Technical Sales

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Detailed Specifications

For user manuals and dimensional drawings, visit the product page resources tab on ni.com.

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NI PXIe-5665

3.6 GHz / 14 GHz RF Vector Signal Analyzer with Digital Downconversion

- 20 Hz to 3.6 GHz / 14 GHz frequency range
- 129 dBc/Hz typical phase noise at 10 kHz offset at 800 MHz
- 25/50 MHz instantaneous bandwidth
- ±0.35 dB typical flatness within 20 MHz bandwidth
- ±0.1 dB typical amplitude accuracy
- Optional preamp < 3.6 GHz
- <-165 dBm/Hz typical display averaged noise level at 1 GHz
- Optional preselector > 3.6 GHz
- 16-bit ADC
- RF list mode support

Overview

The NI PXIe-5665 RF vector signal analyzer offers industry-leading accuracy and performance with wide instantaneous bandwidths (up to 50 MHz) optimized for automated test ranging from a low frequency of 20 Hz to 3.6 GHz / 14 GHz. Combined with high-performance PXI controllers and the high-speed PCI Express data bus, these modules can perform common automated measurements significantly faster than traditional instruments.

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Application and Technology

You can use an NI PXIe-5665 as either a spectrum analyzer or vector signal analyzer with NI LabVIEW or LabWindows™/CVI software. In addition, you can use the NI PXIe-5665 with the NI Modulation Toolkit for LabVIEW to analyze custom and standard modulation formats.

When combined with NI or third-party analysis toolkits, the NI PXIe-5665 can perform measurements for a broad range of communications standards such as GSM, EDGE, WCDMA, WiMAX, LTE, Bluetooth, WLAN, DVB-C/H/T, ATSC, and MediaFLO. Because all measurements are software-defined, you can simply reconfigure the measurements using standard specific toolkits. With these toolkits, the NI PXIe-5665 provides a low-cost solution to high-performance RF measurements.

	NI PXIe-5661	NI PXIe-5663	NI PXIe-5665
Frequency Range	9 kHz to 2.7 GHz	10 MHz to 6.6 GHz	20 Hz to 3.6 GHz / 14 GHz
Phase Noise	-90 dBc/Hz at 10 kHz offset from a 1 GHz carrier	-105 dBc/Hz at 10 kHz offset from a 1 GHz carrier	-129 dBc/Hz at 10 kHz offset from

			an 800 MHz carrier
Architecture	Three stage	Single stage	Three stage
List Mode	No	Yes	Yes
Peer to Peer Streaming	No	Yes	Yes
Absolute Amplitude Accuracy	±0.6 dB	±0.65 dB	± 0.1 dB
Average Noise Floor	-122 dBm/Hz	-158 dBm/Hz	-165 dBm/Hz
Bandwidth	20 MHz	Up to 50 MHz	25 MHz or 50 MHz

Table 1. Comparison of NI Vector Signal Analyzers

Industry-Leading Accuracy and Noise Floor (High-Performance RF Measurements)

The NI PXIe-5665 offers phase noise of -129 dBc/Hz (10 kHz offset at an 800 MHz carrier frequency) and an average noise level of up to -165 dBm/Hz at a 1 GHz carrier frequency, which enables high-accuracy spectral and I/Q measurements. A 16-bit ADC, a high-performance RF front end, and the three-stage architecture provide industry-leading noise floors and spurious-free dynamic range (SFDR).

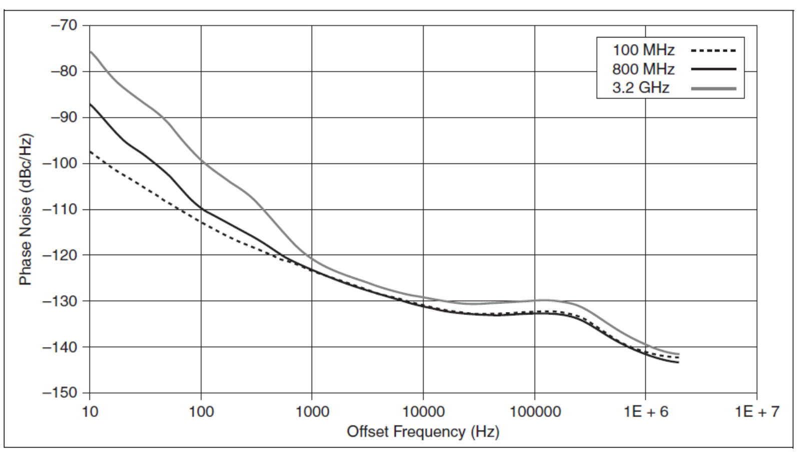

Figure 1. Phase Noise

With the high-performance NI PXIe-5665, you can test products and standards such as LTE and WCDMA to their full capabilities. The images below show adjacent channel power ratio (ACPR) and error vector magnitude (EVM) measurements on WCDMA and LTE standards, respectively.

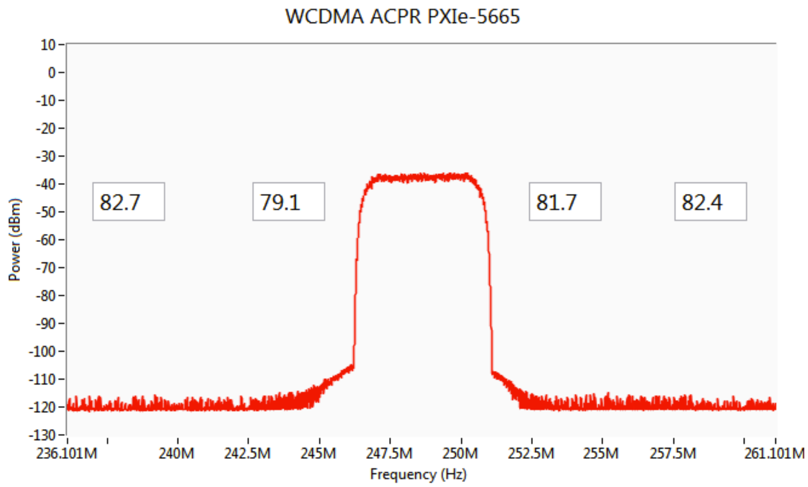

Figure 2. ACPR Measurement on a WCDMA (TM1 64 DPCHs) Signal Generated by a Vector Signal Generator Connected to a Filter

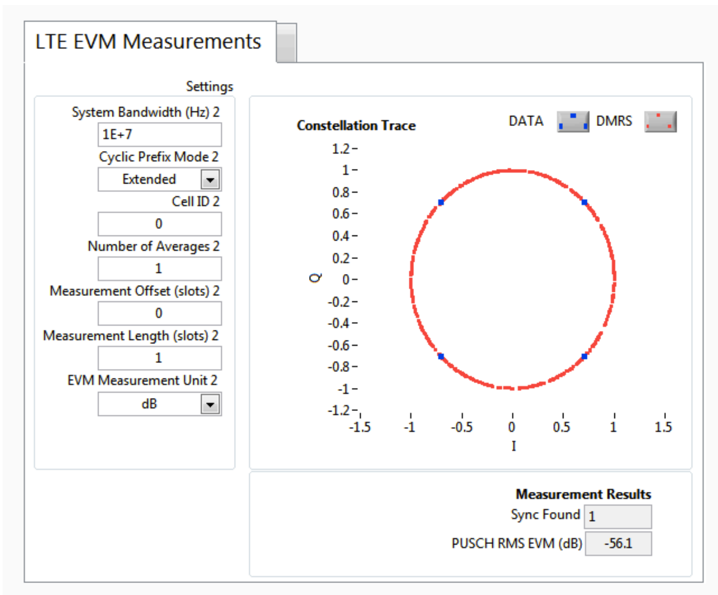

Figure 3. EVM Measurement of -56.1 dB on a LTE Signal Generated by an NI PXIe-5673

Architecture

The three-stage topology of the NI PXIe-5665 provides image rejection of the RF input signal with no ambiguity of the displayed signal. This architecture makes the NI PXIe-5665 ideal for high-accuracy measurements and low noise floors.

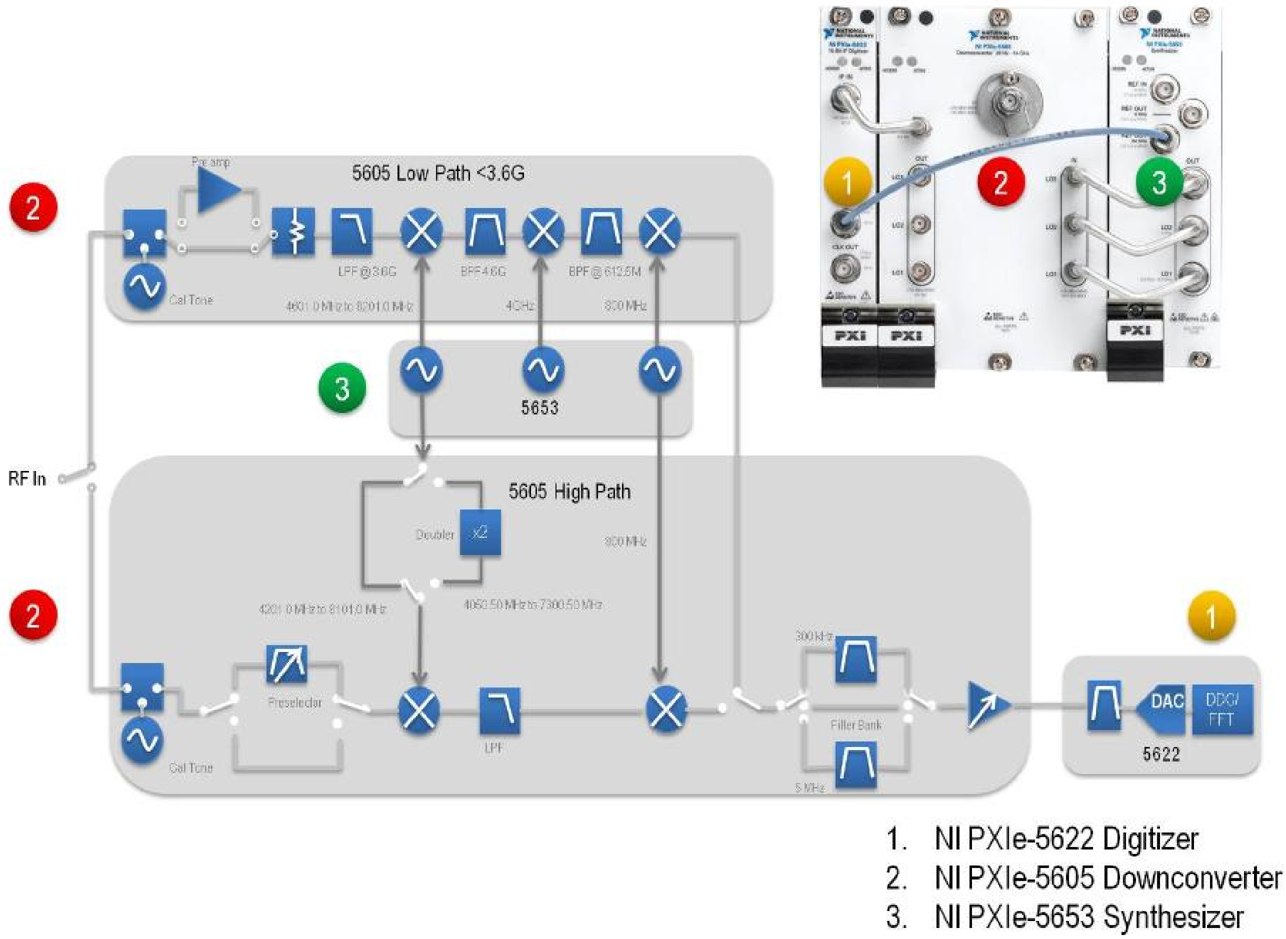

Figure 4. Block Diagram of an NI PXIe-5665

Figure 4 shows the NI PXIe-5603 downconverter, which upconverts the RF to a higher intermediate frequency and then downconverts it to a frequency that you can digitize for processing. Image rejection is achieved with a lowpass filter (LPF) that limits the RF signal at the input of the first mixer.

