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**PXI-5650**

# CALIBRATION PROCEDURE

## NI PXI-5663

This document contains instructions for writing a manual calibration procedure for the NI PXI-5663 (NI 5663) RF vector signal analyzer. For more information about calibration, visit [ni.com/calibration](http://ni.com/calibration).

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## Software Requirements

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To calibrate the NI 5663, you must install NI-RFSA version 2.3 or later and the NI Spectral Measurements Toolkit version 2.4 or later on the calibration system.



**Note** NI-RFSA version 2.1 does not include adjustment VIs.

You can download NI-RFSA from [ni.com/updates](http://ni.com/updates).

NI-RFSA supports programming the calibration procedures in LabVIEW, C, and LabWindows™/CVI™. Refer to Table 1 for file locations.

**Table 1.** File Locations

File Name and Location	Description
<IVI>\bin\niRFSA.dll	NI-RFSA instrument driver containing the entire NI-RFSA API, including calibration functions.
<LabVIEW>\instr.lib\niRFSA\niRFSA.llb	LabVIEW VI library containing VIs for calling the NI-RFSA calibration API. You can access calibration VIs from the NI-RFSA calibration section of the LabVIEW Functions palette.

For more information about calibration VIs and functions, install NI-RFSA and refer to the *NI RF Vector Signal Analyzers Help*, accessible through **Start»Programs»National Instruments»NI RFSA»Documentation»NI RF Vector Signal Analyzers Help**.

This calibration procedure calibrates the NI PXIe-5663 RF vector signal analyzer as a single device. To calibrate the NI 5601 or NI 5652, refer to their calibration procedures at [ni.com/manuals](http://ni.com/manuals).

## Documentation Requirements

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

- *NI 5663 Specifications*
- *NI 5661/5663/5663E RF Vector Signal Analyzers Getting Started Guide*
- *NI RF Vector Signal Analyzers Help*, which includes LabVIEW and LabWindows/CVI application programming references

These documents are installed with NI-RFSA. You also can find the latest versions of these documents at [ni.com/manuals](http://ni.com/manuals).

## Calibration Interval

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NI recommends that you perform a complete calibration for the NI 5663 at least once a year. Adjust the recommended calibration interval based on the measurement accuracy demands of your application.

# Test Equipment

NI recommends that you use the equipment in Table 2 to calibrate the NI 5601. If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

**Table 2.** Required Equipment for NI 5663 Calibration

Equipment	Recommended Model	Minimum Requirements
Power meter	Anritsu ML2438A	Display resolution: <0.01 dB Settling: <0.1% Instrumentation accuracy: <0.5% Noise: <0.5% full-scale (lowest range) Zero set and drift: <0.5% full-scale (lowest range) Reference power uncertainty: <0.9% Reference output VSWR: <1.04:1
Power sensor A Power sensor B	Anritsu MA2473D or equivalent	Input VSWR: 10 MHz to 50 MHz..... <1.9 :1 50 MHz to 150 MHz..... <1.17 :1 150 MHz to 2 GHz ..... <1.12 :1 2 GHz to 12.4 GHz ..... <1.22 :1  Linearity: -55 dBm to 20 dBm ..... <1.8 %  Rise time: <4 μs  Calibration factor uncertainty: 50 MHz ..... <1.48% 100 MHz ..... <1.37% 300 MHz ..... <1.42% 500 MHz ..... <0.96% 1 MHz ..... <0.99% 2 GHz ..... <1.04% 3 GHz ..... <1.05% 4 GHz ..... <1.64% 5 GHz ..... <1.39% 6 GHz ..... <1.45% 7 GHz ..... <1.26%
Signal generator (RF source)	Anritsu MG3692B	Frequency range: 10 MHz to 6.6 GHz Power level: -60 dBm to 20 dBm
50 Ω terminator (2 required)	NI 778353-01	—

**Table 2.** Required Equipment for NI 5663 Calibration (Continued)

Equipment	Recommended Model	Minimum Requirements
<b>Optional:</b> Signal generator (PN source)	Rhode & Schwarz SMA100A-B22	Frequency range: 1 GHz  Power level: 0 dBm  Phase noise (1 GHz) 100 Hz .....-107 dBc/Hz 1 kHz .....-125 dBc/Hz 10 kHz .....-137 dBc/Hz 100 kHz .....-137 dBc/Hz 1 MHz.....-150 dBc/Hz
PXI Express chassis	NI PXIe-1065 or NI PXIe-1075	—
PXI Express controller	NI PXIe-8105	—
SMA (m)-SMA (m) semi-rigid cable*	NI 198775A-01	—
SMA (m)-SMA (m) semi-rigid cable*	NI 198776A-01	—
SMA (m)-SMA (m) semi-flexible cable*	NI 190412B-03	—
SMA (m)-SMA (f) right angle adapter	Huber+Suhner 53-SMA-50-0-2/111_N	—
3.5 mm (m)-to-3.5 mm (m) adapter	Huber+Suhner 32-PC35-50-0-2/199_NE	—
3.5 mm (f) power splitter (2 resistor type)	Aeroflex 1593	—
SMA (m)-to- SMA (m) cable (36 in.)	Huber+Suhner ST-18/SMAm/SMAm/36	—
3.5 mm (m)-to-3.5 mm (f) 30 dB attenuator	Huber+Suhner 6630 SMA-50-1/199NE	—
N(m)-to-3.5 mm (f) adapter	Huber+Suhner 33_N-SMA-50-1/ 113_UE	—
* Included in the NI PXIe-5663 cable accessory kit.		

# Test Conditions

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

- Maintain an ambient temperature of 23 °C ±5 °C.
- Keep the relative humidity between 10% and 90%, noncondensing.
- 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](http://ni.com/manuals).
- (Optional) Clean the chassis fan filters at least every six months. Some chassis include fan filters. Depending on the amount of chassis use and the ambient dust levels, filters might require more frequent cleaning. If regular maintenance of dirty or clogged filters is not possible, you can remove the filters to maintain adequate cooling.
- Allow a warm-up time of at least 30 minutes after NI-RFSA is loaded and recognizes the NI 5663. The warm-up time ensures that the measurement circuitry of the NI 5663 is at a stable operating temperature.
- Use an SMA torque wrench (5 in. · lb, Agilent 8710-1582 or equivalent) to tighten any connection with an SMA connector.
- Use a 3.5 mm torque wrench (8 in. · lb, Agilent 8710-1765 or equivalent) to tighten 3.5 mm or 2.92 mm (K) connections without an SMA connector.
- Lock all test equipment to the same reference frequency. Refer to the *NI 5663/5663E Timing Configurations* topic in the *NI RF Vector Signal Analyzers Help*.

## Calibration Procedures

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The calibration process includes the following procedures:

1. **Initial Setup**—Install the NI 5663 and configure it in Measurement & Automation Explorer (MAX).
2. **Test System Characterization**—Characterize the response of the test system. Use the measured response during the verification tests.
3. **Verification Procedures**—Measure the operation of the NI 5663. This procedure checks whether the device is operating within its published specifications.

If the NI 5663 fails any of the verification tests, complete the following steps:



**Note** Complete the verification for all NI 5663 specifications where as-found data is required before performing any module calibrations.

