PXIe-5665 Features

2025-03-21

Contents

PXIe-5665

Up to 14 GHz PXI Vector Signal Analyzer

- 20 Hz to 3.6 GHz or 14 GHz frequency range
- Up to 50 MHz instantaneous bandwidth
- Phase noise of -129 dBc/Hz at 10 kHz offset from 800 MHz carrier frequency
- Average noise level up to -165 dBm/Hz at a 1 GHz carrier frequency
- RF list mode support

System Components

The PXIe-5665 is a modular vector signal analyzer consisting of the following three PXI Express hardware modules:

- PXIe-5622 IF Digitizer
- PXIe-5603 or PXIe-5605 RF Signal Downconverter
- PXIe-5653 RF Analog Signal Generator

Note There is no single device labeled "PXIe-5665".

PXIe-5665 Front Panel

The PXIe-5665 consists of the following hardware module front panels, containing multiple connectors and LED indicators.

- PXIe-5622 Front Panel and LEDs
- PXIe-5603 or PXIe-5605 Front Panel and LEDs
- PXIe-5653 Front Panel and LEDs

Figure 1. PXIe-5665 (3.6 GHz Configuration)

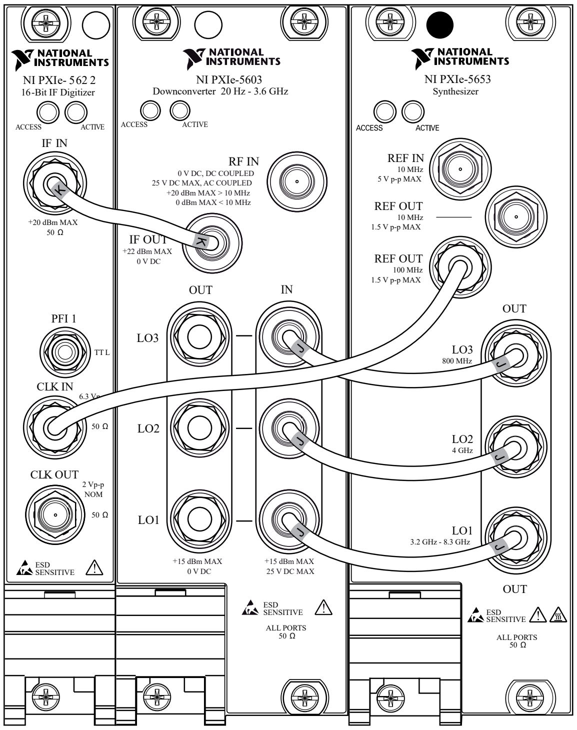
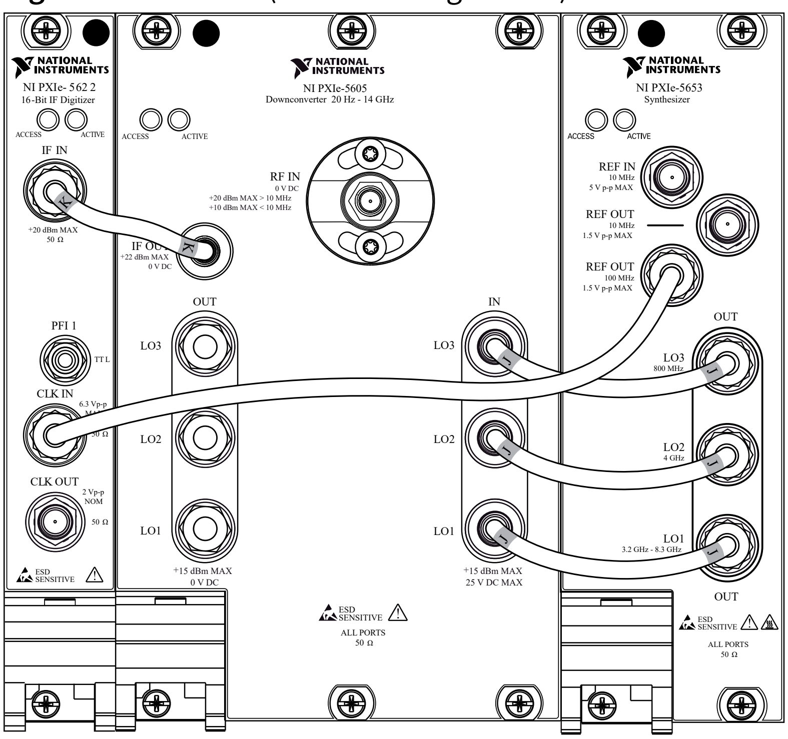


Figure 2. PXIe-5665 (14 GHz Configuration)

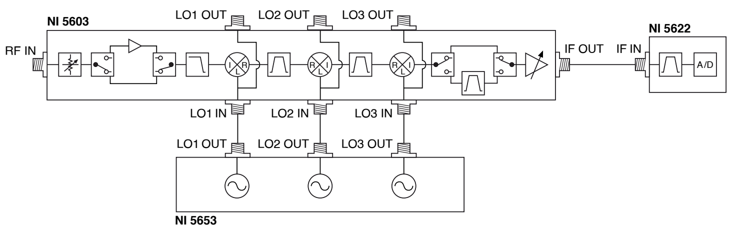


PXIe-5665 Block Diagram

The PXIe-5665 system includes the PXIe-5622, PXIe-5603/5605, and the PXIe-5653 modules. The block diagram for the PXIe-5665 differs based on your device configuration and operating frequency range.

PXIe-5665 3.6 GHz

The following block diagram represents the PXIe-56653.6 GHz configuration, which contains the PXIe-5603.



PXIe-5665 14 GHz

The PXIe-566514 GHz operates in the following distinct frequency bands up to 14 GHz:

- **Low Band**— Range of RF frequencies less than or equal to 3.6 GHz.
- **High Band**—Range of RF frequencies greater than 3.6 GHz and less than or equal to 14 GHz.

The following block diagrams represent the PXIe-566514 GHz configuration operating in the high or low band frequency range. The 14 GHz configuration contains the PXIe-5605.

Figure 3. PXIe-5665 14 GHz Low Band

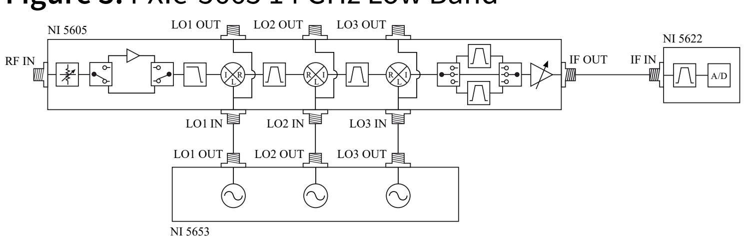
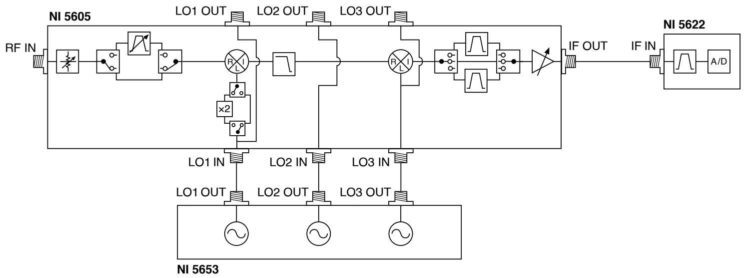


Figure 4. PXIe-5665 14 GHz High Band



Related concepts:

- PXIe-5665 Signal Path

Frequencies ≤ 3.6 GHz (RF Stage)

In the PXIe-5665 (3.6 GHz) configuration, the PXIe-5603 upconverts the RF signal to a higher intermediate frequency and then downconverts it to a frequency that can be digitized for processing. The three-stage topology provides image rejection of the RF input signal with no ambiguity of the displayed signal. The image rejection is achieved with a lowpass filter (LPF) that limits the RF signal at the input of the first mixer. Because the frequency of the first LO is greater than the highest possible tuned RF frequency, the LPF also helps reduce the LO reradiation from the RF input. You can use the PXIe-5665 (3.6 GHz) as a vector signal analyzer or a spectrum analyzer.

When the PXIe-5665(14 GHz) input frequency is less than 3.6 GHz, the PXIe-5605 upconverts the RF signal to a higher intermediate frequency and then downconverts it to a frequency that can be digitized for processing. The PXIe-5605 RF front end includes a mechanical step attenuator, which is variable up to 75 dB in 5 dB steps. When the PXIe-5605 is operating in the low band signal path, the solid-state attenuator provides an additional 31 dB of attenuation, variable in 1 dB steps. An optional preamplifier improves the device noise figure. The RF input is AC-coupled by default, but you can also configure the input to be DC-coupled using NI-RFSA.

> **Notice** The PXIe-5605 has no internal DC block, which allows the PXIe-5605 to make measurements at frequencies as low as 20 Hz. High-frequency components in the PXIe-5605 can be damaged when DC signals are applied directly to the RF IN connector of the PXIe-5605. NI is not responsible for damage resulting from improper signal connections. The PXIe-5605 ships with a SMA DC block attached to the RF IN connector to prevent damage to

> the device when a DC input signal is present. You must remove the DC block to make measurements using frequencies less than 10 kHz because the series capacitive reactance of the device increases as the RF input frequency drops from 10 kHz to 20 Hz. NI recommends that you keep the DC block attached to the RF IN connector for all measurements at frequencies greater than or equal to 10 kHz to maximize the accuracy of the device.

> **Notice** To reinstall the DC block on the PXIe-5605 RF IN connector, use a torque wrench set to a maximum torque of 0.79 N · m to 1.02 N · m (7 lb · in to 9 lb · in.). Using more than the recommended amount of torque may damage the RF IN connector. NI is not responsible for damage resulting from improper signal connections.

> **Notice** If the RF attenuation is set to 0 dB with the DC block attached, an input DC voltage greater than ±2 V may damage the internal components of the PXIe-5605. To prevent damage to the PXIe-5605, ensure that the DC voltage at the RF IN connector is between -2 VDC and +2 VDC. With the DC block removed, the maximum allowed voltage is 0 VDC.

Frequencies Between 3.6 GHz and 14 GHz (RF Stage)

In the high band signal path, the PXIe-5605 acts as a two-stage downconverter.

The only available attenuation in this frequency band is the mechanical step attenuator, which provides 75 dB of attenuation, variable in 5 dB steps. An optional preselector assists in filtering unwanted frequency components from the RF input before the signal reaches the first mixer. The RF input is AC-coupled by default, but you can also configure the input to be DC-coupled by removing the DC block when your application requires measurements using frequencies less than 10 kHz.

> **Note** For frequencies greater than 7.5 GHz, the PXIe-5665 (14 GHz) doubles the LO1 signal to facilitate the high-frequency signal downconversion using the available LO1 output signal of the PXIe-5653.

All Frequencies (IF Stage)

You can adjust the IF gain of in 1 dB steps to optimize the power level into the IF digitizer.

The final IF stage has a switched filter bank that allows you to further optimize the system third-order intercept point (IP3) to make advanced measurements, such as adjacent channel power ratio (ACPR). The switched filter bank provides a through (80 kHz) filter, a 300 kHz filter, and a 5 MHz filter (PXIe-5605 only).

The PXIe-5653 supplies a low phase noise LO. You can use the PXIe-5603 and PXIe-5605 LO outputs to daisy chain multiple downconverters with a single LO source. Using the same LO source is useful for phase-coherent signal acquisition applications, such as multiple input, multiple output (MIMO) systems. When using this configuration, every PXIe-5603/5605 is tuned to the same RF frequency.

The IF signal leaves the RF downconverter through the IF OUT connector and enters the IF IN connector on the PXIe-5622 IF digitizer. The PXIe-5622 digitizes the IF signal and digitally downconverts it to baseband, resulting in complex I/Q data stored in the digitizer onboard memory. The I/Q data is then transferred to the host PC for processing.

Related concepts:

- PXIe-5603 Downconverter IF Filter
- PXIe-5605 Downconverter IF Filter
- Phase Coherency

PXIe-5665 Signal Path

An RF source signal takes the following paths from the PXIe-5665 front panel to the PXI Express controller, depending on your PXIe-5665 configuration and operating frequency range.

(3.6 GHz or 14 GHz) for Frequencies ≤ 3.6 GHz

1. The RF source signal enters the PXIe-5603 or PXIe-5605 front panel at the RF IN

connector.

2. If you purchased the PXIe-5603 or PXIe-5605 with the optional preamplifier and have enabled the preamplifier, the signal source can be amplified, which can improve the noise figure.
3. The PXIe-5603 and PXIe-5605 downconverters tune the signal to a center frequency and frequency-translate it to center around either 187.5 MHz, 190 MHz (PXIe-5605 only), or 199 MHz.
4. The frequency-translated signal is filtered by the IF filter.
5. The filtered signal passes from the RF downconverter module front panel IF OUT connector to the PXIe-5622 IF digitizer module front panel IF IN connector.
6. The PXIe-5622 IF digitizer module filters and conditions the signal and applies gain and dither.
7. The A/D converter (ADC) converts the signal from analog to digital.
8. The onboard memory (buffer) receives digitally downconverted and resampled data.
9. The PXI Express controller sends the data to the host computer.

(14 GHz) for Frequencies Between 3.6 GHz and 14 GHz

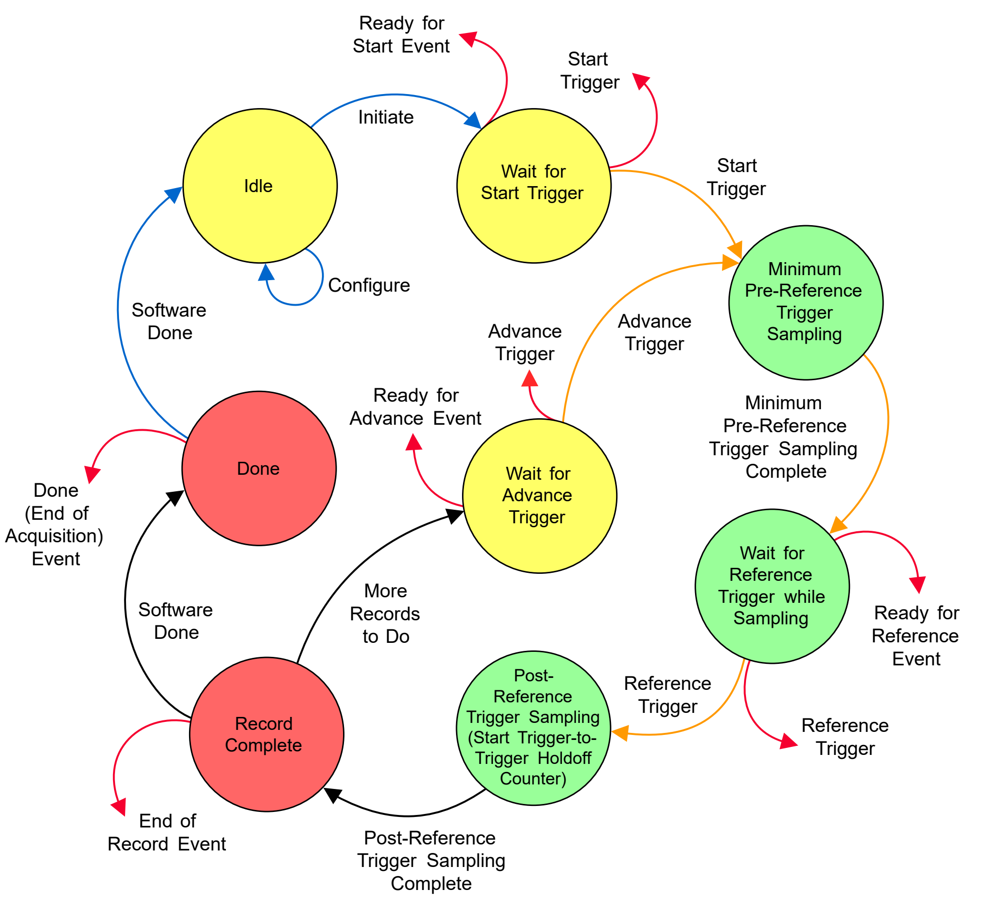
1. The RF source signal enters the PXIe-5605 front panel at the RF IN connector.
2. The optional preselector, which has a 47 MHz typical bandwidth and is used for frequencies > 3.6 GHz, can be enabled by the NI-RFSA driver to filter the RF input signal.
3. The PXIe-5605 downconverter tunes the signal to a center frequency and frequency-translates it to center around either 187.5 MHz, 190 MHz, or 199 MHz, depending on the IF filter you select.
4. The frequency-translated signal is filtered by the IF filter.
5. The filtered signal passes from the PXIe-5605 RF signal downconverter module front panel IF OUT connector to the PXIe-5622 IF digitizer module front panel IF IN connector.
6. The PXIe-5622 IF digitizer module filters and conditions the signal and applies gain and dither.
7. The A/D converter (ADC) converts the signal from analog to digital.
8. The onboard memory (buffer) receives digitally downconverted and resampled data.
9. The PXI Express controller sends the data to the host computer.