A low phase noise LO is supplied by the NI PXIe-5653, which is shown at the bottom of Figure 1. You can use the NI PXIe-5603 LO outputs to daisy chain multiple downconverters with a single LO source. Using the same LO source is helpful for phase-coherent signal acquisition applications such as multiple input, multiple output (MIMO) systems.

Fast Measurement Speed

Using software-defined measurements in the NI LabVIEW graphical development environment with an NI PXIe-5665, you can perform common spectral and modulation measurements up to 30 times faster than traditional instruments.

You can also perform common spectrum analysis measurements quickly due to the processing power of multicore CPUs. For example, you can perform a 50 MHz spectrum sweep in 6 ms with an NI PXIe-8106 embedded controller (30 kHz RBW). While actual performance is system dependent, Figure 5 shows the relationship between measurement time and resolution bandwidth (RBW).

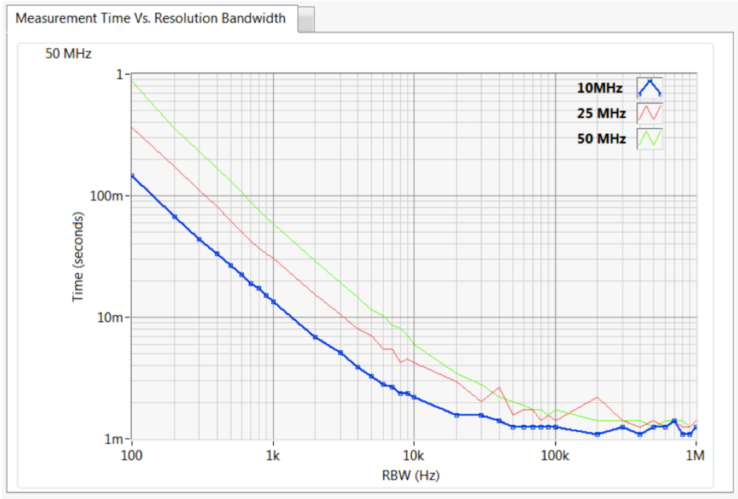

Figure 5. Measurement Time Versus Resolution Bandwidth for Spans of 10, 25, and 50 MHz

RF List Mode

The NI PXIe-5665 features RF list mode support for fast and deterministic RF configuration changes. You supply a configuration list, and the RF modules proceed through the list without additional interaction with the host system and driver. This makes the configuration changes deterministic. Figure 3 shows this determinism with a single tone at 1 GHz stepping through six power levels in 7 dB steps starting with -10 dBm and ending with -45 dBm and a 500 µs dwell time specified for each step.

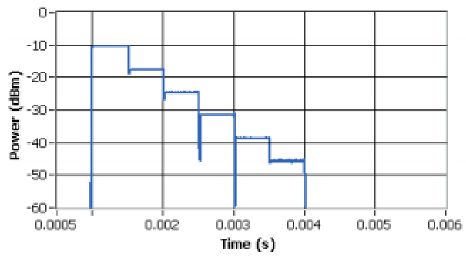

Figure 6. Deterministic 500 µs Power Steps Using the NI PXIe-5665 and RF List Mode

You can use the NI PXIe-5665 in both open- and closed-loop scenarios to specify the source for the configuration trigger that advances from one configuration to the next. In an open-loop situation, the NI PXIe-5665 advances through the list based on a user-defined time specification for each step. The closed-loop scenario relies on an external trigger that may be provided by the DUT to advance through the RF configuration list.

RF Record and Playback

You can combine an NI PXIe-5665 RF vector signal analyzer with a PXI RF vector signal generator for record and playback applications. In this application, you use an NI PXIe-5665 to continuously record an RF signal as a file on a redundant array of inexpensive disks (RAID) volume. Then you use an RF vector signal generator to stream the recorded waveform from disk. With a 2 TB RAID volume, an NI PXIe-5665 can be used to stream 50 MHz of RF bandwidth continuously to disk for more than 1.5 hours.

Because of the PCI Express data bus on the vector signal analyzer, you can also use multiple analyzers to stream data to disk. With more than 1 GB/s of total system bandwidth, you can stream more than 100 MHz continuously to disk using multiple analyzers.

Peer-to-Peer Streaming

With NI peer-to-peer data streaming technology, you can continuously transfer data to and from vector signal analyzers and vector signal generators at rates greater than 800 MB/s with minimal latency. High-performance data switches on NI PXI Express chassis offer high-bandwidth communication, while routing data from one module directly to another (without transferring data through the host controller) minimizes the latency of the transfer. Peer-to-peer transfers are supported between multiple PXI Express NI FlexRIO field-programmable gate array (FPGA) modules and between select NI PXI Express digitizers and PXI Express NI FlexRIO FPGA modules.

Flexible Software

Programmed with the NI-RFSA instrument driver, NI PXIe-5665 RF vector signal analyzers can be used in a variety of applications. The driver enables both high-level and low-level control of a variety of instrument settings. Figure 7 features a simple LabVIEW example showing basic spectrum acquisition.

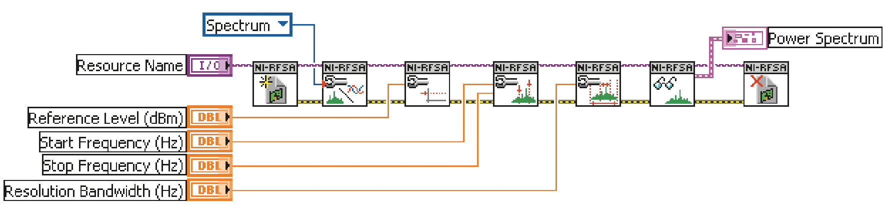

Figure 7. NI LabVIEW Example for Spectrum Sweep

The NI-RFSA driver includes an out-of-the-box soft front panel, which is shown in Figure 8.

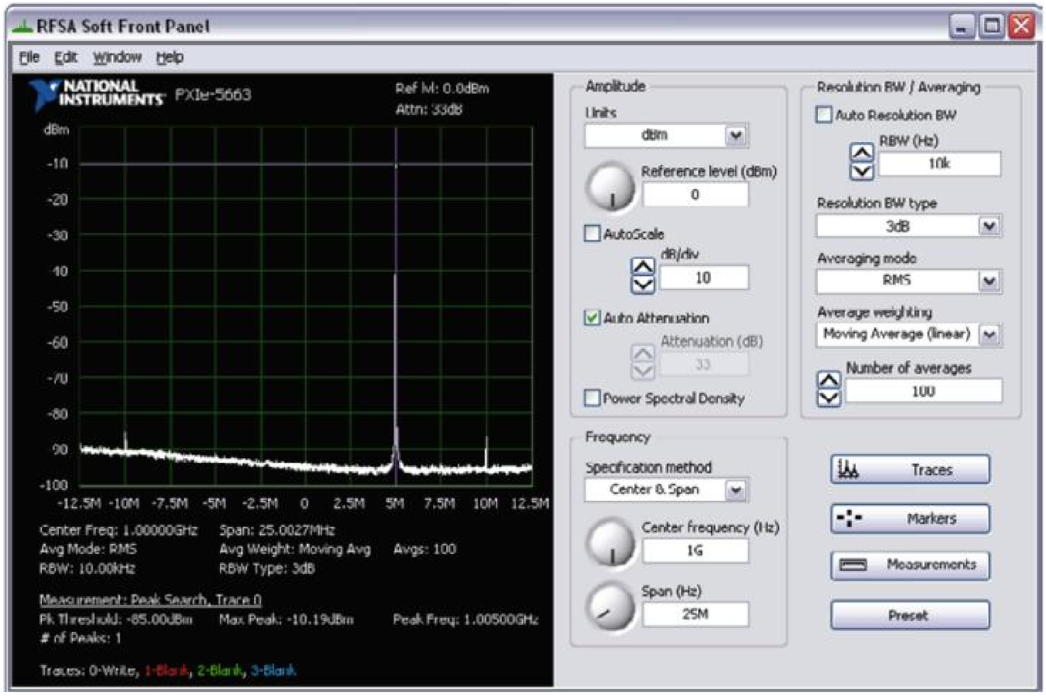

Figure 8. NI-RFSA Soft Front Panel

The NI PXIe-5665 is shipped with two NI toolkits in addition to the NI-RFSA driver, the NI Modulation Toolkit and the NI Spectral Measurements Toolkit.

With the Spectral Measurements Toolkit for LabVIEW and LabWindows/CVI, you can perform common measurements such as power spectrum, peak power and frequency, in-band power, adjacent channel power, and occupied bandwidth. In addition, the NI Modulation Toolkit for LabVIEW provides tools for vector signal analyzers. With this toolkit, you can perform measurements on a wide variety of modulated signals including schemes such as AM, FM, ASK, FSK, PSK, CPM, MSK, and QAM. In addition, the toolkit computes modulation accuracy measurements such as EVM, MER, rho, and others.

Phase-Coherent Analysis

The flexibility of the NI PXIe-5665 module enables multiple instruments to share a common start trigger, a reference clock, and even an LO. As a result, you can synchronize at least four NI PXIe-5665 RF vector signal analyzers for phase-coherent acquisition.

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Support and Services

System Assurance Programs

NI system assurance programs are designed to make it even easier for you to own an NI system. These programs include configuration and deployment services for your NI PXI, CompactRIO, or Compact FieldPoint system. The NI Basic System Assurance Program provides a simple integration test and ensures that your system is delivered completely assembled in one box. When you configure your system with the NI Standard System Assurance Program, you can select from available NI system driver sets and application development environments to create customized, reorderable software configurations. Your system arrives fully assembled and tested in one box with your software preinstalled. When you order your system with the standard program, you also receive system-specific documentation including a bill of materials, an integration test report, a recommended maintenance plan, and frequently asked question documents. Finally, the standard program reduces the total cost of owning an NI system by providing three years of warranty coverage and calibration service. Use the online product advisors at ni.com/advisor to find a system assurance program to meet your needs.

Calibration

NI measurement hardware is calibrated to ensure measurement accuracy and verify that the device meets its published specifications. To ensure the ongoing accuracy of your measurement hardware, NI offers basic or detailed recalibration service that provides ongoing ISO 9001 audit compliance and confidence in your measurements. To learn more about NI calibration services or to locate a qualified service center near you, contact your local sales office or visit ni.com/calibration.