1. **Module Calibration**—Perform a calibration of the individual modules. Refer to the following module calibration procedures at [ni.com/manuals](http://ni.com/manuals):
  - *NI PXI-5650/5651/5652 Calibration Procedure*
  - *NI PXIe-5622 Calibration Procedure*
  - *NI PXIe-5601 Calibration Procedure*

2. Reverification—Repeat the verification procedure for the NI 5663 to ensure that it is operating within the device specifications after adjustment.

## Initial Setup

Refer to the *NI 5661/5663/5663E RF Vector Signal Analyzers Getting Started Guide* for information about how to install the NI-RFSA software and the NI 5663 hardware and how to configure the NI 5663 in MAX.

## Test System Characterization

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

Measure the power splitter (and attenuation) response at the RF input frequencies used in the verification tests.



**Caution** The connectors on the DUT and test equipment are fragile. Perform the instructions in this procedure with great care to prevent damaging any DUTs or test equipment.

## Power Splitter Reference Output

Designate either of the two outputs of the power splitter as the reference output.

## Power Sensor Zero/Calibration

1. Connect channel A of the power meter to power sensor A.
2. Connect channel B of the power meter to power sensor B.
3. Zero and calibrate the power sensors using the appropriate frequency for the calibration.

## RF Input Calibration

This section describes how to calibrate the RF input you will use to verify the NI 5663.



**Note** Perform the power sensor zero/calibration prior to the step. The power splitter reference output must have been defined prior to the step.

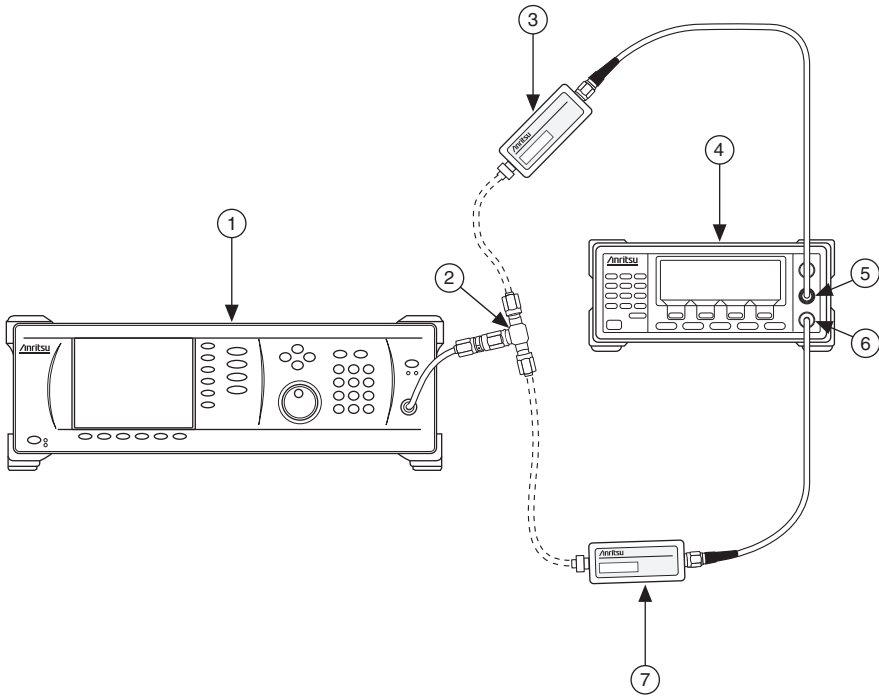
## RF Input Calibration (Without Attenuator)

Use the results of this procedure in the *Absolute Accuracy Verification*, *LO Output Power Verification*, *Sideband Spurs Verification*, and *Phase Noise Verification* tests.

1. Connect the power splitter input to the RF source output through the 3.5 mm-to-3.5 mm cable.
2. Connect power sensor A to the previously designated reference output of the power splitter.

- Connect power sensor B to the other output of the power splitter. Figure 1 shows the completed equipment setup.

**Figure 1. RF Input Calibration (Without Attenuator) Equipment Setup**



1	RF Source	3	Power Sensor A	5	Power Meter Channel A	7	Power Sensor B
2	Power Splitter	4	Power Meter	6	Power Meter Channel B		

- Measure the channel A and channel B power (using the appropriate frequency for the power sensor) for all frequencies between 10 MHz and 7 GHz with the RF source power set to 0 dBm.



**Note** Use the log frequency progression: 10, 20, 30, ..., 100, 200, 300, ..., 1,000 MHz, and so on.

- Calculate the RF input calibration factor (dB) for each frequency using the following equation:

$$\text{RF Input Calibration Factor} = \text{Channel B Power} - \text{Channel A Power}$$

### RF Input Calibration (with Attenuator)

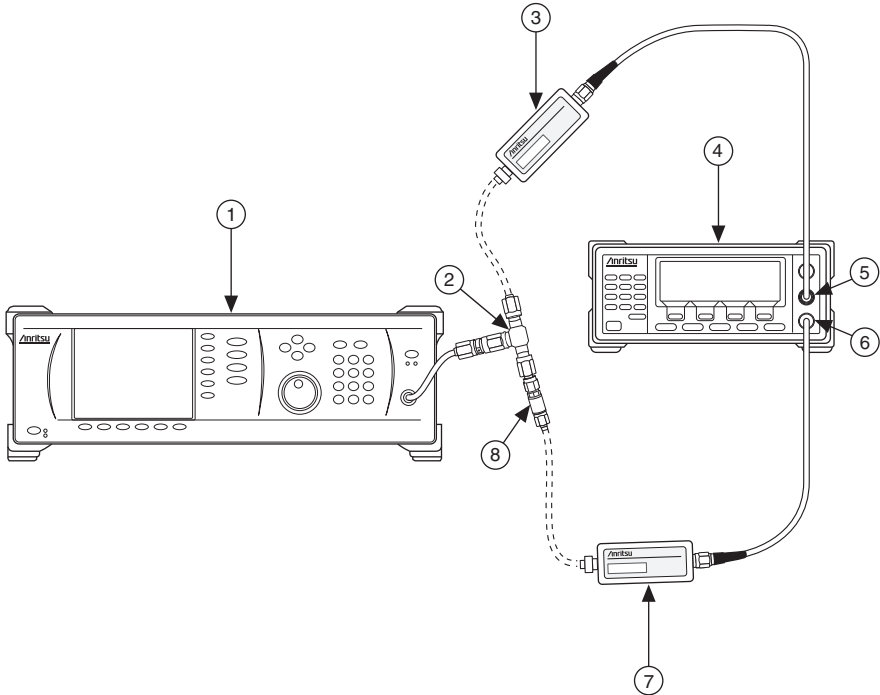
Use the results of the *RF Input Calibration (with Attenuator)* procedure in the absolute accuracy test.

- Connect the power splitter input to the RF source output through the 3.5 mm-to-3.5 mm cable.
- Connect power sensor A to the previously designated reference output of the power splitter.



3. Connect power sensor B to the other output of the power splitter through the 30 dB attenuator. Figure 2 shows the completed equipment setup.

**Figure 2.** RF Input Calibration (with Attenuator) Equipment Setup



1	RF Source	4	Power Meter	7	Power Sensor B
2	Power Splitter	5	Power Meter Channel A	8	30 dB Attenuator
3	Power Sensor A	6	Power Meter Channel B		

4. Measure the channel A and channel B power (using the appropriate frequency for the power sensor) for all frequencies between 10 MHz and 7 GHz with the RF source power set to 0 dBm.