Related concepts:

- PXIe-5665 Block Diagram

Hardware State Diagram

The following figure shows the acquisition engine state diagram for the IF digitizer in your vector signal analyzer. This state diagram models the PXIe-5665 when it acquires data in the I/Q mode.



Arrow Color	Indication
Blue	State transitions always caused by software
Black	State transitions caused by the internal state machine of the device

Arrow Color	Indication
Red	Output signals
Orange	User-configurable state transitions caused by software or hardware

Basic Hardware States

Many digitizers share a common digital architecture called Synchronization and Memory Core (SMC). SMC-based digitizers can be in any of the following basic states during the course of operation.

- **Idle**—The module is not sampling a waveform. All the session attributes are programmable in this state. In this state, the attributes have not necessarily been applied to hardware yet, so the hardware configuration of the module may not match the session attribute values. Also, the module remains configured as it was the last time a session was committed. When you call Initiate, all the attributes are programmed to the hardware. If you recently reset the computer, the module is in the Idle state.
- **Wait for Start Trigger**—The module transitions to this state when you initiate an acquisition. If the Start Trigger source is configured as None, the module immediately transitions from this state and generates a Start Trigger. If you configure the Start Trigger source as a software or hardware trigger from one of the available sources, the module remains in this state until the configured trigger occurs. When the module recognizes a trigger condition, it transitions from this state on the next clock cycle and generates a Start Trigger. The default Start Trigger source is None.
- **Minimum Pre-Reference Trigger Sampling**—The module can transition into this state two ways: receiving the Start Trigger from the Start Trigger source or receiving the Advance trigger from the Advance trigger source. The transition into this state depends on the previous state of the module. While in this state, the module samples according to the session attributes configured. The module remains in this state until three conditions are satisfied: the minimum Pre-Reference trigger sampling completes, the time-to-digital converter (TDC) is ready, and the trigger-to-trigger delay has expired. The first time through this state, the trigger-to-trigger delay does not have an effect. When the three conditions are satisfied, the module transitions from this state on the next clock cycle. Use the

Pretrigger Samples property or NIRFSA_ATTR_REF_TRIGGER_PRETRIGGER_SAMPLES attribute to specify the number of samples to be acquired before the Reference Trigger is received.
- **Wait for Arm Reference Trigger while Sampling** —After the module finishes the Minimum Pre-Reference Trigger Sampling state, the module transitions into this state. While in this state, the module continues to acquire Pre-Reference trigger samples according to the session attributes configured. If you configure the Arm Reference trigger source as None, the module transitions from this state on the next clock edge. If you configure the Arm Reference trigger source as a software trigger or a hardware trigger from one of the available sources, the module remains in this state until the configured trigger occurs. When the module recognizes a trigger condition, the module transitions from this state. The default Arm Reference trigger source is None.
- **Wait for Reference Trigger while Sampling**—After the module receives Arm Reference trigger from the Arm Reference trigger source, the module transitions into this state. If you configure the Reference trigger Source as a software or hardware trigger from one of the available sources, the module remains in this state until the configured trigger occurs. When the module recognizes a trigger condition, the module transitions from this state. The default Reference trigger source is None.
- **Post-Reference Trigger Sampling**—After the module receives the Reference trigger, the module transitions into this state. At the beginning of this state, the module starts a trigger-to-trigger delay counter. You can configure this delay counter using Reference Trigger Delay property and the NIRFSA_ATTR_REF_TRIGGER_DELAY attribute to delay the module from looking for a Reference trigger between records. At the same time, the trigger-to-trigger delay counter is started, the module begins sampling Post-Reference trigger samples according to the session attributes configured. When the Post-Reference trigger sampling is completed, the module transitions from this state.
- **Record Complete**—After the module completes Post-Reference trigger sampling state, the module transitions into this state. The module leaves this state after the current record has been stored in the onboard memory. Upon leaving this state, the module generates an End of Record Event.
- **Wait for Advance Trigger**—After the module has completed a record and determines that there are still more records to complete, the module transitions into this state. If you configure the Advance Trigger source as None, the module transitions from this state on the next clock edge. If you configure the Advance

Trigger source as a software or hardware trigger from one of the available sources, the module remains in this state until the configured trigger occurs. Upon the module recognizing a trigger condition, the module transitions from this state. The default Advance Trigger source is None.
- **Done**—After the module completes a record and determines that all the records are done, it transitions into this temporary state. Upon entering this state, the module generates the End of Acquisition Event. The software transitions the module from this state and back to the Idle state when you call either a Fetch or Check Status VI or function.

Power On and Reset Conditions

The PXIe-5665 hardware is in the following state after powering on or restarting the system and allowing the PC operating system and NI-RFSA to fully load. These conditions are also true after a device reset that you perform directly from NI Measurement & Automation Explorer (MAX).

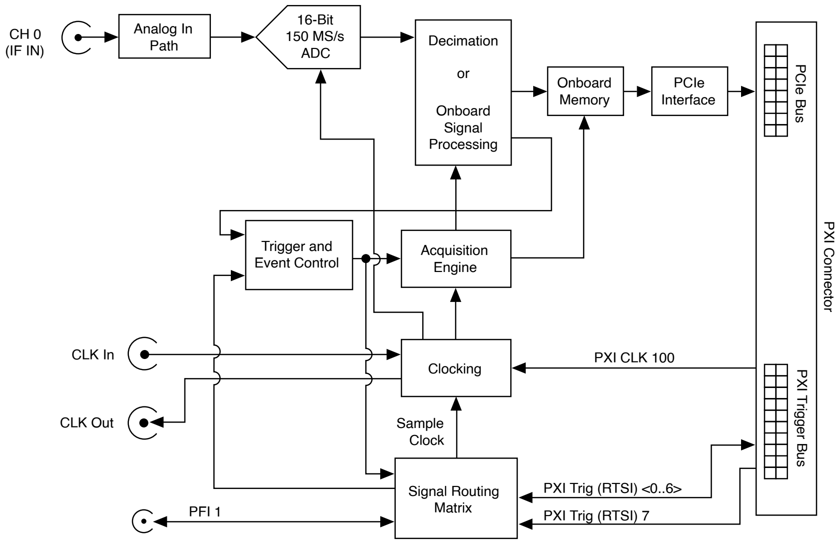
- Thermal shutdown monitoring is activated.
- The PXIe-5603/5605 downconverter is set with a default attenuation value of 10 dB.
- PXIe-5603/5605, PXIe-5622, and PXIe-5653 front panel ACCESS LEDs are green.
- PXIe-5603/5605, PXIe-5622, and PXIe-5653 module front panel ACTIVE LEDs are off.
- Warm up begins (if applicable).

PXIe-5622

150 MS/s, 16-bit PXI IF digitizer.

- 1 dBm, 4 dBm, and 7 dBm input ranges
- 3 MHz to 250 MHz direct path frequency range
- 50 MHz alias-protected IF bandwidth, centered at 187.5 MHz
- 50 Ω input impedance
- 64 MB or 256 MB of onboard memory
- Serves as the IF digitizer within the PXIe-5663E, PXIe-5665, and PXIe-5667 Vector Signal Analyzer systems

PXIe-5622 Block Diagram



PXIe-5622 Front Panel and LEDs

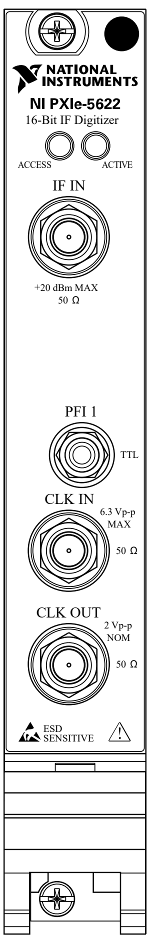


Table 1. Connector Descriptions

Connector	Description
IF IN	Analog input connection for data and triggering.
PFI 1	Digital trigger input.
CLK IN	Imports an external Reference or Sample clock.
CLK OUT	Exports the Reference or Sample clock.

Table 2. LED Indicators

LED	Indication
ACCESS	Indicates the basic hardware status of the module. OFF—The module is not yet functional, or the module has detected a problem with a power rail. AMBER—The module is being accessed. Accessed means that the device setup registers are being written to in order to control the device. GREEN—The module is ready to be programmed by NI-RFSA. RED—The module has exceeded approved operating temperature and thermal shutdown has occurred.
ACTIVE	Indicates the module state. OFF—Module is not armed, triggered, or acquiring a waveform. AMBER—The module is armed and waiting for a trigger. GREEN—The module has received a Reference (Stop) trigger or is acquiring a waveform. RED—The module has detected an error. Access the module with NI-RFSA to determine the cause of the error. This LED remains red until the error condition is removed.

Updating Digitizer Firmware

You may need to update the firmware for your PXIe-5622 IF Digitizer to get new features or critical bug fixes. The firmware for most NI IF digitizers is included with the most recent version of the NI-SCOPE driver, however, to update the firmware for the PXIe-5622, you must run a firmware update utility.

Complete the following steps to update firmware for the PXIe-5622.

1. Ensure that you have installed the latest version of NI-SCOPE on your host PC.
2. Ensure that your device and PXI Express chassis are properly connected to your host PC.
3. Locate and run the following program: `Program Files (x86)\National Instruments\NI-DAQ\fpgafiles\ni<device number>\NI-PXIe-<device number> Firmware Updater.exe`
4. When the program finishes, restart your host PC and PXI Express chassis.

PXIe-5603

PXIe, 3.6 GHz PXI RF Signal Downconverter

- Three-stage superheterodyne downconverter
- Typically used only within the PXIe-5665 and the PXIe-5667 Vector Signal Analyzers for analyzing vector signals and spectrum
- Manual IF filter selection

PXIe-5603 Front Panel and LEDs

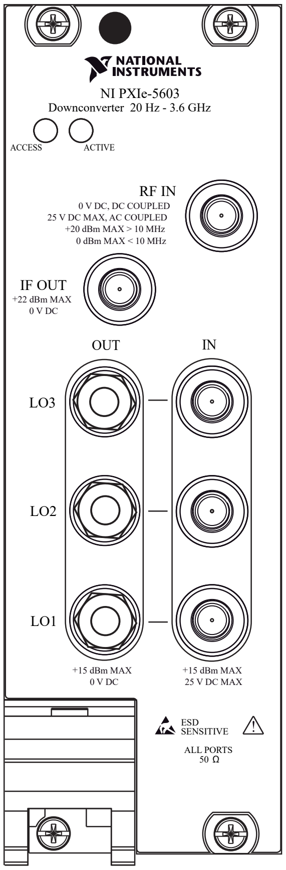


Table 3. Connector Descriptions

Connector	Use
RF IN	Rated at 0 VDC when DC coupled and 25 VDC when AC coupled. NI recommends setting the NI-RFSA Channel Coupling property to AC Coupled when the input signal is ≥ 10 MHz.
IF OUT	Output terminal for the frequency-translated IF signal.
LO1 IN	Input terminal for the LO1 (3.2 GHz to 8.3 GHz) source.
LO2 IN	Input terminal for the LO2 (4 GHz) source.

Connector	Use
LO3 IN	Input terminal for the LO3 (800 MHz) source.
LO1 OUT	Output terminal for the LO1 (3.2 GHz to 8.3 GHz) source. In multichannel systems, LO1 OUT exports the signal received at LO1 IN to other PXIe-5603 modules. This connector is disabled by default.
LO2 OUT	Output terminal for the LO2 (4 GHz) source. In multichannel systems, LO2 OUT exports the signal received at LO2 IN to other PXIe-5603 modules. This connector is disabled by default.
LO3 OUT	Output terminal for the LO3 (800 MHz) source. In multichannel systems, LO3 OUT exports the signal received at LO3 IN to other PXIe-5603 modules. This connector is disabled by default.

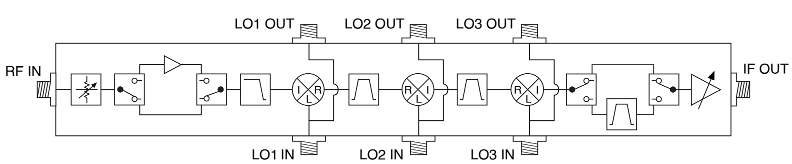
Table 4. LED Indicators

LED	Indication
ACCESS	Indicates the basic hardware status of the module. • **OFF**—The module is not yet functional, or the module detected a problem with a power rail. • **AMBER**—The module is being accessed. ***Accessed*** means that the device setup registers are being written to in order to control the device. • **GREEN**—The module is ready to be programmed.

LED	Indication
ACTIVE	Indicates the module state. • **OFF**—The module is in a quiescent state. • **AMBER**—The module is waiting for the Advance Trigger from the configuration list. • **GREEN**—The module is triggered and is running a step from the configuration list. • **RED**—The module detected an error state. An error state may indicate the module exceeded approved operating temperature and thermal shutdown occurred or that the module detected a power supply failure. If the power supply fails, contact NI technical support.

PXIe-5603 Block Diagram

The PXIe-5603 includes a 30 dB mechanical step attenuator (adjustable in 10 dB steps), a solid-state step attenuator, and an optional, switchable 15 dB preamplifier before the first mixer. These components control the signal level at the input of the first mixer.



PXIe-5603 Downconverter IF Filter

You can allow NI-RFSA to automatically control IF filtering or you can manually select the IF filter.

Manual selection is useful when the PXIe-5622 IF digitizer is not being used as well as in other applications, such as in-band retuning.

The PXIe-5603 supports the following IF bandpass filters:

- **Through**—Provides a nominal 80 MHz bandwidth at -6 dB, although the effective bandwidth of the device may be further reduced by the anti-aliasing filter in the digitizer or other options. The through path has a nominal IF output frequency of 187.5 MHz.
- **300 kHz** —Provides a nominal 300 kHz bandwidth at -3 dB and a nominal IF output frequency of 199 MHz.

IF Filter Selection in Spectrum Acquisitions

For spectrum acquisitions, NI-RFSA automatically selects the appropriate filter based on the requested acquisition span.

You can change the bandwidth using the Device Instantaneous Bandwidth property or the NIRFSA_ATTR_DEVICE_INSTANTANEOUS_BANDWIDTH attribute. You can use this property or attribute to determine the actual bandwidth achieved by the downconverter in (external digitizer mode) or the PXIe-5665.

IF Filter Selection in I/Q Acquisitions

For I/Q acquisitions, NI-RFSA defaults to the widest IF bandwidth available.

You can change the bandwidth using the Device Instantaneous Bandwidth property or the NIRFSA_ATTR_DEVICE_INSTANTANEOUS_BANDWIDTH attribute. You can also change the bandwidth using the IF Filter Bandwidth property or the NIRFSA_ATTR_IF_FILTER_BANDWIDTH attribute. You can use these properties or attributes to determine the actual bandwidth achieved by the PXIe-5603/5605 or the PXIe-5665.

> **Note** When you set a bandwidth, NI-RFSA selects the smallest bandwidth filter that is at least as large as your specified bandwidth.

PXIe-5605

PXIe, 7 GHz or 14 GHz PXI RF Signal Downconverter

- Three-stage superheterodyne downconverter
- Typically used only within the PXIe-5665 and the PXIe-5667 Vector Signal Analyzers

for analyzing vector signals and spectrum
- Manual IF filter selection
- Yttrium-iron-garnet (YIG)-tunable preselection filter (preselector) for RF frequencies between 3.6 GHz and 14 GHz

PXIe-5605 Front Panel and LEDs

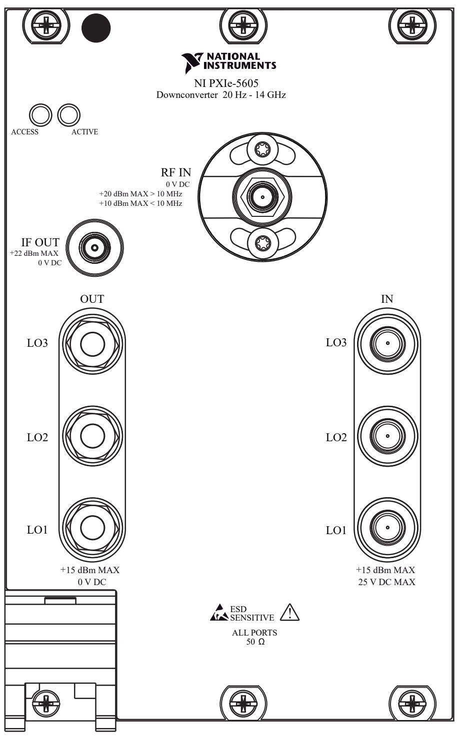


Table 5. Connector Descriptions

Connector	Use
RF IN	Rated at 0 VDC when DC coupled and 25 VDC when AC coupled. NI recommends setting the Channel Coupling property to AC Coupled when the input signal is ≥ 10 MHz. To properly configure the input attenuators, set the reference level at or above the input signal level using the Reference Level property.
IF OUT	Output terminal for the frequency-translated IF signal.

