CALIBRATION PROCEDURE

PXIe-5673

Vector Signal Generator

This document contains the verification procedures for the PXIe-5673 Vector Signal Generator. Refer to `ni.com/calibration` for more information about calibration solutions.

Contents

NATIONAL INSTRUMENTS™

Software

To calibrate the PXIe-5673, you must install NI-RFSG version 1.8 or later on the calibration system. You can download the latest version of NI-RFSG at `ni.com/updates`.

NI-RFSG supports programming the calibration procedures in LabVIEW. Refer to Table 1 for file locations.

Table 1. Calibration File Locations

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\niRFSG.llb`	LabVIEW VI library containing VIs for calling the NI-RFSG calibration API. You can access calibration VIs from the NI-RFSG Calibration section of the LabVIEW Functions palette.

Documentation

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

- *PXIe-5673 Specifications*
- *NI RF Signal Generators Getting Started Guide*
- *NI RF Signal Generators Help,* including LabVIEW programming references

The latest versions of these documents are available on `ni.com/manuals`.

This calibration procedure calibrates the PXIe-5673 as a single device. To calibrate the PXIe-5450 Waveform Generator, PXIe-5611 IQ Modulator, or PXI-5650/5651/5652 RF Analog Signal Generator individually, refer to their calibration procedures at `ni.com/manuals`.

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 PXIe-5673 at least once a year. You can shorten this calibration interval based on the accuracy demands of your application.

Test Equipment

Table 2 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.

Table 2. Recommended Equipment for PXIe-5673 Calibration

Equipment	Recommended Model	Where Used	Minimum Requirements
Spectrum analyzer	Rohde & Schwarz (R&S) FSU Spectrum Analyzer with high-frequency preamplifier option (B23)	Modulation impairments, Modulation bandwidth and impairments, Output power level accuracy, Output intermodulation products, Noise floor, RF harmonics, Baseband linearity-related spurs, Single-sideband phase noise, Frequency accuracy	Frequency range: 50 MHz to 19.8 GHz Noise floor: <-152 dBm/Hz to 6.6 GHz
SMA(m)-to-SMA(m) cable, 36 inches	Huber+Suhner (H+S) ST-18-SMAm/ SMAm/36		Operating frequency: DC to 18 GHz Impedance: 50 Ω Insertion loss: <1.5 dB Return loss: >19 dB Connectors: SMA(m)
BNC(m)-to-BNC(m) cable, 36 inches	—		50 Ω, RG-233
Frequency reference	Symmetricom/Datum 8040 Rubidium Frequency Standard	Modulation impairments, Modulation bandwidth and impairments, Output power level accuracy, Output intermodulation products, Noise floor, RF harmonics, Baseband linearity-related spurs, Single-sideband phase noise	Frequency: 10 MHz Frequency accuracy: ±1E-9
BNC(m)-to-SMA(m) cable, 36 inches	—		50 Ω, RG-233
Power meter	Anritsu ML2438A and an MA2472 diode sensor	LO output power, Output power level accuracy	Frequency range: 50 MHz to 6.6 GHz Power range: -70 dBm to +10 dBm Accuracy: 0.5%
SMA(m)-to-N(f) adapter	S.M. Electronics SM4241		VSWR: 1.15:1

Table 2. Recommended Equipment for PXIe-5673 Calibration (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
Power splitter	Aeroflex/Weinschel 1593	Output power level accuracy	VSWR: 1.25:1 Amplitude tracking: <0.25 dB
6 dB attenuator	Anritsu 41KB-6		Frequency range: DC to 12 GHz VSWR: 1.1:1
SMA(m)-to-SMA(m) adapter	(H+S) 32_N-SMA-50-1/ 11_NE		VSWR: 1.05:1
50 Ω terminator (included in the PXIe-5673 kit)	NI 778353-01	—	—
PXIe-5673 cable accessory kit (Matched-length I/Q semi-rigid SMA cables (4x) LO semi-rigid SMA cable (1) RF flexible SMA cable (1x))	NI 780567-01	—	—
SMA torque wrench (1 N · m)	NI 187106-01	—	—

Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-5673 meets published specifications.

- Verify that the PXIe-5611, PXIe-5450, and PXI-5650/5651/5652 are properly connected as indicated in the *NI RF Signal Generators Getting Started Guide* before starting verification.
- Keep cabling as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections, including front panel connections and screws, are secure.
- Use a torque wrench appropriate for the type of RF connector you are using.
  NI recommends using a 0.565 N · m (5 lb · in.) torque wrench for SMA connectors and a 0.90 N · m (8 lb · in.) torque wrench for 3.5 mm connectors.

