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**PXIe-5663E**

# CALIBRATION PROCEDURE

## NI PXIe-5663E

This document contains instructions for writing a manual calibration procedure for the NI PXIe-5663E (NI 5663E) 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 5663E, 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.

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.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-5663E RF vector signal analyzer as a single device. To calibrate the NI 5601, NI 5622, and NI 5650/5651/5652, refer to their calibration procedures at [ni.com/manuals](http://ni.com/manuals).

## Documentation Requirements

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

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

These documents are installed with NI-RFSA.

You might find the following additional documents helpful:

- *NI PXI-5650/5651/5652 Calibration Procedure*
- *NI PXIe-5622 Calibration Procedure*
- *NI PXIe-5601 Calibration Procedure*

You 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 5663E 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 5663E. If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

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

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

<b>Equipment</b>	<b>Recommended Model</b>	<b>Minimum Requirements</b>
50 $\Omega$ terminator (2 required)	NI 778353-01	—
Signal generator (PN source)	Rhode & Schwarz SMA100A with SMA-B22 option	Frequency range: 500 MHz, 1 GHz, 2 GHz, 2.9 GHz, and 3 GHz  Power level: 0 dBm  Phase noise (10 kHz offset): <-130 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)- 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)-SMA (m) cable (36 in.)	Huber+Suhner ST-18/SMAm/SMAm/36	—
3.5 mm (m)- 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-5663E cable accessory kit.		

## Test Conditions

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

- Maintain an ambient temperature of 23 °C  $\pm$ 5 °C.
- Keep the relative humidity between 10% and 90%, noncondensing.

- Ensure that the PXI/PXI Express chassis air 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 5663E. The warm-up time ensures that the measurement circuitry of the NI 5663E is at a stable operating temperature.
- Use an SMA torque wrench (5 lb · in., Agilent 8710-1582 or equivalent) to tighten any connection with an SMA connector.
- Use a 3.5 mm torque wrench (8 lb · in., 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 5663E 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 procedures.
3. *Verification Procedures*—Measure the operation of the NI 5663E. This procedure checks whether the device is operating within its published specifications.

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



**Note** Complete the verification for all NI 5663E 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 PXIe-5650/5651/5652 Calibration Procedure*
  - *NI PXIe-5622 Calibration Procedure*
  - *NI PXIe-5601 Calibration Procedure*
2. *Reverification*—Repeat the verification procedure for the NI 5663E 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 5663E hardware and how to configure the NI 5663E 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 procedures.



**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 5663E.



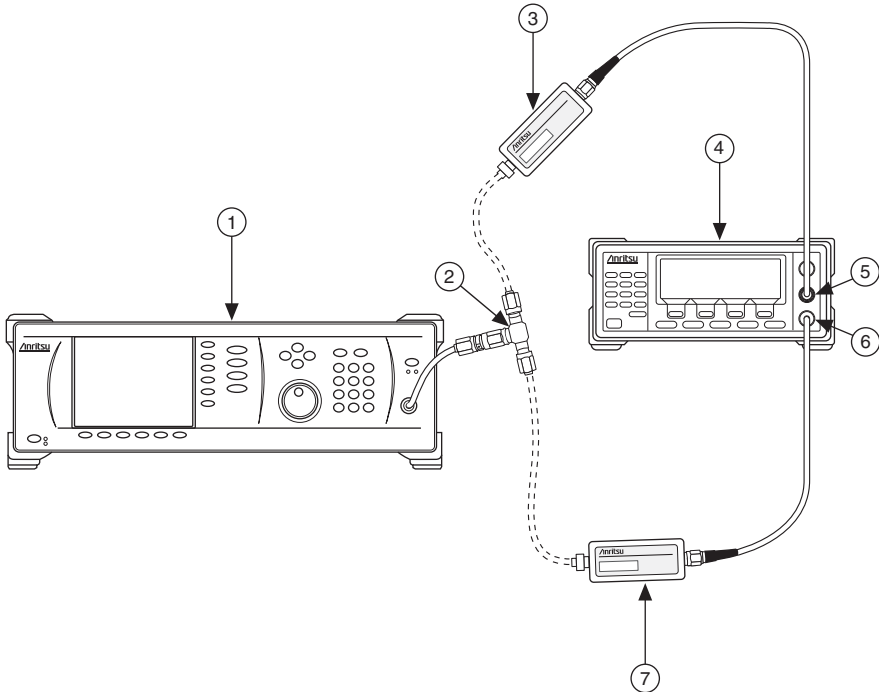
**Note** Perform the power sensor zero/calibration prior to the step. The power splitter reference output must have been defined prior to the step.