**Note** Use the log frequency progression: 10, 20, 30, ..., 100, 200, 300, ..., 1,000 MHz, and so on.

5. Calculate the RF input attenuated calibration factor (dB) for each frequency using the following equation:

$$RF \text{ Input Attenuated Calibration Factor} = \text{Channel B Power} - \text{Channel A Power}$$

## As-Found and As-Left Limits

The as-found limits are the published specifications for the NI 5663. NI uses these limits to determine whether the NI 5663 meets the device specifications when it is received for calibration.

The as-left limits are equal to the published NI specifications for the NI 5663, less guard bands for temperature drift and drift over time. NI uses these limits to determine whether the NI 5663 meets the device specifications over its calibration interval.



**Note** Where there is no difference between an “As Found” and an “As Left” limit, only a “Test Limit” is specified.

## Verification Procedures

Verification tests the following NI 5663 specifications:

- Absolute accuracy
- Average noise level
- LO output power
- Non-input-related spurs (residual spurs)
- Sideband spurs
- Phase noise

Verification of the NI 5663 is complete only after you have successfully completed all tests in this section.



**Caution** The connectors on the DUT and test equipment are fragile. Perform the instructions in this procedure with great care to prevent damaging any DUTs or test equipment.

## Verifying Reference Accuracy

The NI 5663 reference accuracy specification is derived from the NI 5652 frequency accuracy. For more information about NI PXI-5652 calibration values, refer to the *NI PXI-5650/5651/5652 Calibration Procedure* available at [ni.com/manuals](http://ni.com/manuals).

## Absolute Accuracy Verification

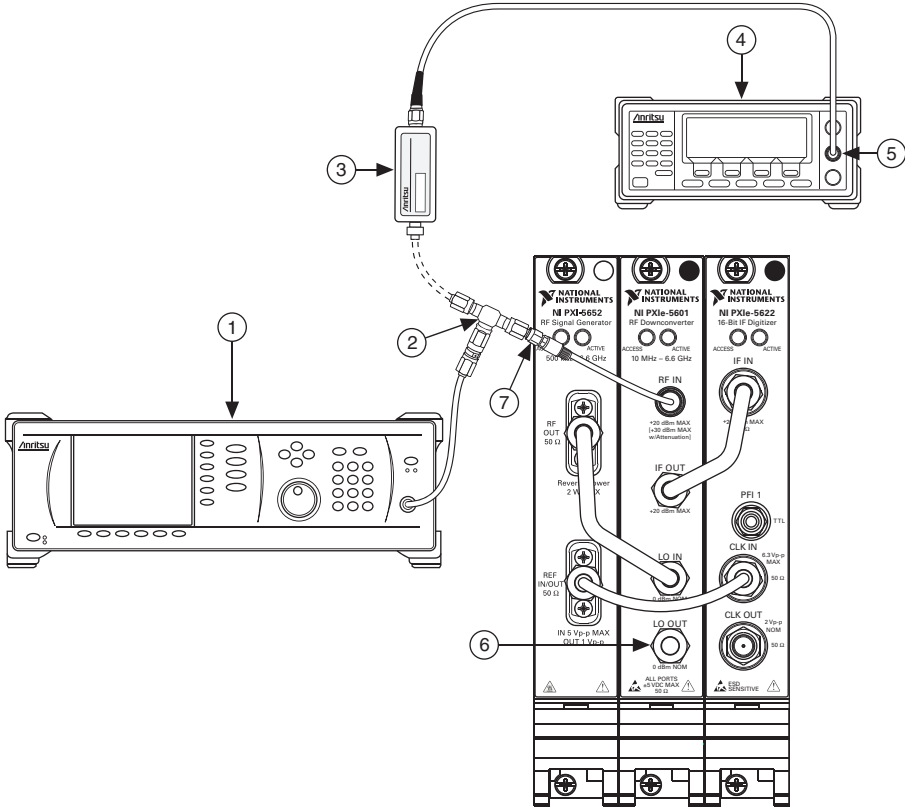
Table 5 shows the test limits.

### Reference Levels Less than -30 dBm

1. Connect the RF source to the power splitter input through the 3.5 mm-to-3.5 mm cable.
2. Connect the power splitter reference output to power sensor A.
3. Connect the other power splitter output to the NI 5601 RF IN connector through the 30 dB attenuator and 3.5 mm (m)-to-3.5 mm (m) adapter.

- Connect a 50  $\Omega$  terminator to the NI 5601 LO OUT connector. Figure 3 shows the completed equipment setup.

**Figure 3. Absolute Accuracy Equipment Setup**



- |                  |                  |                          |                     |
|------------------|------------------|--------------------------|---------------------|
| 1 RF Source      | 3 Power Sensor A | 5 Power Meter Channel A  | 7 30 dB Attenuator* |
| 2 Power Splitter | 4 Power Meter    | 6 50 $\Omega$ Terminator |                     |

\* Used for reference levels <-30 dBm.

- Create a new session for the NI 5663 using the niRFSa Initialize VI or the niRFSa\_init function.
- Perform a self-calibration on the NI 5622 using the niRFSa Self Cal VI or the niRFSa\_SelfCal function.
- Lock the NI PXI-5652 to the reference used by the test equipment. Use the niRFSa Configure Ref Clock VI or the niRFSa\_ConfigureRefClock function.
- Set the NI 5663 to make a spectrum acquisition using the niRFSa Configure Acquisition Type VI or the niRFSa\_ConfigureAcquisitionType function.

9. Set the NI 5663 for a resolution bandwidth according to Table 3 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.

**Table 3. NI 5663 Settings (All Frequencies)**

Device Setting	Value
Reference Level	-60 to 15 dBm, 5 dB steps
Span	5 MHz
Resolution Bandwidth	100 kHz

10. Set the NI 5663 reference level according to Table 3 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
11. Set the NI 5663 center frequency according to Table 4 and span according to Table 3 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the niRFSA\_ConfigureSpectrumCenterFrequencySpan function.

**Table 4. NI 5663 Center Frequencies**

Beginning (MHz)	Ending (MHz)	Step (MHz)
10	100	10
200	300	100
330	—	—
400	6,400	200
6,590	—	—

12. Commit the settings to hardware using the niRFSA Commit VI or the niRFSA\_Commit function.
13. Set the RF source to the center frequency according to Table 4.
14. Adjust the RF source power using the following equation:

$$\text{Channel A Power} + \text{RF Input Attenuated Calibration Factor} = \text{Reference Level} \pm 1 \text{ dB.}$$

*Reference Level* is the value from Table 3. Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Attenuated Calibration Factor* may require interpolation.



**Note** Set the signal generator to its maximum power if it does not have sufficient power to reach the reference level.

15. Record the channel A power.

16. Set the NI 5663 to read the power spectrum using the niRFSA Read Power Spectrum VI or the niRFSA\_ReadPowerSpectrumF64 function.
17. Get the spectrum information using the niRFSA Get Spectral Info for SMT VI or the niRFSA\_GetSpectralInfoForSMT function.
18. Perform a peak search using the SMT Spectrum Peak Search VI or the SmtSpectrumPeakSearch function. Set the peak threshold to 20 dB below the NI 5663 reference level.
19. Sort the peaks and record the maximum. Save this value as *RFSA Power*.
20. Calculate the *Absolute Accuracy* at each RF frequency using the following formula:

$$\textit{Absolute Accuracy} = \textit{RFSA Power} - (\textit{Channel A Power} + \textit{RF Input Attenuated Calibration Factor})$$

*RF Input Attenuated Calibration Factor* is the same as that from step 14.