- Ensure that the PXI/PXI Express chassis fan speed is set to HIGH, that the fan filters, if present, are clean, and that the empty slots contain filler panels. For more information, 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 PXIe-5611 is at a stable operating temperature.
- Perform a self-calibration on the PXIe-5450 Waveform Generator.
- In each verification procedure, insert a delay 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.
- Zero and calibrate the power meter sensors before each test.

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.

Test System Characterization

Use the following procedures to characterize the test system response. Use the results of these procedures in the *Verification* section of this document.

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 PXI-5650/5651/5652, power meter, and spectrum analyzer, as shown in Figure 1.

1. Disconnect the PXIe-5611 LO IN front panel connector from the PXI-5650/5651/5652 RF OUT front panel connector.
2. Connect the power meter power sensor to the PXI-5650/5651/5652 RF OUT front panel connector.
3. Generate a tone with the PXI-5650/5651/5652 with the following niRFSG property settings:
    - Frequency (Hz): 85 MHz
    - Power Level (dBm): -10 dBm
4. Use the power meter to measure the output power.

5. Repeat steps 3 through 4 for the following frequency ranges in 5 MHz increments, including endpoints:
   - PXI-5650: 85 MHz to 1.3 GHz
   - PXI-5651: 85 MHz to 3.3 GHz
   - PXI-5652: 85 MHz to 6.6 GHz

   Store the resulting measurements as *direct [i]* (dB).
6. Disconnect the power sensor from the PXI-5650/5651/5652 RF OUT front panel connector.
7. Connect the input port of the power splitter to the PXI-5650/5651/5652 RF OUT front panel connector through the SMA(m)-to-SMA(m) adapter.

   Note 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.

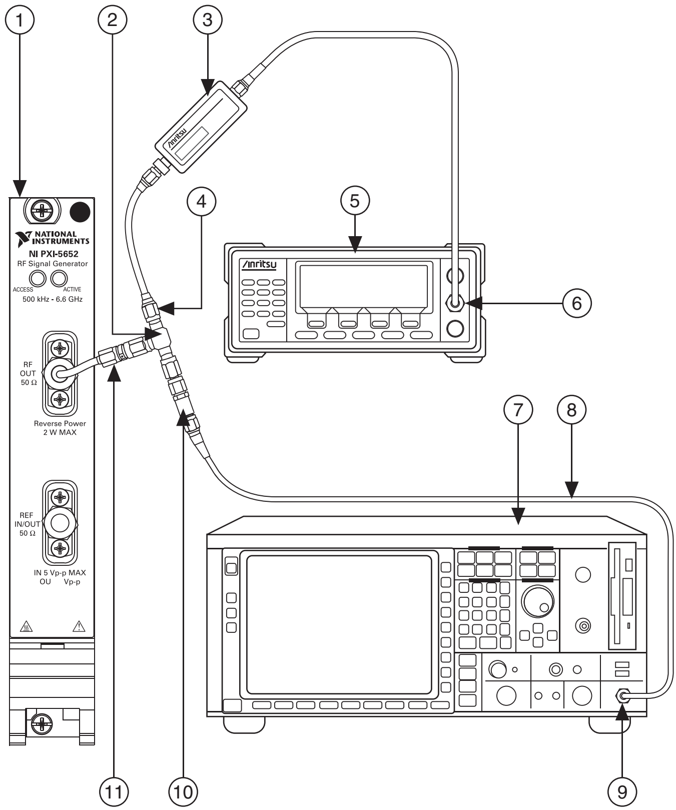
8. Connect one available output port of the power splitter to the power sensor without a cable, if possible. Label this port A.

   Note 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.

9. Connect the other output port of the power splitter to a 6 dB attenuator. Label this port B.
10. Connect the other port of the 6 dB attenuator to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable as shown in Figure 1.

11. Configure the reference level of the spectrum analyzer to -30 dBm. The spectrum analyzer is used only for termination.

Figure 1. Splitter Characterization Setup



1	PXI-5650/5651/5652 RF Analog Signal Generator (PXI-5652 shown)	6	CH A Connector
2	Splitter	7	Spectrum Analyzer
3	Power Sensor	8	SMA(m)-to-SMA(m) Cable
4	N(f)-to-SMA(m) Adapter	9	RF INPUT Connector
5	Power Meter	10	6 dB Attenuator
		11	SMA(m)-to-SMA(m) Adapter

12. Repeat steps 3 through 4 for the following frequency ranges in 5 MHz increments, including endpoints:
    - PXI-5650: 85 MHz to 1.3 GHz
    - PXI-5651: 85 MHz to 3.3 GHz
    - PXI-5652: 85 MHz to 6.6 GHz

    Store the resulting measurements as *splitter [i]* (dB).