Technical Support

Get answers to your technical questions using the following National Instruments resources.

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While you may never need your hardware repaired, NI understands that unexpected events may lead to necessary repairs. NI offers repair services performed by highly trained technicians who quickly return your device with the guarantee that it will perform to factory specifications. For more information, visit ni.com/repair.

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Detailed Specifications

NI PXIe-5665 Specifications

This document lists specifications for the NI PXIe-5665 (NI 5665) RF vector signal analyzer, the NI PXIe-5653, NI PXIe-5603, and NI PXIe-5605.

The NI 5665 3.6 GHz VSA comprises the following modules:

- NI PXIe-5603 (NI 5603) RF downconverter
- NI PXIe-5622 (NI 5622) IF digitizer
- NI PXIe-5653 (NI 5653) synthesizer/LO source

The NI 5665 14 GHz VSA comprises the following modules:

- NI PXIe-5605 (NI 5605) RF downconverter
- NI 5622 IF digitizer
- NI 5653 synthesizer/LO source

There is no physical device named "NI PXIe-5665."

When not otherwise specified, the specifications for the NI 5665 in this document refer to both the NI 5665 3.6 GHz VSA and the NI 5665 14 GHz VSA. Specifications for center frequencies greater than 3.6 GHz apply only to the NI 5665 14 GHz VSA and the NI 5605 RF downconverter.

Specifications describe the warranted, traceable product performance over ambient temperature ranges of 0 °C to 55 °C, unless otherwise noted.

- 30 minutes warm-up time.
- Calibration cycle is maintained.
- Chassis fan speed is set to High. In addition, NI recommends using slot blockers and EMC filler panels in empty module slots to minimize temperature drift.
- The NI 5603/NI 5605, NI 5622, and NI 5653 are used as the downconverter, digitizer, and LO source, respectively.
- The NI 5653 onboard 100 MHz clock is used as the Reference clock for the NI 5622.
- Modules are connected with NI cables as shown in the *NI 5665 RF Vector Signal Analyzers Getting Started Guide*.
- NI-RFSA instrument driver is used.
- Self-calibration is performed after instrument temperature is stable.
- NI 5603—The Channel Coupling property is set to DC Coupled or the NIRFSA_ATTR_CHANNEL_COUPLING attribute is set to NIRFSA_VAL_DC for RF tuned frequencies less than 10 MHz and is set to AC Coupled or NIRFSA_VAL_DC for RF tuned frequencies greater than or equal to 10 MHz.
- NI 5605—The Channel Coupling property is set to DC Coupled or the NIRFSA_ATTR_CHANNEL_COUPLING attribute is set to NIRFSA_VAL_DC for RF tuned frequencies less than 10 kHz and is set to AC Coupled or NIRFSA_VAL_DC for RF tuned frequencies greater than or equal to 10 kHz. For measurements at frequencies less than 10 kHz, remove the DC block accessory form the NI 5605 RF IN connector.

Note The NI 5605 downconverter module has an external DC block. Components in the NI 5605 can be damaged when DC signals are applied directly to the RF IN connector. The NI 5605 ships with an SMA DC block attached to the RF IN connector to prevent damage to the device when a DC input signal is present. The DC block must be removed to make measurements at frequencies less than 10 kHz. 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. For more information about removing or reinstalling the DC block for the NI 5605, refer to the *NI 5665 Theory of Operation topic* in the *NI RF Vector Signal Analyzers Help*.

National Instruments RF devices are capable of producing and/or acquiring accurate signals within common Medical Implantable Communication System (MICS) frequency bands. NI RF devices are tested and verified in manufacturing for many measurements. For more information about RF device applications, visit ni.com/niglobal to contact a National Instruments branch office.

Caution Refer to the *Read Me First: Safety and Electromagnetic Compatibility* document for important safety and electromagnetic compatibility information. To obtain a copy of this document online, visit ni.com/manuals, and search for the document title.

Specifications are subject to change without notice. For the most recent device specifications, visit ni.com/manuals.

Specifications describe the warranted, traceable product performance over ambient temperature ranges of 0 °C to 55 °C, unless otherwise noted.

Typical values describe useful product performance beyond specifications that are not covered by warranty and do not include guardbands for measurement uncertainty or drift. Typical values may not be verified on all units shipped from the factory. Unless otherwise noted, typical values cover the expected performance of units over ambient temperature ranges of 23 °C ± 5 °C with a 90% confidence level, based on measurements taken during development or production.

2σ specifications describe the 95th percentile values in which 95% of the cases are met with a 95% confidence for any ambient temperature of 23 °C ± 5 °C.

Nominal values (or supplemental information) describe additional information about the product that may be useful, including expected performance that is not covered under Specifications or Typical values. Nominal values are not covered by warranty.

After installing the NI-RFSA instrument driver, you can access all NI-RFSA documentation by navigating to **Start»All Programs»National Instruments»NI-RFSA»Documentation**.

Hot Surface If the NI PXIe-5665 has been in use, the device or the shield may exceed safe handling temperatures and may cause discomfort. Allow the NI PXIe-5665 to cool before touching the device shield or removing the device from the chassis.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) as stated in the product specifications. These requirements and limits are designed to provide reasonable protection against harmful interference when the product is operated in its intended operational electromagnetic environment.

This product is intended for use in industrial locations. There is no guarantee that harmful interference will not occur in a particular installation, when the product is connected to a test object, or if the product is used in residential areas. To minimize the potential for the product to cause interference to radio and television reception or to experience unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any changes or modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories.

Frequency

Frequency range[1]	
NI 5665 3.6 GHz VSA	20 Hz to 3.6 GHz
NI 5665 14 GHz VSA	20 Hz to 14 GHz
Tuning resolution[2]	533 nHz

Bandwidth

Table 1. NI 5665 Equalized Bandwidth

Frequency Range	RF Vector Signal Analyzer Bandwidth Configuration	Equalized Bandwidth
>10 MHz to 14 GHz	25 MHz (Standard)	25 MHz
	50 MHz (Optional)	50 MHz

Note Self-calibration performed using the NI-RFSA instrument driver with the preselector disabled. When using the preselector on the NI 5605, the signal is not equalized. Equalization is performed by digital filters in the digitizer. The IF through path is limited to either 50 MHz or 25 MHz depending on the digitizer option you purchased.

Resolution Bandwidth

(Typical)

3 dB bandwidth	Fully adjustable
Bandwidth range	
Standard	<1 Hz to 25 MHz
Optional	<1 Hz to 50 MHz
Selectivity 60dB : 3 dB Ratio	
60dB : 3 dB Ratio	
Flat Top window	2.5
7-term Blackman Harris window	4.1

Note These additional window types are supported: Uniform, Hanning, Hamming, Blackman-Harris, Exact Blackman, Blackman, Flat Top, 4-term Blackman-Harris, and Low Side Lobe.

Frequency Reference

Internal Frequency Reference[3]

Frequency	10 MHz
Initial calibration accuracy	$\pm 50 \times 10^{-9}$ over a temperature range from 15 °C to 35 °C

Temperature stability	
15 °C to 35 °C	$\pm 10 \times 10^{-9}$, maximum
0 °C to 55 °C	$\pm 50 \times 10^{-9}$
Aging after 30 days of continuous operation	
Per day	$\pm 0.5 \times 10^{-9}$
Per year	$\pm 100 \times 10^{-9}$
Accuracy	Initial calibration accuracy ± Aging ± Temperature stability

External Frequency Reference Input

Frequency	5 MHz to 100 MHz in 1 MHz steps
Lock range	$\pm 0.2 \times 10^{-6}$
Amplitude	0.5 $V_{pk\text{-}pk}$ to 2.0 $V_{pk\text{-}pk}$ into 50 Ω (≥1 $V_{pk\text{-}pk}$ recommended)
Absolute maximum amplitude	5 $V_{pk\text{-}pk}$
Input impedance	50 Ω nominal, AC-coupled
Connector	SMA
REF OUT 10 MHz reference output[5]	
Accuracy	10 MHz ×Frequency reference accuracy
Amplitude	
Maximum	1.5 $V_{pk\text{-}pk}$ into 50 Ω
Typical	1.2 $V_{pk\text{-}pk}$ into 50 Ω
Coupling	AC coupled
Connector	SMA
REF OUT 100 MHz reference output[6]	
Accuracy	100 MHz × Frequency reference accuracy
Amplitude	
Maximum	1.5 $V_{pk\text{-}pk}$ into 50 Ω
Typical	1.0 $V_{pk\text{-}pk}$ into 50 Ω
Coupling	AC coupled
Connector	SMA

Spectral Purity

Single Sideband (SSB) Phase Noise

(Typical)

Table 2. SSB Phase Noise (dBc/Hz)

Offset	Phase Noise (dBc/Hz)	
	23 °C ± 5 °C	0 °C to 55 °C
10 Hz	—	-87, nominal
100 Hz	-106	-105
1 kHz	-121	-119
10 kHz	-129	-128
100 kHz	-128	-127
1 MHz	-140	-140

Note Values are based on an RF center frequency of 800 MHz, NI 5653 internal frequency reference, NI 5622 digitizer directly clocked, no dither and the LO YIG Main Coil Drive property set to Normal or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute set to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL.

Figure 1. Nominal Phase Noise at 800 MHz Center Frequency (No Dithering, Spurs Not Shown)[7]

Figure 2. Nominal Phase Noise at 100 MHz, 800 MHz, 4GHz, and 8 GHz[8](Direct Clocking, No Dithering, Preselector Disabled, and Spurs Not Shown)

Figure 3. NI 5665 14 GHz VSA Nominal Phase Noise at 8 GHz (Direct Clocking, No Dithering, and Spurs Not Shown)

Residual FM

10 Hz to 10 kHz, 800 MHz center frequency	< 0.5 Hz (rms), typical

AM Noise

(Nominal)

Figure 4. AM Noise for Carrier Frequencies of 100 MHz, 800 MHz, 4 GHz, and 8 GHz (Spurs Not Shown)[9]

Amplitude

Amplitude Range

(Nominal)

Amplitude range	Average Noise Level to +30 dBm[10]
RF input attenuation	
NI 5665 3.6 GHz VSA	
Mechanical	0 dB to 30 dB in 10 dB steps
Electronic	0 dB to 40 dB in 1 dB steps
NI 5665 14 GHz VSA	
Mechanical	0 dB to 75 dB in 5 dB steps (20 Hz to 14 GHz)
Electronic	0 dB to 30 dB in 1 dB steps (20 Hz to 3.6 GHz)

Average Noise Level

Table 3. NI 5665 Average Noise Level, Preamplifier Disabled and Preselector Disabled

Center Frequency	23 °C ±5 °C		0 °C to 55 °C	
	Specification (dBm/Hz)	Typical (dBm/Hz)	Specification (dBm/Hz)	Typical (dBm/Hz)
20 Hz to 10 kHz	—	—	—	-70
>10 kHz to 10 MHz	—	—	—	-100
>10 MHz to 100 MHz	-149	-152	-149	-151
>100 MHz to 300 MHz	-152	-157	-151	-154
>300 MHz to 1.7 GHz	-151	-154	-151	-153
>1.7 GHz to 2.8 GHz	-149	-152	-149	-151
>2.8 GHz to 3.6 GHz	-148	-151	-148	-150
>3.6 GHz to 7.5 GHz	-148	-151	-147	-150
>7.5 GHz to 8.5 GHz	-146	-151	-145	-150
>8.5 GHz to 12 GHz	-147	-151	-146	-150
>12 GHz to 14 GHz	-145	-147	-144	-146

Note Values are based on input-terminated, 0 dB RF attenuation for center frequency ≥ 10 MHz, 20 dB RF attenuation for center frequency < 10 MHz, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, ≤-50 dBm reference level, and >10 averages. RMS average noise level is normalized to a 1 Hz noise bandwidth. When the average noise level is measured as the displayed average noise level (DANL) associated with spectrum analyzers, there is a net 2.5 dB improvement caused by averaging log and other measurement biases in spectrum analyzer DANL. For example, the equivalent DANL at 2 GHz is -151.5 dBm/Hz.