Connector	Use
LO1 IN	Input terminal for the LO1 (3.2 GHz to 8.3 GHz) source.
LO2 IN	Input terminal for the LO2 (4 GHz) source.
LO3 IN	Input terminal for the LO3 (800 MHz) source.
LO1 OUT	Output terminal for the LO1 (3.2 GHz to 8.3 GHz) source. In multichannel systems, LO1 OUT exports the signal received at LO1 IN to other PXIe-5605 modules. This connector is disabled by default.
LO2 OUT	Output terminal for the LO2 (4 GHz) source. In multichannel systems, LO2 OUT exports the signal received at LO2 IN to other PXIe-5605 modules. This connector is disabled by default.
LO3 OUT	Output terminal for the LO3 (800 MHz) source. In multichannel systems, LO3 OUT exports the signal received at LO3 IN to other PXIe-5605 modules. This connector is disabled by default.

Table 6. LED Indicators

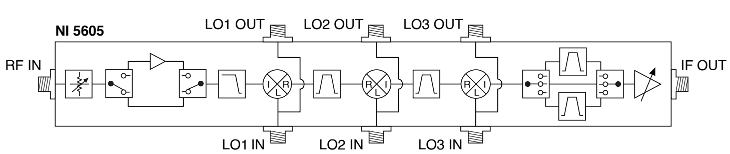
LED	Indication
ACCESS	Indicates the basic hardware status of the module. • **OFF**—The module is not yet functional, or the module detected a problem with a power rail. • **AMBER**—The module is being accessed. ***Accessed*** means that the device setup

LED	Indication
	registers are being written to in order to control the device. • **GREEN**—The module is ready to be programmed.
ACTIVE	Indicates the module state. • **OFF**—The module is in a quiescent state. • **AMBER**—The module is waiting for the Advance Trigger from the configuration list. • **GREEN**—The module is triggered and is running a step from the configuration list. • **RED**—The module detected an error state. An error state may indicate the module exceeded approved operating temperature and thermal shutdown occurred or that the module detected a power supply failure. If the power supply fails, contact NI technical support.

PXIe-5605 Block Diagram

The functionality of the PXIe-5605 depends on the operating frequency range of your vector signal analyzer.

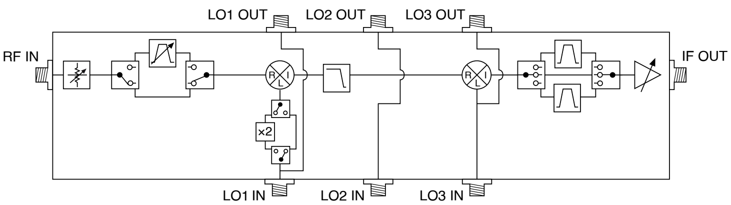
The following block diagram represents the PXIe-5605 for frequencies less than or equal to 3.6 GHz.



The PXIe-5605 RF front end includes a mechanical step attenuator, which is variable up to 75 dB in 5 dB steps. When the PXIe-5605 is operating in the low band signal path, the solid-state attenuator provides an additional 31 dB of attenuation, variable in 1 dB steps. The RF input is AC-coupled by default, but you can also configure the input to be

DC-coupled using NI-RFSA.

The PXIe-5605 acts as a two-stage downconverter when the vector signal analyzer is operating in the high band signal path. The following block diagram represents the PXIe-5605 for frequencies greater than 3.6 GHz.



The only available attenuation in this frequency band is the mechanical step attenuator, which provides 75 dB of attenuation, variable in 5 dB steps. An optional preselector assists in filtering unwanted frequency components from the RF input before the signal reaches the first mixer.

PXIe-5605 Preselector

The PXIe-5605 contains an optional yttrium-iron-garnet (YIG)-tunable preselection filter (preselector) that you can use to reduce unwanted frequency components from the RF input for frequencies between 3.6 GHz and 14 GHz.

The preselector is a high Q filter that suppresses signals outside the preselector passband by a typical amount of 75 dB. NI-RFSA enables the preselector by default for frequencies greater than 3.6 GHz. The preselector rejects the image frequencies and reduces LO reradiation by filtering these spurious signals. You can use the NI-RFSA Preselector Enabled property to enable or disable the preselector.

Enabling the PXIe-5605 preselector has the following implications:

- The preselector introduces amplitude and phase errors to the incoming signal at the RF IN connector. These errors are not corrected by NI-RFSA.
- The preselector has a varying passband ripple that changes with the device center frequency.
- The preselector draws current when enabled, which causes the module temperature to increase.

- The preselector bandwidth changes with temperature and increases as the tuned frequency increases. The preselector can also be affected by vibrations to the PXIe-5605 module.

PXIe-5605 Downconverter IF Filter

You can allow NI-RFSA to automatically control IF filtering or you can manually select the IF filter.

Manual selection is useful when the PXIe-5622 IF digitizer is not being used as well as in other applications, such as in-band retuning.

The PXIe-5605 supports the following IF bandpass filters:

- **Through**—Provides a nominal 80 MHz bandwidth at -6 dB, although the effective bandwidth of the device may be further reduced by the anti-aliasing filter in the digitizer or other options. The through path has a nominal IF output frequency of 187.5 MHz.
- **5 MHz** —Provides a nominal 5 MHz bandwidth at -3 dB and a nominal IF output frequency of 190 MHz.
- **300 kHz** —Provides a nominal 300 kHz bandwidth at -3 dB and a nominal IF output frequency of 199 MHz.

IF Filter Selection in Spectrum Acquisitions

For spectrum acquisitions, NI-RFSA automatically selects the appropriate filter based on the requested acquisition span.

You can change the bandwidth using the Device Instantaneous Bandwidth property or the NIRFSA_ATTR_DEVICE_INSTANTANEOUS_BANDWIDTH attribute. You can use this property or attribute to determine the actual bandwidth achieved by the downconverter in (external digitizer mode) or the PXIe-5665.

IF Filter Selection in I/Q Acquisitions

For I/Q acquisitions, NI-RFSA defaults to the widest IF bandwidth available.

You can change the bandwidth using the Device Instantaneous Bandwidth property or the NIRFSA_ATTR_DEVICE_INSTANTANEOUS_BANDWIDTH attribute. You can also change the bandwidth using the IF Filter Bandwidth property or the NIRFSA_ATTR_IF_FILTER_BANDWIDTH attribute. You can use these properties or attributes to determine the actual bandwidth achieved by the PXIe-5603/5605 or the PXIe-5665.

> **Note** When you set a bandwidth, NI-RFSA selects the smallest bandwidth filter that is at least as large as your specified bandwidth.

PXIe-5653

PXIe, 8.3 GHz PXI RF Analog Signal Generator

- 800 MHz to 8.3 GHz frequency range
- Continuous-wave generation capabilities
- Typically used within the PXIe-5665, PXIe-5667, or PXIe-5668 Vector Signal Analyzer systems as a synthesizer/local oscillator source

PXIe-5653

Figure 5. PXIe-5653 Front Panel and LEDs

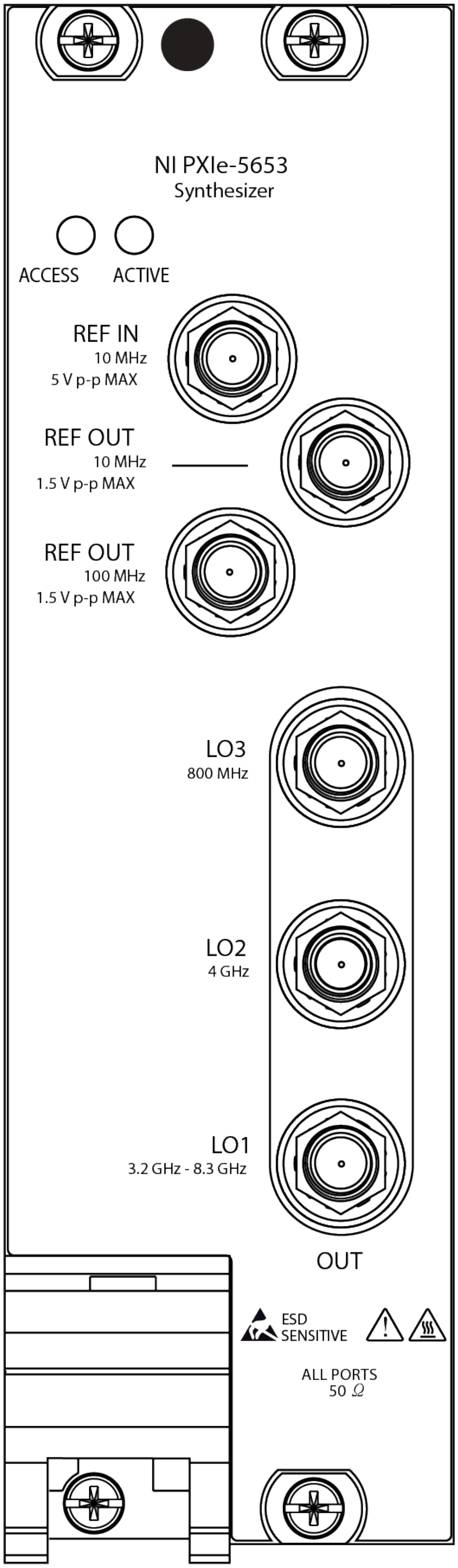


Table 7. Connector Descriptions

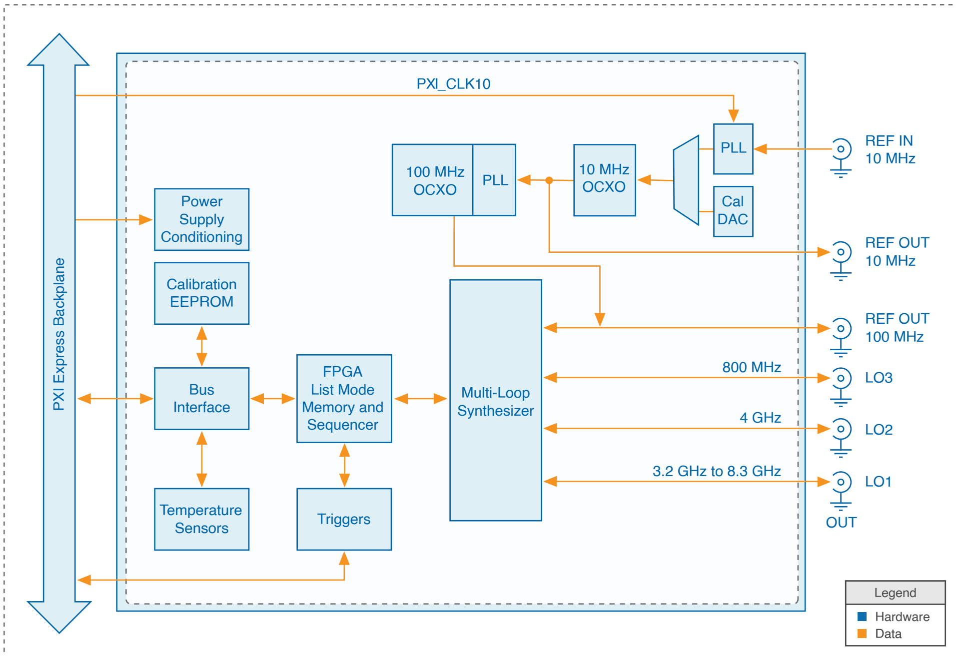
Connector	Description
REF IN	Accepts a 10 MHz frequency signal with a maximum voltage of 2 V_{pk-pk}.
REF OUT (10 MHz)	Routes a frequency reference signal from the synthesizer/LO module onboard 10 MHz oven-controlled crystal oscillator (OCXO).
REF OUT (100 MHz)	Routes a frequency reference signal from the synthesizer/LO module onboard 100 MHz OCXO.
LO1 OUT	Output terminal for the LO1 (3.2 GHz to 8.3 GHz) source. LO1 OUT is an SMA connector with an impedance of 50 Ω (nominal).
LO2 OUT	Output terminal for the LO2 (4 GHz) source. LO2 OUT is an SMA connector with an impedance of 50 Ω (nominal).
LO3 OUT	Output terminal for the LO3 (800 MHz) source. LO3 OUT is an SMA connector with an impedance of 50 Ω (nominal).

Table 8. LED Indicators

LED	Indication
ACCESS	Indicates the basic hardware status of the module. • **OFF**—The module is not yet functional, or the module detected a problem with a power rail. • **AMBER**—The module is being accessed. ***Accessed*** means that the device setup registers are being written to in order to control the device. • **GREEN**—The module is ready to be programmed.
ACTIVE	Indicates the module state. • **OFF**—The module is not generating a signal. • **AMBER**—The module phased-locked loops (PLLs) are attempting to lock. • **GREEN**—The module is generating a signal; applicable PLLs are locked. • **RED**—The module detected an error state. An error state may indicate the module exceeded approved operating temperature and thermal shutdown occurred or that the module detected a power supply failure. If the power supply fails, contact NI technical support.

PXIe-5653 Block Diagram

The PXIe-5653 includes an FPGA list mode memory and sequencer, triggers, multi-loop synthesizer, and phase-locked loops (PLLs). The PXIe-5653 provides a low phase noise LO to vector signal analyzers.



PXIe-5665 Amplitude (Spectrum)

You can adjust the amplitude of the incoming signal to avoid certain spurious effects.

Large amplitude signals can overload the system and cause spurious effects. These spurs may be large enough to be mistaken for signals. This effect can be avoided by properly adjusting the amplitude of the incoming signal. Achieving proper signal levels may involve attenuating the signal before it reaches the amplifiers and the mixer, either by programming the internal attenuators or by using external attenuation.

You must properly configure the PXIe-5665 vector signal analyzer before making a measurement. A small signal can be mistaken for noise if the resolution bandwidth setting is too large or the input attenuation is too high. When measuring small signals, optimize the signal-to-noise ratio by minimizing input attenuation and resolution bandwidth. Ensure that the reduced input attention is not too low for large amplitude RF input signals.

When the reference level is reduced to a low setting, you can enable the internal preamplifier for frequency ranges from 10 MHz to 3.6 GHz to view weak signals below the noise floor of the PXIe-5665. Because the internal preamplifier has a wide bandwidth that is not preselected, large signals, even those outside the selected frequency span, may force the PXIe-5665 into compression.

Related information:

- Noise Floor

Compression

Like any high-linearity device, the PXIe-5665 has limitations on the maximum power levels it can support.

When the system power level limit is determined by analog circuitry, it is referred to as ***device compression*** or ***device saturation***. When the system signal limit is determined by a digitizer, it is referred to as the ***full-scale limit*** of the digitizer. While there are some characteristic differences between device compression and digitizer full-scale limits, they are similar enough to combine them for the purpose of setting the PXIe-5665 such that neither limit impairs a DUT compression measurement. In this section, the combined effect is singularly referred to as ***compression***.

A reasonable starting point to instrument level (gain) setting, and many other measurements, is to set the measuring instrument such that the average power of the input signal is 10 dB to 20 dB below any input-referred compression point. Optimum performance depends on the input signal power and the instrument reference level, manual attenuation, and center frequency settings, among others. For digitally modulated signals, set the reference level while being aware of the peak to average ratio of the signal to ensure sufficient headroom.

A power input (to the PXIe-5603/5605 downconverter) equal to the reference level (set by the Reference Level property or the NIRFSA_ATTR_REFERENCE_LEVEL attribute) results in a power level to the PXIe-5622 IF digitizer that is roughly equal to the digitizer full-scale power level minus 10 dB. Provided the PXIe-5603/5605 has sufficient gain at the center frequency, nominal means that the actual power level delivered to the digitizer is within 2 dB to 3 dB of the full-scale minus 10 dB target.