13. Subtract the power measurements from step 12 from the measurements in step 5 for each corresponding frequency, as shown in the equation below. Store the resulting calculations as *splitter loss [i]* (dB). The result is an array representing the loss through the splitter for the entire needed frequency range in 5 MHz increments.

splitter loss [i] (dB) = *direct [i]* - *splitter [i]*

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.

As-Found and As-Left Limits

The as-found limits are the published specifications for the PXIe-5673. NI uses these limits to determine whether the PXIe-5673 meets the device specifications when it is received for calibration.

The as-left limits are equal to the published NI specifications for the PXIe-5673 less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to determine whether the PXIe-5673 meets the device specifications over its calibration interval.

Verification

This section describes the steps you must follow to verify the published specifications for the PXIe-5673.

Verification tests the following PXIe-5673 specifications:

- LO output power accuracy
- Modulation impairments
- Modulation bandwidth and impairments
- Output power level accuracy
- Intermodulation products
- Noise floor
- RF harmonics
- Baseband linearity-related spurs
- Phase noise
- Frequency accuracy

Note Ensure that the PXIe-5611, PXIe-5450, and PXI-5650/5651/5652 are properly connected and associated in MAX, as indicated in the *NI RF Signal Generators Getting Started Guide,* before starting verification.

Verification of the PXIe-5673 is complete only after you have successfully completed all tests in this section.

Verifying LO Output Power Accuracy

Complete the following steps to verify the LO output power accuracy of the PXIe-5673 module using a power meter.

1. Connect the PXIe-5611 LO OUT front panel connector to the power meter through the SMA(m)-to-N(f) adapter.
2. Generate a signal with the following niRFSG 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 3.
5. Repeat steps 2 through 4 for the following frequency ranges in 10 MHz increments, including endpoints:
   - PXI-5650: 85 MHz to 1.3 GHz
   - PXI-5651: 85 MHz to 3.3 GHz
   - PXI-5652: 85 MHz to 6.6 GHz

   Store the resulting measurements.

Table 3. LO Output Power Accuracy Verification Upper Test Limits

LO Output Power (dBm)	LO Output Power Test Limit (dB)
0	±1.0
Note: This specification is unwarranted.	

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 PXIe-5673 using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.
3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.

4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.
5. Generate a single-sideband tone with a +1 MHz offset from the carrier signal with the following niRFSG 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 appears at 85 MHz.
6. 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 5) + 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 of the spectrum analyzer 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.

7. Use the spectrum analyzer to measure the mean power of the image using the following spectrum analyzer parameter settings:
   - Center frequency: (Frequency in step 5) -1 MHz
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
8. 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 5
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External

9. Calculate the image suppression ratio (ISR) and carrier suppression ratio (CSR) according to the following formulas and save the values:

$$ISR = Measured\ Image\ Power - Measured\ RF\ Output\ Power$$

$$CSR = Measured\ Carrier\ Leakage\ Power - Measured\ RF\ Output\ Power$$

10. Repeat steps 5 though 9 for the following LO frequency ranges in 10 MHz steps, including endpoints:
    - PXI-5650: 85 MHz to 1.3 GHz
    - PXI-5651: 85 MHz to 3.3 GHz
    - PXI-5652: 85 MHz to 6.6 GHz

    Store the resulting measurements.

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

11. Use Table 4 to compare the *ISR* and *CSR* from step 9 for each LO frequency.

Table 4. Modulation Impairments Verification Upper Test Limits

CW Source	LO Frequency (MHz)	ISR (dBc) Test Limit	CSR (dBc) Test Limit
PXI-5650/5651/5652	85 MHz to 400 MHz	-43	-44
	>400 MHz to 1.3 GHz	-50	-44
PXI-5651/5652	1.3 GHz to 2.5 GHz	-50	-44
	>2.5 GHz to 3.3 GHz	-46	-44
PXI-5652	>3.3 GHz to 5.5 GHz	-46	-44
	>5.5 GHz to 6.6 GHz	-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 PXIe-5673 using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.

3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.
5. Generate an I/Q tone at -50 MHz offset from the carrier with the following niRFSG property settings:
   - Frequency (Hz): 200 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn
6. 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 5) + (offset in step 5)
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
7. Use the spectrum analyzer to measure the mean output power of image using the following spectrum analyzer parameter settings:
   - Center frequency: (Frequency in step 5) - (offset in step 5)
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
8. Calculate the ISR according to the following formula and save the values:

   ISR = Measured Image Power - Measured RF Output Power

9. Repeat steps 5 through 8 for every offset frequency from -50 MHz to +50 MHz in 5 MHz increments while keeping the LO frequency fixed.