Table 4. NI 5665 Average Noise Level, Preamplifier Present and Enabled

Center Frequency	23 °C ±5 °C		0 °C to 55 °C	
	Specification (dBm/Hz)	Typical (dBm/Hz)	Specification (dBm/Hz)	Typical (dBm/Hz)
10 MHz to 100 MHz	-161	-163	-159	-161
>100 MHz to 300 MHz	-162	-167	-161	-166
>300 MHz to 1.7 GHz	-162	-165	-162	-164
>1.7 GHz to 2.8 GHz	-161	-164	-161	-163
>2.8 GHz to 3.6 GHz	-160	-163	-160	-163

Note Values are based on input-terminated, 0 dB RF attenuation for center frequency ≥ 10 MHz, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, ≤-50 dBm reference level, and >10 averages. RMS average noise level normalized to a 1 Hz noise bandwidth. When the average noise level is measured as the DANL associated with spectrum analyzers, there is a net 2.5 dB improvement due to averaging of log and other measurement biases in spectrum analyzer DANL. For example, the equivalent DANL at 2 GHz is -163.5 dBm/Hz.

Table 5. NI 5665 Average Noise Level, Preselector (YIG-Tuned Filter) Present and Enabled

Center Frequency	23 °C ±5 °C		0 °C to 55 °C	
	Specification (dBm/Hz)	Typical (dBm/Hz)	Specification (dBm/Hz)	Typical (dBm/Hz)
>3.6 GHz to 7.5 GHz	-144	-147	-142	-146
>7.5 GHz to 8.5 GHz	-140	-145	-140	-144
>8.5 GHz to 12 GHz	-141	-145	-140	-144
>12 GHz to 14 GHz	-140	-142	-139	-141

Note Values are based on input-terminated, 0 dB RF attenuation, IF through path, ≤-50 dBm reference level, and >10 averages. RMS average noise level normalized to a 1 Hz noise bandwidth. When the average noise level is measured as the DANL associated with spectrum analyzers, there is a net 2.5 dB improvement due to averaging of log and other measurement biases in spectrum analyzer DANL. For example, the equivalent DANL at 8 GHz is -142.5 dBm/Hz.

Amplitude Accuracy

Frequency Response

Table 6. NI 5665 3.6 GHz VSA Frequency Response, Preamplifier Disabled and Preselector Disabled

Center Frequency	23 °C ±5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specifications (dB)	Typical (dB)
10 MHz to 100 MHz	±0.60	±0.30	±0.20	±0.80	±0.40
>100 MHz to 1.7 GHz	±0.35	±0.15	±0.10	±0.80	±0.40
>1.7 GHz to 2.8 GHz	±0.40	±0.20	±0.20	±0.80	±0.40
>2.8 GHz to 3.6 GHz	±0.45	±0.20	±0.20	±1.30	±0.80

Note Frequency response is measured relative to the 612.5 MHz calibration tone frequency. Values are based on an IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, signal-to-noise ratio > 20 dB, and using the automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of self-calibration. RF attenuation is 20 dB for frequencies <10 MHz and is 10 dB for frequencies >10 MHz.

Table 7. NI 5665 14 GHz VSA Frequency Response, Preamplifier Disabled and Preselector Disabled

Center Frequency	23 °C ±5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
10 MHz to 100 MHz	±0.60	±0.30	±0.20	±0.80	±0.40
>100 MHz to 1.7 GHz	±0.35	±0.20	±0.15	±0.80	±0.40
>1.7 GHz to 2.8 GHz	±0.42	±0.31	±0.25	±1.20	±0.70
>2.8 GHz to 3.6 GHz	±0.62	±0.41	±0.30	±1.20	±0.70

Note Frequency response is measured relative to the 612.5 MHz calibration tone frequency. Values are based on an IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, signal-to-noise ratio > 20 dB, and using the automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of self-calibration. RF attenuation is 20 dB for frequencies <10 MHz and is 10 dB for frequencies >10 MHz.

Table 8. NI 5665 Frequency Response, Preamplifier Present and Enabled

Center Frequency	Device	23 °C ±5 °C			0 °C to 55 °C	
		Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
10 MHz to 100 MHz	NI 5665	±0.75	±0.50	±0.30	±1.0	±0.6
>100 MHz to 2.8 GHz	NI 5665	±0.45	±0.40	±0.25	±1.0	±0.6
>2.8 GHz to 3.6 GHz	NI 5665 3.6 GHz VSA	±0.45	±0.40	±0.25	±1.5	±0.8
	NI 5665 14 GHz VSA	±0.50	±0.40	±0.30	±1.5	±0.8

Note Frequency response is measured relative to the 612.5 MHz calibration tone frequency. Values are based on an IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, signal-to-noise ratio > 20 dB, and using automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of a self-calibration. RF attenuation is 20 dB for frequencies <10 MHz and is 10 dB for frequencies >10 MHz.

Absolute Amplitude Accuracy

Table 9. NI 5665 3.6 GHz VSA Absolute Amplitude Accuracy, Preamplifier Disabled and Preselector Disabled

Center Frequency	23 °C ± 5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
612.5 MHz	±0.35		±0.10	±0.50	±0.35
>20 Hz to 1 MHz[55]	—	—	±1.20	—	±1.20
>1 MHz to 10 MHz [55]	—	—	±1.00	—	±1.00
>10 MHz to 100 MHz	±0.35 + Frequency response	±0.15	±0.10	±1.15	±0.40
>100 MHz to1.7 GHz	±0.35 + Frequency response	±0.15	±0.10	±1.15	±0.40
>1.7 GHz to 2.8 GHz	±0.35 + Frequency response	±0.20	±0.15	±1.15	±0.40
>2.8 GHz to 3.6 GHz	±0.35 + Frequency response	±0.20	±0.15	±1.60	±0.80

Note Values are based on -10 dBm to -50 dBm reference level, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, and using automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of a self-calibration. RF attenuation is 20 dB for frequencies < 10 MHz and is 10 dB for frequencies >10 MHz.

Note The absolute amplitude accuracy is measured at the center frequency. The absolute amplitude accuracy measurements are made after the hardware has settled. The high band to low band signal path transitions can take up to 200 ms for hardware to settle to within 0.1 dB of the final amplitude.

Table 10. NI 5665 14 GHz VSA Absolute Amplitude Accuracy, Preamplifier Disabled and Preselector Disabled

Center Frequency	23 °C ± 5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
612.5 MHz	±0.46		±0.28	±0.75	±0.40
>20 Hz to 1 MHz [55]	—	—	±1.20	—	±1.20
>1 MHz to 10 MHz [55]	—	—	±1.00	—	±1.00
>10 MHz to 100 MHz	±0.46 + Frequency response	±0.38	±0.25	±1.25	±0.70
>100 MHz to 1.7 GHz	±0.46 + Frequency response	±0.32	±0.25	±1.20	±0.70
>1.7 GHz to 2.8 GHz	±0.46 + Frequency response	±0.38	±0.28	±1.50	±0.80
>2.8 GHz to 3.6 GHz	±0.46 + Frequency response	±0.48	±0.30	±1.60	±0.80
>3.6 GHz to 7.5 GHz	±0.70	±0.48	±0.30	±1.60	±0.80
>7.5 GHz to 8.5 GHz	±0.80	±0.48	±0.30	±1.60	±0.80
>8.5 GHZ to 14 GHz	±1.25	±0.90	±0.60	±2.00	±1.10

Note Values are based on -10 dBm to -50 dBm reference level, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, and using automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of a self-calibration. RF attenuation is 20 dB for frequencies < 10 MHz and is 10 dB for frequencies >10 MHz.

Note The absolute amplitude accuracy is measured at the center frequency. The absolute amplitude accuracy measurements are made after the hardware has settled. The high band to low band signal path transitions can take up to 200 ms for hardware to settle to within 0.1 dB of the final amplitude.

Table 11. NI 5665 3.6 GHz VSA Absolute Amplitude Accuracy, Preamplifier Present and Enabled

Center Frequency	23 °C ±5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
612.5 MHz	±0.35	—	±0.25	±0.80	±0.50
>10 MHz to 100 MHz	±0.35 + Frequency response	±0.40	±0.20	±1.20	±0.60
>100 MHz to 2.8 GHz	±0.35 + Frequency response	±0.40	±0.20	±1.20	±0.60
>2.8 GHz to 3.6 GHz	±0.35 + Frequency response	±0.40	±0.20	±1.70	±0.80

Note Values are based on -10 dBm to -50 dBm reference level, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, and using automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of a self-calibration. RF attenuation is 20 dB for frequencies < 10 MHz and is 10 dB for frequencies >10 MHz.

Note The absolute amplitude accuracy is measured at the center frequency. The absolute amplitude accuracy measurements are made after the hardware has settled. The high band to low band signal path transitions can take up to 200 ms for hardware to settle to within 0.1 dB of the final amplitude.

Table 12. NI 5665 14 GHz VSA Absolute Amplitude Accuracy, Preamplifier Present and Enabled

Center Frequency	23 °C ± 5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
612.5 MHz	±0.70	—	±0.25	±1.10	±0.50
>10 MHz to 100 MHz	±0.70 + Frequency response	±0.75	±0.60	±1.70	±0.60
>100 MHz to 300 MHz	±0.70 + Frequency response	±0.75	±0.60	±1.50	±0.60
>300 MHz to 2.8 GHz	±0.70 + Frequency response	±0.75	±0.60	±1.75	±0.70
>2.8 GHz to 3.6 GHz	±0.70 + Frequency response	±0.75	±0.60	±1.90	±0.80

Note Values are based on -10 dBm to -50 dBm reference level, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, and using automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of a self-calibration. RF attenuation is 20 dB for frequencies < 10 MHz and is 10 dB for frequencies >10 MHz.

Note The absolute amplitude accuracy is measured at the center frequency. The absolute amplitude accuracy measurements are made after the hardware has settled. The high band to low band signal path transitions can take up to 200 ms for hardware to settle to within 0.1 dB of the final amplitude.

Table 13. NI 5665 14 GHz VSA Absolute Amplitude Accuracy, Preselector (YIG-Tuned Filter) Present and Enabled

Center Frequency	23 °C ± 5 °C			0 °C to 55 °C	
	Specification (dB)	2σ (dB)	Typical (dB)	Specification (dB)	Typical (dB)
>3.6 GHz to 7.5 GHz	±4.00	±3.00	±2.50	±5.00	±4.00
>7.5 GHz to 14 GHz	±4.00	±2.50	±2.25	±5.00	±4.00

Note Values are based on -10 dBm to -50 dBm reference level, 10 dB RF attenuation, and using the automatic calibration correction of the NI-RFSA instrument driver within ±5 °C of a self-calibration.

