CALIBRATION PROCEDURE

NI PXIe-5601

This document contains information for calibrating the National Instruments PXIe-5601 (NI 5601) RF downconverter. For more information about calibration, visit ni.com/calibration.

Contents

Software Requirements

Calibrating the NI 5601 requires installing NI-RFSA 2.3 or later on the calibration system. You must also install NI-RFSG 1.4 or later. You can download NI-RFSA from `ni.com/updates`. NI-RFSA supports programming a self-calibration and an external calibration in the LabVIEW, LabWindows™/CVI™, and C application development environments (ADEs). When you install NI-RFSA, you need to install support only for the ADE that you intend to use.

LabVIEW support is in the `<LabVIEW>\instr.lib\niRFSA\niRFSA.llb` file, and all calibration functions appear in the NI-RFSA Calibration palette. For LabWindows/CVI users, the NI-RFSA function panel, located at `C:\Program Files\IVI Foundation\IVI\Bin\niRFSA.dll`, provides access to the available functions.

Documentation Requirements

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

- *NI PXIe-5601 Specifications*—Provides the published specification values for the NI 5601. Refer to the most recent NI PXIe-5601 Specifications online at `ni.com/manuals`.
- *NI 5661/5663/5663E RF Vector Signal Analyzers Getting Started Guide*—Provides instructions for installing and configuring your NI 5601 device.
- *NI RF Vector Signal Analyzers Help*—Includes detailed information about the NI 5601 device and information about creating applications that use the NI-RFSA driver.

These documents are installed with NI-RFSA. You also can find the latest versions of these documents at `ni.com/manuals`.

Calibration Interval

NI recommends a calibration interval of one year for the NI 5601. 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 1 to calibrate the NI 5601. If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

Table 1. Required Equipment for NI 5601 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% FS (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 7 GHz...........<1.22:1 Linearity: -55 dBm to 20 dBm .....<1.8% Rise time: <4 µs Calibration factor uncertainty: (Sensors must be calibrated with an uncertainty that meets the following specifications) 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 (LO source)	NI PXI/PXIe-5652	—
Signal generator (RF source)	Anritsu MG3692B	Frequency range: 10 MHz to 6.6 GHz Power level: -60 dBm to 20 dBm

Table 1. Required Equipment for NI 5601 Calibration (Continued)

Equipment	Recommended Model	Minimum Requirements
Spectrum analyzer	Rohde & Schwarz FSU26	Frequency range: 10 MHz to 6.6 GHz Power level: -60 dBm to 20 dBm Resolution bandwidth: 10 Hz to 1 MHz Phase noise (1 GHz, typical): 100 Hz .... -100 dBc/Hz 1 kHz .... -120 dBc/Hz 10 kHz .... -130 dBc/Hz 100 kHz .... -130 dBc/Hz 1 MHz .... -142 dBc/Hz
PXI Express chassis	NI PXIe-1065 or NI PXIe-1075	—
PXI Express controller	NI PXIe-8105	—
SMA (m)-to-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.) (2 required)	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	—
3.5 mm (m) 50 Ω terminator (2 required)	NI part number 778353-01 (Applied Specialties 8018-6005), or equivalent	—

Test Conditions

The following setup and environmental conditions are required to ensure the NI 5601 meets published specifications:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Verify that all connections to the device, including front panel connections, are secure.
- Maintain an ambient temperature of 23 °C ±5 °C.
- Keep the relative humidity between 10% and 90%, noncondensing.

- Allow a warm-up time of at least 30 minutes after NI-RFSA is loaded and recognizes the NI 5601. The warm-up time ensures that the measurement circuitry of the NI 5601 is at a stable operating temperature.
- 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 about chassis fans, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `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.
- 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.
- All procedures assume an NI PXI/PXIe-5652 as the LO source for the NI 5601.
- 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*.

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

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX).
2. *Test System Characterization*—Characterize the response of the test system. You use the measured response during the verification procedures.
3. *Verification*—Measure the operation of the NI 5601 to confirm whether the device is operating within its published specifications.

If the NI 5601 fails any of the verification procedures, complete the following steps:

Note Complete the verification for all NI 5601 specifications where as-found data is required before performing any module calibrations.

1. Adjustment—Perform an adjustment on the NI 5601. Refer to the *Adjustment* section in this document.
2. Reverification—Repeat the verification procedure for the NI 5601 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 software and hardware and how to configure the device in MAX.

The NI PXI/PXIe-5652 must be selected as the LO for the NI 5601 in MAX.

Test System Characterization

These procedures characterize the test system response. Use the results of these procedures to complete the *Verification*.

Measure the power splitter (and attenuation) response at the RF input frequencies used in the verification procedures. Measure the spectrum analyzer response at the IF output frequencies used in the verification procedures.

Power Splitter Reference Output

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

Power Sensor Zero/Calibration

1. Connect the power meter channel A to power sensor A.
2. Connect the power meter channel B to power sensor B.
3. Zero and calibrate the power sensors using the built-in power meter function.

RF Input Calibration

This section describes how to calibrate the RF input that you use to verify the NI 5601.

Note Perform the *Power Sensor Zero/Calibration* prior to this step. You must also define the *Power Splitter Reference Output* prior to this step.

RF Input Calibration (Without Attenuator)

Use the results of this procedure in the following procedures:

- *Absolute Gain Accuracy Verification*
- *LO Output Power Verification*
- *Instantaneous Bandwidth Verification*
- *Gain Compression Verification*
- *Reference Level Adjustment for RF Frequencies ≥120 MHz*
- *Reference Level Adjustment for RF Frequencies ≤120 MHz*
- *IF Attenuation Calibration Adjustment*

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.

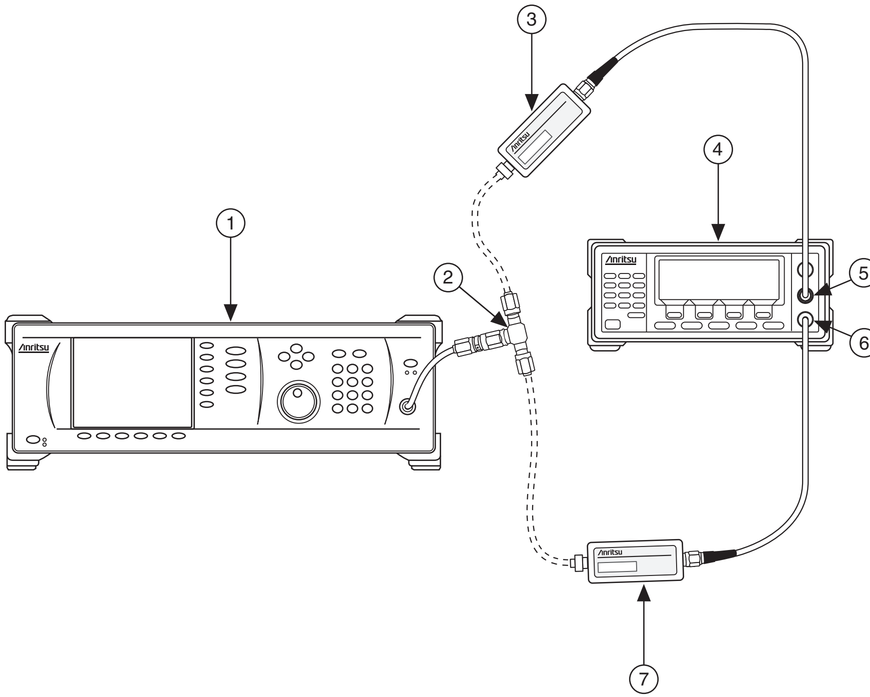
3. Connect power sensor B to the other output of the power splitter. Figure 1 shows the completed equipment setup.
4. Measure the channel A and channel B power, using the appropriate frequency for the power sensor, for all frequencies between 10 MHz and 7 GHz with the RF source power set to 0 dBm.

Note Use the log-like frequency progression: 10, 20, 30, ..., 100, 200, 300, ..., 1,000 MHz, and so on. Also include the discrete frequencies 53 MHz and 187.5 MHz.

5. Calculate the *RF Input Calibration Factor* (dB) for each frequency using the following equation:

RF Input Calibration Factor = *Channel B Power* - *Channel A Power*

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



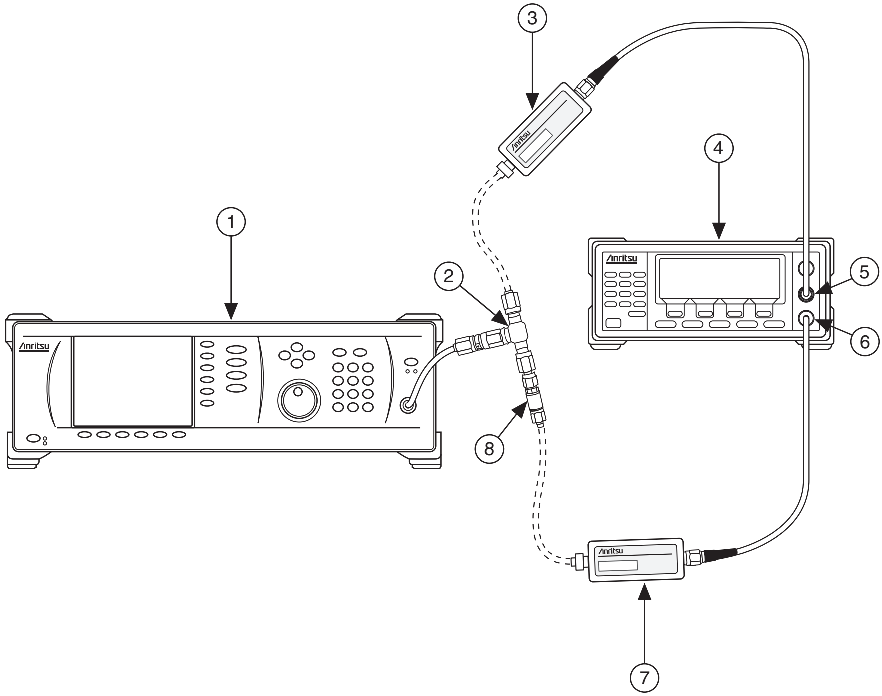
1	RF Source	3	Power Sensor A	5	Power Meter Channel A	7	Power Sensor B
2	Power Splitter	4	Power Meter	6	Power Meter Channel B		

RF Input Calibration (with Attenuator)

The absolute gain accuracy verification procedure uses the results of this 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.
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	3	Power Sensor A	5	Power Meter Channel A	7	Power Sensor B
2	Power Splitter	4	Power Meter	6	Power Meter Channel B	8	30 dB Attenuator