   Tip Set the niRFSG 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.

10. 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.

11. Compare each value calculated in step 10 to the limits in Table 5 and compare only the ISR values calculated for offset frequencies between -10 MHz and 10 MHz in step 5 to the limits in Table 6.

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

12. Repeat steps 5 through 11 for each LO frequency in Table 5.

Table 5. Modulation Bandwidth Impairment Verification Test Limits

CW Source	LO Frequency	Modulation Bandwidth Test Limits (dB)	
		Maximum	Minimum
PXI-5650/5651/5652	200 MHz	3	-3
	1.3 GHz	3	-3
PXI-5651/5652	2.4 GHz	3	-3
	3.3 GHz	3	-3
PXI-5652	4.0 GHz	3	-3
	5.8 GHz	3	-3

Table 6. Modulation Bandwidth Impairment Verification Test Limits for Offset Frequencies Between -10 MHz and +10 MHz

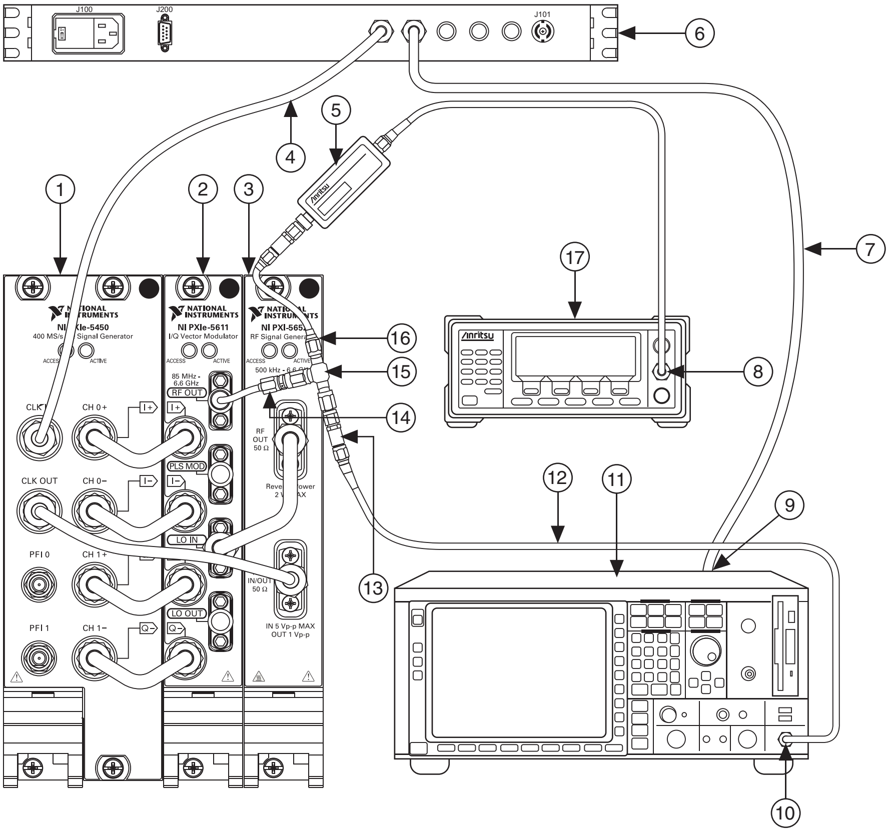
CW Source	LO Frequency	Test Limits ISR (dBc)
PXI-5650/5651/5652	200 MHz	-41
	1.3 GHz	-48
PXI-5651/5652	2.4 GHz	-48
	3.3 GHz	-45
PXI-5652	4.0 GHz	-45
	5.8 GHz	-41

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

Verifying Output Power Level Accuracy

Complete the following steps to verify the output power level accuracy of the PXIe-5673 using a power meter, rubidium frequency standard, spectrum analyzer, power splitter, and 6 dB attenuator.

Figure 2. Connecting Hardware to Verify Output Power Level Accuracy



1. PXIe-5450 Waveform Generator
2. PXIe-5611 IQ Modulator
3. PXI-5650/5651/5652 RF Analog Signal Generator (PXI-5652 shown)
4. BNC(m)-to-SMA(m) Cable
5. Power Sensor
6. Rubidium Frequency Source Rear Panel
7. BNC(m)-to-BNC(m) Cable Power Meter
8. CH A Connector
9. Connection from Rubidium Frequency Source to Spectrum Analyzer REF IN Rear Panel Connector
10. RF INPUT Connector
11. Spectrum Analyzer
12. SMA(m)-to-SMA(m) Cable
13. 6 dB Attenuator
14. SMA(m)-to-SMA(m) Adapter
15. Power Splitter
16. N(f)-to-SMA(m) Adapter
17. Power Meter

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. Connect the input port of the power splitter to the PXIe-5611 RF OUT front panel connector through the SMA(m)-to-SMA(m) adapter.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.
3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.