Related reference:

- Compression Measurement Setup

Single-Tone Harmonic Distortion and Two-Tone Intermodulation Distortion

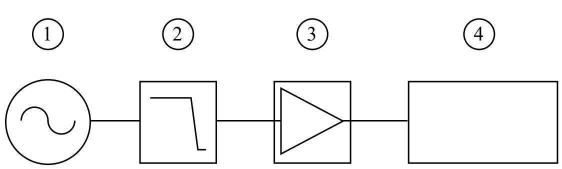
You can configure the PXIe-5665 for single-tone and two-tone distortion measurements.

Single-tone distortion measurements are also referred to as harmonic distortion measurements. Two-tone distortion measurements are also referred to as intermodulation distortion (IMD) measurements. The underlying mechanisms of nonlinearity are the same for harmonic and IMD distortion effects.

> **Note** You can use a variety of different techniques to perform single-tone harmonic distortion measurements and two-tone intermodulation distortion measurements on your system. This topic provides only a typical equipment setup. NI recommends using the best equipment setup for your specific application.

Single-Tone Harmonic Distortion Measurement Setup

In a typical harmonic distortion measurement setup, a lowpass or bandpass filter passes the fundamental signal to the DUT while suppressing its harmonics. This setup injects a clean sinusoidal signal into the DUT. Any harmonic content at the DUT output is assumed to be generated by the DUT rather than the signal source.



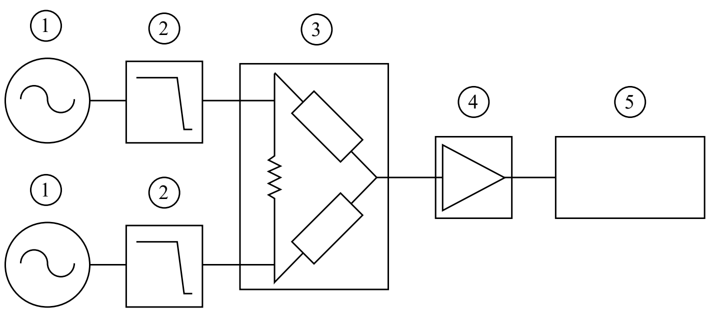
1. Signal Source
2. Lowpass Filter
3. DUT
4. Vector Signal Analyzer

NI recommends that you perform a system calibration before connecting the DUT to ensure that the source or the PXIe-5665 is not contributing significant distortion levels.

You can ensure the distortion is minimal by removing the DUT shown in the preceding figure and observing the output spectrum.

Two-Tone Intermodulation Distortion Measurement Setup

In a typical IMD_3 measurement setup, lowpass filters are employed at the source outputs to suppress harmonics coming from the signal sources.



1. Signal Source
2. Lowpass Filter
3. Combiner
4. DUT
5. Vector Signal Analyzer

NI recommends that you perform a system calibration before connecting the DUT to ensure that the source or the PXIe-5665 is not contributing significant distortion levels.

You can ensure the distortion is minimal by removing the DUT shown in the preceding figure and observing the output spectrum.

Choosing an Optimal PXIe-5665 Setting for Measuring IP_2 and IP_3

Adding and subtracting premixer attenuation in the PXIe-5665 may not be similar to the standard IMD models, such as the IP_2 and IP_3 behavioral models. Complete the following steps to determine whether the PXIe-5665 contributes to any apparent DUT distortion and adjust the instrument settings accordingly.

Use the NI-RFSA SFP (Classic) in spectrum mode as you complete the following steps.

1. Power on the system shown in either of the preceding figures, including the signal source. Allow the equipment to warm up as specified in the device specifications (typically 30 minutes).
2. Measure both the fundamental power level and the distortion product power level. Notice the difference in power level between the fundamental and the distortion product.
   In both single-tone (harmonic) and two-tone (intermodulation) distortion tests, the distortion products appear at calculable frequencies that are dependent upon the input frequencies.
3. If the fundamental signal and distortion products are not within the PXIe-5665 bandwidth, adjust the center frequency until the desired signals appear.
4. If the expected distortion products are below the instrument noise floor, complete the following steps:
   a. Either increase the signal source(s) power level, decrease the resolution bandwidth, or decrease the PXIe-5603/5605 attenuation by decreasing the value specified for the Reference Level property or the NIRFSA_ATTR_REFERENCE_LEVEL attribute.
   b. Perform the power level measurement in step 2. When the distortion products are visible, continue to the next step.
5. Using the internal RF attenuator of the PXIe-5603/5605, apply a known attenuation value.
6. Measure both the fundamental power level and the distortion product power level. Notice the difference in power level between the fundamental and the distortion product.
   For linear vector signal analyzer performance, all measured powers should decrease by the amount of the attenuation the inserted attenuator provided. If the PXIe-5665 is linear, the PXIe-5665 contributes little to the distortion measurement of the DUT. In this event, remove the attenuator and proceed with the distortion calculations indicated in the harmonic distortion and intermodulation distortion topics using the measurements taken in either this step or step 2.
7. If any tone levels do not respond linearly to the attenuator inserted in the preceding step, the PXIe-5665 contributes to the distortion measurement. Complete the following steps to correct for this contribution.
   a. Remove the attenuation that was applied in step 5.
   b. Either decrease the signal source(s) power level or increase the PXIe-5603/5605 attenuation by increasing the value of the Reference Level property or the NIRFSA_ATTR_REFERENCE_LEVEL attribute.

c. Return to step 2.

> **Note** Finding the optimal instrument setting to make valid distortion measurements often requires repeating steps 2 through 7.

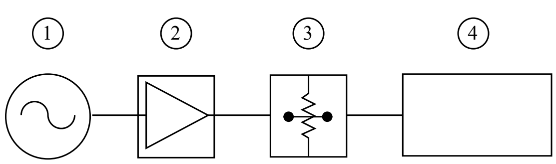
If you cannot make a valid measurement after completing the preceding steps, repeat the process and change to manual attenuation mode when setting the Reference Level property or NIRFSA_ATTR_REFERENCE_LEVEL attribute, and alter the attenuation values instead of changing the reference level. If you are manually controlling the attenuation, you can adjust RF attenuation (attenuation prior to the signal cascade to the mixer) independently from the IF attenuation.

When manually controlling the attenuation, changing RF attenuation always results in a hardware change. Changing the reference level may affect a hardware change. The change may represent a combination of display and hardware changes, or it may entail only display changes. When using the manual attenuation, you may obtain a more optimal setting for the particular distortion measurement than using the default auto-coupled reference level.

If you complete steps 1 through 7 in both the standard and manual attenuation modes and you cannot make a valid measurement, you likely need an instrument with higher dynamic range to evaluate the DUT.

Compression Measurement Setup

The following figure shows the typical compression measurement setup for the PXIe-5665. Note that the attenuator is internal to the PXIe-5603/5605 downconverter. You can use a variety of different techniques to perform compression measurements for your system. NI recommends using the best equipment setup for your specific application.



1. Signal Source
2. DUT

3. Attenuator
4. Vector Signal Analyzer

Choosing an Optimal PXIe-5665 Attenuation Setting for Compression Measurements

To test the compression limits for a DUT, ensure that the PXIe-5665 itself is not contributing any substantial error by being driven to near its own compression limits. NI recommends setting a measurement instrument 10 dB to 20 dB below the compression specifications.

Complete the following steps to help ensure that the measurement system does not substantially contribute to DUT compression testing.

> **Note** Use the NI-RFSA Soft Front Panel (SFP) in spectrum mode as you complete the following steps.

> **Tip** Estimate the DUT gain and compression point and apply these values to the reference level setting and signal source power level before completing the following steps. This process allows you to complete the steps faster.

1. Power on the system in the previous diagram, including the signal source. Allow the equipment to warm up as specified in the device specifications (typically 30 minutes).
2. Tune the PXIe-5665 to the signal source frequency. A 10 dB per division vertical scale is a good first setting.

   > **Note** During compression measurements, the frequency span of the PXIe-5665 can be substantially narrower than the maximum frequency span of the PXIe-5665. This situation occurs because the input for compression measurements is typically a discrete tone.

3. Disable the PXIe-5665 preamplifier, if present, to reduce internal distortion.
4. Adjust the PXIe-5665 reference level to obtain a signal power that is between the reference level setting and the second graticule down.
5. Increase the signal source power until one of the following conditions is met:

- The power of the tone displayed in the PXIe-5665 fails to track dB-for-dB the input level changes. For example, if you change the DUT input power by 1 dB and the PXIe-5665 measured power changes by only 0.5 dB, a reasonable conclusion is that compression is being approached, which is indicated by the dB-for-dB tracking failure.
- The power of the tone exceeds the PXIe-5665 reference level.

6. If the measured power level exceeds the PXIe-5665 reference level, increase the reference level by at least 10 dB. Repeat this step as necessary.
7. Set the PXIe-5665 reference level such that the displayed power level is approximately 8 dB to 12 dB below the reference level. This level is the recommended setting and is nominally 20 dB below the digitizer full-scale rating. Lower reference level (higher gain) settings may be used if instrument linearity is assured.
   To assure linearity, temporarily increase the internal step attenuator by 10 dB. The displayed power of the PXIe-5665 should decrease by the amount of increased attenuation, indicating that the PXIe-5665 is operating within its linear range.

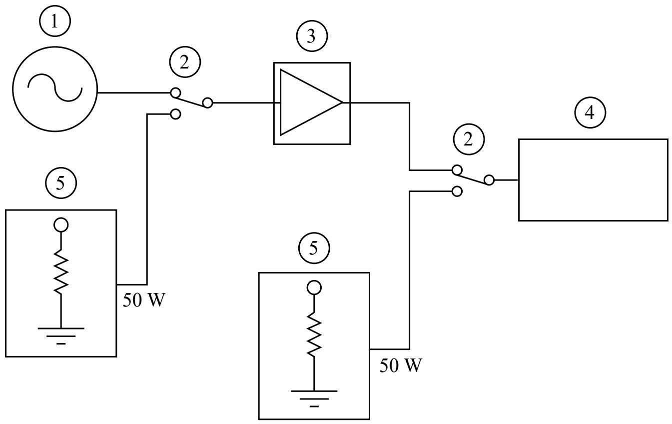
At this point, under normal circumstances, the PXIe-5665 is sufficiently below its own compression point so as not to affect any DUT compression tests. As you proceed with DUT compression testing, you may need to further fine-tune the PXIe-5665.

Noise Figure

The PXIe-5665, like all devices, has some inherent noise. Measure the noise figure to determine the ratio of the actual output noise to the noise that would remain if the instrument did not contribute its own thermal noise.

Noise Figure Measurement Setup

A typical noise figure measurement setup for the PXIe-5665 is shown in the following figure. You can use a variety of different techniques (for example, Y-factor and cold source techniques) to perform noise figure measurements for your system. This topic provides only a typical equipment setup. NI recommends using the best equipment setup for your specific application.



1. Signal Source
2. Switch
3. DUT
4. Vector Signal Analyzer
5. Termination

Measuring Noise Figure with the PXIe-5665

Use the NI-RFSA SFP (Classic) in spectrum mode as you complete the following steps. If your application requires the use of the preselector, complete the steps with the preselector enabled.

Complete the following steps to measure the DUT noise figure:

1. Power on the PXIe-5665 and allow 30 minutes of warm-up time.
2. Power on the DUT, if necessary, and provide for the required warm-up time.
3. Tune the PXIe-5665 to the frequency of interest.
4. Set the PXIe-5665 bandwidth type to **ENBW**.
5. Set the ENBW value to approximately 1 kHz.
6. Terminate the PXIe-5603/5605 front panel RF IN connector with a matched resistive load.
7. Obtain an average reading of the noise power level (measured in watts or watts/Hz, but not in dBm or dBm/Hz).

   > **Tip** Take enough readings to obtain a good average.

8. Convert a reading (taken in dBm) to watts and divide the reading by the noise bandwidth to normalize the value to 1 Hz. This value is the noise floor (W/Hz) of the

PXIe-5665 at that frequency (N_{rfsa}).

9. Remove the load termination from the PXIe-5603/5605 front panel RF IN connector.
10. Connect the DUT output to the PXIe-5603/5605 front panel RF IN connector.
11. Apply a small known signal, P_{in} (dB), into the DUT input. This signal level should be more than 10 dB below the 1 dB compression point of the DUT.
12. Measure the output signal level, P_{out} (dB), on the PXIe-5665.
13. Calculate the power gain of the DUT using the following formula:

    $Gain\left(G_{DUT}\right) = P_{out} - P_{in}$
14. Remove the signal source and terminate the DUT input with a matched resistive load.
15. Make another averaged reading of the noise with the DUT attached by repeating steps 8 and 9. This average is the noise value for the DUT and the PXIe-5665

    $\left(N_m\right)$

    .
16. Substitute your values into the following equation:

    $$NF = 10\log\left[\frac{N_m - N_{rfsa}}{kT} + 1\right] - G_{DUT}$$

    where

    - N_{rfsa}
      is the value from step 8
    - G_{DUT}
      is the value from step 13
    - N_m
      is the value from step 15

Related information:

- Noise Floor
- 1 dB Gain Compression Point

PXIe-5665 RF Attenuation and Signal Levels

The PXIe-5603/5605 IF chain contains step attenuators and a switchable amplifier to optimize the IF gain of the downconverter and provide an optimal signal level to the digitizer.

The PXIe-5603 RF signal downconverter includes a 30 dB mechanical step attenuator (adjustable in 10 dB steps), a solid-state step attenuator, and an optional, switchable 15 dB preamplifier before the first mixer. These components control the signal level at the input of the first mixer.

The PXIe-5605 RF signal downconverter includes a 75 dB mechanical attenuator, which is used by default over the entire operating frequency of the device and can be set in 5 dB steps. When the device is operating in the low band signal path, at frequencies less than or equal to 3.6 GHz, you can also configure a 31 dB solid-state attenuator in 1 dB steps and use the optional 15 dB preamplifier to improve the noise figure of the device. NI-RFSA calculates the amount of attenuation using the value of the Mixer Level property or the NIRFSA_ATTR_MIXER_LEVEL attribute (-10 dBm by default) and the reference level such that the total ***RF Attenuation*** is either 10 dB or ***RF Attenuation*** = ***Reference Level*** - ***Mixer Level*** + 15 dB (from the optional preamplifier), whichever value is greater. You can manually set the mixer level using the Mixer Level property or the NIRFSA_ATTR_MIXER_LEVEL attribute.

> **Note** For the PXIe-5603/5605, RF solid-state attenuation is not available for frequencies greater than 3.6 GHz.

You can choose to engage the solid-state attenuator on the PXIe-5665 (3.6 GHz) and in the low band signal path on the PXIe-5665 (14 GHz) by changing the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute, which have default RF attenuation step size values of 10 dB for the PXIe-5603 and 5 dB for the PXIe-5605. The default attenuation values omit the use of the solid-state attenuator, but you can set the RF attenuation step size to a value other than a multiple of the default value, which forces NI-RFSA to use the solid-state attenuator to achieve the remainder of the attenuation required.

The total RF attenuation of the PXIe-5665 (3.6 GHz) and low band signal path on the PXIe-5665 (14 GHz) is calculated based on the mechanical and solid-state attenuation. For the PXIe-5603/5605 RF downconverter, the default minimum mechanical attenuation is 10 dB, and other supported values are 0 dB, 20 dB, and 30 dB. For the PXIe-5605, the default minimum mechanical attenuation is 10 dB, and other supported values are 0 dB to 75 dB in 5 dB steps. You can allow NI-RFSA to calculate the mechanical attenuation value and change only the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute. If you set the RF attenuation step size to a value other than a multiple of 5 dB, NI-RFSA uses the maximum mechanical attenuation to set RF attenuation step size and achieves the remainder with the solid-state attenuation.

> **Note** For the PXIe-5605, certain combinations of RF attenuation step size settings and device center frequencies can wear down the mechanical attenuator over time. This occurs if your application requires you to reconfigure your device center frequency from the low band to the high band, or vice versa, and you set the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute to a value other than a multiple of 5. In the low band, NI-RFSA uses a combination of mechanical and solid-state attenuation to set the RF attenuation step size to a value other than a multiple of 5, but in the high band, NI-RFSA uses only mechanical attenuation to compensate for the RF attenuation remainder. If your application does not require reconfiguring the device center frequencies from the low band to high band or vice versa, setting the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute to a value other than a multiple of 5 does not wear down the mechanical attenuator.

You can also use the Mechanical Attenuation property or the NIRFSA_ATTR_MECHANICAL_ATTENUATION attribute to set the mechanical attenuator to a fixed value, which ensures that the RF attenuation varies only by the solid-state attenuation specified by the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute setting. By setting the mechanical attenuator to a fixed value, you can sweep the RF attenuation for the device from the set mechanical attenuation value to the following values without using the mechanical attenuator, which can also reduce test time in some cases.