21. Compare the *Absolute Accuracy* to the Verification Test Limits in Table 5.
22. Repeat steps 9 to 21 for all the settings in Tables 3 and 4.
23. Close the NI 5663 session using the niRFSA Close VI or the niRFSA\_close function.

## Reference Levels Greater than or Equal to -30 dBm

1. Connect the RF source to the power splitter input through the 3.5 mm-to-3.5 mm cable.
2. Connect the power splitter reference output to power sensor A.
3. Connect the other power splitter output to the NI 5601 RF IN connector through the 3.5 mm (m)-to-3.5 mm (m) adapter.
4. Connect a 50  $\Omega$  terminator to the NI 5601 LO OUT connector. Figure 3 in the preceding section shows the test limits.
5. Create a new session for the NI 5663 using the niRFSA Initialize VI or the niRFSA\_init function.
6. Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.
7. Lock the NI PXI-5652 to the reference used by the test equipment. Use the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
8. Set the NI 5663 to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
9. Set the NI 5663 for a resolution bandwidth according to Table 3 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.
10. Set the NI 5663 reference level according to Table 3 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
11. Set the NI 5663 center frequency according to Table 4 and span according to Table 3 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the niRFSA\_ConfigureSpectrumFrequencyCenterSpan function.
12. Commit the settings to hardware using the niRFSA Commit VI or the niRFSA\_Commit function.

13. Set the source to the center frequency shown in Table 4.
14. Adjust the RF source power so that:

$$\text{Channel A Power} + \text{RF Calibration Factor} = \text{Reference Level} \pm 1 \text{ dB}$$

*Reference Level* is the value from Table 3. Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Calibration Factor* may require interpolation.



**Note** Set the signal generator to its maximum power if it doesn't have sufficient power to reach the reference level.

15. Record the channel A power.
16. Set the NI 5663 to read the power spectrum using the niRFSA Read Power Spectrum VI or the niRFSA\_ReadPowerSpectrumF64 function.
17. Get the spectrum information using the niRFSA Get Spectral Info for SMT VI or the niRFSA\_GetSpectralInfoForSMT function.
18. Perform a peak search using the SMT Spectrum Peak Search VI. Set the peak threshold to 20 dB below the NI 5663 reference level.
19. Sort the peaks and record the maximum. Save this value as *RFSA Power*.
20. Calculate the *Absolute Accuracy* using the following formula:

$$\text{Absolute Accuracy} = \text{RFSA Power} - (\text{Channel A Power} + \text{RF Input Calibration Factor})$$

Calculation of the *RF Input Calibration Factor* may require interpolation.

21. Compare the *Absolute Accuracy* to the Verification Test Limits in Table 5.
22. Repeat steps 9 to 21 for all the settings in Tables 3 and 4.
23. Close the NI 5663 session using the niRFSA Close VI or the niRFSA\_close function.

**Table 5.** Absolute Accuracy Verification Test Limits

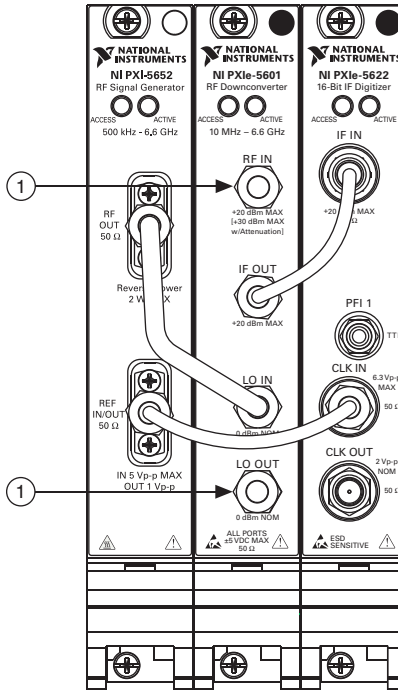
Frequency	As-Found Limit	As-Left Limit
10 MHz to <120 MHz	±2.20 dB	±1.70 dB
120 MHz to <400 MHz	±1.70 dB	±1.00 dB
400 MHz to <3.0 GHz	±1.60 dB	±0.97 dB
3.0 GHz to <5.5 GHz	±1.70 dB	±1.03 dB
5.5 GHz to 6.6 GHz	±1.60 dB	±0.93 dB

# Average Noise Level Verification

Table 8 shows the test limits.

1. Connect a 50  $\Omega$  terminator to the NI 5601 RF IN and LO OUT connectors. Figure 4 shows the completed equipment setup.

**Figure 4. Average Noise Level Equipment Setup**



1 50  $\Omega$  Terminator

2. Create a new session for the NI 5663 using the niRFSA Initialize VI or the niRFSA\_init function.
3. Perform an internal self-calibration on the NI 5622 using niRFSA Self Cal VI or the niRFSA\_SelfCal function.
4. Lock the NI PXI-5652 to the reference used by the test equipment. Use the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
5. Set the NI 5663 to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.

6. Set the NI 5663 for a resolution bandwidth according to Table 6 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.

**Table 6. NI 5663 Settings**

Frequency Range	RF Attenuation	Reference Level	Span	Resolution Bandwidth
10 MHz to <30 MHz	0 dB	-10 dBm	5 MHz	3 kHz
30 MHz to 6,600 MHz	0 dB	-50 dBm	5 MHz	2 kHz

7. Set the NI 5663 reference level according to Table 6 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
8. Set the NI-RFSA Attenuation (dB) property or the niRFSA\_ATTR\_ATTENUATION attribute to 0.
9. Set the NI 5663 center frequency according to Table 7 and span according to Table 6 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the niRFSA\_ConfigureSpectrumFrequencyCenterSpan function.

**Table 7. RF Frequencies**

Start (MHz)	Stop (MHz)	Step (MHz)
10	30	10
40	80	20
300	1,100	100
1,300	1,900	100
2,100	2,300	100
2,500	3,200	100
3,400	3,900	100
4,100	5,700	100
5,900	6,400	100
6,590	—	—

**Note:** RF frequencies are selected to avoid false results from spurious responses.

10. Use the niRFSA Property Node to set the following properties:
  - Spectrum Averaging Mode to **RMS Averaging**
  - Spectrum Number of Averages to **20**
  - Spectrum Resolution Bandwidth Type to **ENBW**
  - Spectrum Units to **Volts Squared**



or set the following attributes:

- NIRFSA\_ATTR\_SPECTRUM\_AVERAGING\_MODE to NIRFSA\_VAL\_RMS\_AVERAGING
  - NIRFSA\_ATTR\_SPECTRUM\_NUMBER\_OF\_AVERAGES to 20
  - NIRFSA\_ATTR\_RESOLUTION\_BANDWIDTH\_TYPE to NIRFSA\_VAL\_RBW\_ENBW
  - NIRFSA\_ATTR\_POWER\_SPECTRUM\_UNITS to NIRFSA\_VAL\_VOLTS\_SQUARED
11. Commit the settings to hardware using the niRFSA Commit VI or the niRFSA\_Commit function.
  12. Set the NI 5663 to read the power spectrum using the niRFSA Read Power Spectrum (Cluster) VI or the niRFSA\_ReadPowerSpectrumF64 function.
  13. Get the spectrum information using the niRFSA Get Spectral Info for SMT VI or the niRFSA\_GetSpectralInfoForSMT function.
  14. Set the following properties or attributes using the SMT Spectrum Unit Conversion VI or the SmtSpectrumUnitConversion function:
    - **units** to dBm
    - **peak scaling** to RMS
    - **psd?** (or **psdOnOff**) to TRUE
    - **impedance** to 50
  15. Calculate the mean value of the spectrum. This value is the *NI 5663 Average Noise Level*.
  16. Compare the *NI 5663 Average Noise Level* to the test limits in Table 8.
  17. Repeat steps 6 to 16 for all combinations of settings in Tables 6 and 7.
  18. Close the NI 5663 session using the niRFSA Close VI or the niRFSA\_close function.