Note 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 5 of this section.

5. Connect port A of the power splitter to the power meter through the SMA(m)-to-N(f) adapter.

Note 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 6 dB attenuator in step 6 of this section.

6. Connect port B of the power splitter to the 6 dB attenuator.
7. Connect the available port of the 6 dB attenuator to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
8. Generate a single-sideband tone with a +1 MHz offset from the carrier with the following niRFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 5 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn
9. Use the power meter to measure power splitter-compensated output power.

Note Measurements must be adjusted to account for the splitter loss stored in the *Characterizing the Power Splitter* section, as shown in the following equation.

Measurement = power meter reading [i] + splitter loss [i]

10. Repeat steps 8 through 9 for the following frequency ranges in 20 MHz increments, including endpoints:
    - PXI-5650: 85 MHz to 1.3 GHz
    - PXI-5651: 85 MHz to 3.3 GHz
    - PXI-5652: 85 MHz to 6.6 GHz

    Store the resulting measurements.
11. Set the niRFSG Power Level property to `0` dBm, and repeat steps 8 through 10.
12. Set the niRFSG Power Level property to `-30` dBm, and repeat steps 8 through 10, 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 8) + 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: niRFSG Power Level property
13. Use the power meter measurements to calculate a correction for the spectrum analyzer inaccuracies and attenuator loss with the following equation:

$$Corrections\ [i] = Power\ Meter\ [i] - SpecAn\ [i]$$

Note The *SpecAn [i]* values in the above equation are used only to determine the *Corrections [i]* values that are used in the `-60` dBm and `-90` dBm measurements described in steps 14 and 15. When verifying the `-30` dBm measurements, you need to use only the *Power Meter [i]* values.

14. Set the niRFSG Power Level property to `-60` dBm, and repeat steps 8 through 10 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 8) + 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

Note To maintain the same measurement uncertainty as the power meter, you must apply the corrections found in step 15 to the measured results as shown in the following equation:

$$AdjustedMeasurement\ [i] = SpecAn\ [i] + Corrections\ [i] + Splitter\ Loss\ [i]$$

15. Set the niRFSG Power Level property to `-90` dBm and repeat steps 8 through 10 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 8) + 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
16. Measure tone power with the spectrum analyzer and calculate the adjusted tone power using the *AdjustedMeasurement [i]* equation from step 14.
17. Compare the measured values from steps 8 through 15 to the corresponding limits in Table 7.

Table 7. Output Power Level Accuracy Verification Test Limits

Output Power (dBm)	As-Found Limit (dB)	As-Left Limit (dB)
5	±0.75	±0.55
0	±0.75	±0.55
-10	±0.75	±0.55
-30	±0.75	±0.55
-60	±0.75	±0.55
-90	±0.75	±0.55

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

Verifying Output Intermodulation Products

Complete the following steps to verify the output intermodulation (IMD) performance of an PXIe-5673 using a spectrum analyzer. Complete this test for each iteration in Table 8.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.
3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-BNC(m) cable.
5. Generate two single-sideband tones simultaneously at 2 MHz (F_1) offset from the carrier and 2.3 MHz (F_2) offset from the carrier with the following niRFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: Arb Waveform
   - Power Level Type: Peak Power
   - Reference Clock Source: ClkIn

   The power of each tone should be approximately -6 dBm.
6. Set the output power for the given measurements in Table 8.
7. Use the spectrum analyzer to measure the mean amplitude of the first fundamental tone. Name this value P_1. For example, when the LO is set to 85 MHz, measure the first fundamental signal power at 87 MHz (LO + F_1). Use the following spectrum analyzer parameter settings:
   - Center frequency: (Frequency in step 5) + F_1
   - Reference level: 0 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
8. Use the spectrum analyzer to measure the mean amplitude of the second fundamental tone. Name this value P_2. For example, when the LO is set to 85 MHz, measure the second fundamental signal powers at 87.3 MHz (LO + F_2). Use the following spectrum analyzer parameter settings:
   - Center frequency: (Frequency in step 5) + F_2
   - Reference level: 0 dBm
   - Frequency span: 0 Hz

- Resolution bandwidth: 500 Hz
- Sweep time: 5 ms
- Reference clock source: External