### 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](#) procedures.

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

**Figure 1. RF Input Calibration (No 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		

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 calibration factor (dB) for each frequency using the following equation:

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

### RF Input Calibration (with Attenuator)

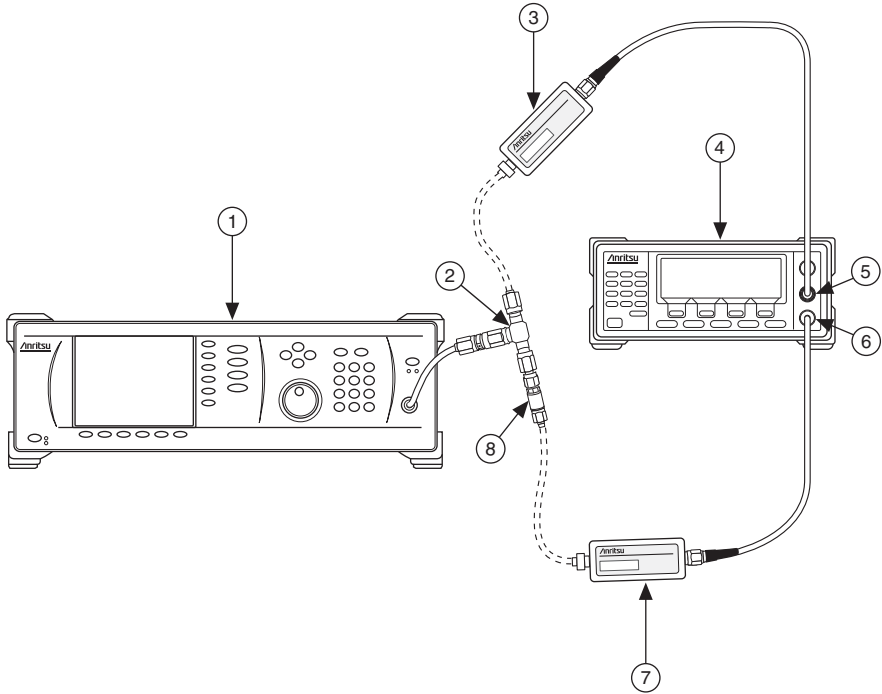
The results of this procedure are used in the *Absolute Accuracy Verification* procedure.

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 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	

- 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 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 5663E. NI uses these limits to determine whether the NI 5663E meets the device specifications when it is received for calibration.

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

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

Verification of the NI 5663E is complete only after you have successfully completed all procedures 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 5663E reference accuracy specification is derived from the NI 5652 frequency accuracy. For more information about NI PXIe-5652 calibration values, refer to the *NI PXIe-5650/5651/5652 Calibration Procedure* available at [ni.com/manuals](http://ni.com/manuals).