**Table 8.** Average Noise Level Verification Test Limits

Frequency	As-Found Limit	As-Left Limit
10 MHz to <30 MHz	<-155 dBm/Hz	<-156 dBm/Hz
30 MHz to <120 MHz	<-159 dBm/Hz	<-160 dBm/Hz
120 MHz to <3 GHz	<-155 dBm/Hz	<-156 dBm/Hz
3 GHz to <5 GHz	<-153 dBm/Hz	<-154 dBm/Hz
5 GHz to 6.6 GHz	<-151 dBm/Hz	<-152 dBm/Hz

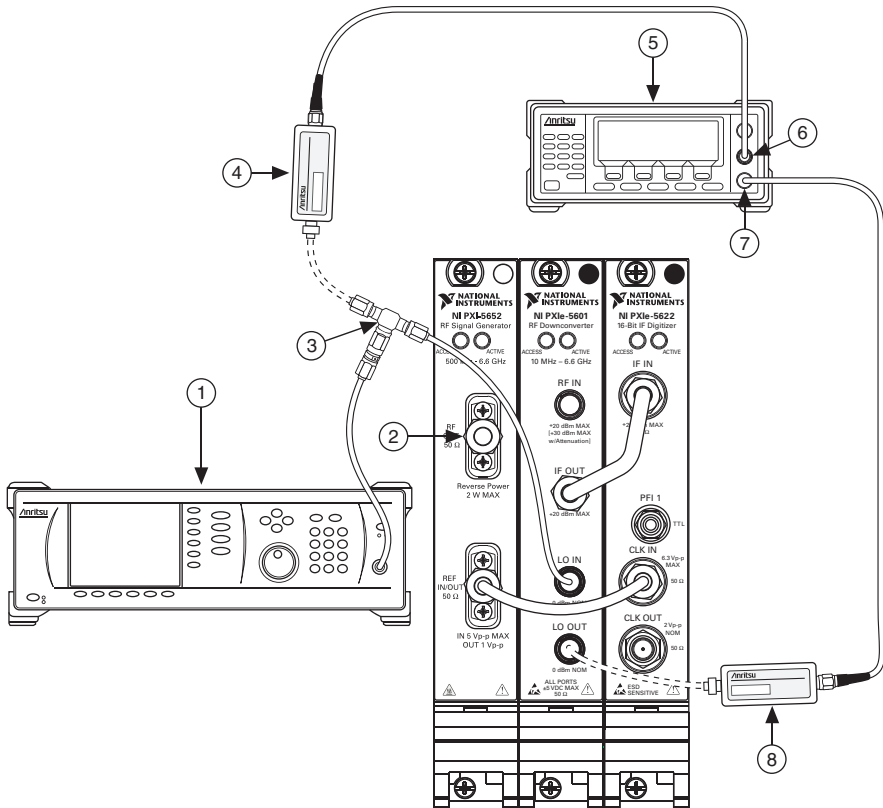
If the results are within the selected test limit, the device has passed this portion of the verification.

# LO Output Power Verification

Table 10 shows the test limits.

1. Disconnect the NI 5652 from the NI 5601 if it is connected.
2. Connect the RF source to the power splitter input through the 3.5 mm-to-3.5 mm cable.
3. Connect the power splitter reference output to power sensor A.
4. Connect the other power splitter output to the NI 5663 LO IN connector through the 3.5 mm (m) to 3.5 mm (m) adapter.
5. Connect a 50  $\Omega$  terminator to the NI 5652 RF OUT connector.
6. Connect power sensor B to the NI 5663 LO OUT connector through the SMA to SMA right-angle adapter. Figure 5 shows the completed equipment setup.

**Figure 5. LO Output Power Equipment Setup**



1 RF Source	3 Power Splitter	5 Power Meter	7 Power Meter Channel B
2 50 $\Omega$ Terminator	4 Power Sensor A	6 Power Meter Channel A	8 Power Sensor B

7. Create a new session for the NI 5663 using the niRFSAs Initialize VI or the niRFSAs\_init function.

8. Lock the NI PXI-5652 to the reference used by the test equipment. Use the `niRFSA Configure Ref Clock VI` or the `niRFSA_ConfigureRefClock` function.
9. Set the NI 5663 center frequency according to Table 9 using the Center Span instance of the `niRFSA Configure Spectrum Frequency VI` or the `niRFSA_ConfigureSpectrumFrequencyCenterSpan` function.
10. Commit the settings to hardware using the `niRFSA Commit VI` or the `niRFSA_Commit` function.



**Note** The NI PXI-5652 and NI PXIe-5601 are tuned so that they can control the NI PXIe-5601 internal state. The NI PXI-5652 is not otherwise used in this test.

11. Set the RF source to the center frequency shown in Table 9.

**Table 9.** NI 5663 LO Output Power Settings

Center Frequency			
Start (MHz)	Stop (MHz)	Step (MHz)	Span (Hz)
10	6,510	100	100
6,600	—	—	100

12. At each center frequency, perform the following steps:
  - a. Adjust the RF source power to satisfy the following equation:
 
$$\text{Channel A Power} + \text{RF Input Calibration Factor} = 0 \text{ dBm} \pm 0.5 \text{ dB}$$
 Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require interpolation.
  - b. Measure and record the channel B power. This value is the *LO Output Power*. Use the appropriate RF frequency for the channel B sensor.
13. Compare the *LO Output Power* to the test limits in Table 10.
14. Repeat steps 9 through 13 for all frequencies in Table 9.
15. Close the NI 5663 session using the `niRFSA Close VI` or the `niRFSA_close` function.

**Table 10.** LO Output Verification Test Limits

Frequency	Test Limit
10 MHz to 6.6 GHz	0 dBm $\pm$ 3.5 dB (nominal)
<b>Note:</b> LO Input Power = 0 dBm $\pm$ 0.5 dB.	

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

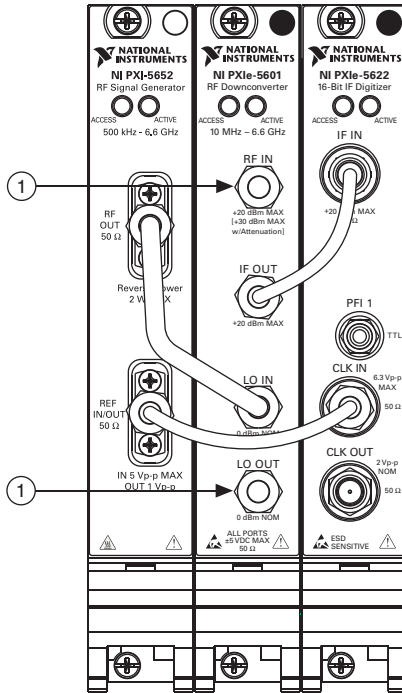
# Non-Input-Related Spurs (Residual Spurs) Verification

Table 12 shows the test limits.