Note The absolute amplitude accuracy is measured at the center frequency. The absolute amplitude accuracy measurements are made after the hardware has settled. The high band to low band signal path transitions can take up to 200 ms for hardware to settle to within 0.1 dB of the final amplitude.

Spurious Responses

Non-Input-Related (Residual) Spurs[12]

Table 14. NI 5665 Non-Input-Related (Residual) Spurs, Preselector Disabled (23 °C ± 5 °C)

Frequency	Specification (dBm)	Typical (dBm)
100 MHz to 3.6 GHz	-95	-100
>3.6 GHz to 7.5 GHz	-92	-100

Frequency	Specification (dBm)	Typical (dBm)
>7.5 GHz to 8.5 GHz	-90	-98
>8.5 GHz to 14 GHz	-90	-98

LO-Related Spurious Responses

LO-related sideband spurs 10 kHz to 10 MHz offset from center frequency (23 °C ±5 °C)	
Specification	-73 dBc
Typical	-78 dBc

Note The LO-related sideband spurs that appear in observed signals are caused by LO signals mixing and other internal spurious signals in the downconverter. These spurious signals exclude the image frequency-related spurs and intermediate frequency divided by 2 because they are specified separately. Values are based on -10 dBm input level, -10 dBm reference level, IF through path, and preamplifier disabled.

Higher-Order RF Responses[13]

(Typical)

Typical NI 5665 higher-order RF responses(23 °C ±5 °C)	
100 MHz to 3.6 GHz center frequency	-80
>3.6 GHz to 14 GHz center frequency	-80

Note The higher-order RF responses are measured greater than 10 MHz offset from the carrier signal at a mixer level of -40 dBm.

Image Rejection

Table 15. NI 5665 Image Rejection (dBc) (23 °C ±5 °C)

Center Frequency	Specification (dBc)	Typical (dBc)
100 MHz to 2.2 GHz	-80	-89
>2.2 GHz to 3.6 GHz	-77	-87
>3.6 GHz to 14 GHz	-80	-85
Note Values are based on 0 dBm input signal, 10 dB RF attenuation, 0 dBm reference level, and preamplifier disabled. For center frequencies greater than 3.6 GHz, the preselector is enabled. Specification includes images from all conversion stages.		

IF Rejection[14]

(Typical)

Table 16. NI 5665 3.6 GHz VSA IF Rejection (23 °C ±5 °C)

Center Frequency	IF1 (dBc)	IF2 (dBc)	IF3 (dBc)
100 MHz to 3.6 GHz	-59	-70	-92
Note IF rejection is the suppression of an input signal at the IF frequency when the RF signal analyzer is tuned elsewhere. Values are based on 0 dBm input signal, 10 dB RF attenuation, 0 dBm reference level, IF through path, and preamplifier disabled.			

Table 17. NI 5665 14 GHz VSA IF Rejection (23 °C ±5 °C)

Center Frequency	IF1 (dBc)	IF2 (dBc)	IF3 (dBc)
100 MHz to 3.6 GHz	-59	-92	-92
>3.6 GHz to 14 GHz	-87	-92	—
Note IF rejection is the suppression of an input signal at the IF frequency when the RF signal analyzer is tuned elsewhere. Values are based on 0 dBm input signal, 10 dB RF attenuation, 0 dBm reference level, IF through path, and preamplifier disabled. For center frequencies greater than 3.6 GHz, the preselector is enabled.			

Digital Downconverter Spur

NI 5622 maximum numerical controlled oscillator spur	−100 dBFS, typical[15]

Linearity

Third-Order Intermodulation Distortion

Table 18. NI 5665 Input Third-Order Intercept Point (IP_3), Preamplifier Disabled

Center Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
10 MHz to ≤100 MHz	+16	+19	+17	+18
>100 MHz to 700 MHz	+19	+22	+18	+21
>700 MHz to 3.6 GHz	+20	+24	+19	+22
>3.6 GHz to 8.5 GHz	+20	+24	+19	+24
>8.5 GHz to 14 GHz	+20	+24	+19	+22

Center Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
Note Values are based on two -10 dBm input tones(-10 dBm equivalent mixer level) at 700 kHz apart, 0 dB RF attenuation, preamplifier disabled, -10 dB reference level, and the 300 kHz IF filter. Specifications for frequencies greater than 3.6 GHz apply when the preselector is enabled or disabled. Mixer level is equivalent to input signal level minus RF attenuation.				

Table 19. NI 5665 Input Third-Order Intercept Point (IP_3), Preamplifier Present and Enabled

Center Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Nominal (dBm)	Specification (dBm)	Nominal (dBm)
10 MHz to ≤100 MHz	-3.0	+1.0	-4.0	+0.0
>100 MHz to 700 MHz	+2.0	+2.5	+1.0	+2.0
>700 MHz to 3.6 GHz	+2.5	+3.5	+1.0	+2.0
Note Values are based on two -30 dBm tones (-30 dBm equivalent mixer level) spaced at 700 kHz apart, 0 dB RF attenuation, preamplifier disabled, -30 dBm reference level, and the 300 kHz filter. Mixer level is equivalent to input signal level minus RF attenuation plus preamplifier gain.				

Second Harmonic Distortion (Input SHI)

Table 20. NI 5665 Input SHI, Preamplifier Disabled and Preselector Enabled

Source Frequency	Device	23 °C ± 5 °C		0 °C to 55 °C	
		Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
50 MHz to 300 MHz	NI 5665	—	+52	—	+50
>300 MHz to 700 MHz	NI 5665	+42	+53	+41	+50
>700 MHz to 1.80 GHz	NI 5665 3.6 GHz VSA	+50	+53	+45	+50
	NI 5665 14 GHz VSA	+44	+51	+40	+45
>1.80 GHz to 7.0 GHz	NI 5665	+54	+62	+52	+62
Note Values are based on a -10 dBm mixer level and 300 kHz IF filter. Mixer level is equivalent to input signal level minus RF attenuation. For center frequencies greater than 3.6 GHz, the preselector is enabled.					

Table 21. NI 5665 Input SHI, Preamplifier Present and Enabled

Center Frequency	Device	23 °C ± 5 °C			0 °C to 55 °C		
		Specification (dBm)	Nominal (dBm)	Typical (dBm)	Specification (dBm)	Nominal (dBm)	Typical (dBm)
50 MHz to <300 MHz	NI 5665	—	+17	—	—	+17	—
300 MHz to 1.8 GHz	NI 5665 3.6 GHz VSA	+15	—	+17	+12	—	+17
	NI 5665 14 GHz VSA	+20	—	+30	+20	—	+30
Note Values are based on a -40 dBm mixer level and 300 kHz IF filter. Mixer level is equivalent to input signal level minus RF attenuation plus preamplifier gain.							

Table 22. NI 5665 Input SHI, Preselector (YIG-Tuned Filter) Disabled

Source Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
1.8 GHz to 4.25 GHz	+28	+45	+25	+40
>4.25 GHz to 7.0 GHz	+18	+30	+15	+30
Note Values are based on a -10 dBm mixer level and 300 kHz IF filter. Mixer level is equivalent to input signal level minus RF attenuation.				

Gain Compression[16]

Table 23. NI 5665 1 dB Gain Compression Level, Preamplifier Disabled and Preselector Disabled

Center Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
10 MHz to 100 MHz	+8.0	+9.5	+6.0	+8.0
>100 MHz to 1.7 GHz	+8.0	+9.5	+6.0	+8.0
>1.7 GHz to 3.6 GHz	+6.0	+8.0	+5.0	+7.0
>3.6 GHz to 14 GHz	+6.0	+8.0	+5.0	+7.0
Note Values are based on a two-tone technique, tone separation at >900 kHz, 0 dB RF attenuation, 0 dBm reference level, and 300 kHz IF filter.				

Table 24. NI 5665 1 dB Gain Compression Level, Preamplifier Present and Enabled

Center Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
10 MHz to 100 MHz	-18	-12	-18	–12
>100 MHz to 1.7 GHz	-15	-11	-15	-11
>1.7 GHz to 3.6 GHz	-18	-11	-18	-11
Note Values are based on a two-tone technique, tone separation at >900 kHz, 0 dB RF attenuation, -30 dBm reference level, and 300 kHz IF filter.				

Table 25. NI 5665 1 dB Gain Compression Level, Preselector (YIG-Tuned Filter) Present and Enabled

Center Frequency	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBm)	Typical (dBm)	Specification (dBm)	Typical (dBm)
>3.6 GHz to 7.5 GHz	+6	+8	+5	+7
>7.5 GHz to 8.5 GHz	+6	+8	+5	+7
>8.5 GHz to 14 GHz	+6	+8	+5	+7
Note Values are based on a two-tone technique, tone separation at >900 kHz, 0 dB RF attenuation, -30 dBm reference level, and 300 kHz IF filter.				

Clipping (ADC Overrange)[17]

Single tone, relative to the reference level	10 dB, nominal

Dynamic Range

(Nominal)

Figure 5. NI 5603/NI 5605 RF Downconverter Dynamic Range, Preamplifier Disabled [18]

Figure 6. NI 5603/NI 5605 Downconverter Nominal Dynamic Range, Preamplifier Present and Enabled [19]

Figure 7. NI 5605 Downconverter Nominal Dynamic Range for Frequencies 3.6 GHz to 7.5 GHz, Preselector Present and Enabled [20]

Figure 8. NI 5605 Downconverter Nominal Dynamic Range for Frequencies 7.5 GHz to 14 GHz, Preselector Present and Enabled [21]

Modulation

IF Amplitude Response

Table 26. Typical NI 5665 IF Amplitude Response (23 °C ±5 °C)

IF Passband	Preamplifier Disabled Center Frequency ≤ 3.6 GHz (dB)	Preamplifier Present and Enabled Center Frequency ≤ 3.6 GHz (dB)	Preselector Disabled Center Frequency > 3.6 GHz (dB)
≤5 MHz	±0.15	±0.20	±0.10
≤10 MHz	±0.25	±0.30	±0.20
≤25 MHz	±0.35	±0.40	±0.45
≤40 MHz	±0.40	±0.45	±0.70
≤50 MHz	±0.40	±0.45	±0.80
Note IF passband response is relative to IF center frequency. The specification applies when RF center frequency is ≥100 MHz, 0 dB RF attenuation, IF through path, IF equalization is enabled, and self-calibration is performed. The standard 25 MHz bandwidth option for the NI 5665 provides IF bandwidth up to 25 MHz.			

IF Phase Linearity (Deviation from Linear Phase)

Table 27. Typical NI 5665 Deviation from Linear Phase (Degrees)(23 °C)

IF Passband	Preamplifier Disabled Center Frequency < 3.6 GHz[22]	Preamplifier Present and Enabled Center Frequency < 3.6 GHz [23]	Preselector Disabled Center Frequency > 3.6 GHz
≤5 MHz	±0.1	±0.2	±0.1
≤10 MHz	±0.3	±0.4	±0.3
≤25 MHz	±1.4	±1.6	±1.0
≤40 MHz	±2.1	±1.8	±1.4
≤50 MHz	±2.9	±2.5	±2.1
Note IF passband response is relative to IF center frequency. The specification applies when RF center frequency is ≥100 MHz, 0 dB RF attenuation, IF through path, IF equalization is enabled, and self-calibration is performed. The standard 25 MHz bandwidth option for the NI 5665 provides IF bandwidth up to 25 MHz.			