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

Note Use the log-like 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 Input Attenuated Calibration Factor = *Channel B Power* - *Channel A Power*

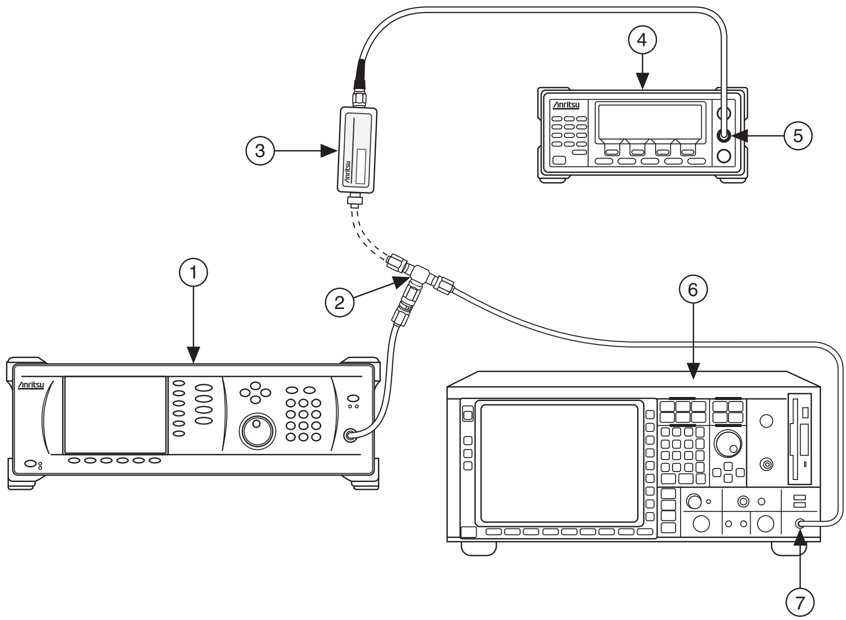
IF Output Calibration

Use the results of the IF output calibration procedure in the following procedures:

- *Absolute Gain Accuracy Verification*
- *Average Noise Level Verification*
- *Reference Level Adjustment for RF Frequencies ≤120 MHz*
- *Reference Level Adjustment for RF Frequencies ≥120 MHz*,
- *IF Attenuation Calibration Adjustment*
- *IF Response Adjustment*

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 the other output of the power splitter to the spectrum analyzer input through the 3.5 mm-to-3.5 mm cable. Figure 3 shows the completed equipment setup.

Figure 3. IF Output Equipment Setup



1	RF Source	4	Power Meter	6	Spectrum Analyzer
2	Power Splitter	5	Power Meter Channel A	7	Spectrum Analyzer Input
3	Power Sensor A				

4. Measure the channel A power and the spectrum analyzer power, using the appropriate frequency for the power sensor, using the following settings:
   - RF source power (for both 53 MHz and 187.5 MHz): 0 dBm
   - Reference level: 0 dBm

- Frequency span: 10 Hz
- Resolution bandwidth: 200 Hz
- Center frequency: 53 MHz, 187.5 MHz

5. Calculate the *IF Calibration Factor* (dB) for each frequency using the following formula:

   IF Calibration Factor = Channel A Power + RF Input Calibration Factor - Spectrum Analyzer Power

   Use the appropriate frequency for the channel A power sensor and the appropriate *RF Input Calibration Factor*.

As-Found and As-Left Limits

The as-found limits are the published specifications for the NI 5601. NI uses these limits to determine whether the NI 5601 meets the device specifications when it is received for calibration.

The as-left limits are equal to the published NI specifications for the NI 5601, less guard bands for temperature drift and drift over time. NI uses these limits to determine whether the NI 5601 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

Verification of the NI 5601 is complete only after you have successfully completed all procedures in this section.

Note Limits in the following sections are based upon the August 2009 edition of the *NI PXIe-5601 Specifications*. Refer to the most recent specifications online at `ni.com/manuals`. If a more recent edition of the specifications is available, recalculate the limits based upon the latest specifications.

Absolute Gain Accuracy Verification

Reference Levels Less than -30 dBm

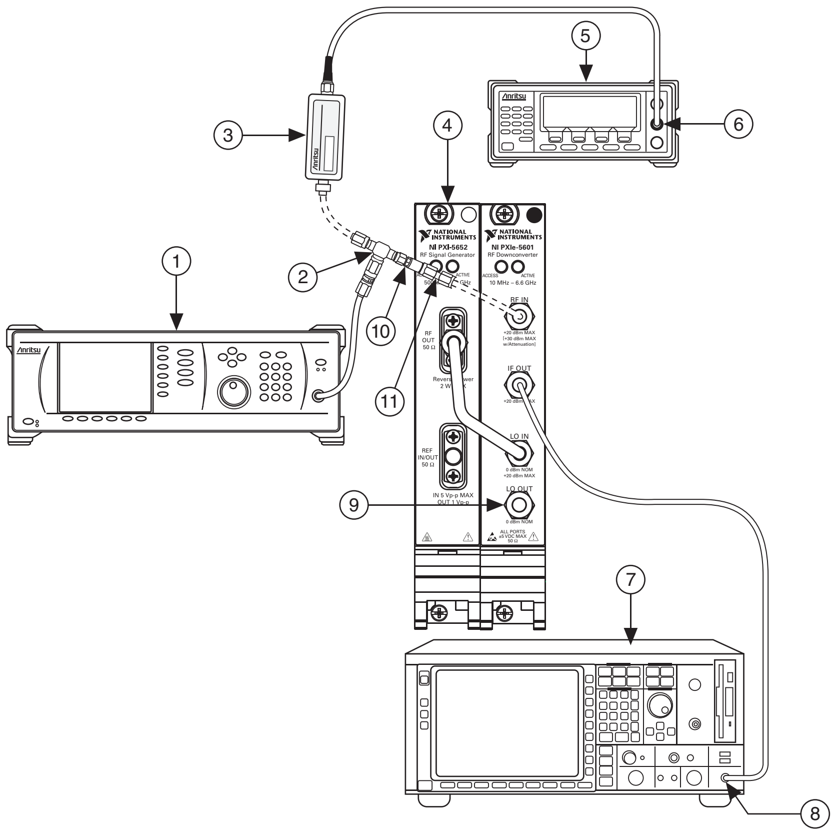
Note Compare the results from these measurements with the specification for reference levels <-49 dBm in Table 6, or to the specification for reference levels ≥-49 dBm and <-30 dBm in Table 7, as appropriate.

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.

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-to-3.5 mm adapter and 3.5 mm-to-3.5 mm 30 dB attenuator.
4. Ensure that the 50 Ω terminator (NI part number 778353-01) that shipped with the NI 5601 is connected to the NI 5601 LO OUT connector. Figure 4 shows the completed equipment setup.

Figure 4. Absolute Gain Accuracy Equipment Connections



1	RF Source	5	Power Meter	9	50 Ω Terminator (Shipped with the NI 5601)
2	Power Splitter	6	Power Meter Channel A	10	30 dB Attenuator[1]
3	Power Sensor A	7	Spectrum Analyzer	11	Adapter
4	LO Source	8	Spectrum Analyzer Input		

Note The preceding figure shows the NI PXI-5652, but you can also use the NI PXIe-5652. The figure shows spectrum analyzer connections.

1 The 30 dB attenuator is used only for reference levels <-30 dBm.

5. Connect the NI 5601 IF OUT connector to power sensor B or to the spectrum analyzer input. To choose which connection to make, refer to the following conditions:
   - Use the spectrum analyzer with the 3.5 mm-to-3.5 mm cable for RF frequencies ≤120 MHz.
   - Use power sensor B with the SMA (m)-to-SMA (f) right-angle adapter for RF frequencies ≥120 MHz.
6. Create a new session for the NI 5601 using the niRFSA Initialize With Options VI or the `niRFSA_initWithOptions` function. Set the Driver Setup portion of the **option string** parameter to `DriverSetup=Digitizer:<external>`.
7. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSA Configure Ref Clock VI or the `niRFSA_ConfigureRefClock` function.
8. Set the NI 5601 reference level according to Table 2 using the niRFSA Configure Reference Level VI or the `niRFSA_ConfigureReferenceLevel` function.

Table 2. NI 5601 Settings (All Frequencies)

Parameter	Value
Reference Level	-60 dBm to 15 dBm, 5 dB steps
Span	5 MHz

9. Set the NI 5601 center frequency according to Table 3 and set the span according to Table 2. Use the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the `niRFSA_ConfigureSpectrumFrequencyCenterSpan` function.

Table 3. NI 5601 Center Frequency

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

10. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.

11. If you used the spectrum analyzer, set the reference level, frequency span, and resolution bandwidth according to Table 4. Set the center frequency according to Table 5.

Table 4. Spectrum Analyzer Settings

Parameter	Value
Reference Level	0 dBm
Frequency Span	10 Hz
Resolution Bandwidth	200 Hz

Table 5. Spectrum Analyzer Center Frequency Settings

NI 5601 Center Frequency	IF Frequency (Spectrum Analyzer Center Frequency)
10 MHz to <120 MHz	187.5 MHz
120 MHz to <330 MHz	53 MHz
330 MHz to 6.6 GHz	187.5 MHz

12. Set the RF source to the same frequency you set for the NI 5601 center frequency according to Table 3.
13. At each NI 5601 center frequency and reference level setting, perform the following steps:
    a. Adjust the RF source power, in dBm, using the following equation:

    Channel A Power + *RF Input Attenuated Calibration Factor* = *Reference Level* ±1 dB

    When making the adjustment, use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Attenuated Calibration Factor* may require linear interpolation.

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

    b. Record the channel A power.
    c. Measure the channel B power or spectrum analyzer power using one of the following methods:
       - If you are using the power meter, measure and record the channel B power. Use the appropriate IF frequency from Table 5 for the channel B sensor.
       - If you are using the spectrum analyzer, measure and record the *Spectrum Analyzer Power*. Correct the *Spectrum Analyzer Power* using the appropriate *IF Calibration Factor* for the IF frequency in Table 5 and the following formula:

Corrected Spectrum Analyzer Power = *Spectrum Analyzer Power* + *IF Calibration Factor*

d. Calculate the *NI 5601 Calculated Gain* at each RF frequency using the following formula:

NI 5601 Calculated Gain = *Channel B Power* (or *Corrected Spectrum Analyzer Power*) - (*Channel A Power* + *RF Input Attenuated Calibration Factor*)

Use the same *RF Input Attenuated Calibration Factor* that you used in Step 13a.