- PXIe-5603: mechanical attenuation + 44 dB
- PXIe-5605: mechanical attenuation + 31 dB

> **Note** The values you enter for mechanical attenuation are coerced upward. For example, choosing 12 dB results in a minimum mechanical attenuation of 20 dB (for the PXIe-5603) or 15 dB (for the PXIe-5605).

Related information:

- Reference

Programming Attenuation Using NI-RFSA

Given a reference level, NI-RFSA configures the hardware attenuation for optimal performance. However, you can customize some aspects of the configuration.

The topics in this section provide information about the ways in which you can customize attenuation-related properties and attributes, as well as any special considerations your adjustments might require.

Device Attenuation Value Relationships

The coupling between the reference level, solid-state attenuation, and mechanical attenuation varies depending on which attributes or properties are set.

The following table describes the relationship between the applicable attributes or properties. In the following table, ***Total Attenuation*** comprises both mechanical attenuation and solid-state attenuation.

The ***Set Mixer Level Offset***, ***Set Mechanical Attenuation***, and ***Set Total Attenuation*** columns indicate whether you need to set the applicable property or attribute to achieve the behavior specified in the ***Description*** column. The ***Restriction*** column specifies any parameter relationships you should observe.

> **Note** The Reference Level property and the NIRFSA_ATTR_REFERENCE_LEVEL attribute also affect the NI-RFSA behavior. If you set this property or attribute, the value,
> P_{REF}
> , is used in the formulas shown in the following table. If you do not set this value, NI-RFSA uses the default value of 0 dBm for calculations in which reference level is a factor.

Set Mixer Level Offset	Set Mechanical Attenuation	Set Total Attenuation	Description	Restriction
No	No	No	There are no user constraints on the settings. The total attenuation is calculated based on the specified reference level and default mixer level. **Note** Even if you do not set the Reference Level property or the NIRFSA_ATTR_REFERENCE_LEVEL, the default value of 0 dBm is used in all calculations.	$P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$ $P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$
Yes	No	No	Total attenuation is calculated based on the reference level and mixer level.	$P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$ $P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$
No	Yes	No	The total attenuation, consisting of mechanical and solid state attenuators, is calculated based on the stated reference level and default mixer level. The amount of mechanical attenuation is user-constrained; the remaining solid-state attenuation is calculated to best match the values you specify.	$P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$ $P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$
Yes	Yes	No	This configuration is similar to the preceding configuration, with the exception that a user-specified mixer level (offset) constraint is taken into the equation instead of a default value.	$P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$ $P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$
No	No	Yes	The attenuators are set based on the user-specified total attenuation constraint. The balance between mechanical and solid state attenuators is calculated by NI-RFSA.	$P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$ $P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$
No	Yes	Yes	This configuration is similar to the preceding configuration, with the exception that the balance between mechanical and electronic attenuation is calculated based on the user-	$P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$ $P_{REF} - (A_{NSS} + A_{MECH}) + G_{PA} \leq$

Set Mixer Level Offset	Set Mechanical Attenuation	Set Total Attenuation	Description	Restriction
			specified constraints.	
Yes	N/A	Yes	This configuration produces an error. The mixer level and the total attenuation are both specified as part of the same setup. In this invalid configuration, mechanical attenuation is irrelevant.	N/A

where

- A_{MECH} is the nominal mechanical attenuation in dB
- A_{NSS} is the nominal solid-state attenuation in dB
- G_{PA} is the nominal preamplifier gain in dB
- P_{MIX} is the mixer level in dBm
- P_{REF} is the reference level in dBm

Note

P_{MIX} satisfies the following relationship: -100 dBm ≤ P_{MIX} ≤ +5 dBm

Note The gain, G_{PA}, is 15 dB when the preamplifier is present and enabled, and 0 dB when the preamplifier is not present or disabled.

Note The IF gain of the PXIe-5665 is nominally

$P_{IF} - P_{REF} + A_{NSS} + A_{MECH} - G_{PA}$

> , where
> P_{IF}
> is set with the IF Output Power Level property or the NIRFSA_ATTR_IF_OUTPUT_POWER_LEVEL attribute.

Attenuation-Related Properties and Attributes

You can customize the hardware attenuation configuration by explicitly setting the following NI-RFSA properties and attributes.

LabVIEW Property	LabWindows CVI/C Attribute
RF Attenuation	NIRFSA_ATTR_ATTENUATION
RF Attenuation Step Size	NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE
Mechanical Attenuation	NIRFSA_ATTR_MECHANICAL_ATTENUATION
Mixer Level	NIRFSA_ATTR_MIXER_LEVEL
Mixer Level Offset	NIRFSA_ATTR_MIXER_LEVEL_OFFSET
IF Output Power Level	NIRFSA_ATTR_IF_OUTPUT_POWER_LEVEL
IF Output Power Level Offset	NIRFSA_ATTR_IF_OUTPUT_POWER_LEVEL_OFFSET
External Gain	NIRFSA_ATTR_EXTERNAL_GAIN

Related information:

- Reference

Relationship Between Reference Level, RF Attenuation, and Mixer Level

The reference level, RF attenuation, and mixer level settings interact with each other. Customizing the value of one setting can have an effect on the value of another setting.

RF attenuation refers to all the attenuation that occurs before the mixer, which includes both solid-state (or electronic) attenuators and mechanical attenuators. NI-RFSA uses the value of the Reference Level property or the NIRFSA_ATTR_REFERENCE_LEVEL attribute even if you do not set it. The default value is 0 dBm. The reference level determines the amount of RF attenuation deployed based on the mixer level. If you do not specify a value for the Mixer Level property or the NIRFSA_ATTR_MIXER_LEVEL attribute, the default value is -10 dBm.

If you set the mixer level, the RF attenuation is calculated so that it satisfies the following equation:

reference level - RF attenuation ≤ mixer level

NI-RFSA adjusts the settings to get close to the desired mixer level, but it does not return an error if the signal level is too low. NI-RFSA does return an error if the reference level is so high that even with the maximum available RF attenuation, it cannot lower the signal at mixer below the specified mixer level. Because of the relationship between mixer level and RF attenuation, you cannot set both the mixer level and the RF attenuation at the same time or NI-RFSA returns an error.

To configure the mixer level, specify the value of the Mixer Level property or the NIRFSA_ATTR_MIXER_LEVEL attribute, or the Mixer Level Offset or the NIRFSA_ATTR_MIXER_LEVEL_OFFSET attribute (but not both-setting both results in an error). If you are interested in particular mixer levels, specify a mixer level. If you are interested in the noise/distortion, specify a mixer level offset. Mixer level offset does not depend on absolute mixer levels, so it supports the PXIe-5665 as well as other devices. When the mixer level is specified in conjunction with the reference level, the RF attenuation is determined by the formula reference level - RF attenuation ≤ mixer level. Notice that no matter how low the reference level is, the RF attenuation never drops below the minimal amount designed to protect the front end of the downconverter. The default RF attenuation for the PXIe-5603/5605 is 10 dB.

To control the RF attenuation setting directly, use the RF Attenuation property or the NIRFSA_ATTR_ATTENUATION attribute. You can specify a value as low as 0 dB.

> **Note** NI-RFSA returns an error if you set both the RF attenuation and mixer level at the same time.

Controlling RF Attenuation Step Size

To change the RF attenuation step size for your device, use the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute.

Note For the PXIe-5603, the driver uses 1 dB steps to change RF attenuation. For the PXIe-5605, the available RF attenuation changes depending on the specified center frequency. In the high band signal path, frequencies greater than 3.6 GHz, the only available RF attenuation is the mechanical attenuator that you can change in 5 dB steps. In the low band signal path, frequencies less than or equal to 3.6 GHz, an additional 31 dB of solid-state attenuation is available in 1 dB steps. The default step size for the PXIe-5605 is 5 dB. This default value indicates that even when in the low band signal path, NI-RFSA changes the RF attenuation in 5 dB steps using only the mechanical attenuator. You can use the RF Attenuation Step Size property or the NIRFSA_ATTR_RF_ATTENUATION_STEP_SIZE attribute to affect when the device changes the RF attenuation settings. To use the solid-state attenuation in the low band signal path, change the step size to a value other than a multiple of 5 (for example, a step size of 1 dB). If you use a value other than a multiple of 5 while in the high band signal path of the PXIe-5605, NI-RFSA returns an error.

Controlling Mechanical Attenuation

To control the mechanical attenuator directly, specify a mechanical attenuation value using the Mechanical Attenuation property or the NIRFSA_ATTR_MECHANICAL_ATTENUATION attribute.

The value you specify works together with the value of the RF Attenuation property or the NIRFSA_ATTR_ATTENUATION attribute. You can set both values, but you are not required to do so. For example, you can set the mechanical attenuation to a certain value and then perform a power sweep by changing the reference level in a loop. Without specifying a mechanical attenuation value, NI-RFSA calculates the attenuation value every time based on the prescribed algorithm, and that calculation could include different amounts of mechanical and electronic attenuation. By constraining the mechanical part, you can achieve faster sweep times, resulting from the lower settling times for the electronic attenuators compared to the mechanical attenuators, and it can cause less wear on the mechanical attenuator.

Enabling the RF Preamplifier

The last RF front-end property and attribute, which can be set in addition to the mixer level or attenuation, are the RF Preamplifier Enabled property or the NIRFSA_ATTR_PREAMP_ENABLED attribute. You can enable the preamplifier in conjunction with low reference levels but only if the input signals are low.

Controlling IF Output Power Level and Offset

You can specify either the IF output power level or the IF output power level offset.

> **Notice** NI-RFSA returns an error if you specify both the IF output power level and the IF output power level offset at the same time.

Choose between IF output power level and IF output power level offset as follows:

- If you are familiar with your digitizer requirements, set the IF Output Power Level property or the NIRFSA_ATTR_IF_OUTPUT_POWER_LEVEL attribute to the expected value.
- If you want to achieve better dynamic range at the output without considering the absolute value of the output, use the IF Output Power Level Offset property or the NIRFSA_ATTR_IF_OUTPUT_POWER_LEVEL_OFFSET attribute.

Resetting Attenuation-Related Settings

After you set attenuation-related properties and settings, the settings you select persist until you reset them.

If you are using LabVIEW, use the NI-RFSAProperty Node to reset a property. To reset a property in the Property Node, select the property, right-click the Property Node, and select **Change To » Default Value** from the shortcut menu.

If you are using LabWindows/CVI, use the niRFSA_ResetAttribute function to reset an attribute.

PXIe-5665 Timing Configurations

The timebases of the PXIe-5622 IF digitizer and the PXIe-5653 synthesizer/LO source module must be frequency-locked to a common reference clock. The following clock sources are available:

- **100 MHz PXIe-5653 LO synthesizer/LO source onboard Reference Clock**—The PXIe-5653 supplies this 100 MHz source through the REF OUT (100 MHz) connector.
- **10 MHz external Reference Clock**—Connect the external clock signal, from your stable frequency reference, to the REF IN connector on the PXIe-5653.
- **10 MHz PXI backplane clock**—This 10 MHz Reference Clock signal is supplied on the PXI backplane.

Note Although using the 10 MHz PXI backplane clock as a reference is possible, NI does not recommend doing so.The frequency accuracy and stability of the 10 MHz PXI backplane reference results in increased phase noise.

Note Do not use the PXIe-5653 REF OUT (10 MHz) connector as a reference source for timing configurations.

Related reference:

- PXIe-5665 Front Panel

Related information:

- Reference

Configuring Onboard Reference Clock Timing

The default configuration of the PXIe-5665 allows the PXIe-5653 to export its internal 100 MHz reference to the PXIe-5622 so that the PXIe-5622 and the PXIe-5653 devices are frequency-locked.

Complete the following steps to configure the PXIe-5665 to use the PXIe-5653 internal clock.

1. Connect the 100 MHz REF OUT connector on the PXIe-5653 front panel to the CLK IN connector on the PXIe-5622 IF digitizer front panel.
2. Set the Ref Clock Source property to OnboardClock or the NIRFSA_ATTR_REF_CLOCK_SOURCE attribute to NIRFSA_VAL_ONBOARD_CLOCK_STR.

Configuring External Reference Clock Timing

Complete the following steps to lock to an external reference source.

1. Connect the external signal to the PXIe-5653 REF IN connector.
2. Connect the 100 MHz REF OUT terminal on the PXIe-5653 to the CLK IN connector on the PXIe-5622.
3. Specify RefIn as the Reference Clock source using the niRFSA Configure Ref Clock VI or the niRFSA_ConfigureRefClock function.
   NI-RFSA uses a default Reference Clock rate of 10 MHz. Use the niRFSA Configure Ref Clock VI or the niRFSA_ConfigureRefClock function to specify a different Reference Clock rate if you do not want to use the default value. The PXIe-5653 accepts any frequency from 5 MHz to 100 MHz in 1 MHz steps on the REF IN terminal as the Reference Clock.

Configuring PXI 10 MHz Backplane Clock Timing

NI recommends that you configure your system so the PXIe-5622 IF digitizer uses the source provided by the PXIe-5653100 MHz REF OUT front panel connector. You can also configure the PXIe-5665 to lock to the PXI 10 MHz backplane clock. The default configuration locks the PXIe-5653 and PXIe-5622 to the PXI 10 MHz reference.

Complete the following step to configure the PXIe-5665 to use the PXI 10 MHz backplane clock.

1. Ensure the device is setup using the default cable configuration.
2. Set the Ref Clock Source property to PXI_Clk or the NIRFSA_ATTR_REF_CLOCK_SOURCE attribute to NIRFSA_VAL_PXI_CLK_STR.
   The PXIe-5653 can lock to the PXI Express backplane Reference Clocks if the backplane Reference Clocks meet the frequency accuracy requirements of the PXIe-5653.

   > **Note** The PXI Express backplane Reference Clock, when left free running, may not meet the accuracy requirements of the PXIe-5653. The PXIe-5653 requirements are more stringent than PXI Express backplane accuracy requirements because of the high-performance OCXO on the PXIe-5653. Locking to the PXI Express backplane Reference Clock requires that the

> PXI Express backplane Reference Clock be locked to another, more accurate external reference.

Phase Coherency

Sharing a local oscillator (LO) has implications for PXIe-5665 phase coherency.

Phase coherency guarantees that two devices are locked to the same frequency with a constant phase offset between them. ***Phase offset*** is the difference between the phases of two signals.

Phase coherency is achieved on multiple PXIe-5665 devices with the default device configuration. Phase coherency is guaranteed because a single LO is shared between each PXIe-5665 module in the daisy chain.

Connecting the PXIe-5665 to the PXIe-5673E

You can use the PXIe-5665 with the PXIe-5673E vector signal generator to generate and analyze communications signals up to 3.6 GHz with the PXIe-5665 (3.6 GHz) and up to 14 GHz with the PXIe-5665 (14 GHz).

Complete the following steps, as applicable for your configuration, to set up an internal or external Reference Clock with the PXIe-5665 and PXIe-5673E.

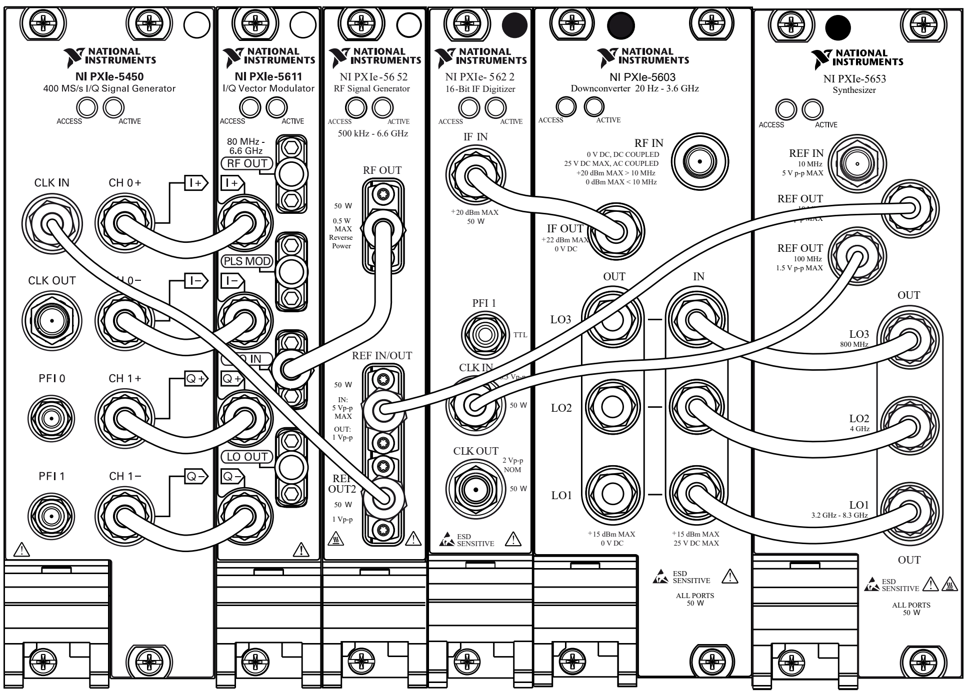
1. Install an PXIe-5603/5605 RF signal downconverter module in an available PXI Express or hybrid slot that has at least one empty slot to the left and at least two empty slots to the right.
2. Install an PXIe-5622 IF digitizer module immediately to the left of the PXIe-5603/5605.
3. Install an PXIe-5653 RF analog signal generator immediately to the right of the PXIe-5603/5605.
4. Install the PXIe-5652 RF analog signal generator that shipped with your PXIe-5673E immediately to the left of the PXIe-5622.
5. Install the PXIe-5611 I/Q modulator that shipped with your PXIe-5673E immediately to the left of the PXIe-5652.
6. Install the PXIe-5450 waveform generator that shipped with your PXIe-5673E

immediately to the left of the PXIe-5611.