Error Vector Magnitude (EVM) and Modulation Error Ratio (MER)

(Nominal)

Data length in the following two tables is a 1,250 symbol pseudorandom bit sequence (PRBS) at a -30 dBm power level. These results were obtained using the independent onboard clocks for the vector signal analyzer and do not include software equalization using the NI Modulation Toolkit. Results are the composite effect of both the NI 5665 and the NI 5673E RF vector signal generator.

Table 28. 825 MHz Carrier Frequency

QAM Order	Symbol Rate (kS/s)	α_{RRC}	EVM (% RMS)	MER (dB)
	160	0.25	0.23	53.5
	800	0.21	0.29	52.3

QAM Order	Symbol Rate (kS/s)	α_{RRC}	EVM (% RMS)	MER (dB)
4	4,090	0.22	0.41	49.2
16	17,600	0.25	0.52	45.1
	32,000	0.25	0.74	43.0
64	5,360	0.15	0.31	48.0
	6,952	0.15	0.36	46.9
	40,990	0.22	0.79	40.2
256	6,952	0.15	0.33	46.8

Table 29. 3.4 GHz Carrier Frequency

QAM Order	Symbol Rate (kS/s)	α_{RRC}	EVM (% RMS)	MER (dB)
4	160	0.25	0.57	45.2
	800	0.25	0.53	48.6
	4,090	0.22	0.63	45.1
16	17,600	0.25	0.70	42.1
	32,000	0.25	1.98	39.9
64	5,360	0.15	0.46	44.4
	6,952	0.15	0.51	44.1
	40,990	0.22	1.06	38.2
256	6,952	0.15	0.45	44.0

Table 30. 5.8 GHz Carrier Frequency

QAM Order	Symbol Rate (kS/s)	α_{RRC}	EVM (% RMS)	MER (dB)
4	160	0.25	0.72	44.0
	800	0.25	0.62	44.3
	4,090	0.22	0.63	44.2
16	17,600	0.25	0.67	41.2
	32,000	0.25	0.86	39.8
64	5,360	0.15	0.47	43.7
	6,952	0.15	0.50	42.9
	40,990	0.22	0.98	39.4
256	6,952	0.15	0.44	43.5

Measurement Speed

Measurement duration is made up of tuning time plus analysis time. The tuning benchmark includes programming time, frequency settling time, and amplitude settling time. Programming time partially overlaps frequency settling time and amplitude settling time. Measurement duration is dependent on the specific measurement settings used.

Amplitude Settling Time[24]

Table 31. Nominal NI 5665 Amplitude Settling Time

Center Frequency	Device	Mechanical Attenuator Stationary	Mechanical Attenuator State Changed
>100 MHz to ≤3.6 GHz	NI 5665 3.6 GHz VSA	25 µs	5 ms
	NI 5665 14 GHz VSA		40 ms
>3.6 GHz to ≤14 GHz	NI 5665 14 GHz VSA	25 µs	40 ms

Tuning Time

Table 32. Nominal NI 5665 Tuning Time (ms)

Step Size	Tuning Time (ms)[25]	
	Fast Configuration[26]	Normal Configuration[27]
50 MHz	1.8	5.6
75 MHz	1.9	7.7
250 MHz	2.3	9.3
1.0 GHz	6.6	15.0
3.5 GHz	14.5	19.6

RF Configuration List Mode Tuning Time

Table 33. Nominal NI 5665 RF Configuration List Mode Tuning Time (ms)

Step Size	Tuning Time (ms)[25]	
	Fast Configuration[26]	Normal Configuration[27]
50 MHz	1.2	7.1
75 MHz	1.5	8.1
250 MHz	1.9	11.1
1.0 GHz	10.1	15.1

Step Size	Tuning Time (ms)[25]	
	Fast Configuration[26]	Normal Configuration[27]
3.5 GHz	17.1	20.1

The maximum tuning time for an arbitrary frequency jump depends on the locking time and the settling time for the LO. You can calculate the LO frequency for a given RF frequency using the following equation:

where f_{LO} = LO frequency, f_{RF} = RF center frequency, and f_{If} = IF path center frequency.

Table 34. NI 5665 IF Path Center Frequency

Instantaneous Bandwidth[28]	IF Path Center Frequency
≤300 kHz	199.0 MHz
>300 kHz and < 5 MHz	190.0 MHz
>5 MHz	187.5 MHz

You can calculate the tuning time for an arbitrary frequency jump using the following equations:

where ∆LOFrequency is the LO frequency step size.

Note If your application uses the NI 5665 14 GHz VSA device with the preselector enabled, add the preselector tuning time to the values you calculate using these equations.

Note Refer to the NI 5653 LO Specifications section of this document for LO tuning times.

Preselector Tuning Time

(Nominal)

Table 35. NI 5665 14 GHz VSA Preselector Tuning Time

Center Frequency Step Size	Preselector Tuning Time (ms)[29]
≤100 MHz	2.1
500 MHz	3.4
1.0 GHz	5.1
2.0 GHz	8.4
3.0 GHz	11.6
3.5 GHz	13.3
4.0 GHz	15.0
6.0 GHz	21.5

Analysis Time Versus Span[30]

(Nominal)

Figure 9. NI 5665 Analysis Time for Center Frequencies < 3.6 GHz

Figure 10. NI 5665 14 GHz VSA Analysis Time, Preselector Disabled[31]

Figure 11. NI 5665 14 GHz VSA Analysis Time, Preselector Enabled[31]

Data Streaming[32]

Maximum continuous transfer rate	300 MB/s, nominal

Input and Output Characteristics

RF IN Front Panel Connector (NI 5603/NI 5605)

Connector	SMA female
Impedance	50 Ω, nominal
Coupling	AC and DC
Maximum safe DC input voltage	
AC coupled	±25 V DC[33]
DC coupled	±0 V DC[34]

Maximum Safe Continuous RF Power

Table 36. NI 5603 Maximum Safe Continuous RF Power

Mechanical Attenuation	Level
≥10 dB	+30 dBm
0 dB	+20 dBm

Table 37. NI 5605 Maximum Safe Continuous RF Power

Mechanical Attenuation	Level	
	<10 MHz	≥10 MHz
≥10 dB	+25 dBm	+30 dBm
0 dB	+10 dBm	+20 dBm

Voltage Standing Wave Ratio (VSWR) of RF Input

(Nominal)

Table 38. NI 5603 VSWR

Attenuation [35]	Center Frequency	VSWR
≥10 dB	>100 MHz to ≤3.6 GHz	≤1.4:1
0 dB	>100 MHz to ≤3.6 GHz	≤2.0:1

Table 39. NI 5605 VSWR

Attenuation [36]	Center Frequency	VSWR
≥10 dB	>100 MHz to ≤14 GHz	≤1.3:1
0 dB	>100 MHz to ≤14 GHz	≤3.3:1

IF OUT Front Panel Connector (NI 5603/NI 5605)

Connector	SMA female
Impedance	50 Ω, nominal
Return loss	15 dB, nominal
Maximum IF output level	+22 dBm
Output voltage	0 V DC

LO IN and LO OUT Front Panel Connectors (NI 5603/NI 5605)

Connector	SMA female
Impedance	50 Ω, nominal
Coupling	AC
LO IN maximum safe power level	+15 dBm
LO IN maximum safe voltage	
NI 5603	25 V DC
NI 5605	0 V DC
LO OUT maximum safe power level	+15 dBm
LO OUT maximum safe voltage	0 V DC
LO frequency	
LO1	4.6 GHz to 8.3 GHz
LO2	4.0 GHz
LO3	800 MHz
LO output level	
LO1	+5 dBm to +12 dBm, nominal (varies with frequency)
LO2	+9 dBm, nominal
LO3	+9 dBm, nominal

LO Output (NI 5653)

Output power	
LO1	+5 dBm to +12 dBm, nominal (varies with frequency)
LO2	+8 dBm to +10 dBm, nominal

LO3		+8.5 dBm to +12 dBm, nominal

Power Requirements

Table 40. NI 5665 Power Requirements (Voltages ±5%)

Module	From +3.3 VDC	From +12 VDC
NI 5603	1.70 A (5.61 W)	1.80 A (21.60 W)
NI 5605	1.20 A (3.96 W)	3.40 A (40.80 W)
NI 5622	1.75 A (5.78 W)	2.25 A (27.00 W)
NI 5653	1.10 A (3.63 W)	4.00 A (48.00 W)

Calibration

Interval		1 year

NI 5653 LO Specifications

LO frequency (nominal)		
LO1		3.2 GHz to 8.3 GHz
LO2		4.0 GHz
LO3		800 MHz

Single Sideband (SSB) Phase Noise (LO1)

LO1 = 5.4125 GHz

Table 41. Phase Noise (dBc/Hz), NI 5665 Center Frequency = 800 MHz

Offset	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBc/Hz)	Typical (dBc/Hz)	Nominal (dBc/Hz)	Typical (dBc/Hz)
10 Hz	—	—	<-73[37]	—
100 Hz	<-89	<-94	—	<-89
1 kHz	<-118	<-122	—	<-119
10 kHz	<-128	<-131	—	<-130
100 kHz	<-125	<-128	—	<-127
1 MHz	<-141	<-144	—	<-143
5 MHz	<-155	<-157	—	<-155
Note LO YIG Main Coil Drive property set to Normal or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute is set to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL.				

LO1 = 7.8125 GHz

Table 42. Phase Noise (dBc/Hz), NI 5665 Center Frequency = 3.2 MHz

Offset	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBc/Hz)	Typical (dBc/Hz)	Nominal (dBc/Hz)	Typical (dBc/Hz)
10 Hz	—	—	<-70[37]	—
100 Hz	<-86	<-92	—	<-86
1 kHz	<-115	<-119	—	<-116
10 kHz	<-127	<-130	—	<-129
100 kHz	<-125	<-128	—	<-127
1 MHz	<-141	<-144	—	<-143
5 MHz	<-155	<-157	—	<-155
Note LO YIG Main Coil Drive property set to Normal or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute is set to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL.				