14. Recall the *NI 5601 Stored Gain* for each test frequency using the niRFSA Downconverter Gain property or the `NIRFSA_ATTR_DOWNCONVERTER_GAIN` attribute.
15. Calculate the *Absolute Gain Accuracy* using the following formula:

Absolute Gain Accuracy = *NI 5601 Calculated Gain* - *NI 5601 Stored Gain*

16. Compare the *Absolute Gain Accuracy* to the *Verification Test Limits* in Tables 6 or 7, as appropriate.
17. Repeat steps 8 to 16 for all the settings in Tables 2 and 3.

Note NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

18. Close the NI 5601 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-to-3.5 mm adapter.
4. Ensure that the 50 Ω terminator that shipped with the NI 5601 is connected to the NI 5601 LO OUT connector.
5. Connect the NI 5601 IF OUT connector to power sensor B or to the spectrum analyzer input. To choose which connection to make, refer to the following conditions:
   - Use the spectrum analyzer with the 3.5 mm-to-3.5 mm cable for RF frequencies ≤120 MHz.
   - Use power sensor B with the SMA (m)-to-SMA (f) right angle adapter for RF frequencies ≥120 MHz.

   Figure 4 shows the completed equipment setup.
6. Create a new session for the NI 5601 using the niRFSA Initialize With Options VI or the `niRFSA_initWithOptions` function. Set the Driver Setup portion of the **option string** parameter to `DriverSetup=Digitizer:<external>`.
7. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSA Configure Ref Clock VI or the `niRFSA_ConfigureRefClock` function.

8. Set the NI 5601 reference level according to Table 2 using the niRFSA Configure Reference Level VI or the `niRFSA_ConfigureReferenceLevel` function.
9. Set the NI 5601 center frequency according to Table 3 and the span according to Table 2 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 Initiate VI or the `niRFSA_Initiate` function.
11. If you use the spectrum analyzer, set the reference level, span, and resolution bandwidth according to Table 4. Set the center frequency according to Table 5.
12. Set the RF source to the same frequency as the *NI 5601 Center Frequency* according to Table 3.
13. At each NI 5601 center frequency and reference level setting, perform the following steps:
    a. Adjust the RF source power, in dBm, to satisfy the following equation:

       Channel A Power + *RF Input Calibration Factor* = *Reference Level* ±1 dB

       When making the adjustment, use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.

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

    b. Record the *Channel A Power*.
    c. Measure the *Channel B Power* or *Spectrum Analyzer Power* using one of the following methods:
       - If you are using the power meter, measure and record the *Channel B Power*. Use the appropriate IF frequency from Table 5 for the channel B sensor.
       - If you are using the spectrum analyzer, measure and record the *Spectrum Analyzer Power*. Correct the *Spectrum Analyzer Power* using the appropriate *IF Calibration Factor* for the IF frequency in Table 5 and the following equation:

Corrected Spectrum Analyzer Power = *Spectrum Analyzer Power* + *IF Calibration Factor*

    d. Calculate the *NI 5601 Calculated Gain* at each RF frequency using the following formula:

NI 5601 Calculated Gain = *Channel B Power* (or *Corrected Spectrum Analyzer Power*) - (*Channel A Power* + *RF Input Calibration Factor*)

       Use the same *RF Input Calibration Factor* that you used in step 13a.

14. Recall the *NI 5601 Stored Gain* for each test frequency using the niRFSA Downconverter Gain property or the `NIRFSA_ATTR_DOWNCONVERTER_GAIN` attribute.
15. Calculate the *Absolute Gain Accuracy* using the following formula:

Absolute Gain Accuracy = *NI 5601 Calculated Gain* - *NI 5601 Stored Gain*

16. Compare the *Absolute Gain Accuracy* to the verification test limits in Table 7.
17. Repeat steps 8 to 16 for all the settings in Tables 2 and 3.

> **Note** NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

18. Close the NI 5601 session using the niRFSA Close VI or the `niRFSA_close` function.

Table 6. Absolute Gain Accuracy Verification Test Limits

Frequency	<-49 dBm Reference Levels	
	As-Found Limit	**As-Left Limit**
10 MHz to <30 MHz	±1.5 dB	±0.88 dB
30 MHz to <120 MHz	±1.5 dB	±0.88 dB
120 MHz to <300 MHz	±1.5 dB	±0.88 dB
300 MHz to <400 MHz	±1.4 dB	±0.65 dB
400 MHz to <3 GHz	±1.3 dB	±0.65 dB
3 GHz to <5.5 GHz	±1.3 dB	±0.65 dB
5.5 GHz to <6.6 GHz	±2.5 dB	±1.85 dB

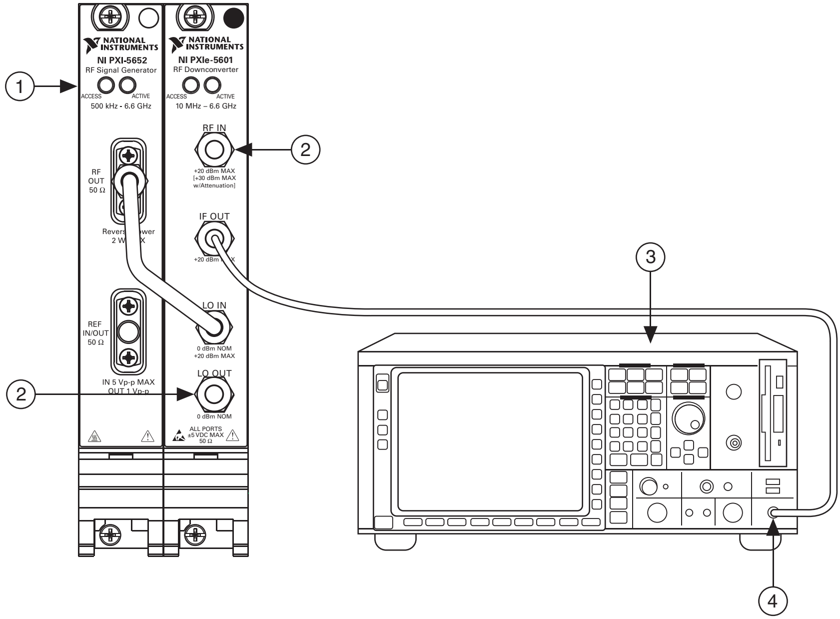
Table 7. Absolute Gain Accuracy Verification Test Limits

Frequency	≥-49 dBm Reference Levels	
	As-Found Limit	**As-Left Limit**
10 MHz to <30 MHz	±1.5 dB	±0.88 dB
30 MHz to <120 MHz	±1.5 dB	±0.88 dB
120 MHz to <300 MHz	±1.5 dB	±0.88 dB
300 MHz to <400 MHz	±1.4 dB	±0.65 dB
400 MHz to <3 GHz	±1.3 dB	±0.65 dB
3 GHz to <5.5 GHz	±1.3 dB	±0.65 dB
5.5 GHz to <6.6 GHz	±1.3 dB	±0.65 dB

Average Noise Level Verification

1. Connect a 50 Ω terminator to the NI 5601 RF IN connector. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.
2. Connect the NI 5601 IF OUT connector to the spectrum analyzer input through the 3.5 mm-to-3.5 mm cable. Figure 5 shows the completed equipment setup.

Figure 5. Average Noise Level Equipment Setup



1	LO Source	3	Spectrum Analyzer
2	50 Ω Terminator	4	Spectrum Analyzer Input

Note The figure shows the NI PXI-5652, but you can also use the NI PXIe-5652.

3. Create a new session for the NI 5601 using the niRFSA Initialize With Options VI or the `niRFSA_initWithOptions` function. Set the Driver Setup portion of the **option string** parameter to `DriverSetup=Digitizer:<external>`.
4. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSA Configure Ref Clock VI or the `niRFSA_ConfigureRefClock` function.

5. Set the NI 5601 reference level according to Table 8 using the niRFSA Configure Reference Level VI or the `niRFSA_ConfigureReferenceLevel` function.

Table 8. NI 5601 Settings

Frequency Range	Reference Level	RF Attenuation	Span
10 MHz to 30 MHz	-10 dBm	0 dB	10 Hz
30 MHz to 6,600 MHz	-50 dBm	0 dB	10 Hz

6. Set the RF attenuation according to Table 8 using the niRFSA Attenuation property or the `NIRFSA_ATTR_ATTENUATION` attribute.
7. Set the NI 5601 center frequency according to Table 9 and set the span according to Table 8 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the `niRFSA_ConfigureSpectrumFrequencyCenterSpan` function.
8. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
9. Set the spectrum analyzer using the following settings:
   - Reference level: -50 dBm
   - Frequency span: 100 Hz
   - Resolution bandwidth: 3 kHz
   - Video bandwidth: 10 Hz
   - Center frequency: Refer to Table 9

Table 9. Center Frequency Settings

NI 5601 Center Frequency	Spectrum Analyzer Center Frequency
10 MHz to <120 MHz	187.5 MHz
120 MHz to <330 MHz	53 MHz
330 MHz to 6.6 GHz	187.5 MHz

10. Use the spectrum analyzer noise marker to measure the average noise.
11. Record the average noise measured on the spectrum analyzer. This value is the *Measured Noise* and is used in step 13.
12. Recall the *NI 5601 Stored Gain* for each setting using the niRFSA Downconverter Gain property or the `NIRFSA_ATTR_DOWNCONVERTER_GAIN` attribute.
13. Calculate the *NI 5601 Input Noise* using the following formula:

    NI 5601 Input Noise = Measured Noise + IF Calibration Factor - NI 5601 Stored Gain

14. Compare the *NI 5601 Input Noise* to the limits in Table 11.

15. Repeat steps 5 to 14 for all frequencies in Table 10.

Table 10. 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.		