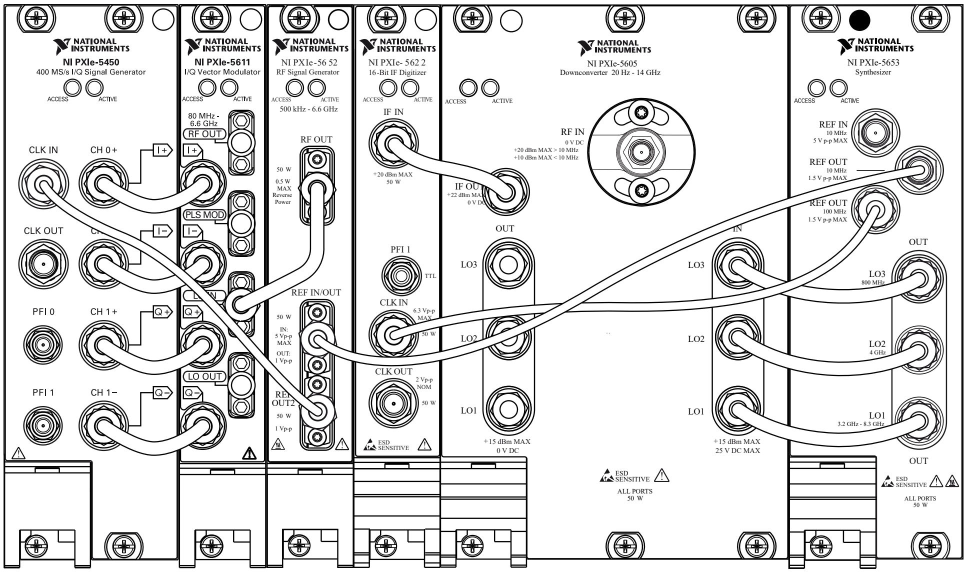
7. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 0+/I+ on the PXIe-5450 to I+ on the PXIe-5611.
8. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 0-/I- on the PXIe-5450 to I- on the PXIe-5611.
9. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 1+/Q+ on the PXIe-5450 to Q+ on the PXIe-5611.
10. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 1-/Q- on the PXIe-5450 to Q- on the PXIe-5611.
11. Using a semi-rigid SMA-to-SMA coaxial cable (labeled B), connect RF OUT on the PXIe-5652 to LO IN on the PXIe-5611.
12. Using a semi-rigid SMA-to-SMA cable (labeled K), connect IF OUT on the PXIe-5603/5605 to IF IN on the PXIe-5622.
13. Using a semi-rigid SMA-to-SMA cable (labeled J), connect LO1 OUT on the PXIe-5653 to LO1 IN on the PXIe-5603/5605.
14. Using a semi-rigid SMA-to-SMA cable (labeled J), connect LO2 OUT on the PXIe-5653 to LO2 IN on the PXIe-5603/5605.
15. Using a semi-rigid SMA-to-SMA cable (labeled J), connect LO3 OUT on the PXIe-5653 to LO3 IN on the PXIe-5603/5605.
16. Using a flexible coaxial cable, connect REF OUT (100 MHz) on the PXIe-5653 to CLK IN on the PXIe-5622.
17. Using a flexible coaxial cable, connect REF OUT (10 MHz) on the PXIe-5653 to REF IN/OUT on the PXIe-5652.
18. Using a flexible coaxial cable, connect REF OUT2 on the PXIe-5652 to CLK IN on the PXIe-5450.
19. If you want to use an external clock, use a flexible coaxial cable to connect the external clock of your choice to the REF IN connector on the PXIe-5653. Set the clock rate to the output frequency of the external clock source for the Reference Clock using the `clock rate` parameter of the niRFSA Configure Ref Clock VI or the `refClockRate` parameter of the niRFSA_ConfigureRefClock function.
20. Set the PXIe-5673E clock source parameter of the niRFSG Configure Ref Clock VI to RefIn or set the `clockSource` parameter of the niRFSG_ConfigureRefClk function to RefIn. Set the clock rate to 10 MHz for the Reference Clock using the `clock rate` parameter of the niRFSG Configure Ref Clock VI or the `refClockRate` parameter of the niRFSG_ConfigureRefClk function.
21. Connect a 50 Ω termination to the following connectors:
    - LO OUT on the PXIe-5611

- LO1 OUT on the PXIe-5603/5605
- LO2 OUT on the PXIe-5603/5605
- LO3 OUT on the PXIe-5603/5605

The following figure shows an interconnected PXIe-5665 (3.6 GHz) and PXIe-5673E using an internal clock.



The following figure shows an interconnected PXIe-5665 (14 GHz) and PXIe-5673E using an internal clock.



Connecting the PXIe-5665 to the PXIe-5673

You can use the PXIe-5665 with the PXIe-5673 vector signal generator to generate and analyze communications signals up to 3.6 GHz with the PXIe-5665 (3.6 GHz) and up to 14 GHz with the PXIe-5665 (14 GHz).

Complete the following steps, as applicable, to set up an internal or external Reference Clock with the PXIe-5673 and the PXIe-5665.

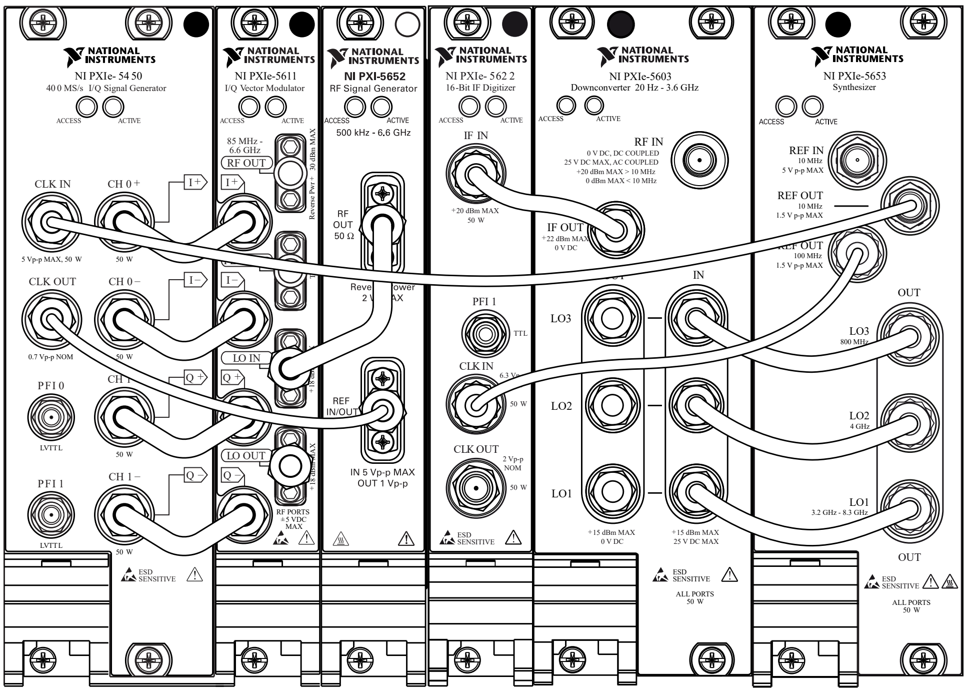
1. Install an PXIe-5603/5605 RF signal downconverter module in an available PXI Express or hybrid slot that has at least one empty slot to the left and at least two empty slots to the right.
2. Install an PXIe-5622 IF digitizer module immediately to the left of the PXIe-5603/5605.
3. Install an PXIe-5653 RF analog signal generator immediately to the right of the PXIe-5603/5605.
4. Install the PXI-5652 RF analog signal generator that shipped with your PXIe-5673 immediately to the left of the PXIe-5622.
5. Install the PXIe-5611 I/Q modulator that shipped with your PXIe-5673 immediately to the left of the PXI-5652.
6. Install the PXIe-5450 waveform generator that shipped with your PXIe-5673 immediately to the left of the PXIe-5611.
7. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 0+/I+ on the

PXIe-5450 to I+ on the PXIe-5611.

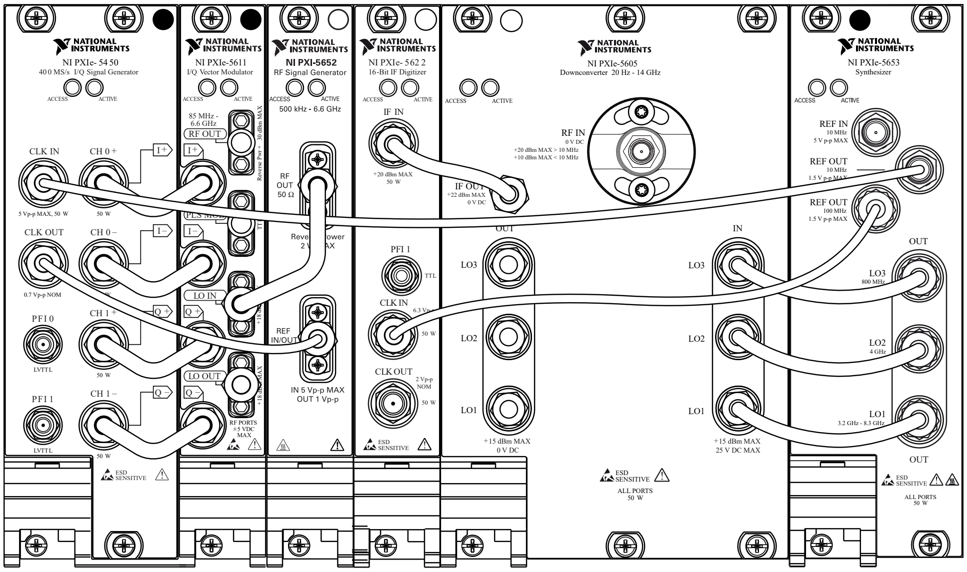
8. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 0-/I- on the PXIe-5450 to I- on the PXIe-5611.
9. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 1+/Q+ on the PXIe-5450 to Q+ on the PXIe-5611.
10. Using a semi-rigid SMA-to-SMA cable (labeled A), connect CH 1-/Q- on the PXIe-5450 to Q- on the PXIe-5611.
11. Using a semi-rigid SMA-to-SMA coaxial cable (labeled B), connect RF OUT on the PXI-5652 to LO IN on the PXIe-5611.
12. Using a semi-rigid SMA-to-SMA cable (labeled K), connect IF OUT on the PXIe-5603/5605 to IF IN on the PXIe-5622.
13. Using a semi-rigid SMA-to-SMA cable (labeled J), connect LO1 OUT on the PXIe-5653 to LO1 IN on the PXIe-5603/5605.
14. Using a semi-rigid SMA-to-SMA cable (labeled J), connect LO2 OUT on the PXIe-5653 to LO2 IN on the PXIe-5603/5605.
15. Using a semi-rigid SMA-to-SMA cable (labeled J), connect LO3 OUT on the PXIe-5653 to LO3 IN on the PXIe-5603/5605.
16. Using a flexible coaxial cable, connect REF OUT (100 MHz) on the PXIe-5653 to CLK IN on the PXIe-5622.
17. Using a flexible coaxial cable, connect REF OUT (10 MHz) on the PXIe-5653 to CLK IN on the PXIe-5450.
18. Using a flexible coaxial cable, connect REF IN/OUT on the PXI-5652 to CLK OUT on the PXIe-5450.
19. If you want to use an external clock, use a flexible coaxial cable to connect the external clock of your choice to the REF IN connector on the PXIe-5653. Set the clock rate to the output frequency of the external clock source for the Reference Clock using the `clock rate` parameter of the niRFSA Configure Ref Clock VI or the `refClockRate` parameter of the niRFSA_ConfigureRefClock function.
20. Set the PXIe-5673`clock source` parameter of the niRFSG Configure Ref Clock VI to ClkIn or set the `clockSource` parameter of the niRFSG_ConfigureRefClk function to ClkIn. Set the clock rate to 10 MHz for the Reference Clock using the `clock rate` parameter of the niRFSG Configure Ref Clock VI or the `refClockRate` parameter of the niRFSG_ConfigureRefClk function.
21. Connect a 50 Ω termination to the following connectors:
    - LO OUT on the PXIe-5611
    - LO1 OUT on the PXIe-5603/5605
    - LO2 OUT on the PXIe-5603/5605

- ◦ LO3 OUT on the PXIe-5603/5605

The following figure shows an interconnected PXIe-5665 (3.6 GHz) and PXIe-5673 using an internal clock.



The following figure shows an interconnected PXIe-5665 (14 GHz) and PXIe-5673 using an internal clock.



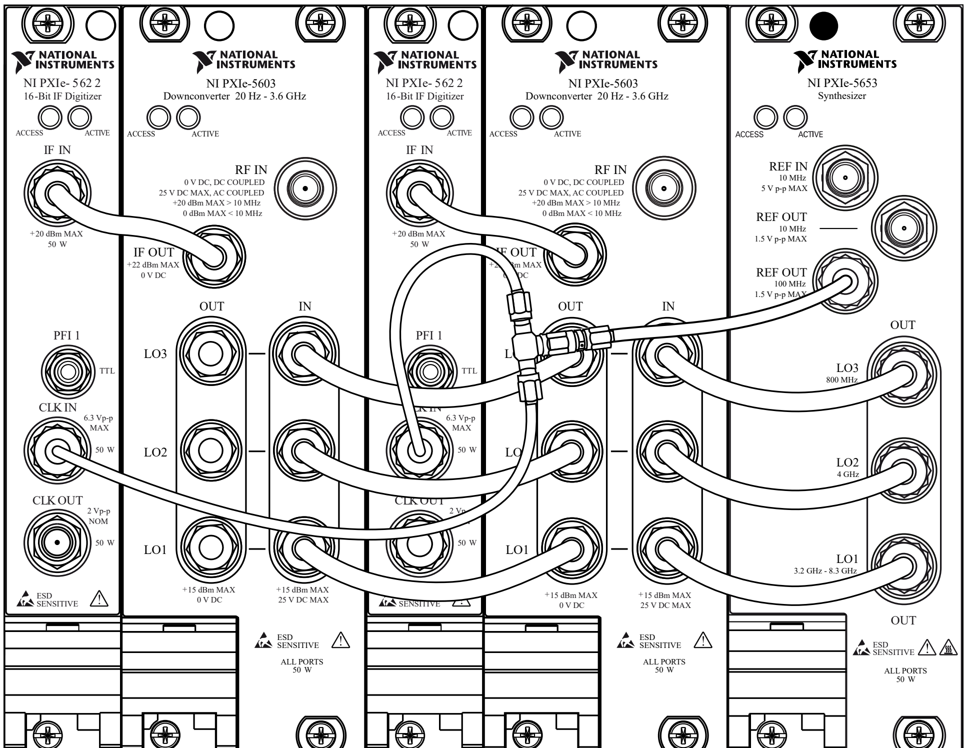
Connecting Multiple PXIe-5665 Devices

You must install one PXIe-5665 before following these steps to install multiple modules. Refer to the device getting started guide for detailed installation instructions.