Figure 12. LO1 Phase and Amplitude Noise (AM) (Nominal) [38]

Figure 13. LO1 Phase Noise Measured Performance Comparison, Normal Tuning Versus Fast Tuning Speed[39]

Single Sideband (SSB) Phase Noise (LO2)

LO2 (4 GHz)

Table 43. Noise Density, NI 5665 Center Frequencies > 3.6 GHz

Offset	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBc/Hz)	Typical (dBc/Hz)	Nominal (dBc/Hz)	Typical (dBc/Hz)
10 Hz	—	—	<-76, nominal[*]	—
100 Hz	<-92	<-97	—	<-92

Offset	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBc/Hz)	Typical (dBc/Hz)	Nominal (dBc/Hz)	Typical (dBc/Hz)
1 kHz	<-121	<-125	—	<-122
10 kHz	<-134	<-137	—	<-135
100 kHz	<-134	<-137	—	<-135
1 MHz	<-143	<-146	—	<-145
5 MHz	<-155	<-157	—	<-155

Figure 14. LO2 Phase and Amplitude Noise (Nominal) [41]

Single Sideband (SSB) Phase Noise (LO3)

LO3 (800 MHz)

Table 44. Noise Density, NI 5665 Center Frequencies > 3.6 GHz

Offset	23 °C ± 5 °C		0 °C to 55 °C	
	Specification (dBc/Hz)	Typical (dBc/Hz)	Nominal (dBc/Hz)	Typical (dBc/Hz)
10 Hz	—	—	<-90, nominal[*]	—
100 Hz	<-104	-111	—	<-106
1 kHz	<-135	-139	—	<-134
10 kHz	<-148	-152	—	<-149
100 kHz	<-149	-153	—	<-150
1 MHz	<-158	-160	—	<-156
5 MHz	<-160	-163	—	<-159

Figure 15. LO3 Phase Noise [43]

NI 5653 Frequency Lock Time[44]

Table 45. NI 5653 Maximum Lock Time (0 °C to 55 °C)

Frequency Step Size	Fast Tuning Mode (ms)	Normal Tuning Mode (ms)
≤25 MHz	0.85	3
≤50 MHz	1.10	6
≤75 MHz	1.35	7
≤80 MHz	1.35	7
≤90 MHz	1.35	7
≤100 MHz	1.35	7
≤250 MHz	1.80	10
≤500 MHz	6	12
≤1.0 GHz	10	14
≤2.0 GHz	13	17
≤3.0 GHz	15	18
≤5.1 GHz	17	20

NI 5653 Frequency Settling Time[47]

Table 46. NI 5665 Maximum Settling Time (0 °C to 55 °C)

Settling Accuracy (Relative to Final Frequency)	Fast Tuning Mode[48] (ms)	Normal Tuning Mode[49] (ms)
1.0×10^{-6}	0.00	0.00
0.1×10^{-6}	0.75	1.00
0.01×10^{-6}	1.60	6.00

NI 5603/5605 Downconverter Specifications

Instantaneous Bandwidth

Typical (23 ± 5 °C)

IF passband bandwidth		
IF through path (≥80 MHz)		6 dB
IF through path (≥50 MHz)		3 dB
≥5 MHz[50]		3 dB
≥300 kHz		3 dB
RF preselector[51] passband bandwidth		

Preselector enabled (≥47 MHz)		6 dB

IF Frequencies

Table 47. Nominal NI 5665 Downconverter IF Frequencies

RF Center Frequency	IF Signal Path	IF1	IF2	IF3
20 Hz to 3.6 GHz	Through	4.6125 GHz	612.5 MHz	187.5 MHz
	5 MHz	4.6100 GHz	610.0 MHz	190.0 MHz
	300 kHz	4.6010 GHz	601.0 MHz	199.0 MHz
>3.6 GHz	Through	612.5 MHz	187.5 MHz	—
	5 MHz	610.0 MHz	190.0 MHz	—
	300 kHz	601.0 MHz	199.0 MHz	—

Amplitude Range

The NI 5603/NI 5605 amplitude range is the same as the *Amplitude Range* specified for the NI 5665.

Average Noise Level

(Typical)

Preamplifier Disabled

Table 48. NI 5665 Downconverter Average Noise Level, Preamplifier Disabled

Center Frequency	23 ± 5 °C (dBm/Hz)	0 to 55 °C (dBm/Hz)
20 Hz to 10 kHz	—	-70
>10 kHz to 10 MHz	—	-100
>10 MHz to 100 MHz	-152	-151
>100 MHz to 300 MHz	-157	-154
>300 MHz to 1.7 GHz	-154	-153
>1.7 GHz to 2.8 GHz	-152	-151
>2.8 GHz to 12 GHz	-151	-150
>12 GHz to 14 GHz	-147	-146

Note Values based on input terminated, no input signal, 0 dB RF attenuation for center frequency ≥10 MHz, 20 dB RF attenuation for center frequency < 10 MHz, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, ≤-50 dBm reference level, IF through path, and >10 averages. RMS average noise level normalized to a 1 Hz noise bandwidth. When the average noise level is measured as DANL, there is a 2.5 dB improvement; for example, the equivalent DANL measured at 2 GHz is -154.5 dBm/Hz.

Preamplifier Present and Enabled

Table 49. NI 5665 Downconverter Average Noise Level, Preamplifier Present and Enabled

Center Frequency	23 °C ± 5 °C (dBm/Hz)	0 °C to 55 °C (dBm/Hz)
10 MHz to 100 MHz	-163	-161
>100 MHz to 300 MHz	-167	-166
>300 MHz to 1.7 GHz	-165	-164
>1.7 GHz to 2.8 GHz	-164	-163
>2.8 GHz to 3.6 GHz	-163	-163

Note Values based on input terminated, no input signal, 0 dB RF attenuation, IF through path for center frequency ≥ 100 MHz, 300 kHz IF filter for center frequency < 100 MHz, ≤−50 dBm reference level, IF through path, and >10 averages. RMS average noise level measured in a 1 Hz noise bandwidth using NI-RFSA I/Q acquisition mode. When the average noise level is measured as DANL, there is a 2.5 dB improvement; for example, the equivalent DANL measured at 2 GHz is -166.5 dBm/Hz.

Preselector (YIG-Tuned Filter) Present and Enabled

Table 50. NI 5665 Downconverter Average Noise Level, Preselector (YIG-Tuned Filter) Present and Enabled

Center Frequency	23 °C ± 5 °C (dBm/Hz)	0 °C to 55 °C (dBm/Hz)
>3.6 GHz to 7.5 GHz	-147	-146
>7.5 GHz to 8.5 GHz	-145	-144
>8.5 GHz to 12 GHz	-145	-144
>12 GHz to 14 GHz	-142	-141

Note Values based on input terminated, 0 dB RF attenuation, IF through path, ≤−50 dBm reference level, IF through path, and >10 averages. RMS average noise level normalized to a 1 Hz noise bandwidth. When the average noise level is measured as the DANL associated with spectrum analyzers, there is a 2.5 dB improvement caused by the averaging of log and other measurement biases in spectrum analyzer DANL. For example, the equivalent DANL at 8 GHz is -147.5 dBm/Hz.

Downconverter Gain Accuracy

(Typical)

The NI 5603/NI 5605 gain accuracy after use of the internal self-calibration factor is the same as the *Amplitude Accuracy* specification. The receiver that is used with the NI 5603/NI 5605 downconverter should have resolution and temperature stability equal to or better than that of the NI 5622 digitizer.

Downconverter Conversion Gain

Figure 16. NI 5603 Typical Maximum Conversion Gain (Center Frequency < 3.6 GHz)

Figure 17. NI 5605 Low Band Conversion Gain (Center Frequency < 3.6 GHz)

Figure 18. NI 5605 High Band Conversion Gain (Center Frequency > 3.6 GHz)

Spurious Response Level

The NI 5603/NI 5605 spurious response level is the same as or better than the NI 5665 *Spurious Responses* specification when the NI 5653 is used as the LO and the NI 5622 is used as the digitizer.

Image and IF Rejection

Table 51. NI 5665 Image Rejection (23 °C ±5 °C)

Center Frequency	Image Rejection (dBc)
100 MHz to 2.2 GHz	-89
>2.2 GHz to 3.6 GHz	-87
>3.6 GHz to 14 GHz	-85

Note Values are based on 0 dBm input signal, 10 dB RF attenuation, 0 dBm reference level, and preamplifier disabled. For center frequencies greater than 3.6 GHz, the preselector is enabled. Specification includes images from all conversions stages.

The NI 5603/NI 5605 IF Rejection are the same as those specified for the NI 5665.

Linearity and Dynamic Range Specifications

The NI 5603/NI 5605 linearity (TOI, SHI, two tone compression) and dynamic range specifications are the same as or better than the NI 5665 *Linearity* and *Dynamic Range* specifications.

Measurement Configuration Speed

The NI 5603/NI 5605 measurement configuration speed specification is the same as or better than the NI 5665 Measurement Speed specification when the NI 5653 is used as the LO.

NI 5622 IF Digitizer Module Specifications[52]

IF IN	
Connector	SMA female
Impedance	50 Ω
Return loss	15 dB, nominal
PFI 1	
Direction	Bidirectional
Connector	SMB
Impedance (as input)	150 kΩ
CLK IN	
Connector	SMA female
Impedance	50 Ω
Input amplitude, sine wave	0.63 $V_{pk\text{-}pk}$ to 2.8 $V_{pk\text{-}pk}$ (0 dBm to +13 dBm)
Input amplitude, square wave	0.25 $V_{pk\text{-}pk}$ to 2.8 $V_{pk\text{-}pk}$
Maximum input overload	6.3 $V_{pk\text{-}pk}$ (+20 dBm)
CLK OUT	
Connector	SMA
Output impedance	50 Ω
Output amplitude, 50 Ω load	>+10 dBm
Output amplitude, 1 kΩ load	>2 $V_{pk\text{-}pk}$

Physical Characteristics

Figure 19. NI 5665 3.6 GHz VSA System Front Panel

Figure 20. NI 5665 14 GHz VSA System Front Panel

NI 5603	3U, Two Slot, PXI Express module 21.6 cm × 4.0 cm × 13.0 cm (8.5 in. × 1.6 in. × 5.1 in.)
NI 5605	3U, Four Slot, PXI Express module 21.6 cm × 8.2 cm × 13.0 cm (8.5 in. × 3.2 in. × 5.1 in.)
NI 5622	3U, One Slot, PXI Express module 21.6 cm × 2.0 cm × 13.0 cm (8.5 in. × 0.8 in. × 5.1 in.)
NI 5653	3U, Two Slot, PXI Express module 21.6 cm × 4.0 cm × 13.0 cm (8.5 in. × 1.6 in. × 5.1 in.)
Weight	
NI 5603	907 g (32.0 oz)
NI 5605	1,882 g (66.4 oz)
NI 5622	376 g (13.3 oz)
NI 5653	1,076 g (37.8 oz)
Combined Unit	
NI 5665 3.6 GHz VSA	2,359 g (83.1 oz)
NI 5665 14 GHz VSA	3,334 g (117.5 oz)

Environment	
Maximum altitude	2,000 m (at 25 °C ambient temperature)
Pollution Degree	2

Indoor use only.

Operating Environment

Ambient temperature range	0 °C to 55 °C (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2. Meets MIL PRF-28800F Class 3 low temperature limit and MIL PRF-28800F Class 2 high temperature limit.)
Relative humidity range	10% to 90%, noncondensing (Tested in accordance with IEC-60068-2-56.)

Storage Environment

Ambient temperature range	-41 °C to +71 °C (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2. Meets MIL PRF-28800F Class 3 limits.)
Relative humidity range	5% to 95%, noncondensing (Tested in accordance with IEC-60068-2-56.)
Operational shock	30 g peak, half-sine, 11 ms pulse (Tested in accordance with IEC-60068-2-27. Test profile developed in accordance with MIL-PRF-28800F)
Random vibration	
Operating	5 Hz to 500 Hz, 0.3 g_{rms}
Nonoperating	5 Hz to 500 Hz, 2.4 g_{rms} (Tested in accordance with IEC-60068-2-64. Nonoperating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.)