16. Close the NI 5601 session using the niRFSA Close VI or the `niRFSA_close` function.

Table 11. Average Noise Level Verification Test Limits

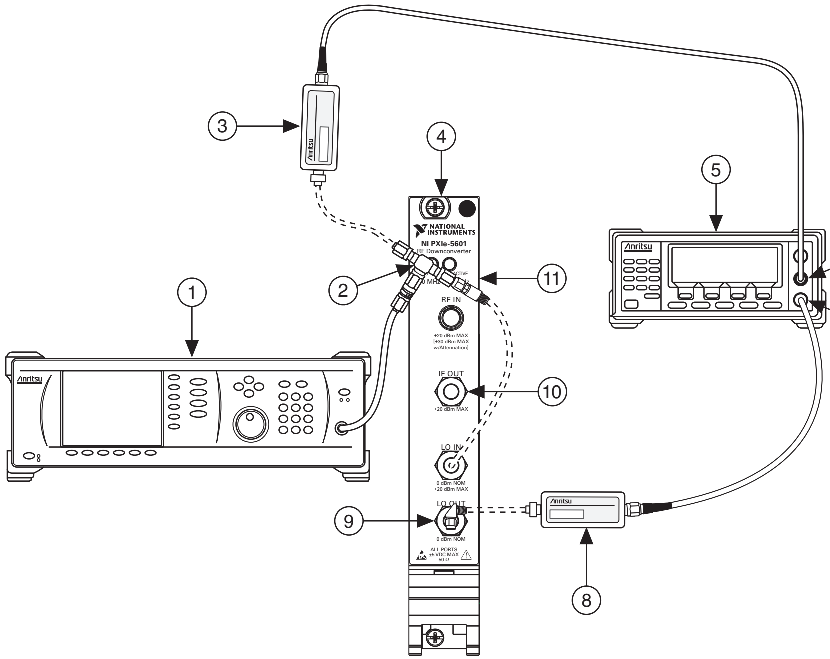
Frequency	As-Found Limit	As-Left Limit
10 MHz to <30 MHz	<-159 dBm/Hz	<-160 dBm/Hz
30 MHz to <120 MHz	<-159 dBm/Hz	<-160 dBm/Hz
120 MHz to <3 GHz	<-155 dBm/Hz	<-156 dBm/Hz
3 GHz to <5 GHz	<-153 dBm/Hz	<-154 dBm/Hz
5 GHz to 6.6 GHz	<-151 dBm/Hz	<-152 dBm/Hz

LO Output Power Verification

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 a 50 Ω terminator to the NI 5601 IF OUT connector.
4. Connect the other power splitter output to the NI 5601 LO IN connector through the 3.5 mm-to-3.5 mm adapter.

5. Connect power sensor B to the NI 5601 LO OUT connector through the SMA (m)-to-SMA (f) right angle adapter. Figure 6 shows the completed equipment setup.

Figure 6. LO Output Equipment Connections



1	RF Source	5	Power Meter	9	Right-Angle Adapter
2	Power Splitter	6	Power Meter Channel A	10	50 Ω Terminator
3	Power Sensor A	7	Power Meter Channel B	11	Adapter
4	LO Source	8	Power Sensor B		

6. Create a new session for the NI 5601 using the niRFSA Initialize With Options VI or the `niRFSA_initWithOptions` function. Set the Driver Setup portion of the **option string** parameter to `DriverSetup=Digitizer:<external>`.
7. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSA Configure Ref Clock VI or the `niRFSA_ConfigureRefClock` function.
8. Set the NI 5601 center frequency according to Table 12 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the `niRFSA_ConfigureSpectrumFrequencyCenterSpan` function. Set the **span** parameter to 100 Hz.

Table 12. NI 5601 Center Frequency

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

9. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
10. Set the RF source to the same frequency you used for the NI 5601 center frequency according to Table 12.
11. At each NI 5601 center frequency, perform the following steps:
    a. Adjust the RF source power, in dBm, to satisfy the following equation:

       Channel A Power + *RF Input Calibration Factor* = 0 dBm ±0.5 dB

       When making the adjustment, use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.
    b. Wait at least 200 ms.
    c. Measure and record the channel B power. This value is the *LO Output Power*. Use the appropriate RF frequency from Table 12 for the channel B sensor.
12. Compare the *LO Output Power* to the test limit in Table 13.
13. Repeat steps 8 to 12 for all frequencies in Table 12.

Note NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

14. Close the NI 5601 session using the niRFSA Close VI or the `niRFSA_close` function.

Table 13. LO Output Verification Test Limits

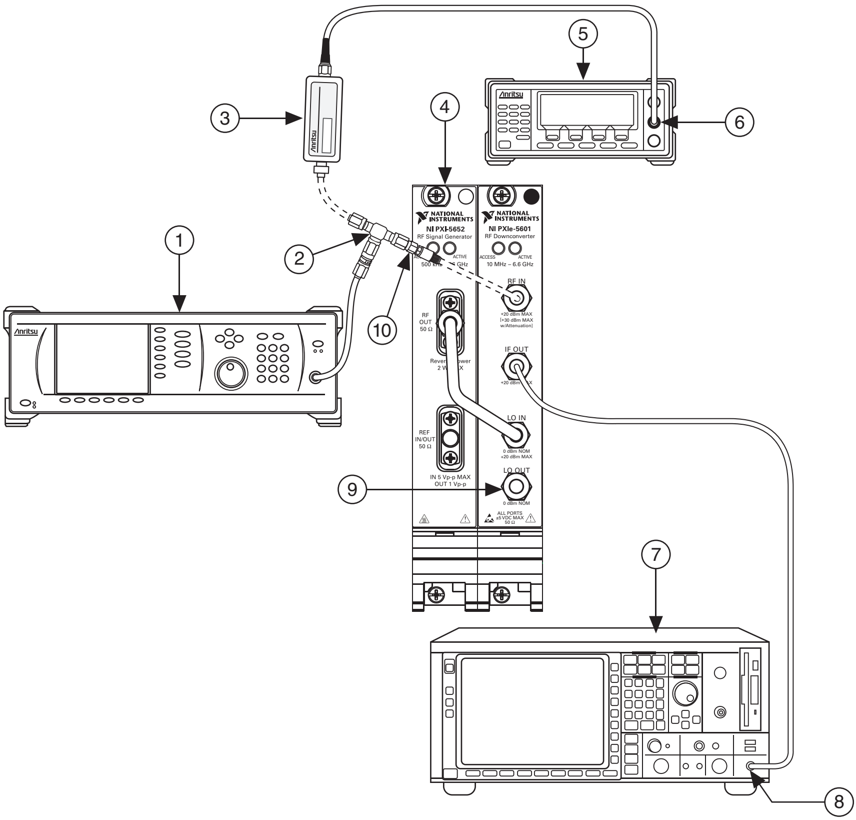
Frequency	As-Found or As-Left Limit
110 MHz to 6.6 GHz	0 dBm ±3.5 dB (nominal)
Note: LO Input Power = 0 dBm ±0.5 dB.	

Instantaneous Bandwidth Verification

1. Connect the NI 5601 IF OUT connector to the spectrum analyzer input through the 3.5 mm-to-3.5 mm cable.
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. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.

5. Connect the other power splitter output to the NI 5601 through the 3.5 mm-to-3.5 mm adapter. Figure 7 shows the completed equipment setup.

Figure 7. Instantaneous Bandwidth Equipment Setup



1	RF Source	5	Power Meter	8	Spectrum Analyzer Input
2	Power Splitter	6	Power Meter Ch A	9	50 Ω Terminator
3	Power Sensor A	7	Spectrum Analyzer	10	Adapter
4	LO Source				

Note The figure shows the NI PXI-5652, but you can also use the NI PXIe-5652.

6. Create a new session for the NI 5601 using the niRFSA Initialize With Options VI or the `niRFSA_initWithOptions` function. Set the Driver Setup portion of the **option string** parameter to `DriverSetup=Digitizer:<external>`.
7. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSA Configure Ref Clock VI or the `niRFSA_ConfigureRefClock` function.

8. Set the NI 5601 reference level according to Table 14 using the niRFSA Configure Reference Level VI or the `niRFSA_ConfigureReferenceLevel` function.

Table 14. NI 5601 Settings (All Frequencies)

NI 5601 Parameter	Value
Reference Level	0 dBm
Span	5 MHz

9. Set the NI 5601 center frequency to the *RF Input Frequency* shown in Table 15 and set the span according to Table 14 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 Initiate VI or the `niRFSA_Initiate` function.
11. Set the RF source to the *RF Input Frequency* shown in Table 15.

Table 15. Frequencies

RF Input Frequency (MHz)	IF Output Frequency (MHz)	NI 5601 Center Frequency		
		Start (MHz)	Stop (MHz)	Number of Points
50	187.5	45	55	21
200	53	190	210	41
1,000	187.5	975	1,025	101

12. Adjust the RF source power, in dBm, to satisfy the following equation:

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

When making the adjustment, use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.

13. Set the spectrum analyzer using the following settings:
    - Reference level: 10 dBm
    - Frequency span: 1 kHz
    - Resolution bandwidth: 1 kHz
    - Video bandwidth: 200 Hz
    - Number of averages: 10
14. Set the spectrum analyzer center frequency to the *IF Output Frequency* listed in Table 15.
15. Record the spectrum analyzer peak marker power as *Spectrum Analyzer Power at IF Center Frequency*. You do not need to correct this reading for the *IF Calibration Factor*.

16. Set the NI 5601 center frequency according to the *NI 5601 Center Frequency* value in Table 15 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the `niRFSA_ConfigureSpectrumFrequencyCenterSpan` function.
17. Tune the spectrum analyzer to a frequency that satisfies the following equation:

Spectrum Analyzer Frequency = *IF Output Frequency* - *RF Input Frequency* + *NI 5601 Center Frequency*

18. Record the spectrum analyzer peak marker power as *Spectrum Analyzer Power*. You do not need to correct this reading for the *IF Calibration Factor*.
19. Normalize the response to the appropriate IF output frequency to satisfy the following equation:

NI 5601 Normalized Response = (*Spectrum Analyzer power*) - (*Spectrum Analyzer Power at IF Center Frequency*)

20. Compare the *NI 5601 Normalized Response* to the test limits in Table 16.
21. Repeat steps 16 to 20 for all NI 5601 center frequency values for the given *IF Output Frequency* (row) in Table 15.
22. Repeat steps 9 to 21 for all IF output frequencies in Table 15.