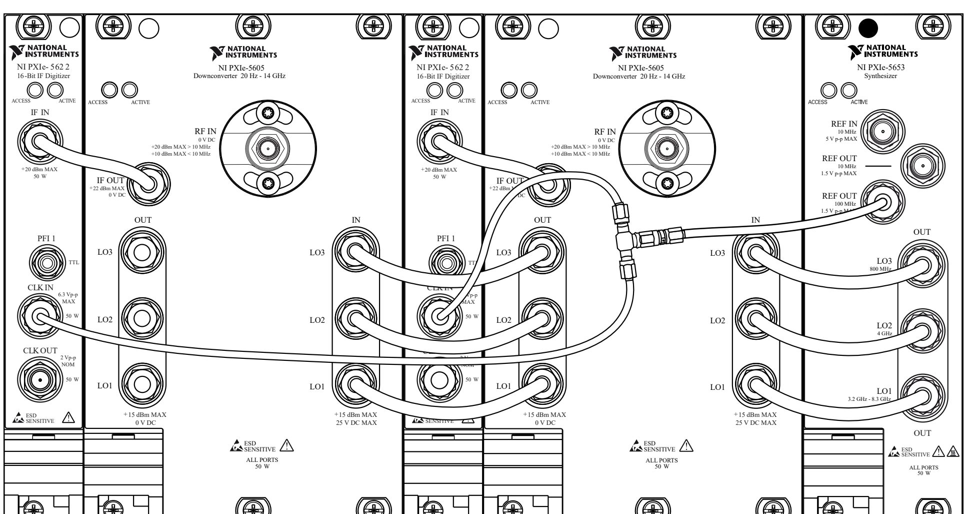
1. Install an additional PXIe-5603/5605 RF signal downconverter in the slot immediately to the left of the original PXIe-5622 IF digitizer.
2. Install an additional PXIe-5622 in the slot immediately to the left of the second PXIe-5603/5605, installed in the previous step.
3. If installed, remove the three 50 Ω terminations from the three LO OUT connectors (LO1 OUT, LO2 OUT, and LO3 OUT) on the original PXIe-5603/5605.
4. Using three semi-rigid SMA-to-SMA coaxial cables (labeled M), connect the three LO OUT connectors on the original downconverter to the associated LO IN connectors on the second downconverter as follows:
   - LO1 OUT to LO1 IN
   - LO2 OUT to LO2 IN
   - LO3 OUT to LO3 IN
5. Using a flexible SMA-to-SMA coaxial cable, connect the 100 MHz REF OUT connector on the PXIe-5653 to the input connector of a two-way splitter. Connect the outputs of the two-way splitter to the CLK IN connectors on each PXIe-5622.
6. Using a short semi-rigid SMA-to-SMA coaxial cable (labeled K), connect the IF OUT connector on the second RF signal downconverter to the IF IN connector on the second PXIe-5622.

7. Connect a 50 Ω termination to each of the LO OUT connectors (LO1 OUT, LO2 OUT, and LO3 OUT) on the second RF signal downconverter.

The following figure shows an interconnected PXIe-5665 (3.6 GHz) using two RF signal downconverters and two IF digitizers.



The following figure shows an interconnected PXIe-5665 (14 GHz) using two RF signal downconverters and two IF digitizers.



Using Internal and External Clock Signals with Multiple PXIe-5665 Devices

You can have one external clock or one PXIe-5653 internal clock connected in common with multiple PXIe-5665 devices.

After interconnecting multiple PXIe-5665 devices, complete the following steps to allow multiple PXIe-5603/5605 modules to share a common LO source.

1. Launch NI Measurement & Automation Explorer (MAX).
2. In the Configuration pane, expand the **Devices and Interfaces** tree to see the list of installed devices.
3. Expand your chassis tree item.
   MAX lists all available devices under the chassis. Your device names may vary.
4. In the NI 5603 or NI 5605 Configuration dialog box, use the drop-down **LO** listbox to specify the PXIe-5653 module that is connected to the PXIe-5603 or PXIe-5605 by coaxial cables.
5. For all additional downconverter daisy-chained devices, in the NI 5603 or NI 5605 Configuration dialog box, select **External** from the drop-down **LO** listbox.
6. To set up either an external clock or an internal clock, complete the following steps. Notice that the internal clock source, if used, is the master PXIe-5665 (the first PXIe-5665 in the daisy chain).
   a. For each PXIe-5665 in the daisy chain except the last device, export the Reference Clock to the CLK OUT terminal using the niRFSA Export Signal VI or the niRFSA_ExportSignal function.
   b. For each PXIe-5665 in the daisy chain except the last device, specify that the LO source is exported by setting the LO Export Enabled property or the NIRFSA_ATTR_LO_EXPORT_ENABLED attribute to TRUE.
   c. For each PXIe-5665 in the daisy chain except the first device, use the niRFSA Configure Ref Clock VI or the niRFSA_ConfigureRefClock function to configure the Reference Clock source. For an internal clock, specify the CLK IN terminal as the Reference Clock source and set the Reference Clock rate to 100 MHz.
   d. For an external clock, set the first PXIe-5665 to use REF IN as the Reference Clock source.

PXIe-5665 Module Front Panel Temperatures

The PXIe-5665 system modules have the following typical front panel temperatures.

- **PXIe-5603** — 31.0 °C (87.8 °F) when placed next to the PXIe-5622 IF digitizer and PXIe-5653 RF analog signal generator
- **PXIe-5605** — 26.0 °C (78.8 °F) when placed next to the PXIe-5622 IF digitizer and PXIe-5653 RF analog signal generator at an ambient temperature of 23 °C (73 °F)
- **PXIe-5622** — 31.4 °C (88.5 °F)
- **PXIe-5653** — 30.4 °C (86.7 °F)

Note The temperatures are based on systems with proper airflow, normal operation, and an ambient temperature of 25 °C (77 °F). To ensure sufficient airflow for all modules, place slot blockers in empty chassis slots, and use blank front covers where applicable. Set the chassis fan to high speed.

Notice Allow time for the PXIe-5665 modules to cool before removing them from the PXI Express chassis. Use caution when handling a recently removed module.

Device Warm-Up

NI recommends warming up the PXIe-5665 hardware for 30 minutes before operation.

The unit is fully functional prior to this time, but frequency, amplitude accuracy, and other specifications are not at warranted levels until the device has fully completed warming up.

Note Warm up begins when the PXI Express chassis has been powered on and the operating system has completely loaded.

Digital IF Equalization

Digital IF equalization is a calibration that involves measuring and then compensating for IF magnitude and phase response.

IF equalization calibration gives the PXIe-5665 the ability to measure lower levels of error vector magnitude (EVM). For spectrum measurements, IF equalization results in a higher degree of magnitude accuracy across the IF bandwidth.

To achieve the desired IF flatness and overall accuracy specifications, equalization must be performed. Equalization attempts to correct for the following factors:

- Frequency response of the digitizer
- RF response of the downconverter
- IF response of the downconverter

To enable digital IF equalization, use either the Digital IF Equalization Enabled property or the NIRFSA_ATTR_DIGITAL_IF_EQUALIZATION_ENABLED attribute.

Related information:

- Reference

Spurious Performance

Signals at the PXIe-5603/5605 RF IN and IF OUT front panel connectors can contain the desired signal as well as spurious responses. This topic briefly describes the sources of the most common spurs in the spurious response sections of the device specifications.

Spurious responses are categorized as ***input-related*** or ***non-input-related***. ***Input-related spurs*** are generated only when an input signal is present at the downconverter RF IN front panel connector. ***Non-input-related spurs*** (also referred to as ***internally generated spurious responses***, ***residual spurs***, or ***residual responses***) are generated whether or not a signal is present at the downconverter RF IN front panel connector.

Input-related spurs include ***mixing spurs***. Mixing spurs are undesired outputs of a mixer that result from the normal actions of the mixer. The mixer output contains desired and undesired combinations of the input and local oscillator (LO) frequency.

Input-related spurs are generated by a single input signal or multiple input signals. Spurious responses generated by a single input signal are normally grouped together as ***spurious responses***. Spurious responses generated by multiple input signals, as well as certain responses generated by single input signals, are often grouped together as ***nonlinearities***. Nonlinearities include second harmonic and third-order intermodulation distortion.

Non-Input Related Spurs

Spurious signals that appear when there is no input signal are known as non-input-related spurs.

These spurs are combinations of internal signals that mix and result in a signal in the PXIe-5665 IF. A common type of input-related spur is generated by the internal LO signals. If one or more of the following equations is satisfied, a spur of this type may be created:

$mf_{LO1} + nf_{LO2} + pf_{LO3} = f_{IF1}$

$mf_{LO1} + nf_{LO2} + pf_{LO3} = f_{IF2}$

$mf_{LO1} + nf_{LO2} + pf_{LO3} = f_{IF3}$ (PXIe-5603 only)

where

- m is an integer
- n is an integer
- p is an integer
- f_{LO2} is equal to 4 GHz (PXIe-5603 or PXIe-5605 for RF frequencies ≤ 3.6 GHz) or 800 MHz (PXIe-5605 for RF frequencies > 3.6 GHz)
- f_{LO3} is equal to 800 MHz (PXIe-5603 or PXIe-5605 for RF frequencies < 3.6 GHz)

Depending on the IF Filter Selection option you choose, f_{LO1} and f_{IFx} can be calculated as shown in the following tables.

Table 9. PXIe-5603 and PXIe-5605 (for RF Frequencies ≤ 3.6 GHz)

IF Filter Selection	f_{IF1}	f_{IF2}	f_{IF3}	f_{LO1} Range
300 kHz	4601.0 MHz	601.0 MHz	199.0 MHz	4,601.0 MHz to 8,201.0 MHz
5 MHz (PXIe-5605 only)	4610.0 MHz	610.0 MHz	190.0 MHz	4,610.0 MHz to 8,210.0 MHz

IF Filter Selection	f_{IF1}	f_{IF2}	f_{IF3}	f_{LO1} Range
Through	4612.5 MHz	612.5 MHz	187.5 MHz	4,612.5 MHz to 8,212.5 MHz

Table 10. PXIe-5605 (for RF Frequencies > 3.6 GHz and ≤ 7.5 GHz)

IF Filter Selection	f_{IF1}	f_{IF2}	f_{LO1} Range
300 kHz	601.0 MHz	199.0 MHz	4,201.0 MHz to 8,101.0 MHz
5 MHz	610.0 MHz	190.0 MHz	4,210.0 MHz to 8,110.0 MHz
Through	612.5 MHz	187.5 MHz	4,212.5 MHz to 8,112.5 MHz

Table 11. PXIe-5605 (for RF Frequencies > 7.5 GHz)

IF Filter Selection	f_{IF1}	f_{IF2}	f_{LO1} Range
300 kHz	601.0 MHz	199.0 MHz	4,050.50 MHz to 7,300.50 MHz
5 MHz	610.0 MHz	190.0 MHz	4,055.00 MHz to 7,305.00 MHz
Through	612.5 MHz	187.5 MHz	4,056.25 MHz to 7,306.25 MHz

LO Leakage to RF and IF

LO leakage is a portion of the LO signal that leaks from the PXIe-5603 or the PXIe-5605 LO IN to the RF IN or IF OUT front panel connectors.

LO leakage to the RF IN front panel connector is most often seen at low tuned frequencies. The PXIe-5665 has three LO frequencies: LO1 tunes along with the RF input frequency, LO2 is fixed at 4 GHz, and LO3 is fixed at 800 MHz.

The following LO leakage signal frequencies are related to the frequency of the LO signal:

- LO3 leakage frequency: 800 MHz

- LO2 leakage frequency: 4,000 MHz
- The LO1 frequency can be calculated, as shown in the following table, where F_{tune} is the tuned frequency of the PXIe-5665 system.

IF Filter Selection	**f_{LO1} Frequency**		
	PXIe-5603 and PXIe-5605 (for Frequencies ≤ 3.6 GHz)	**PXIe-5605 (for Frequencies > 3.6 GHz and ≤ 7.5 GHz)**	**PXIe-5605 (for Frequencies > 7.5 GHz)**
300 kHz	F_{tune} + 4601.0 MHz	F_{tune} + 601.0 MHz	(F_{tune} + 601.0 MHz)/2
5 MHz (PXIe-5605 only)	F_{tune} + 4610.0 MHz	F_{tune} + 610.0 MHz	(F_{tune} + 610.0 MHz)/2
Through	F_{tune} + 4612.5 MHz	F_{tune} + 612.5 MHz	(F_{tune} + 612.5 MHz)/2

Input-Related Spurs

Input-related spurs include mixing spurs, image responses, IF rejection, LO spurs, sideband spurs, and third-order intermodulation distortion (IMD3).

Mixing Spurs

Mixing spurs are undesired output signals from a mixer that result from the nonlinear circuit elements in the first mixer.

The mixer output contains desired and undesired combinations of the input and LO frequencies. The relationship between the mixer input, output, and LO frequencies is represented in the following equation: $f_{IF} = mf_{LO} + nf_{RF}$

where

- f_{IF} represents the output of the mixer
- f_{RF} represents the input of the mixer
- f_{LO} represents the LO frequency
- m and n can be any independent integer value

Image Responses

Every mixer, at each downconverting stage, produces an image response when an undesired signal is present at the RF input. Each image response appears at a frequency 2 x IF away from the tuned RF frequency. The PXIe-5603 and PXIe-5605 use filters to minimize these undesired images, so only the frequency signal of choice remains for analysis.

The desired IF response for the PXIe-5603/5605 downconverter is (m, n) = (1,-1). The downconverter uses filters to reject the lowest-order image (m, n) = (-1,1) of each mixer. However, not all higher-order images (|m| > 1 or |n| > 1) are completely eliminated. Furthermore, the system may be sensitive to certain low-order images. Image responses for multiple-conversion systems, such as the PXIe-5665, can be classified as direct or translated. A direct image is an image at the usual image frequency (2 x IF away from the desired signal). A translated image occurs when the direct image for a mixer in the system is frequency translated by the other mixers ahead of it in the signal path.

The (m, n) for the desired conversions and direct images for the PXIe-5603 and PXIe-5605 are shown in the following table.

Downconverter	**Frequencies**	**First Mixer**	**First Mixer Image (Direct)**	**Second Mixer**	**Second Mixer Image (Direct)**	**Third Mixer**	**Third Mixer Image (Direct)**
PXIe-5603	≤3.6 GHz	(1, -1)	(-1, 1)	(-1, 1)	(1, -1)	(1, -1)	(-1, 1)
PXIe-5605	≤3.6 GHz	(1, -1)	(-1, 1)	(-1, 1)	(1, -1)	(1, -1)	(-1, 1)
	>3.6 GHz and ≤7.5 GHz	(1, -1)	(-1, 1)	(1, -1)	(-1, 1)	–	–
	>7.5 GHz	(2, -1)	(-2, 1)	(1, -1)	(-1, 1)	–	–

The following table lists the direct image frequencies for the PXIe-5603 and the PXIe-5605, for frequencies ≤ 3.6 GHz.

IF Filter Selection	First Mixer[1]	Second Mixer	Third Mixer
300 kHz	f_{in} + 9,202.0 MHz	3,399.0 MHz	999.0 MHz
5 MHz (PXIe-5605)	f_{in} + 9,220.0 MHz	3,390.0 MHz	990.0 MHz
Through	f_{in} + 9,225.0 MHz	3,387.5 MHz	987.5 MHz

The following table lists the direct image frequencies for the PXIe-5605, for frequencies > 3.6 GHz.

IF Filter Selection	First Mixer[1]	Second Mixer
300 kHz	f_{in} + 1,202.0 MHz	999.0 MHz
5 MHz	f_{in} + 1,220.0 MHz	990.0 MHz
Through	f_{in} + 1,225.0 MHz	987.5 MHz

The following table lists the translated image frequencies for the PXIe-5603 and PXIe-5605, for frequencies ≤ 3.6 GHz.

IF Filter Selection	Second Mixer[1]	Third Mixer[1]
300 kHz	f_{in} + 1,202.0 MHz	f_{in} - 398.0 MHz
5 MHz (PXIe-5605 Only)	f_{in} + 1,220.0 MHz	f_{in} - 380.0 MHz
Through	f_{in} + 1,225.0 MHz	f_{in} - 375.0 MHz

The following table lists the translated image frequencies for the PXIe-5605, for frequencies > 3.6 GHz.

IF Filter Selection	Second Mixer[1]
300 kHz	f_{in} - 398.0 MHz
5 MHz	f_{in} - 380.0 MHz
Through	f_{in} - 375.0 MHz

IF Rejection

IF rejection measures the PXIe-5603/5605 downconverter response to frequencies within the IF passband.

The signals are received at the RF IN connector on the downconverter front panel. The frequency of the undesired signal can be calculated as shown in the following table.

The following table lists the IF center frequencies for the PXIe-5603 and PXIe-5605, for frequencies ≤ 3.6 GHz.

IF Filter Selection	IF1	IF2	IF3
300 kHz	4,601.0 MHz	601.0 MHz	199.0 MHz
5 MHz (PXIe-5605 only)	4,610.0 MHz	610.0 MHz	190.0 MHz
Through	4,612.5 MHz	612.5 MHz	187.5 MHz

The following table lists the IF center frequencies for the PXIe-5605, for frequencies > 3.6 GHz.