Compliance and Certifications

Safety

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the Online Product Certification section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions

- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generates radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, refer to the *Online Product Certification* section.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Online Product Certification

To obtain product certifications and the DoC for this product, visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the *NI and the Environment* web page at ni.com/environment. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all products must be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste Electrical and Electronic Equipment, visit ni.com/environment/weee.htm.

RoHS

National Instruments(RoHS)National InstrumentsRoHS ni.com/environment/rohs_china(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

[1] The NI 5665 maximum center frequency is 3.6 GHz when using the NI 5603 and 14 GHz when using the NI 5605.
[2] Tuning resolution refers to the digitial downconversion (DDC) tuning resolution.
[3] The NI 5653 reference oscillator determines this specification.
[4] The NI 5653 reference oscillator determines this specification.
[5] The NI 5653 reference oscillator determines this specification.
[6] The NI 5653 reference oscillator determines this specification.
[7] Measurement made with the IF through path, spurs not shown. Broadband SSB noise floor typically -150 dBc/Hz at 10 MHz offset with 300 kHz IF filter selected.
[8] Frequencies greater than 3.6 GHz apply only to the NI 5665 14 GHz VSA.
[9] Frequencies greater than 3.6 GHz apply only to the NI 5665 14 GHz VSA.
[10] Refer to the Maximum Safe Continuous RF Power section for the lower amplitude range limit under specific conditions.
[11] For frequency ranges from 20 Hz to 10 MHz, the reference level is -10 to -30 dBm. DC coupling causes an additional uncertainty of 0.2 dB for frequencies less than 10 kHz.
[12] Non-input-related spurs (residual spurs) are the responses observed when no input signal is present. The non-input-related spur values are based on ambient temperature of 23 °C ±5 °C, RF input terminated, 0 dB RF attenuation, and -60 dBm reference level. For the NI 5665 14 GHz VSA from 1.65 GHz to 1.75 GHz, the warranted non-input-related spur specification is -85 dBm.
[13] Higher-order RF responses are responses resulting from RF second-order and higher-order harmonic-related spurs.
[14] Refer to the *NI 5603/5605 Downconverter Specifications* section for the IF1,I F2, and IF3 frequency definitions.
[15] The digital downconversion can be optionally bypassed.
[16] Compression of an in-band signal by an out-of-band interfering signal, referenced to the RF input.
[17] The IF power offset defaults to 0 dB.
[18] Values plotted are based on frequencies >700 MHz to ≤3.6 GHz with the preamplifier disabled and an ambient temperature of 23 °C ± 5 °C. RMS average noise level is normalized to a 1 Hz noise bandwidth while using NI-RFSA in I/Q acquisition mode. Third-order distortion is based on two tones with >700 kHz spacing, and using the 300 kHz IF filter. The Second Harmonic Distortion and Third-Order Distortion lines shown, below the Average Noise line are extrapolations. The dynamic range plot shows nominal performance with settings that are optimized for noise performance. If you use the manual RF attenuation settings, IP_3 performance can improve with minimal degradation in noise floor, thus increasing the effective spurious free dynamic range in the power per tone signal range of -10 dB to 0 dB below the reference level.
[19] Values plotted are based on frequencies >700 MHz to ≤3.6 GHz with the preamplifier disabled and an ambient temperature of 23 °C ±5 °C. RMS average noise level is normalized to a 1 Hz noise bandwidth while using NI-RFSA in I/Q acquisition mode. The dynamic range plot shows nominal performance with settings that are optimized for noise performance. If you use the manual RF attenuation settings, IP_3 performance can improve with minimal degradation in noise floor, thus increasing the effective spurious free dynamic range in the power per tone signal range of -10 dB to 0 dB below the reference level.
[20] Values plotted are based on frequencies >3.6 GHz to ≤7.5 GHz with the preselector enabled and an ambient temperature of 23 °C ±5 °C. RMS average noise level is normalized to a 1 Hz noise bandwidth while using NI-RFSA in I/Q acquisition mode. The dynamic range plot shows nominal performance with settings that are optimized for noise performance. If you use the manual RF attenuation settings, IP_3 performance can improve with minimal degradation in noise floor, thus increasing the effective spurious free dynamic range in the power per tone signal range of -10 dB to 0 dB below the reference level.
[21] Values plotted are based on frequencies >7.5 GHz to ≤14 GHz with the preselector enabled and an ambient temperature of 23 °C ±5 °C. RMS average noise level is normalized to a 1 Hz noise bandwidth while using NI-RFSA in I/Q acquisition mode. The dynamic range plot shows nominal performance with settings that are optimized for noise performance. If you use the manual RF attenuation settings, IP_3 performance can improve with minimal degradation in noise floor, thus increasing the effective spurious free dynamic range in the power per tone signal range of -10 dB to 0 dB below the reference level.
[22] When the preamplifier is disabled, the reference levels vary from +20 to -30 dBm.
[23] When the preamplifier is enabled, the reference levels vary from -20 to -50 dBm.
[24] Amplitude settling is within 0.1 dB.

[25] Tuning times refer to tuning with a single band, for example, tuning with in 0 Hz to 3.6 GHz or within 3.6 GHz to 7.5 GHz. The tuning times for tuning within the 7.5 GHz to 14 GHz band are lower than if the frequency spans multiple frequency bands. If your application uses the NI 5665 14 GHz VSA device with the preselector enabled, add the preselector tuning times to the tuning times listed in this table.

[26] Fast Configuration refers to setting the LO YIG Main Coil Drive property to Fast or setting the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_FAST at an accuracy of 1.0 × 10^{-6} of final frequency.

[27] Normal Configuration refers to setting the LO YIG Main Coil Drive property to Normal or setting the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL at an accuracy of 0.1 × 10^{-6} of final frequency.

[28] The instantaneous bandwidth of the device is the value of the Device Instantaneous Bandwidth property or the NIRFSA_ATTR_DEVICE_INSTANTANEOUS_BANDWIDTH attribute.

[29] Tuning time refer to the time required to tune the preselector upwards in frequency. The time required to tune downwards in frequency can be 13 ms to 27 ms for RF center frequencies from 3.6 GHz to 7.5 GHz and can be 26 ms to 48 ms for RF center frequencies from 7.5 GHz to 14 GHz.

[30] Analysis time versus span was measured with a tuned frequency > 10 MHz. For spans smaller than 1 MHz, 190 frequency points were measured; above 1 MHz span, 1,000 frequency points were measured. Analysis time includes acquisition, FFT analysis, and data transfer time. For spans larger than 50 MHz, analysis time also includes tuning time. Tuning Mode refers to the setting of the LO YIG Main Coil Drive property to either Fast or Normal or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to either NIRFSA_ATTR_VAL_LO_YIG_MAIN_COIL_DRIVE_FAST or NIRFSA_ATTR_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL.

[31] Low band refers to RF center frequencies less than 3.6 GHz. High band refers to RF center frequencies from 3.6 GHz to 14 GHz.

[32] Refer to the *NI PXIe-5622 Specifications* for more information about data streaming. The data streaming specification was measured using the NI PXIe-1065 chassis and the NI PXIe-8130 controller. Performance is system-dependent.

[33] DC voltages less than ±25 VDC at the RF IN connector of the NI 5603 are safe for the downconverter. However, high transient currents from low-impedance DC step voltages at the RF IN connector can cause damage to the downconverter. NI is not liable for damage caused by improper signal connections.

[34] Ensure that the DC voltage at the RF IN connector of the NI 5605 is limited to ±2 V even with the DC block attached to the RF IN connector. With the DC block removed, the maximum safe DC input voltage for the RF IN connector is 0 V.

[35] Attenuation available in 1 dB steps.

[36] Attenuation available in 1 dB steps for frequencies less than 3.6 GHz. Attenuation is available in 5 dB steps from 20 Hz to 14 GHz.

[*] When used in a vector signal analyzer (VSA) system, the nominal specification for the VSA improves significantly from this value because the VSA uses all the LOs instead of a single LO. The phase noise of other LOs is correlated to the phase noise on LO1 at low offsets, which results in improved performance of the VSA system.

[38] LO1 Noise Sidebands: LO1 = 5.4125 GHz, 7.8125 GHz. Plots of measured LO1 performance (Phase Noise and AM Noise) shown without spurs.

[39] LO1 frequency is 5 GHz. Representative of nominal performance difference across the entire frequency range of LO1 (shown without spurs). Tuning Mode refers to the setting of the LO YIG Main Coil Drive property to Fast or Normal or setting the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_FAST or NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL.

[*] When used in a vector signal analyzer (VSA) system, the nominal specification for the VSA improves significantly from this value because the VSA uses all the LOs instead of a single LO. The phase noise of other LOs is correlated to the phase noise on LO1 at low offsets, which results in improved performance of the VSA system.

[41] LO2 = 4.0 GHz. Plots of measured LO2 performance (Phase Noise and AM Noise) shown without spurs.

[*] When used in a vector signal analyzer (VSA) system, the nominal specification for the VSA improves significantly from this value because the VSA uses all the LOs instead of a single LO. The phase noise of other LOs is correlated to the phase noise on LO1 at low offsets, which results in improved performance of the VSA system.

[43] LO3 (800 MHz). Phase Noise plot of measured LO3 performance shown without spurs.

[44] NI 5653 Frequency Tuning Time consists of Lock Time + Settling Time to Required Accuracy. For example, in Fast Configuration mode, a 50 MHz step requires 1.1 ms (the frequency lock time) + 0.75 (the frequency settling time), or 1.85 ms to lock and settle to 0.1 ppm accuracy.

[45] Fast Tuning Mode refers to setting the LO YIG Main Coil Drive property to Fast or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_FAST at an accuracy of 1.0 ×10^{-6} of the final frequency.

[46] Normal Tuning Mode refers to setting the LO YIG Main Coil Drive property to Normal or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL at an accuracy of 1.0 ×10^{-6} of the final frequency.

[47] NI 5653 Frequency Tuning Time consists of Lock Time + Settling Time to Required Accuracy. For example, in Fast Configuration mode, a 50 MHz step requires 1.1 ms (the frequency lock time) + 0.75 (the frequency settling time), or 1.85 ms to lock and settle to 0.1 ppm accuracy.

[48] Fast Tuning Mode refers to setting the LO YIG Main Coil Drive property to Fast or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_FAST at an accuracy of 1.0 ×10^{-6} of the final frequency.

[49] Normal Tuning Mode refers to setting the LO YIG Main Coil Drive property to Normal or the NIRFSA_ATTR_LO_YIG_MAIN_COIL_DRIVE attribute to NIRFSA_VAL_LO_YIG_MAIN_COIL_DRIVE_NORMAL at an accuracy of 1.0 ×10^{-6} of the final frequency.

[50] The 5 MHz filter is available only for the NI 5605.

[51] The RF preselector is available only for the NI 5605. Preselector ripple may affect the bandwidth at some frequencies. The typical preselector bandwidth includes the effects of passband ripple and modes.

[52] Refer to the *NI PXIe-5622 Specifications* for detailed information about the digitizer module.

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