Note NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

23. Close the NI 5601 session using the niRFSA Close VI or the `niRFSA_close` function.

Table 16. Instantaneous Bandwidth Verification Test Limits

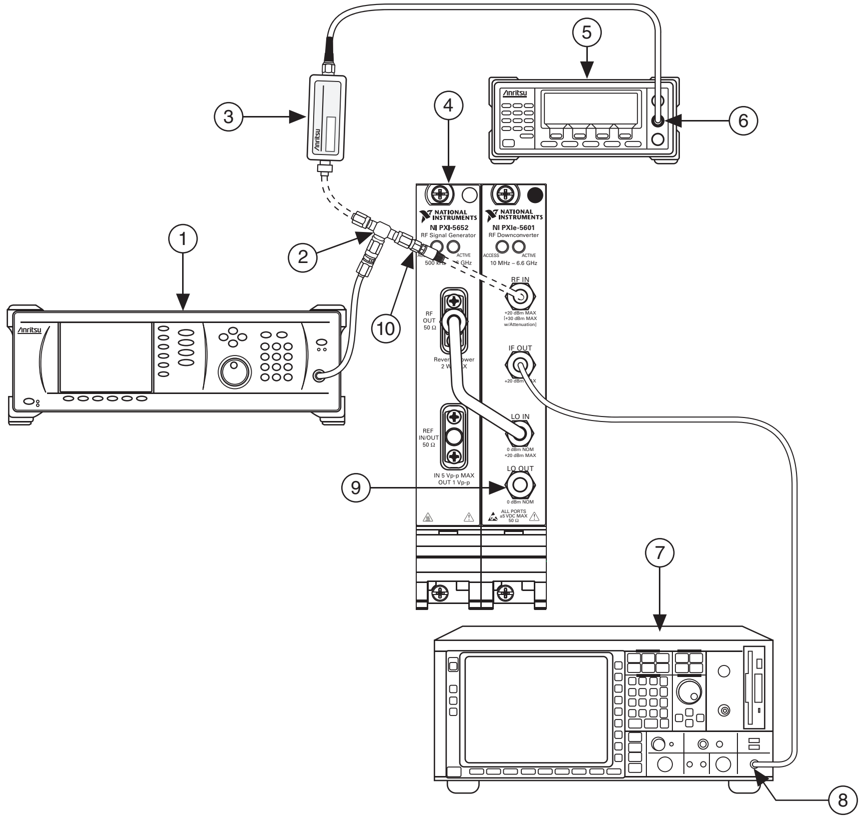
RF Frequency	IF Output Frequency	IF Response (Relative to IF Output Frequency)	
		As-Found Limit	As-Left Limit
10 MHz to <120 MHz	187.5 MHz	±3.0 dB over ±2.5 MHz ±6.0 dB over ±5 MHz	±5.9 dB over -5 MHz to <-2.5 MHz ±2.9 dB over ±2.5 MHz ±5.9 dB over >2.5 MHz to 5 MHz
120 MHz to <330 MHz	53 MHz	±3.0 dB over ±10 MHz	±2.9 dB over ±10 MHz
330 MHz to 6.6 GHz	187.5 MHz	±3.0 dB over ±25 MHz	±2.9 dB over ±25 MHz

Gain Compression Verification

1. Connect the NI 5601 IF OUT connector to the spectrum analyzer input through the 3.5 mm-to-3.5 mm cable.
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. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.
5. Connect the other power splitter output to the NI 5601 RF IN connector through the 3.5 mm-to-3.5 mm adapter. Figure 8 shows the completed equipment setup.

Figure 8. Gain Compression Equipment Setup



1	RF Source	5	Power Meter	8	Spectrum Analyzer Input
2	Power Splitter	6	Power Meter Channel A	9	50 Ω Terminator
3	Power Sensor A	7	Spectrum Analyzer	10	Adapter
4	LO Source				

Note The figure shows NI PXI-5652, but you can also use NI PXIe-5652.

6. Create a new session for the NI 5601 using the niRFSA Initialize With Options VI or the `niRFSA_initWithOptions` function. Set the Driver Setup portion of the **option string** parameter to `DriverSetup=Digitizer:<external>`.

7. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSA Configure Ref Clock VI or the `niRFSA_ConfigureRefClock` function.
8. Set the NI 5601 reference level to -10 dBm using the niRFSA Configure Reference Level VI or the `niRFSA_ConfigureReferenceLevel` function.
9. Set the NI 5601 center frequency according to Table 17 using the Center Span instance of the niRFSA Configure Spectrum Frequency VI or the `niRFSA_ConfigureSpectrumFrequencyCenterSpan` function. Set the **span** parameter to 2 MHz.

Table 17. NI 5601 Center Frequency

Start (MHz)	Stop (MHz)	Step (MHz)
10	—	—
20	—	—
40	—	—
80	—	—
100	—	—
500	6,500	500

10. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
11. Set the spectrum analyzer using the following settings:
    - Reference level: 20 dBm
    - Frequency span: 10 kHz
    - Resolution bandwidth: 1 kHz
    - Video bandwidth: 500 Hz
    - Center frequency: Refer to Table 18

Table 18. NI 5601 IF Output Frequency

NI 5601 Center Frequency	NI 5601 IF Output Frequency (Spectrum Analyzer Center Frequency)
10 MHz to <120 MHz	187.5 MHz
120 MHz to < 330 MHz	53 MHz
330 MHz to 6.6 GHz	187.5 MHz

12. Set the RF source to the center frequency in Table 17.
13. Wait at least 1 second.

14. Adjust the RF source power, in dBm, so that the channel A power reads 20 dB below the 1 dB compression point listed in Table 19. You do not need to correct the channel A power for the RF frequency.
15. Record the *Spectrum Analyzer Power*. You do not need to correct the spectrum analyzer power with the *IF Correction Factor*.
16. Calculate the NI 5601 measured gain using the following formula:

    Measured Gain = Spectrum Analyzer Power - Channel A Power

17. Repeat steps 14 to 16 with 1 dB higher RF source power. The gain calculated in step 16 becomes the *Current Measured Gain*. The gain calculated in the previous iteration becomes the *Previous Measured Gain*.
18. Calculate the *Gain Change* using the following formula:

    Gain Change = Current Measured Gain - Previous Measured Gain

19. Repeat steps 14 to 18 until the *Gain Change* equals -1 dB or less (more negative). You can repeat Steps 14 to 18 with a finer power increment in step 17 to obtain more accurate results.
20. Correct the last channel A power measured in step 14 using the following formula:

    Input Compression Point = Channel A Power + RF Input Calibration Factor

    Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.
21. Compare the *Input Compression Point* to the verification test limits in Table 19.
22. Repeat steps 1 to 21 for all the frequencies in Table 17.

> **Note** NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

23. Close the NI 5601 session using the niRFSA Close VI or the `niRFSA_close` function.

Table 19. Gain Compression Verification Test Limits

Frequency	1 dB Compression Fine
10 MHz to <120 MHz	>-2 dBm
120 MHz to <330 MHz	>2 dBm
330 MHz to 6.6 GHz	>6 dBm
Note: At RF input, -10 dBm reference level.	

Adjustment

Following the adjustment procedure automatically updates the calibration date and temperature in the EEPROM of the NI 5601. The calibration date also updates when you call the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function and the niRFSA Close Ext Cal VI or the `niRFSA_CloseExtCal` function.

Note NI recommends a complete adjustment of your device to renew the calibration interval. However, if you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling only the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function and the niRFSA Close Ext Cal VI or the `niRFSA_CloseExtCal` function.

Adjustment corrects the following NI 5601 specifications:

1. Reference level for RF frequencies ≥120 MHz
2. IF attenuation
3. IF response
4. Reference level for RF frequencies ≤120 MHz

Note These four steps must be done in order, and all four steps must be completed before the NI 5601 adjustment is complete.

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.

Initial Connections

Refer to the *NI 5661/5663/5663E RF Vector Signal Analyzers Getting Started Guide* for information about how to install the NI 5601 and the LO source.

Create Calibration Session

1. Create a new calibration session for the NI 5601 using the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function.

Note This first step opens a new calibration session. Enter the appropriate password for this VI. The default password for password-protected operations is `NI`.

Reference Level Adjustment for RF Frequencies ≥120 MHz

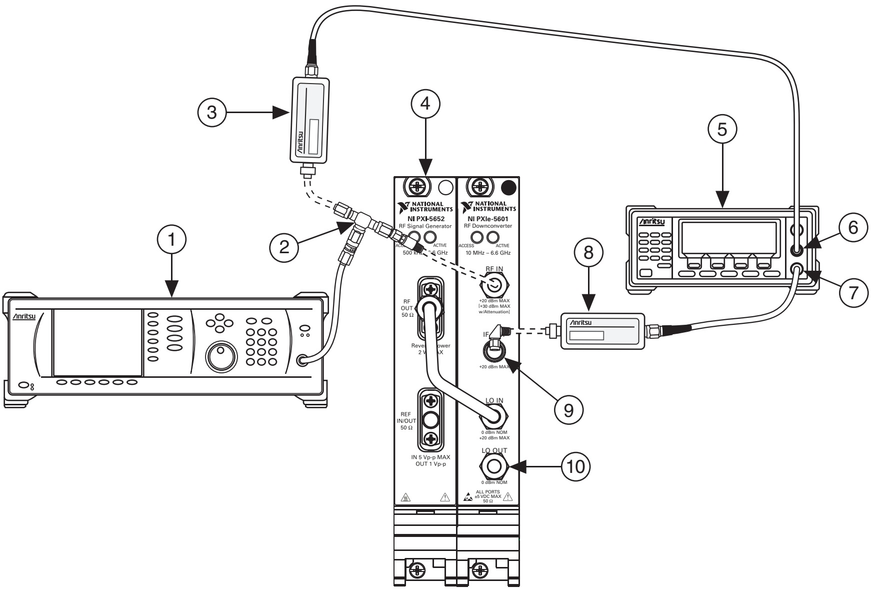
During operation, the NI 5601 uses a lookup table to determine the appropriate RF attenuation and gain and IF attenuation settings to use at a given reference level and RF frequency. After the RF and IF gain and attenuations are found, the NI 5601 determines the appropriate amplitude correction for those settings.

This procedure determines amplitude corrections for the RF attenuation and gain states. Those corrections are stored in the NI 5601.

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-to-3.5 mm adapter.
4. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.
5. Connect the NI 5601 IF OUT connector to the power meter input.

   Figure 9 shows the completed equipment setup.

Figure 9. IF Attenuation Adjustment Equipment Connections



1	RF Source	5	Power Meter	9	Right Angle Adapter
2	Power Splitter	6	Power Meter Channel A	10	50 Ω Terminator
3	Power Sensor A	7	Power Meter Channel B		
4	LO Source	8	Power Sensor B		

Note The figure shows the NI PXI-5652, but you can also use the NI PXIe-5652.

6. Create a new calibration session for the NI 5601 using the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function. Set the `driverSetup` string of the **option string** parameter to `calAction: create`.

Note Each step opens a new calibration session. Enter the appropriate password for this VI. The default password for password-protected operations is `NI`.