9. Use the spectrum analyzer to measure the mean amplitude of the first close-in IMD tone at 86.7 MHz (LO + $2F_1$ - F_2). Name this value I_1. Use the following spectrum analyzer parameter settings:
   - Center frequency: (Frequency in step 5) + F_1
   - Reference level: 0 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
10. Use the spectrum analyzer to measure the mean amplitude of the second close-in IMD tone at 87.6 MHz (LO + $2F_2$ - F_1). Name this value I_2. Use the following spectrum analyzer parameter settings:
    - Center frequency: (Frequency in step 5) + F_2
    - Reference level: 0 dBm
    - Frequency span: 0 Hz
    - Resolution bandwidth: 500 Hz
    - Sweep time: 5 ms
    - Reference clock source: External
11. Calculate output IMD using the following equation:

$$\textit{Output IMD} = \textit{Large IMD tone power } (I_1 \textit{ or } I_2) - \textit{Small fundamental tone power } (P_1 \textit{ or } P_2)$$

12. Compare the *Output IMD* value from step 11 to the corresponding limit in Table 8.
13. Repeat steps 5 through 12 for the following frequency ranges in 250 MHz increments, including endpoints:
    - PXI-5650: 85 MHz to 1.3 GHz
    - PXI-5651: 85 MHz to 3.3 GHz
    - PXI-5652: 85 MHz to 6.6 GHz

    Store the resulting measurements.

14. Repeat steps 5 through 12 with a power level of -30 dBm and a spectrum analyzer reference level of -30 dBm.

Table 8. Intermodulation Products Verification Test Limits with -6 dBm per Tone

CW Source	LO Frequencies	R3 Upper Limits (dBc)
PXI-5650/5651/5652	85 MHz to 250 MHz	-45
	>250 MHz to 1.3 GHz	-48
PXI-5651/5652	>1.3 GHz to 3.3 GHz	-45
PXI-5652	>3.3 GHz to 6.6 GHz	-40

Table 9. Intermodulation Products Verification Test Limits with -36 dBm per Tone

CW Source	LO Frequencies	R3 Upper Limits (dBc)
PXI-5650/5651/5652	85 MHz to 250 MHz	-45
	>250 MHz to 1.3 GHz	-50
PXI-5651/5652	>1.3 GHz to 3.3 GHz	-48
PXI-5652	>3.3 GHz to 6.6 GHz	-46

Verifying Noise Floor

Complete the following steps to verify the noise floor performance of an PXIe-5673 module using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.
3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.
5. Generate an arbitrary waveform signal using an array of all zeros with the following niRFSG property settings:
    - Frequency (Hz): 85 MHz
    - Power Level (dBm): +10 dBm
    - Generation Mode: Arb Waveform

- Power Level Type: Peak Power
- Reference Clock Source: ClkIn

6. Measure the output noise floor 2 MHz above the generated frequency using the spectrum analyzer. Minimize the spectrum analyzer noise contribution by using the preamplifier, minimal attenuation, and a low reference level. Use the following spectrum analyzer parameter settings:
   - Center frequency: (Frequency in step 5) + 2 MHz
   - Reference level: -50 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 100 kHz
   - Sweep time: 5 ms
   - Reference clock source: External
   - Attenuation: 5 dB
   - Preamplifier: On
7. Repeat steps 5 through 6 for the following LO frequency ranges in 250 MHz increments, including endpoints:
   - PXI-5650: 85 MHz to 1.3 GHz
   - PXI-5651: 85 MHz to 3.3 GHz
   - PXI-5652: 85 MHz to 6.6 GHz

   Store the resulting measurements.
8. Compare the measured values to the corresponding limits in Table 10.
9. Repeat steps 5 through 8 for the remaining output power values listed in Table 10.

Table 10. Noise Floor Upper Test Limits

Output Power (dBm)	PXI-5650/5651/5652		PXI-5651/5652	PXI-5652
	LO Frequencies 85 MHz to 250 MHz	LO Frequencies >250 MHz to 1.3 GHz	LO Frequencies >1.3 GHz to 3.3 GHz	LO Frequencies >3.3 GHz to 6.6 GHz
+10	-133 dBm/Hz	-134 dBm/Hz	-134 dBm/Hz	-134 dBm/Hz
0	-140 dBm/Hz	-141 dBm/Hz	-141 dBm/Hz	-141 dBm/Hz
-10	-145 dBm/Hz	-145 dBm/Hz	-145 dBm/Hz	-145 dBm/Hz
-30	-152 dBm/Hz	-152 dBm/Hz	-152 dBm/Hz	-152 dBm/Hz