Refer to [Appendix A: Non-Input-Related Spurs Test Frequencies](#) for the NI 5663 tuned frequency and the equivalent RF frequency for the spurs.

1. Connect the NI 5652 to the NI 5601 if it is not already connected.
2. Connect a 50  $\Omega$  termination to the NI 5601 RF IN and LO OUT connectors. Figure 6 shows the completed equipment setup.

**Figure 6.** Non-Input-Related Spurs Equipment Setup



1 50  $\Omega$  Terminator

3. Create a new session for the NI 5663 using the niRFSA Initialize VI or the niRFSA\_init function.
4. Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.

5. Lock the NI PXI-5652 to the reference used by the test equipment. Use the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
6. Set the NI 5663 to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
7. Set the NI 5663 for a resolution bandwidth according to Table 11 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.

**Table 11. NI 5663 Settings for Non-Input-Related Spurs**

<b>NI 5663 Tuned Frequency</b>	<b>RF Attenuation</b>	<b>Reference Level</b>	<b>Span</b>	<b>Resolution Bandwidth</b>
10 MHz to <120 MHz	0 dB	-60 dBm	10 MHz	500 Hz
120 MHz to <330 MHz	0 dB	-60 dBm	20 MHz	500 Hz
330 MHz to <6600 MHz	0 dB	-60 dBm	50 MHz	500 Hz

8. Set the NI 5663 reference level according to Table 11 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
9. Set the NI 5663 center frequency and span per Table 11 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the niRFSA\_ConfigureSpectrumFrequencyCenterSpan function.
10. Use the niRFSA Property Node to set the following properties:
  - Spectrum Averaging Mode to **RMS Averaging**
  - Spectrum Number of Averages to 10
  - Spectrum Units to **Volts Squared**
 or set the following attributes:
  - NIRFSA\_ATTR\_SPECTRUM\_AVERAGING\_MODE to NIRFSA\_VAL\_RMS\_AVERAGING
  - NIRFSA\_ATTR\_SPECTRUM\_NUMBER\_OF\_AVERAGES to 10
  - NIRFSA\_ATTR\_POWER\_SPECTRUM\_UNITS to NIRFSA\_VAL\_VOLTS\_SQUARED
11. Commit the settings to hardware using the niRFSA Commit VI or the niRFSA\_Commit function.
12. Set the NI 5663 to read the power spectrum using the niRFSA Read Power Spectrum (Cluster) VI or the niRFSA\_ReadPowerSpectrumF64 function.

13. Get the spectrum information using the niRFSA Get Spectral Info for SMT VI or the niRFSA\_GetSpectralInfoForSMT function.
14. Measure power in band using the SMT Power In Band VI or the SmtSpectrumUnitConversion function with the following parameter settings:
  - **units to dBm**
  - **impedance** (called **impedanceOhm** in the function) to 50
  - **center frequency** to the equivalent RF frequency for the spur from [Appendix A: Non-Input-Related Spurs Test Frequencies](#).
  - **bandwidth** to 500

This value is the NI 5663 Spurious Level.
15. Compare the NI 5663 Spurious Level to the verification test limits in Table 12.
16. Repeat steps 9 to 15 for all settings in Table 11.
17. Close the NI 5663 session using the niRFSA Close VI or the niRFSA\_close function.

**Table 12. Non-Input-Related Spurs Verification Test Limits**

Frequency	Test Limit
10 MHz to 6.6 GHz	<-95 dBm

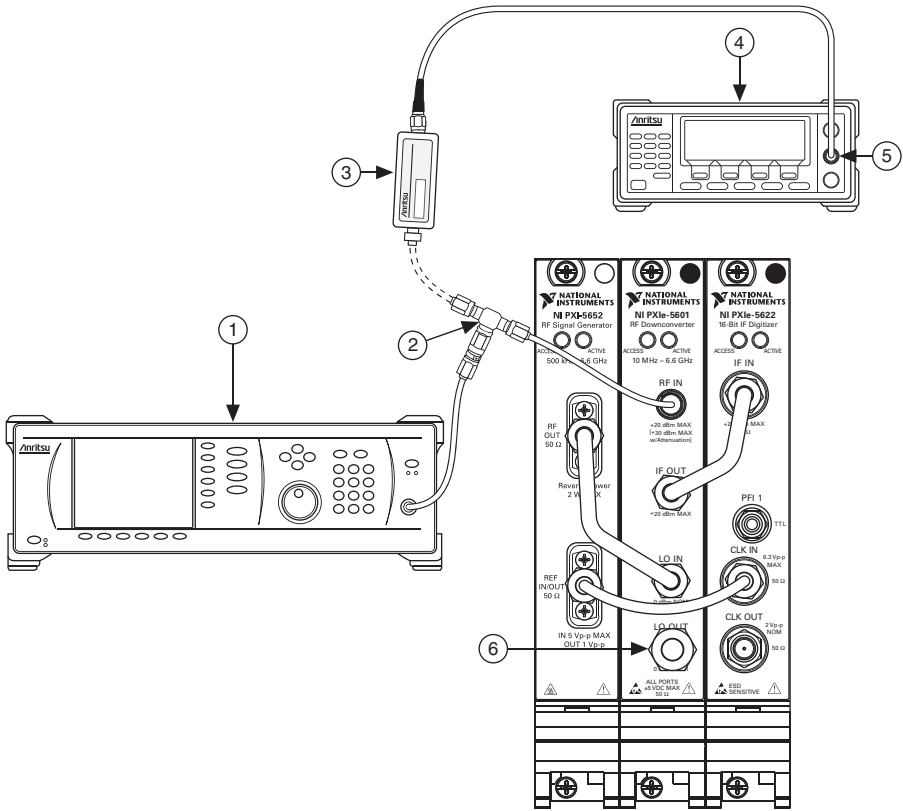
If the results are within the selected test limit, the device has passed this portion of the verification.

## Sideband Spurs Verification

Table 16 shows the test limits.

1. Connect the RF source to the power splitter input through the 3.5 mm-to-3.5 mm cable.
2. Connect the power splitter reference output to power sensor A.
3. Connect the other power splitter output to the NI 5601 RF IN connector through the 3.5 mm (m) to 3.5 mm (m) adapter. Figure 7 shows the completed equipment setup.

**Figure 7. Sideband Spurs Equipment Setup**



- |                  |                  |                         |
|------------------|------------------|-------------------------|
| 1 RF Source      | 3 Power Sensor A | 5 Power Meter Channel A |
| 2 Power Splitter | 4 Power Meter    | 6 50 Ω Terminator       |

4. Create a new session for the NI 5663 using the niRFSAs Initialize VI or the niRFSAs\_init function.
5. Perform an internal self-calibration on the NI 5622 using the niRFSAs Self Cal VI or the niRFSAs\_SelfCal function.
6. Lock the NI PXI-5652 to the reference used by the test equipment. Use the niRFSAs Configure Ref Clock VI or the niRFSAs\_ConfigureRefClock function.
7. Set the NI 5663 to make a spectrum acquisition using the niRFSAs Configure Acquisition Type VI or the niRFSAs\_ConfigureAcquisitionType function.

8. Set the NI 5663 reference level according to Table 13 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.

**Table 13. NI 5663 Settings**

Frequency Range	Reference Level
10 MHz to <6,600 MHz	-30 dBm

9. Set the NI 5663 center frequency according to Table 14 and span according to Table 15 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the niRFSA\_ConfigureSpectrumFrequencyCenterSpan function.