## Absolute Accuracy Verification

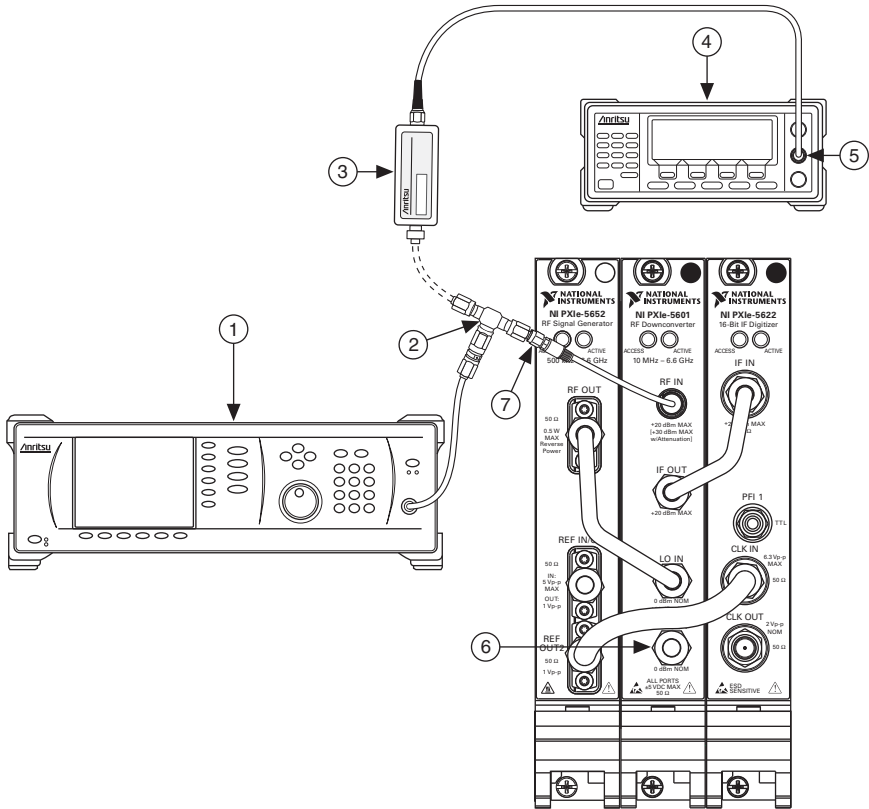
Table 5 shows the test limits.

### 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 5663E using the niRFSa Initialize VI or the niRFSa\_init function.
- Lock the NI PXIe-5652 to the reference used by the test equipment. Use the niRFSa Configure Ref Clock VI or the niRFSa\_ConfigureRefClock function.
- Set the NI 5663E to make a spectrum acquisition using the niRFSa Configure Acquisition Type VI or the niRFSa\_ConfigureAcquisitionType function.

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

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

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

9. Set the NI 5663E reference level according to Table 3 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
10. Perform a self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.
11. Set the NI 5663E 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 5663E Center Frequencies**

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



**Note** The maximum center frequency is 3,400 MHz when verifying the 3.4 GHz NI 5663E.

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 5663E 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 5663E reference level.
19. Sort the peaks and record the maximum. Save this as *RFSA Power*.
20. Calculate the *Absolute Accuracy* at each RF frequency using the following formula:

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

Use the *RF Input Attenuated Calibration Factor* from step 14.

21. Compare the *Absolute Accuracy* to the verification test limits in Table 5.
22. Repeat steps 8 to 21 for all the settings in Tables 3 and 4.
23. Close the NI 5663E session using the niRFSA Close VI or the niRFSA\_close function.

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

Complete this procedure to verify the absolute accuracy of the NI 5663E using reference levels  $\geq -30$  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 shows the connections.
5. Create a new session for the NI 5663E using the niRFSA Initialize VI or the niRFSA\_init function.
6. Lock the NI PXIe-5652 to the reference used by the test equipment. Use the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
7. Set the NI 5663E to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
8. Set the NI 5663E for a resolution bandwidth according to Table 3 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.
9. Set the NI 5663E reference level according to Table 3 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
10. Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.

11. Set the NI 5663E 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 does not have sufficient power to reach the reference level.

15. Record the channel A power.
16. Set the NI 5663E 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 5663E 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 8 to 21 for all the settings in Tables 3 and 4.
23. Close the NI 5663E 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



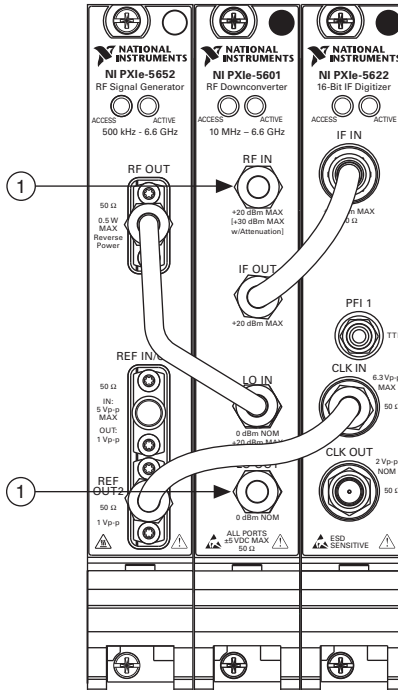
**Note** The maximum frequency is 3.4 GHz when verifying the 3.4 GHz NI 5663E.