Initialize the reference level calibration step using the niRFSA Initialize Calibration Step VI or the `niRFSA_InitializeCalibrationStep` function. Set the **calibration step** parameter in the VI to **Ref Level Calibration**, or set the **calibrationStep** parameter in the function to `NIRFSA_VAL_EXT_CAL_REF_LEVEL_CALIBRATION`.

7. Initialize the NI PXI/PXIe-5652 using the niRFSG Initialize VI or the `niRFSG_init` function.
8. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSG Configure Ref Clock VI or the `niRFSG_ConfigureRefClock` function.
9. Set the NI PXI/PXIe-5652 power level to 0 dBm using the niRFSG Power Level property or the `NIRFSG_ATTR_POWER_LEVEL` attribute.
10. Set the NI PXI/PXIe-5652 frequency to 187.5 MHz using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
11. Commit the settings to hardware using the niRFSG Initiate VI or the `niRFSG_Initiate` function.
12. Call the niRFSA Initiate VI or the `niRFSA_Initiate` function.
13. Read the *Initial Device Temperature* using the niRFSA Device Temperature property or the `NIRFSA_ATTR_DEVICE_TEMPERATURE` attribute. You should take the temperature reading only once, before taking any measurements. Record the *Initial Device Temperature* for use in step 35.
14. Configure the NI 5601 RF signal path by setting the niRFSA RF Path Selection property or the `NIRFSA_ATTR_CAL_RF_PATH_SELECTION` attribute to the *RF Band* according to Table 20.

Table 20. NI 5601 Center Frequency

RF Attenuation Index	Mechanical Attenuator	RF Band	IF Frequency (MHz)	RF		LO		Step Size (MHz)
				Start (MHz)	Stop (MHz)	Start (MHz)	Stop (MHz)	
0-64	Enabled	3	53	120	200	173	253	10
		3		220	300	273	353	20
		3		330	—	383	—	—
		2	187.5	330	501	517.5	688.5	57
		2		600	1,800	787.5	1,987.5	100
		2		1,950	3,000	2,137.5	3,187.5	150
		1		3,000	5,700	2,812.5	5,512.5	150
		1		5,800	6,600	5,612.5	6,412.5	100

Table 20. NI 5601 Center Frequency (Continued)

RF Attenuation Index	Mechanical Attenuator	RF Band	IF Frequency (MHz)	RF		LO		Step Size (MHz)
				Start (MHz)	Stop (MHz)	Start (MHz)	Stop (MHz)	
44, 64	Disabled	3	187.5	120	200	173	253	10
		3		220	300	273	353	20
		3		330	—	383	—	—
		2		330	501	517.5	688.5	57
		2		600	1,800	787.5	1,987.5	100
		2		1,950	3,000	2,137.5	3,187.5	150
		1		3,000	5,700	2,812.5	5,512.5	150
		1		5,800	6,600	5,612.5	6,412.5	100

15. Configure the NI 5601 center frequency by setting the niRFSA Center Frequency property or the `NIRFSA_ATTR_SPECTRUM_CENTER_FREQUENCY` attribute using the RF start frequency shown in Table 20.
16. Set the niRFSA LO Injection Side property or the `NIRFSA_ATTR_LO_INJECTION_SIDE` attribute according to the following list for the RF band being used:
    - For RF Band 1, set to **Low Side** (or `NIRFSA_VAL_LOW_SIDE`)
    - For RF Band 2, set to **High Side** (or `NIRFSA_VAL_HIGH_SIDE`)
    - For RF Band 3, set to **High Side** (or `NIRFSA_VAL_HIGH_SIDE`)
17. Set the niRFSA IF Filter property or the `NIRFSA_ATTR_IF_FILTER` attribute according to the following list for the RF band being used:
    - For RF Band 1, set to **187.5 MHz Wide** (or `NIRFSA_VAL_187_5_MHZ_WIDE`)
    - For RF Band 2, set to **187.5 MHz Wide** (or `NIRFSA_VAL_187_5_MHZ_WIDE`)
    - For RF Band 3, set to **53 MHz** (or `NIRFSA_VAL_53_MHZ`)
18. Set the niRFSA IF1 Attenuation property or the `NIRFSA_ATTR_IF1_ATTEN_VALUE` attribute to 0.
19. Set the niRFSA IF2 Attenuation property or the `NIRFSA_ATTR_IF2_ATTEN_VALUE` attribute to 0.
20. Set the niRFSA RF Attenuation Table property or the `NIRFSA_ATTR_RF_ATTENUATION_TABLE` attribute to 1.
21. Set the niRFSA RF Attenuation Index property or the `NIRFSA_ATTR_RF_ATTENUATION_INDEX` attribute to the index listed in Table 30.
22. Set the niRFSA Mechanical Attenuator Enabled property or the `NIRFSA_ATTR_MECHANICAL_ATTENUATOR_ENABLED` attribute according to Table 20.
23. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
24. Tune the RF source to the RF start frequency in Table 20.

25. Set the RF source power using the value from Table 30 for the RF attenuation index being used.
26. Configure the NI PXI/PXIe-5652 frequency to the LO start frequency shown in Table 20 using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
27. Wait 750 ms or until power sensor A settles to 0.1% of source power, whichever is greater.
28. Measure the *Channel A Power*. Calculate *RF Power* using the following equation:

    RF Power = *Channel A Power* + *RF Input Calibration Factor*

    Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.
29. Measure and record the *IF Power* using power sensor B. Use the appropriate *IF Frequency* from Table 20.
30. Calculate *Gain* using the following formula:

    Gain = *IF Power* - *RF Power*

31. Store the appropriate calibration constants using the niRFSA Cal Adjust Reference Level Calibration VI or the `niRFSA_CalAdjustRefLevelCalibration` function. Set the following parameters:
    - **ref level cal data type**—If *Mechanical Attenuator* from Table 20 is Enabled, set to **Default** (or `NIRFSA_VAL_DEFAULT`). Otherwise, set to **Mechanical Attenuator Disabled** (or `NIRFSA_VAL_EXT_CAL_MECHANICAL_ATTENUATOR_DISABLED`).
    - **RF band**—Refer to Table 20.
    - **attenuator table number**—1.
    - **frequency**—Set to the corresponding frequency from step 15.
    - **gain**—Computed in step 30.
32. Increment the RF start frequency and the LO start frequency by the specified *Step Size* from Table 20. Repeat steps 14 to 31 for each RF frequency starting with 120 MHz up to and including 6.6 GHz.

Note Be sure to include the start and stop frequencies for each row before moving to the next row in the table. This set of iterations should include rows 1 through 8 of Table 20.

33. Repeat steps 14 to 32 for each *RF Attenuation Index* shown for the first eight rows of Table 20.

Note NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

34. Repeat steps 14 to 32 for the last eight rows of Table 20, setting the niRFSA Mechanical Attenuator Enabled property or the `NIRFSA_ATTR_MECHANICAL_ATTENUATOR_ENABLED` attribute as indicated in the table.
35. Read the device temperature using the niRFSA Device Temperature property or the `NIRFSA_ATTR_DEVICE_TEMPERATURE` attribute. Average this reading with the temperature reading from step 13. Record this average for use in the *Reference Level Adjustment for RF Frequencies ≤120 MHz* section.
36. Close the NI 5601 Reference Level Calibration step using the niRFSA Close Calibration Step VI or the `niRFSA_CloseCalibrationStep` function.
37. Close the external calibration by calling the niRFSA Close Ext Cal VI with the **action** parameter set to **Commit** or by calling the `niRFSA_CloseExtCal` function with the **action** parameter set to `NIRFSA_VAL_EXT_CAL_COMMIT`.
38. Close the niRFSG session using the niRFSG Close VI or the `niRFSG_close` function.

IF Attenuation Calibration Adjustment

During operation, the NI 5601 uses a lookup table to determine the appropriate RF attenuation and gain and IF attenuation settings to use at a given reference level and RF frequency. When the RF and IF gain and attenuations are found, the NI 5601 determines the appropriate amplitude correction for those settings.

This procedure determines amplitude corrections for the IF attenuation. Those corrections are stored in the NI 5601.

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-to-3.5 mm adapter.
4. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.
5. Connect the NI 5601 IF OUT connector to power sensor B. Figure 9 shows the completed equipment setup.
6. Create a new calibration session for the NI 5601 using the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function. Set the `driverSetup` string of the **option string** parameter to `calAction: create`.

Note Each step opens a new calibration session. Enter the appropriate password for this VI. The default password for password-protected operations is `NI`.

7. Initialize the IF Attenuation Calibration step using the niRFSA Initialize Calibration Step VI or the `niRFSA_InitializeCalibrationStep` function. Set the **calibration step** parameter in the VI to **IF Attenuation Calibration**, or set the **calibrationStep** parameter in the function to `NIRFSA_VAL_EXT_CAL_IF_ATTENUATION_CALIBRATION`.
8. Initialize the NI PXI/PXIe-5652 using the niRFSG Initialize VI or the `niRFSG_init` function.

9. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSG Configure Ref Clock VI or the `niRFSG_ConfigureRefClock` function.
10. Set the NI PXI/PXIe-5652 power level to 0 dBm using the niRFSG Power Level property or the `NIRFSG_ATTR_POWER_LEVEL` attribute.
11. Set the NI PXI/PXIe-5652 frequency to 187.5 MHz using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
12. Commit the settings to hardware using the niRFSG Initiate VI or the `niRFSG_Initiate` function.
13. Call the niRFSA Initiate VI or the `niRFSA_Initiate` function.
14. Tune the RF source to the RF Frequency in Table 21.

Table 21. NI 5601 Center Frequency

IF Filter	RF Frequency	LO Frequency	RF Band
53 MHz	200 MHz	253 MHz	3
187.5 MHz, Narrow	1 GHz	1,187.5 MHz	2
187.5 MHz, Wide	1 GHz	1,187.5 MHz	2

15. Configure the NI 5601 RF signal path by setting the niRFSA RF Path Selection property or the `NIRFSA_ATTR_CAL_RF_PATH_SELECTION` attribute according to the value referenced in Table 21 to the corresponding values:
    - RF band 2
    - RF band 3
16. Configure the IF filter by setting the niRFSA IF Filter property or the `NIRFSA_ATTR_IF_FILTER` attribute according to the value referenced in Table 21 to the corresponding values:
    - 53 MHz
    - 187.5 MHz, narrow
    - 187.5 MHz, wide
17. Configure the NI 5601 center frequency by setting the niRFSA Center Frequency property or the `NIRFSA_ATTR_SPECTRUM_CENTER_FREQUENCY` attribute using the *RF Frequency* shown in Table 21.
18. Set the RF source power to -32 dBm.
19. Configure the NI PXI/PXIe-5652 frequency to the *LO Frequency* shown in Table 21 using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
20. Wait 750 ms or until power sensor A settles to 0.1% of source power, whichever is greater.
21. Configure the IF attenuation for the device by setting the niRFSA IF1 Attenuation and IF2 Attenuation properties or the `NIRFSA_ATTR_IF1_ATTEN_VALUE` and `NIRFSA_ATTR_IF2_ATTEN_VALUE` attributes. This configuration ensures that Table 22 references all possible value pairs for IF1 and IF2.

22. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
23. Wait 200 ms.
24. Measure the *Channel A Power*. Calculate *RF Power* using the following equation:

    RF Power = Channel A Power + RF Input Calibration Factor

    Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.
25. Measure and record the channel B power. This value is the *IF Power*. Make this measurement using the appropriate IF frequency for the channel B sensor.
26. Calculate *Gain* using the following formula:

    Gain = IF Power - RF Power

27. Store the appropriate calibration constants using the niRFSA Cal Adjust IF Attenuation Calibration VI or the `niRFSA_CalAdjustIFAttenuationCalibration` function. You must provide the following information:
    - IF filter
    - Attenuation settings in a two-element array [IF1, IF2]
    - *Gain* from step 26
28. Repeat steps 21 to 27 for all possible combinations of IF attenuation settings from the valid values in Table 22.

Note NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

Table 22. IF Attenuator Settings

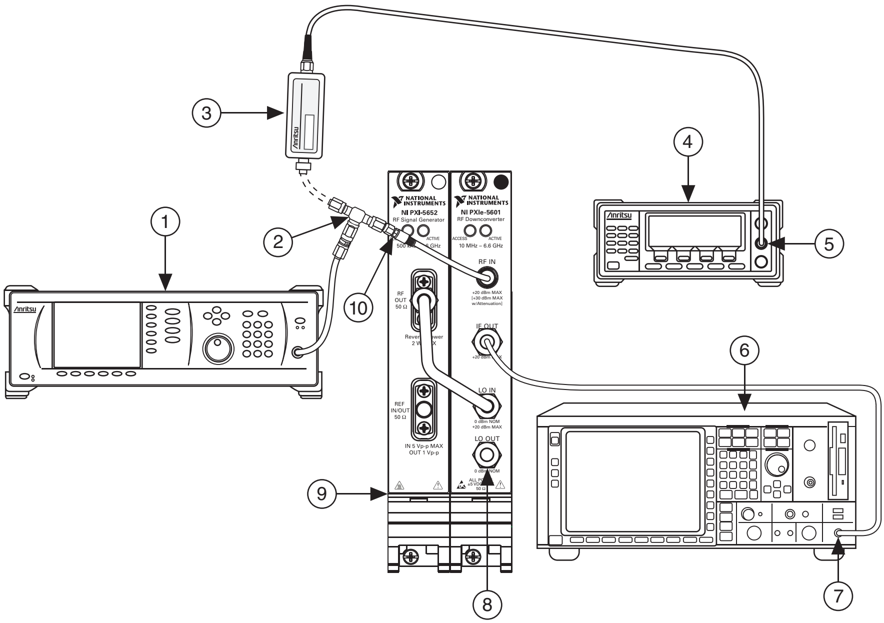
IF1 Attenuator	IF2 Attenuator
0 dB to 15 dB in 1 dB steps	0 dB to 15 dB in 1 dB steps

29. Repeat steps 14 to 28 for all *IF Filters* in Table 21.
30. Close the NI 5601 IF attenuation calibration step using the niRFSA Close Calibration Step VI or the `niRFSA_CloseCalibrationStep` function.
31. Close the external calibration by calling the niRFSA Close Ext Cal VI with the **action** parameter set to **Commit** or by calling the `niRFSA_CloseExtCal` function with the **action** parameter set to `NIRFSA_VAL_EXT_CAL_COMMIT`.
32. Close the niRFSG session using the niRFSG Close VI or the `niRFSG_close` function.

IF Response Adjustment

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-to-3.5 mm adapter.
4. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.
5. Connect the NI 5601 IF OUT connector to the spectrum analyzer through the 3.5 mm-to-3.5 mm cable. Figure 10 shows the completed equipment setup.

Figure 10. Equipment Connections



1	RF Source	5	Power Meter Channel A	8	50 Ω Terminator
2	Power Splitter	6	Spectrum Analyzer	9	LO Source
3	Power Sensor A	7	Spectrum Analyzer Input	10	Adapter
4	Power Meter				

Note The figure shows the NI PXI-5652, but you can also use the NI PXIe-5652.

6. Create a new calibration session for the NI 5601 using the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function. Set the `driverSetup` string of the **option string** parameter to `calAction: create`.

Note Each step opens a new calibration session. Enter the appropriate password for this VI. For password-protected operations, the default password is `NI`.

7. Initialize the IF Response calibration step using the niRFSA Initialize Calibration Step VI or the `niRFSA_InitializeCalibrationStep` function. Set the **calibration step** parameter in the VI to **IF Response Calibration**, or set the **calibrationStep** parameter in the function to `NIRFSA_VAL_EXT_CAL_IF_RESPONSE_CALIBRATION`.
8. Initialize the NI PXI/PXIe-5652 using the niRFSG Initialize VI or the `niRFSG_init` function.
9. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSG Configure Ref Clock VI or the `niRFSG_ConfigureRefClock` function.
10. Set the NI PXI/PXIe-5652 power level to 0 dBm using the niRFSG Power Level property or the `NIRFSG_ATTR_POWER_LEVEL` attribute.
11. Set the NI PXI/PXIe-5652 frequency to 187.5 MHz using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
12. Commit the settings to hardware using the niRFSG Initiate VI or the `niRFSG_Initiate` function.
13. Call the niRFSA Initiate VI or the `niRFSA_Initiate` function.
14. Configure the NI 5601 RF signal path to the following corresponding values by setting the niRFSA RF Path Selection property or the `NIRFSA_ATTR_CAL_RF_PATH_SELECTION` attribute according to the value referenced in Table 23 or 24 that corresponds to the module revision of your NI 5601.
    - RF band 2
    - RF band 3

Table 23. IF Response Settings (NI 5601 Module Revisions Prior to Revision G)

IF Filter	RF Freq. (MHz)	NI 5652 LO Start Freq. (MHz)	NI 5652 LO Stop Freq. (MHz)	NI 5652 LO Freq. Step (MHz)	NI 5601 LO Freq. (MHz)	IF1 Atten. (dB)	IF2 Atten. (dB)	RF Band
187.5 MHz, Wide	1,000	1,277.5	1,097.5	1	187.5	8	3	2
187.5 MHz, Narrow	1,000	1,227.5	1,147.5	1	187.5	8	3	2
53 MHz	200	283	223	0.5	53	14	8	3

Table 24. IF Response Settings (NI 5601 Module Revisions G and Later)

IF Filter	RF Freq. (MHz)	NI 5652 LO Start Freq. (MHz)	NI 5652 LO Stop Freq. (MHz)	NI 5652 LO Freq. Step (MHz)	NI 5601 LO Freq. (MHz)	IF1 Atten. (dB)	IF2 Atten. (dB)	RF Band
187.5 MHz, Wide	1,000	1,307.5	1,067.5	1	187.5	8	3	2
187.5 MHz, Narrow	1,000	1,227.5	1,147.5	1	187.5	8	3	2
53 MHz	200	305	201	0.5	53	8	3	3

15. Configure the IF filter by setting the niRFSA IF Filter property or the `NIRFSA_ATTR_IF_FILTER` attribute to the IF bandwidth value referenced in Table 23 or 24, corresponding to the module revision of your NI 5601, for each of the following filters:
    - 187.5 MHz, wide
    - 187.5 MHz, narrow
    - 53 MHz
16. Configure the IF attenuation for the device by setting the niRFSA IF1 Attenuation and IF2 Attenuation properties or the `NIRFSA_ATTR_IF1_ATTEN_VALUE` and the `NIRFSA_ATTR_IF1_ATTEN_VALUE` attributes. Use the values referenced from Table 23 or 24, corresponding to the module revision of your NI 5601.
17. Configure the NI 5601 center frequency by setting the niRFSA Center Frequency property or the `NIRFSA_ATTR_SPECTRUM_CENTER_FREQUENCY` attribute. Use the RF frequency shown in Table 23 or 24, corresponding to the module revision of your NI 5601.
18. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
19. Configure the spectrum analyzer using the settings shown in Table 25.

Table 25. Spectrum Analyzer Settings

Parameter	Value
Center frequency	*NI 5601 LO frequency - NI 5601 center frequency*
Span	10 Hz
Reference level	20 dBm
Resolution bandwidth	200 Hz

20. Set the RF source frequency to the *RF Frequency* in Table 23 or 24, corresponding to the module revision of your NI 5601.

21. Configure the NI PXI/PXIe-5652 frequency to the *NI 5652 LO Frequency* shown in Table 23 or 24, corresponding to the module revision of your NI 5601. Use the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
22. Set the *RF Source Power*, in dBm, using the following formula and the IF1 and IF2 attenuation values as found in step 16:

    RF Source Power = (IF1 Attenuation + IF2 Attenuation) - 36

23. Use the appropriate frequency for the channel A sensor.
24. Wait 750 ms or until power sensor A settles to 0.1% of the source power, whichever is greater.
25. Read the channel A power. Calculate the *RF Power* using the following formula. Calculation of the *RF Input Calibration Factor* may require linear interpolation.

    RF Power = Channel A Power + RF Input Calibration Factor

26. Measure the output power using the spectrum analyzer. This value is the *IF Power*.

Note To reduce the amount of noise in the spectrum analyzer measurement without sacrificing test time, NI recommends using the following adaptive averaging methodology at each measurement point:

1. Take a measurement with the spectrum analyzer set to zero span. If your analyzer does not support zero span, use a span of 10 Hz.
2. Based on this first measurement, reconfigure the spectrum analyzer as shown in Table 26 and take another reading to obtain the final measurement value. Span is always set to either zero span or 10 Hz.

Table 26. Spectrum Analyzer Settings

First Measurement	Reference Level	Resolution Bandwidth	Samples to Average
-10 dBm	20 dBm	100 Hz	5
<-10 dBm, -40 dBm	0 dBm	200 Hz	10
<-40 dBm	0 dBm	200 Hz	20

27. Calculate *Gain* using the following formula:

    Gain = IF Power - RF Power

28. Repeat steps 20 to 27 for all the LO frequencies for the corresponding *IF Filter* in Table 23 or 24, depending on the module revision of your NI 5601. Store the gain values computed in step 27 in an array. You can repeat steps 19 through 27 with the first spectrum analyzer measurement at a reference level similar to the second measurement. This repetition reduces internal attenuator switching. The second measurement must follow the settings in Table 26.