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

Verifying RF Harmonics

Complete the following steps to verify the harmonic performance of an PXIe-5673 module using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.
3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.
5. Generate a signal with the following niRFSG property settings:
    - Frequency (Hz): 100 MHz
    - Power Level (dBm): 0 dBm
    - Generation Mode: CW
    - Reference Clock Source: ClkIn
6. Use the spectrum analyzer to measure the fundamental tone power using the following spectrum analyzer parameter settings (name this measurement F):
    - Center frequency: Frequency from step 5
    - Reference level: +5 dBm
    - Frequency span: 0 Hz
    - Resolution bandwidth: 500 Hz
    - Sweep time: 5 ms
    - Reference clock source: External
7. Use the spectrum analyzer to measure each harmonic tone listed in Table 11 using the following spectrum analyzer settings (name this measurement H_x, where x is the harmonic number):
    - Center frequency: (Frequency from step 5) × (harmonic number)
    - Reference level: +5 dBm
    - Frequency span: 0 Hz
    - Resolution bandwidth: 500 Hz
    - Sweep time: 5 ms
    - Reference clock source: External

Note Only measure subharmonic tones at fundamental frequencies ≥3.3 GHz.

8. Calculate the power level in dBc of each harmonic tone ≤6.6 GHz by subtracting the fundamental power from step 6 from the harmonic power from step 7, as shown in the following equation:

$$P_{harmonic} = H_x - F$$

9. Compare the values calculated in step 8 to the corresponding limits in Table 11.
10. Repeat steps 6 through 9 for the following frequency ranges:
    - PXI-5650: 100 MHz to 500 MHz in 10 MHz increments, including endpoints and 500 MHz to 1.3 GHz in 50 MHz increments, including endpoints
    - PXI-5651: 100 MHz to 500 MHz in 10 MHz increments, including endpoints and 500 MHz to 3.3 GHz in 50 MHz increments, including endpoints
    - PXI-5652: 100 MHz to 500 MHz in 10 MHz increments, including endpoints, and 500 MHz to 6.6 GHz in 50 MHz increments, including endpoints

Table 11. RF Harmonic Power Upper Test Limits

	PXIe-5650/5651/5652		PXIe-5651/5652		PXIe-5652		
Harmonic	**100 MHz to 250 MHz**	**>250 MHz to 1.3 GHz**	**>1.3 GHz to 2.2 GHz**	**>2.2 GHz to 3.3 GHz**	**>3.3 GHz to 3.5 GHz**	**>3.5 GHz to 4.4 GHz**	**>4.4 GHz to 6.6 GHz**
2nd (2F)	-23.0 dBc	-28.0 dBc	-23.0 dBc	-23.0 dBc	—	—	—
3rd (3F)	-23.0 dBc	-28.0 dBc	-23.0 dBc	—	—	—	—
Half (0.5F)	—	—	—	—	-34.0 dBc	-34.0 dBc	-34.0 dBc
1.5 (1.5F)	—	—	—	—	-41.0 dBc	-46.0 dBc	—

Note Harmonic, subharmonic, and non-integer harmonic levels outside the device frequency range are typical.

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

Verifying Baseband Linearity-Related Spurs

Complete the following steps to verify the baseband-related spur levels of the PXIe-5673 using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.

3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.
5. Generate a single-sideband tone with a +1 MHz offset from the carrier signal with the following niRFSG property settings:
   - Frequency (Hz): 85 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn
6. Use the spectrum analyzer to measure the mean RF output using the following spectrum analyzer parameter settings (name this measurement *RF*):
   - Center frequency: (Frequency in step 5) + 1 MHz
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
7. Use the spectrum analyzer to measure the baseband linearity-related spur using the following spectrum analyzer parameter settings (name this measurement *B*):
   - Center frequency: (Frequency in step 5) - 3 MHz
   - Reference level: +5 dBm
   - Frequency span: 0 Hz
   - Resolution bandwidth: 500 Hz
   - Sweep time: 5 ms
   - Reference clock source: External
8. Calculate the power level of the baseband linearity-related spur in dBc by subtracting the measured RF output power from step 6 from the measured baseband linearity-related spur from step 7, as shown in the following equation:

$$P_{baseband} = B - RF$$

9. Compare the value calculated in step 8 to the corresponding limits in Table 12.
10. Repeat steps 5 through 9 for the following frequency ranges in 200 MHz increments, including endpoints:
    - PXI-5650: 85 MHz to 1.3 GHz
    - PXI-5651: 85 MHz to 3.3 GHz
    - PXI-5652: 85 MHz to 6.6 GHz

    Store the resulting measurements.