# 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 5663E using the niRFSA Initialize VI or the niRFSA\_init function.
3. Lock the NI PXIe-5652 to the reference used by the test equipment. Use the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
4. Set the NI 5663E to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.

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

**Table 6. NI 5663E 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

- Set the NI 5663E reference level according to Table 6 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
- Set the NI-RFSA Attenuation (dB) property or the niRFSA\_ATTR\_ATTENUATION attribute to 0.
- Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.
- Set the NI 5663E 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.



**Note** The maximum start and stop frequencies are 3,400 MHz when verifying the 3.4 GHz NI 5663E.



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 5663E 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 5663E Average Noise Level*.
16. Compare the *NI 5663E Average Noise Level* to the verification test limits in Table 8.
17. Repeat steps 5 to 16 for all combinations of settings in Tables 6 and 7.
18. Close the NI 5663E session using the niRFSA Close VI and 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



**Note** The maximum frequency is 3.4 GHz when verifying the 3.4 GHz NI 5663E.



8. Lock the NI PXIe-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 5663E 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 PXIe-5652 and NI PXIe-5601 are tuned so that they can control the NI PXIe-5601 internal state. The NI PXIe-5652 is not otherwise used in this procedure.

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

**Table 9.** NI 5663E LO Output Power Settings, Center Frequencies

Start (MHz)	Stop (MHz)	Step (MHz)	Span (Hz)
110	6,510	100	100
6,600	—	—	100



**Note** Use center frequencies of 110 MHz through 3,210 MHz and 3,300 MHz (same step and span as shown in Table 9) when verifying the 3.4 GHz NI 5663E.

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 verification limits in Table 10.
14. Repeat steps 9 to 13 for all frequencies in Table 9.
15. Close the NI 5663E session using the niRFSA Close VI or the niRFSA\_close function.

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

Frequency	Test Limit
110 MHz to 6.6 GHz	0 dBm $\pm$ 3.5 dB (nominal)

**Note:** LO Input Power = 0 dBm  $\pm$ 0.5 dB.



**Note** Use frequencies from 110 MHz to 3.3 GHz when verifying the 3.4 GHz NI 5663E.

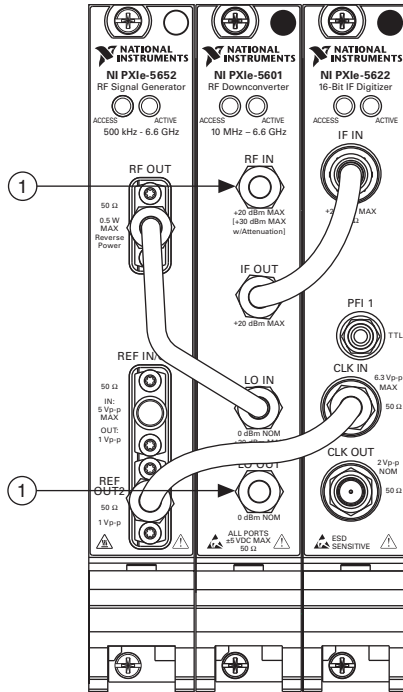
# Non-Input-Related Spurs (Residual Spurs) Verification

Table 12 shows the test limits.

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

1. Connect the NI PXIe-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 5663E using the niRFSA Initialize VI or the niRFSA\_init function.
4. Lock the NI PXIe-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 5663E to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
6. Set the NI 5663E for a resolution bandwidth according to Table 11 using the niRFSA Configure Resolution Bandwidth VI or the niRFSA\_ConfigureResolutionBandwidth function.

