFSG Initialize External Calibration VI.
3. Call the niRFSG 5611 Initialize LO Gain Calibration VI.

Note The **Filter to Calibrate** parameter on the niRFSG Initialize LO Gain Calibration VI is by default set to **All Filters**. If you set the **Filter to Calibrate** parameter to another filter setting, you must repeat steps 3 through 7 for each filter.

4. Call the niRFSG 5611 Configure LO Gain Calibration VI.
5. Use the power meter to measure the output power at the frequency specified by the **Frequency to Measure (Hz)** parameter of the niRFSG 5611 Configure LO Gain Calibration VI.
6. Call the niRFSG 5611 Adjust LO Gain Calibration VI, and pass the value measured in step 5 to the **Measured LO OUT Power (dBm)** parameter.
7. Repeat steps 4 through 6 until the **LO Gain Calibration Complete** parameter returns a value of TRUE.
8. Call the niRFSG Close External Calibration VI to close the session and store the results to the EEPROM on the NI 5611.

Adjusting Modulation Impairments

This adjustment measures and corrects the NI 5611 RF fundamental, carrier, and image tones until the carrier and image tones are sufficiently suppressed.

Complete the following steps to calibrate the modulation impairments of the NI 5611 using a spectrum analyzer.

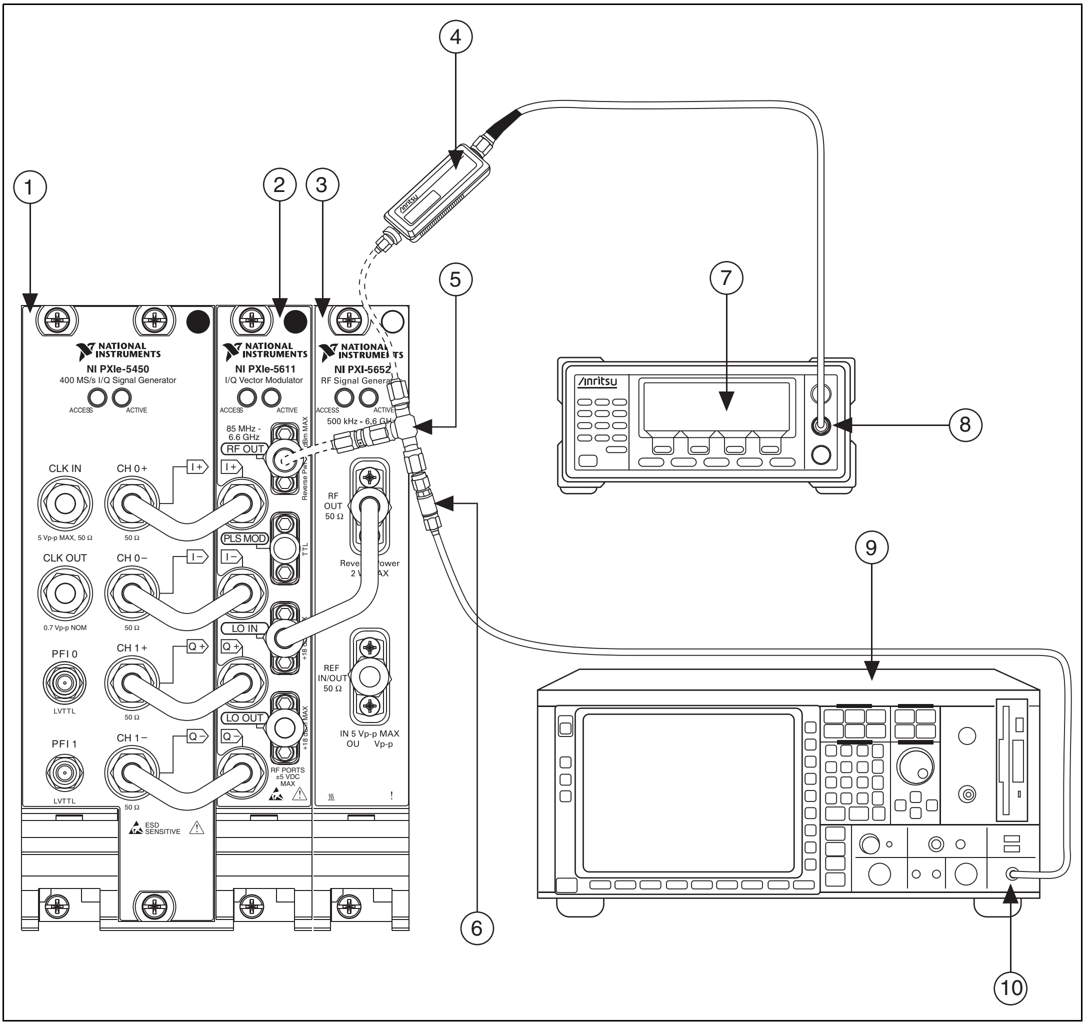
1. Connect the NI 5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector.
2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer 10 MHz REF OUT rear panel connector.
3. Call the niRFSG Initialize External Calibration VI.
4. Call the niRFSG 5611 Initialize Impairment Calibration VI.
5. Call the niRFSG 5611 Configure Impairment Calibration VI.

Note The default behavior of the niRFSG 5611 Configure Impairment Calibration VI is to calibrate all filters. If you choose to calibrate a single filter, repeat the entire RF path calibration procedure for each of the eight filters to complete a full calibration.