Table 12. Baseband Linearity-Spurs Verification Upper Test Limits

CW Source	LO Frequency	Test Limit (dBc)
PXI-5650/5651/5652	85 MHz to 250 MHz	-45
	>250 MHz to 1.3 GHz	-50
PXI-5651/5652	>1.3 GHz to 3.3 GHz	-50
PXI-5652	>3.3 GHz to 6.6 GHz	-50

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

Verifying Single Sideband Phase Noise at 10 kHz Offset

Complete the following steps to verify the single sideband (SSB) phase noise of the PXIe-5673 using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect the PXIe-5450 CLK IN front panel connector to any rubidium frequency reference rear panel BNC connector through the BNC(m)-to-SMA(m) cable.
3. Connect the PXIe-5450 CLK OUT front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-BNC(m) cable.
5. Generate a single-sideband tone with a +3 MHz offset from the carrier signal with the following niRFSG property settings:
   - Frequency (Hz): 1 GHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: Arb Waveform
   - Reference Clock Source: ClkIn
6. Use the spectrum analyzer to measure the maximum power within the configured span of the spectrum analyzer using the following spectrum analyzer parameter settings and record the value:
   - Center frequency: (Frequency in step 5) + 3 MHz
   - Reference level: 0 dBm
   - Frequency span: 100 Hz
   - Resolution bandwidth: 10 Hz
   - Reference clock source: External

7. Use the spectrum analyzer to measure the mean power within the configured span of the spectrum analyzer using the following spectrum analyzer parameter settings and record the value:
   - Center frequency: (Frequency in step 6) + 10 kHz
   - Reference level: 0 dBm
   - Frequency span: 100 Hz
   - Resolution bandwidth: 10 Hz
   - Reference clock source: External
   - Trace averaging: 20 traces
8. Apply the following equation to the value measured in step 7:

$$\textit{phase noise}_{SSB}\ \textit{at 10 kHz offset} = \textit{Measurement} - 10\log(\textit{RBW})$$

9. Subtract the measurement recorded in step 6 from the value calculated in step 8.
10. Verify that the value calculated in step 9 meets the limits as specified in Table 13.
11. Repeat steps 6 through 10 for the remaining frequencies listed in the *Frequency* column in Table 13.

Table 13. SSB Phase Noise at 10 kHz Offset

CW Source	Frequency (GHz)	Test Limit (dBc/Hz)
PXI-5650/5651/5652	0.5	<-111
	1.0	<-105
PXI-5651/5652	2.0	<-98
	3.0	<-95
PXI-5652	4.0	<-93
	5.0	<-90
	6.6	<-90

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

Verifying Frequency Accuracy

Complete the following steps to verify the frequency accuracy of an PXIe-5673 using a spectrum analyzer.

1. Connect the PXIe-5611 RF OUT front panel connector to the spectrum analyzer RF INPUT front panel connector through the SMA(m)-to-SMA(m) cable.
2. Connect any available rubidium frequency reference rear panel BNC connector to the spectrum analyzer REF IN rear panel connector through the BNC(m)-to-SMA(m) cable.

3. Connect the PXIe-5450 CLK IN front panel connector to the PXI-5650/5651/5652 REF IN/OUT front panel connector.
4. Generate a signal with the following niRFSG properties:
   - Frequency (Hz): 400 MHz
   - Power Level (dBm): 0 dBm
   - Generation Mode: CW
   - Reference Clock Source: Onboard Clock
5. Use the spectrum analyzer to measure the frequency of the peak tone using the following spectrum analyzer parameter settings:
   - Center frequency: 400 MHz
   - Reference level: +5 dBm
   - Resolution bandwidth: 100 Hz
   - Span: 100 kHz
   - Reference clock source: External
   - Frequency counter resolution: 1 Hz
6. Verify that the measurement in step 5 is within the 9 ppm test limit, with respect to 400 MHz.

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

Adjustment

To adjust the PXIe-5673 to meet published specifications, you must adjust the modules that comprise the PXIe-5673 system. To calibrate the PXI-5650/5651/5652, PXIe-5450, and PXIe-5611 modules individually, refer to their calibration procedures at `ni.com/manuals`.

Reverification

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

Note If any test fails reverification after performing an adjustment, verify that you have met the *Test Conditions* before returning your device to NI. Refer to *Worldwide Support and Services* for information about support resources or service requests.

Updating Calibration Date

Performing any adjustment procedure on the PXIe-5611 updates the calibration date.

If you do not want to perform an adjustment, you can update the calibration date without making any adjustments by initializing an external calibration and closing the external calibration.

1. Call the niRFSG Initialize External Calibration VI.
2. Call the niRFSG Close External Calibration VI to close the session. Set the **write calibration to hardware?** parameter to TRUE to store the results to the EEPROM on the PXIe-5673.

Worldwide Support and Services

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

Visit ni.com/services for NI Factory Installation Services, repairs, extended warranty, and other services.

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

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