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

NI 5663E Tuned Frequency	RF Attenuation	Reference Level	Span	Resolution Bandwidth
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 <6,600 MHz	0 dB	-60 dBm	50 MHz	500 Hz



**Note** Use an NI 5663E tuned frequency of <3,400 MHz when verifying the 3.4 GHz NI 5663E.

7. Set the NI 5663E reference level according to Table 11 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.
8. Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.
9. Set the NI 5663E center frequency and span according to 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 5663E 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 5663E *Spurious Level*.
15. Compare the NI 5663E *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 5663E 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



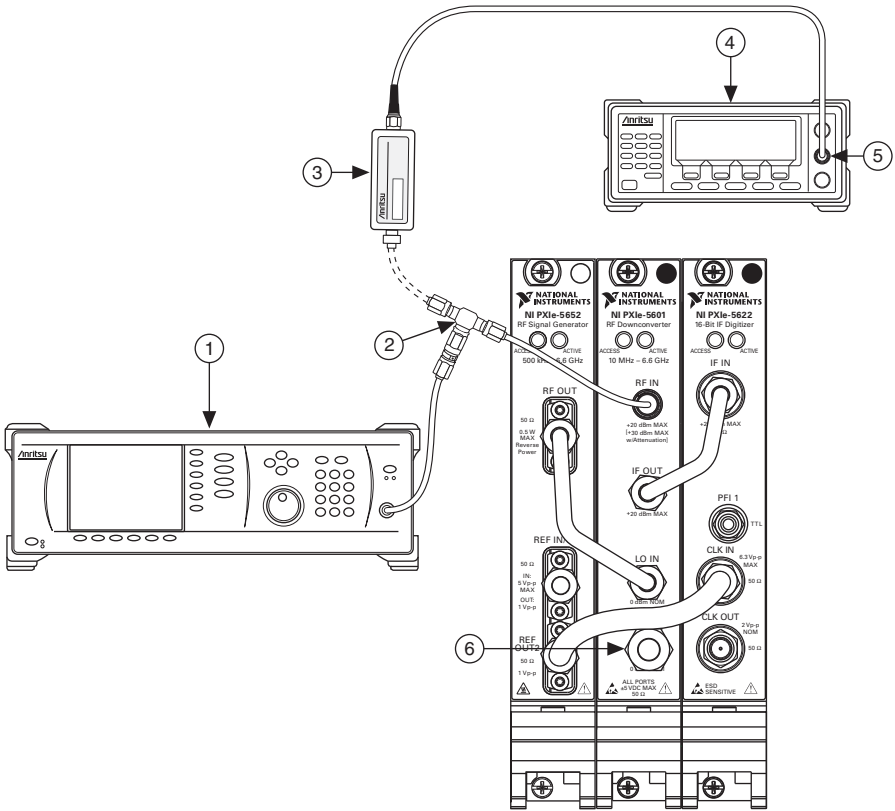
**Note** Use frequencies from 10 MHz to 3.4 GHz when verifying the 3.4 GHz NI 5663E.

## 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       |

- Create a new session for the NI 5663E using the niRFSA Initialize VI or the niRFSA\_init function.
- Lock the NI PXIe-5652 to the reference used by the test equipment. Use the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
- Set the NI 5663E to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
- Set the NI 5663E reference level according to Table 13 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.

**Table 13. NI 5663E Settings**

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



**Note** Use a frequency range of 10 MHz to <3,400 MHz when verifying the 3.4 GHz NI 5663E.

8. Perform an internal self-calibration on the NI 5622 using the niRFSA Self Cal VI or the niRFSA\_SelfCal function.
9. Set the NI 5663E 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. Use the search span in step 18.

**Table 14.** NI 5663E RF Frequencies

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

**Table 15.** NI 5663E 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 5663E 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:
  - N1RFSA\_ATTR\_SPECTRUM\_AVERAGING\_MODE to N1RFSA\_VAL\_RMS\_AVERAGING
  - N1RFSA\_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 5663E 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 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 verification 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 5663E session using the niRFSA Close VI or the niRFSA\_close function.