29. The array from step 28 contains absolute gain data centered about the IF center frequency. Normalize this array to the gain at the IF center frequency. The normalized gain at the center point of the array is 0 dB and reverses the array.
30. Record the normalized gain array from step 29 in the NI 5601 EEPROM using the niRFSA Cal Adjust IF Response Calibration VI or the `niRFSA_CalAdjustIFResponseCalibration` function.

    You must provide the following information:

    - IF filter
    - Bandwidth—Shown in Tables 27 or 28, depending on the module revision of your NI 5601.

Table 27. NI 5601 Bandwidth (NI 5601 Prior to Module Revision G)

IF Filter Value	Bandwidth
187.5 MHz, Wide	180 MHz
187.5 MHz, Narrow	80 MHz
53 MHz	60 MHz

Table 28. NI 5601 Bandwidth (NI 5601 Module Revision G and Later)

IF Filter Value	Bandwidth
187.5 MHz, Wide	240 MHz
187.5 MHz, Narrow	80 MHz
53 MHz	104 MHz

    - RF frequency used for the measurements
    - Normalized gain array computed from step 29

31. Repeat steps 14 to 30 for all the *IF Filters* listed in Table 23 or 24, corresponding to the module revision of your NI 5601.

Note NI recommends keeping your RF signal generator enabled when repeating steps unless making a connection change. Keeping the signal generator enabled reduces the wear on the RF signal generator relays. After making a connection change and enabling your generator, wait 5 seconds for the system to settle.

32. Close the NI 5601 IF Response Calibration step using the niRFSA Close Calibration Step VI or the `niRFSA_CloseCalibrationStep` function.
33. Close the external calibration by calling the niRFSA Close Ext Cal VI with the **action** parameter set to **Commit** or by calling the `niRFSA_CloseExtCal` function with the **action** parameter set to `NIRFSA_VAL_EXT_CAL_COMMIT`.
34. Close the niRFSG session using the niRFSG Close VI or the `niRFSG_close` function.

Reference Level Adjustment for RF Frequencies ≤120 MHz

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-to-3.5 mm adapter.
4. Ensure that the 50 Ω terminator is connected to the NI 5601 LO OUT connector.
5. Connect the NI 5601 IF OUT connector to the spectrum analyzer input. Figure 10 shows the completed equipment setup.
6. Create a new calibration session for the NI 5601 using the niRFSA Init Ext Cal VI or the `niRFSA_InitExtCal` function. Set the `driverSetup` string of the **option string** parameter to `calAction: append`.

Note Each step opens a new calibration session. Enter the appropriate password for this VI. The default password for password-protected operations is `NI`.

Initialize the Reference Level Calibration step using the niRFSA Initialize Calibration Step VI or the `niRFSA_InitializeCalibrationStep` function. Set the **calibration step** parameter in the VI to **Ref Level Calibration**, or set the **calibrationStep** parameter in the function to `NIRFSA_VAL_EXT_CAL_REF_LEVEL_CALIBRATION`.

7. Initialize the NI PXI/PXIe-5652 using the niRFSG Initialize VI or the `niRFSG_init` function.
8. Lock the NI PXI/PXIe-5652 to the Reference Clock used by the external test equipment. Use the niRFSG Configure Ref Clock VI or the `niRFSG_ConfigureRefClock` function.
9. Set the NI PXI/PXIe-5652 power level to 0 dBm using the niRFSG Power Level property or the `NIRFSG_ATTR_POWER_LEVEL` attribute.
10. Set the NI PXI/PXIe-5652 frequency to 187.5 MHz using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
11. Commit the settings to hardware using the niRFSG Initiate VI or the `niRFSG_Initiate` function.
12. Call the niRFSA Initiate VI or the `niRFSA_Initiate` function.
13. Configure the NI 5601 RF signal path by setting the niRFSA RF Path Selection property to RF band 4 or by setting the `NIRFSA_ATTR_CAL_RF_PATH_SELECTION attribute` to `NIRFSA_VAL_EXT_CAL_RF_BAND_4`.

14. Configure the NI 5601 center frequency by setting the niRFSA Center Frequency property or the `NIRFSA_ATTR_SPECTRUM_CENTER_FREQUENCY` attribute using the RF start frequency shown in Table 29.

Table 29. NI 5601 Center Frequency ≤120 MHz

RF Attenuation Index	Mechanical Attenuator	RF			LO		Step Size (MHz)
		Attenuation Table	Start (MHz)	Stop (MHz)	Start (MHz)	Stop (MHz)	
0-64	Enabled	0	10	30	197.5	217.5	10
		1	30	120	217.5	307.5	10
44, 64	Disabled	0	10	30	197.5	217.5	10
		1	30	120	217.5	307.5	10

15. Set the LO injection side using the niRFSA LO Injection Side property or the `NIRFSA_ATTR_LO_INJECTION_SIDE` attribute. Set the niRFSA LO Injection Side property to **High Side** or the `NIRFSA_ATTR_LO_INJECTION_SIDE` attribute to `NIRFSA_VAL_HIGH_SIDE`.
16. Set the niRFSA IF Filter property to **187.5 MHz Narrow** or the `NIRFSA_ATTR_IF_FILTER` attribute to `NIRFSA_VAL_187_5_MHZ_NARROW`.
17. Set the niRFSA IF1 Attenuation property or the `NIRFSA_ATTR_IF1_ATTEN_VALUE` attribute to 0.
18. Set the niRFSA IF2 Attenuation property or the `NIRFSA_ATTR_IF2_ATTEN_VALUE` attribute to 0.
19. Set the niRFSA RF Attenuation Table property or the `NIRFSA_ATTR_RF_ATTENUATION_TABLE` attribute with the value from the appropriate row of Table 29.
20. Set the niRFSA RF Attenuation Index property or the `NIRFSA_ATTR_RF_ATTENUATION_INDEX` attribute to the index shown in Table 30.
21. Set the niRFSA Mechanical Attenuator Enabled property or the `NIRFSA_ATTR_MECHANICAL_ATTENUATOR_ENABLED` attribute according to Table 29.
22. Commit the settings to hardware using the niRFSA Initiate VI or the `niRFSA_Initiate` function.
23. Tune the RF source to the RF start frequency in Table 29.
24. Set the RF source power using the value from Table 30 for the particular RF attenuation index being used.
25. Configure the NI PXI/PXIe-5652 frequency to the *LO Start* frequency shown in Table 29 using the niRFSG Frequency property or the `NIRFSG_ATTR_FREQUENCY` attribute.
26. Wait 750 ms or until power sensor A settles to 0.1% of source power, whichever is greater.
27. Measure the *Channel A Power*. Calculate *RF Input Power* using the following equation:

$$RF\ Input\ Power = Channel\ A\ Power + RF\ Input\ Calibration\ Factor$$

Use the appropriate RF frequency for the channel A sensor. Calculation of the *RF Input Calibration Factor* may require linear interpolation.

28. Measure and record the *IF Power* using the spectrum analyzer.
    a. Set the spectrum analyzer center frequency to the RF start frequency in Table 29.
    b. Measure the Spectrum Analyzer Power and calculate the *IF Power* value using the following formula:

$$IF\ Power = Spectrum\ Analyzer\ Power + IF\ Calibration\ Factor$$

29. Calculate *Gain* using the following formula:

$$Gain = IF\ Power - RF\ Power$$

30. Store the appropriate calibration constants using the niRFSA Cal Adjust Reference Level Calibration VI or the `niRFSA_CalAdjustRefLevelCalibration` function. Set the following parameters:
    - **ref level cal data type**—If *Mechanical Attenuator* from Table 29 is enabled, set to **Default** (or `NIRFSA_VAL_DEFAULT`). Otherwise, set to **Mechanical Attenuator Disabled** (or `NIRFSA_VAL_EXT_CAL_MECHANICAL_ATTENUATOR_DISABLED`).
    - **RF band**—Set to **4**.
    - **attenuator table number**—Refer to Table 29.
    - **frequency**—Set to the corresponding frequency from step 14.
    - **gain**—You computed this in step 29.
31. Increment the RF start frequency and the LO start frequency by the specified *Step Size* from Table 29. Repeat steps 13 to 30 for each frequency up to and including the RF stop frequency for each RF frequency starting with 10 MHz up to and including 120 MHz for the first two rows of Table 29.
32. Repeat steps 13 to 31 for each *RF Attenuation Index* in the first two rows of Table 29.
33. Repeat steps 13 to 31 for the two remaining rows in Table 29, changing the niRFSA Mechanical Attenuator Enabled property or the `NIRFSA_ATTR_MECHANICAL_ATTENUATOR_ENABLED` attribute as indicated in Table 29.
34. Use the temperature stored in Step 13 of the *Reference Level Adjustment for RF Frequencies ≥120 MHz* section. Record the device temperature using the niRFSA Cal Set Temperature VI or the `niRFSA_CalSetTemperature` function.
35. Close the NI 5601 Reference Level Calibration step using the niRFSA Close Calibration Step VI or the `niRFSA_CloseCalibrationStep` function.
36. Close the external calibration by calling the niRFSA Close Ext Cal VI with the **action** parameter set to **Commit** or by calling the `niRFSA_CloseExtCal` function with the **action** parameter set to `NIRFSA_VAL_EXT_CAL_COMMIT`.
37. Close the niRFSG session using the niRFSG Close VI or the `niRFSG_close` function.

Appendix A: Reference Level Calibration Power

The power level used for reference level calibration is determined by the attenuation set in the NI 5601. The following table shows the power level as a function of the attenuation index.

Table 30. Power Level

RF Attenuation Index	RF Source Power (dBm)
0	-35
1	-34
2	-33
3	-32
4	-31
5	-30
6	-29
7	-28
8	-27
9	-26
10	-25
11	-24
12	-23
13	-22
14	-21
15	-20
16	-19
17	-18
18	-17
19	-16
20	-15
21	-14
22	-13
23	-12
24	-11

Table 30. Power Level (Continued)

RF Attenuation Index	RF Source Power (dBm)
25	-10
26	-9
27	-8
28	-7
29	-6
30	-5
31	-4
32	-3
33	-2
34	-1
35 to 64	0

Where to Go for Support

The National Instruments 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.

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372677D-01 Mar13