IF Filter Selection	IF1	IF2
300 kHz	601.0 MHz	199.0 MHz
5 MHz	610.0 MHz	190.0 MHz
Through	612.5 MHz	187.5 MHz

The following table is an example of IF rejection measurements when using the through filter path. The values are based on a center frequency of 100 MHz, which sets an LO1 value of 4.7125 GHz.

Rejection Measurement	Excitation Equation	Excitation at RF IN
IF1	f_{IF1}	4,612.5 MHz
IF2	f_{IF2}	612.5 MHz
IF3	f_{IF3}	187.5 MHz

Rejection Measurement	Excitation Equation	Excitation at RF IN
IF1 image	$f_{LO2} - f_{IF2}$	3,387 MHz
IF2 image	$f_{LO3} + f_{IF3}$	987.5 MHz
RF image	$2f_{IF1} + f_{CF}$	10,225 MHz
Translated IF1 image	$2f_{IF2} + f_{CF}$	2,225 MHz
Translated IF2 image	$\|f_{CF} - 2f_{IF3}$	625 MHz

LO Spurs

The PXIe-5653 output may contain spurious signals in addition to the LO signals. These spurious signals can be translated by the RF input signal to the IF passband or leak into IF passband.

Sideband Spurs

Sideband spurs are also generated in the PXIe-5603/5605 when power supply spurs, logic spurs, and so on, are imposed onto a desired RF signal.

Third-Order Intermodulation Distortion (IMD3)

Two-tone third-order intermodulation distortion (IMD3) is caused when two RF signals, at frequencies f_{RF1} and f_{RF2}, generate intermodulation power at frequencies f_{IMD1} and f_{IMD2}, as shown in the following equations:

$$f_{IMD1} = 2f_{RF1} - f_{RF2}$$

$$f_{IMD2} = 2f_{RF2} - f_{RF1}$$

IMD3 is characterized by the intermodulation intercept point. The intercept point is calculated as shown in the following equation:

$$IP3 = \frac{P_{sig} - P_{1MD}}{n - 1} + P_{sig}$$

where

- IP3 represents the intercept point
- P_{sig} represents the signal power
- P_{IMD} represents the intermodulation distortion power
- n represents any integer

Rearranging the preceding equation and substituting 3 for n for the IMD3 yields the following equation:

$$P_{1MD} = \left(3 \times P_{sig}\right) - \left(2 \times IP3\right)$$

Reduce the intermodulation distortion power by decreasing the level of the RF signals or by increasing the intercept point of the PXIe-5603/5605. Increase the PXIe-5603/5605 intercept point by increasing the reference level or the RF attenuation using techniques previously discussed.

Spurious Signals in Signal Analyzers

There are several different types of spurious responses in signal analyzers. This topic provides an overview of each category of spurious response.

Residual Responses

Residual spurs are the result of the mixing of signals internal to the signal analyzer.

Residual spurs exist independently of the presence of a signal at the RF input of the signal analyzer. Most commonly, the 1^{st} and 2^{nd} LO signals mix in either the 1^{st} or 2^{nd} mixer and fall into the passband of the 1^{st} or 2^{nd} IF path. However, residual spurs can also be the result of the mixing of other internal sources such as digital clocks. Since these spurs are internally generated, they are specified with the input of the analyzer terminated. Other names for these spurs are ***non-input related spurs*** or ***internally generated spurs***.

LO-Related Spurious Responses

Spurs on the LO of a signal analyzer are transferred to the IF with the presence of RF stimulus. The level of the spurs relative to the level of the RF remains constant.

Decreasing the level of the RF stimulus does not reduce the relative level (dBc) of the LO spurs. Spurs on the LO are usually a result of the LO synthesis circuitry, however sometimes another small signal can leak into the LO circuitry and end up as a sideband on the LO. These spurs are sometimes referred to as ***sideband spurs*** or ***close-in spurs***.

Sometimes there is a boundary separating close-in and far-out LO spurs, such as 10 kHz. It is not possible to see LO-related spurious responses in a signal analyzer without the presence of a signal at the input port, making it difficult to distinguish if a spur is on the signal present at the input port or if it is actually an LO-related spur.

IF Response

When the signal analyzer input port is excited with an IF frequency, the input signal can leak into the IF and cause a spurious response.

The ratio of the input signal level at the input port to the spur caused by the input signal is known as ***IF rejection***. Since signal analyzers have multiple conversion stages, there are multiple IF frequencies. While filtering is typically employed throughout the signal chain to reject all IF frequencies, it is still possible to get a response from the 2nd or 3rd IF if filtering is inadequate or if there is a leakage path around the filters.

IF/n Response

Signal analyzers often have a spurious response when the input port is excited by a sub-multiple of the IF frequency.

For example, when a signal at half of the 1st IF frequency is incident on the 1st mixer, the non-linearity of the mixer causes a frequency doubling to occur. The doubled $f_{IF}/2$ is the 1st IF frequency and it falls right in the IF passband resulting in a spur. While IF/2 is the most efficient, higher order multiples of n may have responses as well. IF/n response is distinguished from the IF response for two reasons:

1. IF/n is not rejected by the front-end lowpass filter in the upconverting band (lowband) of a signal analyzer
2. Decreasing the power of the input stimulus (at frequency f_{IF} /n) by Δ dB results in

an increase of suppression of the IF/n response by Δ(|n|-1) dBc.

Image Responses

Every mixer, at each downconverting stage, produces an image response when an undesired signal is present at the RF input. Each image response appears at a frequency 2 x IF away from the tuned RF frequency.

Suppose a signal analyzer has a 1st IF frequency of 4.6 GHz, an LO of 5.6 GHz, and is tuned to 1 GHz. If a 1 GHz signal is incident on the RF IN port, it will show up in the IF. Additionally, if a 10.2 GHz signal is incident on the input port, it will also show up in the IF. For an upconverting signal analyzer, the response to stimulus at 10.2 GHz is known as the image response. Although the image response is far away in frequency ($2f_{IF}$) from the stimulus, it can be very efficient if not properly filtered. The image rejection is a function of the stopband rejection of the filter preceding the 1st mixer. It is important to note that every mixer in the chain will have an image response. While filtering is employed, the instrument may still be sensitive to the image frequencies of downstream mixers. In addition, it is possible that the downstream mixers image can be translated to the RF front-end. For example, the following table shows the ranges for the PXIe-5605.

Measurement Name	**Excitation Equation**	**Excitation Frequency[1] at RF IN (MHz)**	**Analyzer Center Frequency f_{CF} (MHz)**
IF1 Rejection	f_{IF1}	612.5	LF[2] to 3,600
IF2 Rejection	f_{IF2}	612.5	
IF3 Rejection	f_{IF3}	187.5	
IF1 Image Rejection	$f_{LO2} - f_{IF2}$	3,387	
IF2 Image Rejection	$f_{LO3} - f_{IF3}$	987.5	
RF Image Rejection	$2f_{IF1} - f_{CF}$	9,225 to 12,825	
Translated IF1 Image Rejection	$2f_{IF1} + f_{CF}$	1,225 to 4,825	
Translated IF2 Image Rejection	$\|f_{CF} - 2f_{IF3}$	-275 to 3,225	

Second Harmonic Distortion

Second harmonic distortion is the spur that results when a signal analyzer is tuned to twice the excitation frequency of the signal at the input port.

Second harmonic distortion is very important when you are trying to measure the 2nd harmonic of your DUTs because it allows you identify that you are measuring the DUT and not the distortion caused by the non-linearity of the signal analyzer. Second harmonic distortion is specified in terms of an intercept level; second harmonic intercept (SHI).

RF Responses

The following equation describes all responses of the mixer to an RF stimulus at the input of a signal analyzer: $mf_{LO1} + nf_{RF} = f_{IF1}$, where m and n are integers

Certain combinations of m and n have already been discussed in previous sections and are more commonly referred to by name rather than the integers m and n. The following table applies to the upconverting band of a signal analyzer.

m	n	Common Name
1	-1	Desired IF
-1	1	RF Image
1	-2	Second Harmonic Distortion
0	1	IF1 Rejection
0	n	IF1/n Rejection

Responses that are not part of the preceding table can be further characterized by their order. First order RF responses refer to combinations of m and n where $|n| = 1$. Higher order responses refer to combinations of m and n where $|n| > 1$. Higher order RF responses are notable because their relative level in dBc is a function of the mixer level according to the following relation: decreasing the power at f_{RF} by Δ dB results in an increase of suppression of an (m,n) product by $\Delta \times (|n|-1)$ dBc. The relative level of first order RF responses do not fall with decreasing mixer levels.

The most efficient higher order RF responses are (m,n) = (2,-2), (3,-3), (1,-3), and (1,-5). The most efficient 1^{st} order RF responses are (m,n) = (-1,1), (). When RF responses appear on the screen of a signal analyzer, they are usually the result of an RF stimulus that is not within the span, or possibly not even in the passband of the image-reject filter or pre-selector. RF responses that are not within the passband are occasionally referred to as ***out-of-band RF responses***.

PXIe-5665 Factory Calibration

Every PXIe-5665 vector signal analyzer is individually calibrated for accurate frequency and amplitude response at the factory. Each ships with a calibration certificate verifying NIST-traceable accuracy levels.

During frequency-response factory calibration, the PXIe-5665 measures an integrated high-precision calibration signal, which is compared against a NIST-traceable power sensor. Any error in the returned data is quantified as a set of calibration constants. NI-RFSA uses these calibration constants to calculate and to apply corrections to your analysis based on the spectrum of interest.

> **Note** To preserve specified accuracy and NIST traceability, NI recommends returning all modules of the PXIe-5665 to the factory for recalibration every two years.

> **Note** Opening the RF signal downconverter metal enclosure invalidates the PXIe-5665 calibration.

When calibrating the PXIe-5665 system, NI separately calibrates the PXIe-5603/5605 RF signal downconverter, the PXIe-5622 IF digitizer, and the PXIe-5653 RF analog signal generator.

Both an RF response calibration and an IF response calibration are performed on the PXIe-5603/5605. The downconverter RF response calibration corrects the RF downconverter response over frequencies and also provides temperature compensation. The RF response calibration is performed across frequency and across all reference levels. The specified RF response of the downconverter and the PXIe-5665 is met at all frequencies by interpolating between calibration frequencies. Therefore, accurate power measurements are obtained at all frequencies. The downconverter IF response calibration measures the response of the IF filters in the PXIe-5603/5605 across the specified analog IF bandwidth. A factory IF response calibration is also performed on the PXIe-5622 IF digitizer.

NI-RFSA combines the PXIe-5603/5605 and the PXIe-5622 frequency response corrections and generates an PXIe-5665 system frequency response correction in both magnitude and phase for all IF filter paths during self-calibration. The correction results in a flat magnitude response and minimal phase deviation across the bandwidth. For the through path the correction is applied for both spectrum and I/Q acquisitions. For the 300 kHz bandwidth, only the magnitude correction is applied, and only for spectrum acquisitions. I/Q acquisitions that use the 300 kHz IF filter path are not equalized, but both magnitude and phase equalization can be performed in software using the calibration information retrieved by using the niRFSA Get Frequency Response VI or the niRFSA_GetDeviceResponse function.

Related information:

- Reference

PXIe-5665 Self-Calibration

You can configure NI-RFSA to perform a self-calibration on the PXIe-5665 system. You can also configure NI-RFSA to perform a module-level self-calibration on the PXIe-5622 or PXIe-5653 modules.

The niRFSA Self Cal VI and niRFSA_SelfCalibrate function perform the following self-calibration operations for the PXIe-5665 system:

- Preselector alignment
- IF flatness
- Gain reference
- LO self-calibration
- Digitizer self-calibration

During a system self-calibration, the downconverter measures the reference source and compares the resulting measurements to a value stored in the PXIe-5603/5605 EEPROM. Self-calibration is designed to work seamlessly with the PXIe-5622. If you use the PXIe-5603/5605 downconverter only, without the PXIe-5622 digitizer, use the onboard, high-precision tone signal to correct for losses to your receiver by comparing the tone value stored in the PXIe-5603/5605 EEPROM with a recent measured value. To retrieve the tone value that is stored in the PXIe-5603/5605 EEPROM, use the niRFSA Get Gain Reference Cal Baseline VI or the niRFSA_GetGainReferenceCalBaseline function.

Module-Level Self-Calibration

If your application requires module-level self-calibration, you can configure the niRFSA Self Cal VI or the niRFSA_SelfCalibrate function to perform only the module-level self-calibration steps, namely, LO self-calibration and digitizer self-calibration. You can also run the module-level calibration steps in NI Measurement & Automation Explorer (MAX).

> **Note** After you perform a self-calibration at the module level for either the PXIe-5622 or the PXIe-5653 modules, you may need to perform a self-calibration on the PXIe-5665 system. To determine whether you need to perform any of the system self-calibration steps after module-level calibration, use the niRFSA Is Self Cal Valid VI or the niRFSA_IsSelfCalValid function.

Related information:

- Reference

PXIe-5603/5605 Bandpass Selector

The PXIe-5603/5605 RF downconverter module provides a bandpass preselector that can be included in the RF input signal path when downconverting frequencies greater than 3.6 GHz.

The preselector can reject signals that might otherwise interfere with or degrade the accuracy of many measurements. The center frequency of the preselector is controlled by the magnetic field generated by an electromagnet. Ideally, the preselector center frequency varies linearly with current supplied to the electromagnet. In reality, nonlinearities and thermal characteristics cause the preselector center frequency to vary with temperature and exhibit some nonlinearity versus drive current. Each individual preselector has a unique tuning curve, which is a function of temperature, and it can vary slightly over time. The PXIe-5603/5605 must account for the preselector tuning curve when controlling the preselector drive current to ensure that the filter is properly centered at the desired tuned frequency.

When the PXIe-5603/5605 is associated with the PXIe-5622 IF digitizer and the PXIe-5653 RF analog signal generator, NI-RFSA characterizes the preselector tuning curve as part of the device self-calibration process using an internally generated calibration signal and algorithm. When using only the PXIe-5603/5605, the preselector tuning curve must be periodically determined with an external algorithm. The preselector tuning curve can be measured by controlling an LO and digitizer (or other IF receiver) appropriately. Then, you can calculate the tuning coefficients to correct for the preselector nonlinearity at the current operating temperature. Finally, you can program the tuning coefficients into the PXIe-5603/5605 using the niRFSA External Alignment Adjust Preselector VI or the niRFSA_ExternalAlignmentAdjustPreselector function.

Visit ni.com/info and enter the Info Code exk8hs to download a LabVIEW example that demonstrates how to perform self-calibration for a vector signal analyzer with an external digitizer and preselector alignment.

Self-Calibration Guidelines

It is important to perform self-calibration after first connecting your system because of cabling and mismatch effects and some degree of residual error, which result from module interconnections. Self-calibration can help determine and reduce these undesired effects. Additionally, you should periodically run a self-calibration to adjust for performance drifts that occur with product aging.

The PXIe-5665 modules are independently calibrated at the factory; however, you should perform a self-calibration in any of the following situations:

- After first installing and interconnecting your PXIe-5665 system
- When there is a physical change to any of the system components
- When there is a change to system cabling

- When the system is in an environment where external variables, such as temperature, can affect measurements

You should also perform a self-calibration if your device has exceeded any of the following temperature or time limits:

- Preselector alignment (PXIe-5605 only): ±5 °C and/or 7 days
- IF flatness: ±5 °C and/or 7 days
- Gain reference: ±5 °C and/or 7 days
- LO self-calibration: ±10 °C and/or 30 days
- Digitizer self-calibration ±5 °C and/or 90 days

To determine whether your device has exceeded any of these limits, use the niRFSA Is Self Cal Valid VI or the niRFSA_IsSelfCalValid function.

> **Note** NI recommends that you perform a self-calibration if the temperature has drifted more than ±5 °C. For stable operating environments, NI recommends that you run a self-calibration on a weekly basis to help minimize residual errors, drifts, and effects from aging.

Performing a Device Self-Calibration using the NI-RFSA SFP

NI recommends you perform the self-calibration from the NI-RFSA Soft Front Panel (SFP). You can also run a self-calibration programmatically using the NI-RFSA API by calling the niRFSA Self Cal VI or the niRFSA_SelfCalibrate function.

Complete the following steps to perform self-calibration using the NI-RFSA SFP.

1. Launch the NI-RFSA SFP.
2. Click **Device/System** » **Calibration** » **Self Calibration**.
3. Select the self-calibration steps you want to perform from the Self-Calibration dialog box.
4. Click **Next** to run the self-calibration.