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

NI 5663E 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



**Note** Use an NI 5663E tuned frequency <3.4 GHz when verifying the 3.4 GHz NI 5663E.

# Phase Noise Verification

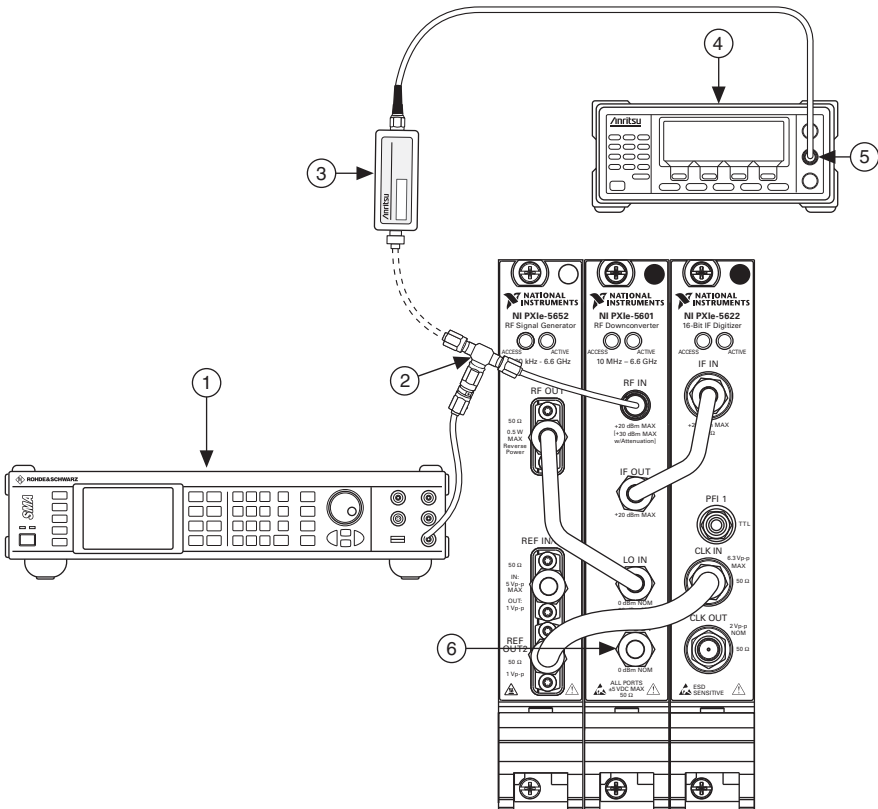
Phase noise is dominated by the NI PXIe-5652; refer to the *NI PXIe-5650/5651/5652 Calibration Procedure* if there are issues with the NI 5663E phase noise.

The frequencies and offsets used in this procedure were chosen to cover all the internal states used by the NI PXIe-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 5663E using the niRFSA Initialize VI or the niRFSA\_init function.
6. Lock the NI PXIe-5652 to its onboard clock using the niRFSA Configure Ref Clock VI or the niRFSA\_ConfigureRefClock function.
7. Set the NI 5663E reference level according to Table 17 using the niRFSA Configure Reference Level VI or the niRFSA\_ConfigureReferenceLevel function.

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

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

8. Set the NI 5663E 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 5663E Center Frequency, PN Source RF Frequency

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

9. Set the NI 5663E to make a spectrum acquisition using the niRFSA Configure Acquisition Type VI or the niRFSA\_ConfigureAcquisitionType function.
10. Set the NI 5663E 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 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

17. Set the NI 5663E to read the power spectrum using the niRFSA Read Power Spectrum VI or the niRFSA\_ReadPowerSpectrumF64 function.
18. Get the spectrum information using the niRFSA Get Spectral Info for SMT VI or the niRFSA\_GetSpectralInfoForSMT function. Use this spectrum 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 5663E reference level. The peak value is the *Signal Peak* that you use in step 23 and the frequency information that you use 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 5663E session using the niRFSA Close VI or the niRFSA\_close function.

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

NI 5663E 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.

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

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



**Note** Use an NI 5663E tuned frequency  $\leq 3,400$  MHz when verifying the 3.4 GHz NI 5663E.

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

NI 5663E 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 5663E 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 5663E 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 5663E 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)

NI 5663E Tuned Frequency (MHz)	Equivalent RF Frequency for Spur (MHz)
6,450	6,451.129518
6,475	6,479.192073
6,575	6,584.645062

## Where to Go for Support

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