**Note** Search span is used later in step 18.

**Table 14. NI 5663 RF Frequencies**

Start (MHz)	Stop (MHz)	Step (MHz)
10	90	20
100	900	200
1,000	1,000	1,000

**Table 15. NI 5663 Search Settings**

Span	Resolution Bandwidth	Search Span
200 kHz	100 Hz	15 kHz
2 MHz	500 Hz	150 kHz
9.59 MHz	500 Hz	1.5 MHz

10. Set the NI 5663 resolution bandwidth according to Table 15 for the span selected in step 9 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.
11. Use the niRFSA Property Node to set the following properties:
  - Spectrum Averaging Mode to **RMS Averaging**
  - Spectrum Number of Averages to 10
 or set the following attributes:
  - NIRFSA\_ATTR\_SPECTRUM\_AVERAGING\_MODE to NIRFSA\_VAL\_RMS\_AVERAGING
  - NIRFSA\_ATTR\_SPECTRUM\_NUMBER\_OF\_AVERAGES to 10



12. Commit the settings to hardware using the `niRFSA Commit VI` or the `niRFSA_Commit` function.
13. Set the RF signal generator to the center frequency in Table 14.
14. Adjust the RF signal generator power to satisfy the following equation:

$$\text{Channel A Power} + \text{RF Input Calibration Factor} = \text{Reference Level} \pm 1 \text{ dB}$$

*Reference Level* is the value from Table 13. Use the appropriate RF calibration factor for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require interpolation.

15. Set the NI 5663 to read the power spectrum using the `niRFSA Read Power Spectrum (Cluster) VI` or the `niRFSA_ReadPowerSpectrumF64` function.
16. Get the spectrum information using the `niRFSA Get Spectral Info for SMT VI` or the `niRFSA_GetSpectralInfoForSMT` function.
17. Capture the peaks using the `SMT Spectrum Peak Search VI` or the `SmtSpectrumPeakSearch` function with the following parameter settings:
  - **single/multiple** (called **searchCriteria** in the function) to **Multiple Peaks**
  - **threshold** to  $-150 \text{ dBm}$
18. Sort the spurs using the search span shown in Table 15. The values found are the *Spurious Sideband Levels* for this span.
19. Calculate the *Spurious Level* using the following formula:
 
$$\text{Spurious Level} = \text{Carrier Level} - \text{Spurious Sideband Level}$$

*Spurious Level* has units of dBc. *Carrier Level* and *Spurious Sideband Level* have units of dBm.
20. Compare the *Spurious Level* to the test limits in Table 16. Ignore spurs within 1 kHz of the carrier.
21. Repeat steps 9 to 20 for all settings in Tables 14 and 15.
22. Close the NI 5663 session using the `niRFSA Close VI` or the `niRFSA_close` function.

**Table 16.** Sideband Spurs Verification Test Limits

NI 5663 Tuned Frequency	Test Limit	
	>1 kHz to ≤100 kHz Offset	>100 kHz Offset
10 MHz to <50 MHz	<-60 dBc	<-60 dBc
50 MHz to <3.3 GHz	<-60 dBc	<-60 dBc
3.3 GHz to 6.6 GHz	Not tested	Not tested

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

# Phase Noise Verification

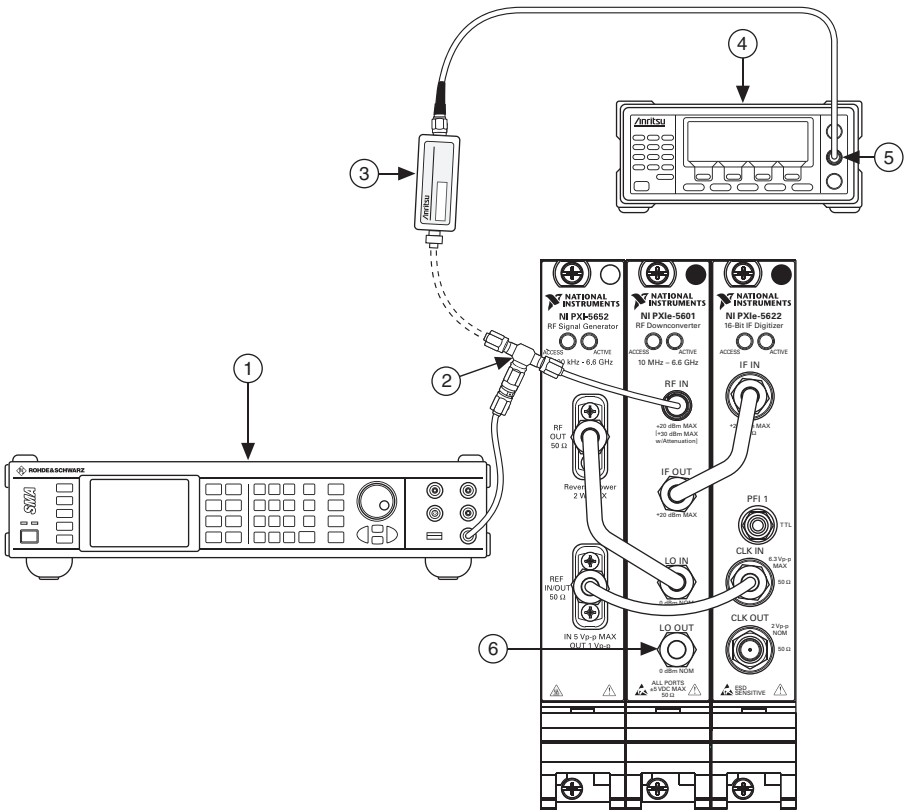
Use this procedure to verify the NI 5663 system. Phase noise is dominated by the NI PXI-5652; refer to the NI PXI-5652 verification and adjustment tests if there are issues with the NI 5663 phase noise.

The frequencies and offsets used in this test were chosen to cover all the internal states used by the NI PXI-5652.

Table 19 shows the test limits.

1. Connect the PN source to the power splitter input through the N (m)-to-3.5 mm (f) adapter and 3.5 mm-to-3.5 mm cable.
2. Connect the power splitter reference output to power sensor A.
3. Connect the other power splitter output to the NI 5601 RF IN connector through the 3.5 mm (m)-to-3.5 mm (m) adapter.

**Figure 8. Phase Noise Equipment Setup**



- |                  |                  |                         |
|------------------|------------------|-------------------------|
| 1 PN Source      | 3 Power Sensor A | 5 Power Meter Channel A |
| 2 Power Splitter | 4 Power Meter    | 6 50 Ω Terminator       |

4. Set the PN source power level to 0 dBm.
5. Create a new session for the NI 5663 using the niRFSA Initialize VI or the niRFSA\_init function.
6. Lock the NI PXI-5652 to its onboard clock using the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
7. Set the NI 5663 reference level according to Table 17 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.

**Table 17. NI 5663 Settings for Phase Noise**

Frequency Range	Reference Level	Span	Resolution Bandwidth
All	0 dBm	30 kHz	100 Hz

8. Set the NI 5663 center frequency according to Table 18 and span according to Table 17 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the niRFSA\_ConfigureSpectrumFrequencyCenterSpan function.