6. Use the spectrum analyzer to measure the mean tone power using the following spectrum analyzer parameter settings:
   - Center frequency: Value specified by the **Frequency to Measure (Hz)** parameter of the niRFSG 5611 Configure LO Filter Calibration VI
   - Reference level: Value specified by the **Spectrum Analyzer Reference Level (dB)** parameter of the niRFSG 5611 Configure Impairment Calibration VI
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
7. Call the niRFSG 5611 Adjust Impairment Calibration VI, and pass the measurement from step 6 to the **Measured RF OUT Power (dBm)** parameter of the niRFSG 5611 Adjust RF Gain Calibration VI.
8. Repeat steps 5 through 7 until the **Impairment Calibration Complete** parameter returns a value of TRUE.
9. Call the niRFSG Close External Calibration VI to close the session and store the results to the EEPROM on the NI 5611.

Adjusting RF Path Gain

This adjustment yields accurate power levels out of the NI 5611 RF OUT front panel connector. Complete the following steps to properly connect the devices, as shown in Figure 4, to adjust RF path gain.



1	NI 5450 Arbitrary Waveform Generator	6	Attenuator
2	NI 5611 I/Q Modulator	7	Power Meter
3	NI 5652 RF Signal Generator	8	CH A Connector
4	Power Sensor	9	Spectrum Analyzer
5	Power Splitter	10	RF INPUT Connector

Figure 4. Connecting Hardware to Adjust RF Path Gain

1. Connect the input port of the power splitter to the NI 5611 RF OUT front panel connector.

2. Connect the PXI Express chassis 10 MHz REF IN rear panel connector to the spectrum analyzer 10 MHz REF OUT rear panel connector.
3. Connect one available port of the power splitter to the power meter.
4. Connect one available port of the power splitter to the 6 dB attenuator.
5. Connect one available port of the 6 dB attenuator to the spectrum analyzer RF INPUT front panel connector.

Note For best results, do not use any cables between the NI 5611, power splitter, and power sensor. Connect these devices directly together.

6. Call the niRFSG Initialize External Calibration VI.
7. Call the niRFSG 5611 Initialize RF Gain Calibration VI.
8. Call the niRFSG 5611 Configure RF Gain Calibration VI, and set the **Instrument Transition Threshold (dBm)** parameter to the power level equal to the bottom of the power meter's accurate range.

Note The default behavior of the niRFSG 5611 Configure RF Gain Calibration VI is to calibrate all filters. If you choose to calibrate a single filter, repeat the entire RF path calibration procedure on each of the eight filters to complete a full calibration.

9. Configure the spectrum analyzer using the following spectrum analyzer parameter settings:
   - Center frequency: value specified by the **Frequency to Measure (Hz)** parameter of the niRFSG 5611 Configure RF Gain Calibration VI
   - Reference level: value specified by the **Spectrum Analyzer Reference Level (dB)** parameter of the niRFSG 5611 Configure Impairment Calibration VI
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 20 ms
   - Attenuation: 5 dB
   - Preamplifier: On
10. Using the instrument(s) specified by the **Measurement Instrument** parameter of the niRFSG 5611 Configure Impairment Calibration VI, measure the mean power of the generated tone at the frequency specified by the **Frequency to Measure (Hz)** parameter of the niRFSG 5611 Configure RF Gain Calibration VI.

Note If the instrument specified is **`Power Meter & Spectrum Analyzer`**, then you must measure the power with the power meter and the spectrum analyzer simultaneously. These measurements are used to correct the spectrum analyzer's inaccuracy.

11. Compensate only the power meter measurement for the loss of the power splitter by subtracting the loss measured in the *Characterizing the Power Splitter* section from the power meter measurement in step 10 in this section.
12. Call the niRFSG 5611 Adjust RF Gain Calibration VI, and pass the measurements from step 11 to the **Power Meter Measurement (dBm)** and/or **Spectrum Analyzer Measurement (dBm)** parameter.
13. When the spectrum analyzer measures a level of ≤ –110 dBm, increase the sweep time for each measurement to 200 ms. The sweep time can return to 20 ms when the **Measurement Instrument** parameter of the niRFSG 5611 Configure RF Gain Calibration VI returns a value of **`Power Meter`**. The sweep time should alternate several times between 20 ms and 200 ms as these conditions are met.

Note Only the instrument indicated by the **Measurement Instrument** parameter is actually used. Values passed for the inactive instrument are ignored. The power meter is used for higher power measurements, and the spectrum analyzer is used for lower power measurements.

14. Repeat steps 8 through 12 until the **RF Gain Calibration Complete** parameter returns a value of TRUE. Additional averaging is required on the spectrum analyzer to minimize the effects of noise at the lower power levels. After a level of –90 dBm or less is measured, increase the sweep time to 200 ms for the remaining measurements of the procedure.
15. Call the niRFSG Close External Calibration VI to close the session and store the results to the EEPROM on the NI 5611.

You have finished adjusting the NI 5611. Repeat the *Verification* section to reverify the performance of the NI 5611 after adjustments.

Appendix A: Calibration Utilities

NI-RFSG provides a full complement of calibration utility VIs. You can use utility VIs to retrieve information about adjustments performed on the NI 5611, change the calibration password, and store small amounts of information in the onboard EEPROM. The Calibration Utility palette includes the following VIs:

- niRFSG Change External Calibration Password VI
- niRFSG Close External Calibration VI
- niRFSG Get External Calibration Last Date And Time VI
- niRFSG Initialize External Calibration VI
- niRFSG Set External Calibration Last Date and Time VI

Calibration VI References

The VIs used in this procedure, including all calibration VIs and functions, are documented in the *NI-RFSG VI Reference,* which you can access from the *NI RF Signal Generators Help* at **Start»All Programs»National Instruments»NI-RFSG»Documentation**.

Where to Go for Support

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

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Germany 49 89 7413130, India 91 80 41190000, Israel 972 3 6393737,
Italy 39 02 41309277, Japan 0120-527196, Korea 82 02 3451 3400,
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