**Table 18. NI 5663 Center Frequency, PN Source RF FrequencySettings for NI 5663 Phase Noise**

Start (MHz)	Stop (MHz)	Step (MHz)
500	—	—
1,000	—	—
1,500	—	—
2,000	—	—
2,900	—	—
3,000	—	—

9. Set the NI 5663 to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
10. Set the NI 5663 resolution bandwidth according to Table 17 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.
11. Commit the settings to hardware using the niRFSA Commit VI or the niRFSA\_Commit function.
12. Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.
13. Set the PN source frequency to the PN source RF frequency in Table 18.
14. Correct the PN source frequency as necessary to obtain a signal centered at the NI 5663 tuned frequency.

15. Adjust the PN source power using the following formula:

$$\text{Channel A Power} + \text{RF Input Calibration Factor} = \text{Reference Level} \pm 1 \text{ dB}$$

*Reference Level* is the value from Table 17. Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require interpolation.

16. Use the niRFSAs Property Node to set the following properties:

- Spectrum Averaging Mode to **RMS Averaging**
- Spectrum Number of Averages to 20
- Spectrum Resolution Bandwidth Type to **ENBW**
- Spectrum Units to **Volts Squared**

or set the following attributes:

- NIRFSA\_ATTR\_SPECTRUM\_AVERAGING\_MODE to NIRFSA\_VAL\_RMS\_AVERAGING
- NIRFSA\_ATTR\_SPECTRUM\_NUMBER\_OF\_AVERAGES to 20
- NIRFSA\_ATTR\_RESOLUTION\_BANDWIDTH\_TYPE to NIRFSA\_VAL\_REW\_ENBW
- NIRFSA\_ATTR\_POWER\_SPECTRUM\_UNITS to NIRFSA\_VAL\_VOLTS\_SQUARED

17. Set the NI 5663 to read the power spectrum using the niRFSAs Read Power Spectrum VI or the niRFSAs\_ReadPowerSpectrumF64 function.

18. Get the spectrum information using the niRFSAs Get Spectral Info for SMT VI or the niRFSAs\_GetSpectralInfoForSMT function. This spectrum is used in steps 19 and 21.

19. Set the parameters for the carrier level using the SMT Spectrum Unit Conversion VI or the SmtSpectrumUnitConversion function:

- **units** to **dBm**
- **peak scaling** to **rms**
- **psd?** (called **psdOnOff** in the function) to **FALSE**
- **impedance** (called **impedanceOhm** in the function) to 50

20. Perform a peak search using the SMT Spectrum Peak Search VI or the SmtSpectrumPeakSearch function. Set the **peak search setting** to **Single Max Peak** with a peak threshold 3 dB below the NI 5663 reference level. The peak value is the *Signal Peak* used in step 23 and the frequency information is used in step 22.

21. Set the parameters for the noise level using the SMT Spectrum Unit Conversion VI:

- **units** to **dBm**
- **peak scaling** to **rms**
- **psd?** (called **psdOnOff** in the function) to **TRUE**
- **impedance** (called **impedanceOhm** in the function) to 50

22. Select the value of the element in the array from step 21 corresponding to the frequency of the signal peak measured in step 20. This value is the *PSD* which you use in step 23.

23. Calculate the phase noise using the following equation:

$$\text{Phase Noise (dBc/Hz)} = \text{PSD} - \text{Signal Peak}$$

24. Compare the *Phase Noise* to the verification test limits in Table 19.

25. Repeat steps 7 to 24 for all frequencies in Table 18.

26. Close the NI 5663 session using the niRFSA Close VI or the niRFSA\_close function.

**Table 19.** Phase Noise Verification Test Limits

NI 5663 Tuned Frequency*	Test Limit
500 MHz	<-112 dBc/Hz
1 GHz	<-105 dBc/Hz
1.5 GHz	<-98 dBc/Hz
2 GHz	<-98 dBc/Hz
2.9 GHz	<-95 dBc/Hz
3 GHz	<-95 dBc/Hz

\* 10 kHz offset, NI 5652 using internal reference.

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

## Appendix A: Non-Input-Related Spurs Test Frequencies

Non-input-related spurs are created by mechanisms within the NI 5663 and are not RF signals. They can be treated as if they are RF signals, however, and you can observe them at particular tunings of the NI 5663. Table 20 gives the NI 5663 tuned frequencies and the RF frequency that would correspond to the spur frequency.

**Table 20.** Non-Input-Related Spurs Test Frequencies

NI 5663 Tuned Frequency (MHz)	Equivalent RF Frequency for Spur (MHz)
140	149.9999988
202	210.0000124
306	300.0000145
350	350
355	359.999997
375	375

**Table 20. Non-Input-Related Spurs Test Frequencies (Continued)**

<b>NI 5663 Tuned Frequency (MHz)</b>	<b>Equivalent RF Frequency for Spur (MHz)</b>
400	425
425	450
475	475
500	512.5
600	590.6250001
625	650
675	675
715	707.4999778
825	825
850	875
1,000	987.5
1,000	1,012.5
1,025	1,037.5
1,180	1,199.92
1,200	1,200
1,204	1,199.92
1,225	1,225
1,245	1,265
1,375	1,400
1,400	1,400
1,425	1,425
1,450	1,438.152174
1,975	1,968.843284
2,050	2,072.977941
2,125	2,113.146552
2,150	2,165.625
2,200	2,211.948529
2,250	2,275

**Table 20. Non-Input-Related Spurs Test Frequencies (Continued)**

<b>NI 5663 Tuned Frequency (MHz)</b>	<b>Equivalent RF Frequency for Spur (MHz)</b>
2,350	2,342.307692
2,400	2,391.477273
2,525	2,513.051471
2,575	2,559.375
2,600	2,585.507246
3,075	3,062.5
3,125	3,112.873134
3,200	3,223.903509
3,275	3,278.479381
3,325	3,331.572165
3,350	3,358.118557
3,450	3,454.411765
3,500	3,519.53125
3,525	3,522.916667
3,550	3,561.970339
3,575	3,594.054878
3,600	3,615.625
3,650	3,674.489796
3,675	3,681.25
3,725	3,743.854167
3,750	3,764.914773
3,850	3,873.798077
3,900	3,923.4375
3,925	3,949.056604
3,935	3,955.694446
4,025	4,029.375
4,035	4,035.182921
4,475	4,478.90625

**Table 20.** Non-Input-Related Spurs Test Frequencies (Continued)

<b>NI 5663 Tuned Frequency (MHz)</b>	<b>Equivalent RF Frequency for Spur (MHz)</b>
4,525	4,531.138393
4,650	4,661.71875
4,675	4,681.404321
4,700	4,707.484568
4,725	4,725
4,915	4,899.999992
5,225	5,200
5,290	5,305.000013
5,300	5,282.916667
5,400	5,401.358696
5,450	5,461.837121
5,475	5,471.09375
5,800	5,822.96875
5,820	5,800.72
5,845	5,851.5
5,875	5,857.276119
5,900	5,888.811728
5,925	5,906.25
5,950	5,934.002976
5,975	5,959.40594
6,000	5,987.575301
6,025	6,009.191176
6,075	6,060.661765
6,225	6,222.861842
6,250	6,249.614198
6,275	6,273.094512
6,425	6,427.667683
6,425	6,443.494212



**Table 20.** Non-Input-Related Spurs Test Frequencies (Continued)

<b>NI 5663 Tuned Frequency (MHz)</b>	<b>Equivalent RF Frequency for Spur (MHz)</b>
6,450	6,451.129518
6,475	6,479.192073
6,575	6,584.645062

## Where to Go for Support

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The National Instruments website is your complete resource for technical support. At [ni.com/support](http://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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