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NI PXIe-5601 Specifications

RF Downconverter

This document lists specifications for the NI PXIe-5601 RF downconverter (NI 5601). Use the NI 5601 with the NI PXIe-5622 IF digitizer and the NI PXI-5652 RF signal generator (used as an LO source) to compose the NI PXIe-5663 RF vector signal analyzer (NI 5663).

Specifications are warranted under the following conditions:

- 30 minutes warm-up time
- Calibration cycle maintained
- Chassis fan speed set to High
- NI 5652 used as LO source
- Modules locked to the PXI backplane
- NI-RFSA instrument driver used with stored calibration data utilized
- NI 5601 module revision G or later

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.

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.

Specifications are subject to change without notice. For the most recent NI 5601 specifications, visit `ni.com/manuals`.

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To access NI RF vector signal analyzer documentation, navigate to **Start»All Programs»National Instruments»NI-RFSA» Documentation**.



Hot Surface If the NI 5601 has been in use, the device or the shield may exceed safe handling temperatures and may cause burns. Allow the NI 5601 to cool before touching the shield or removing the device from the chassis.

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Frequency

Frequency range[1] ..... 10 MHz to 6.6 GHz

Tuning Resolution

Tuned Frequency	Resolution (Hz)
10 MHz to <1.3 GHz	<1
1.3 GHz to <3.1 GHz	<2
3.1 GHz to 6.6 GHz	<4
Note: Values determined using NI 5652 as LO source.	

Bandwidth

Instantaneous Bandwidth

Tuned Frequency	3dB Instantaneous Bandwidth
10 MHz to <120 MHz	>5 MHz (>10 MHz at 6 dB)
120 MHz to <330 MHz	>20 MHz
330 MHz to 6.6 GHz	>50 MHz, >300 MHz*
Note: Calibration data not used. * Bypass path selected, IF center frequency of 10 MHz to 310 MHz.	

[1] The NI 5663 is operational to 1 MHz. The maximum tuned frequency = 6.6 GHz – ½ (frequency span).

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Spectral Purity

Phase Noise

Single Sideband (SSB) Phase Noise	
Tuned Frequency	**Noise Density**
100 MHz	<–125 dBc/Hz
500 MHz	<–112 dBc/Hz
1 GHz	<–105 dBc/Hz
2 GHz	<–98 dBc/Hz
3 GHz	<–95 dBc/Hz
4 GHz	<–93 dBc/Hz
5 GHz	<–90 dBc/Hz
6.6 GHz	<–90 dBc/Hz
Note: 10 kHz offset; measured using NI 5652 with internal Reference clock.	

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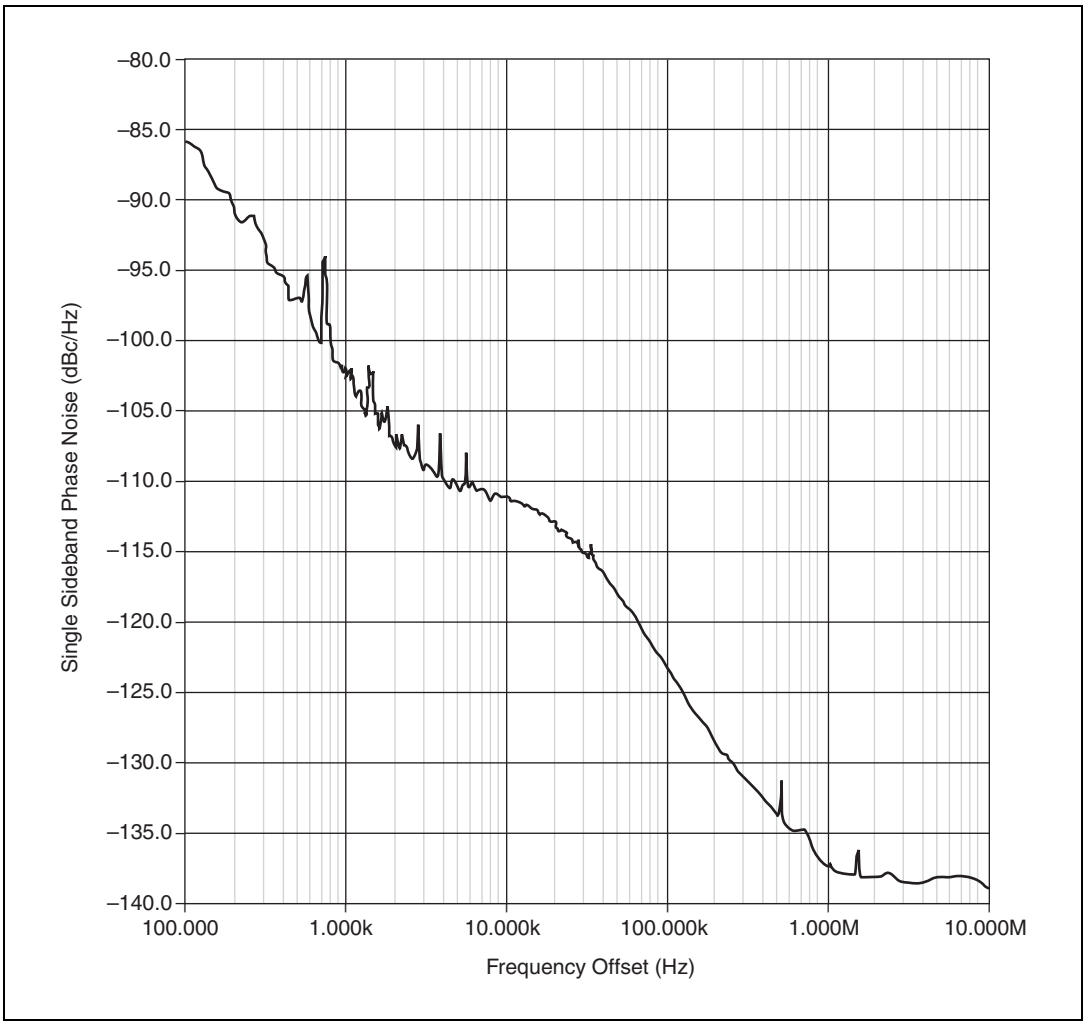


Figure 1. Typical Phase Noise at 1 GHz, Using NI 5652 LO Source and NI 5622 IF Digitizer

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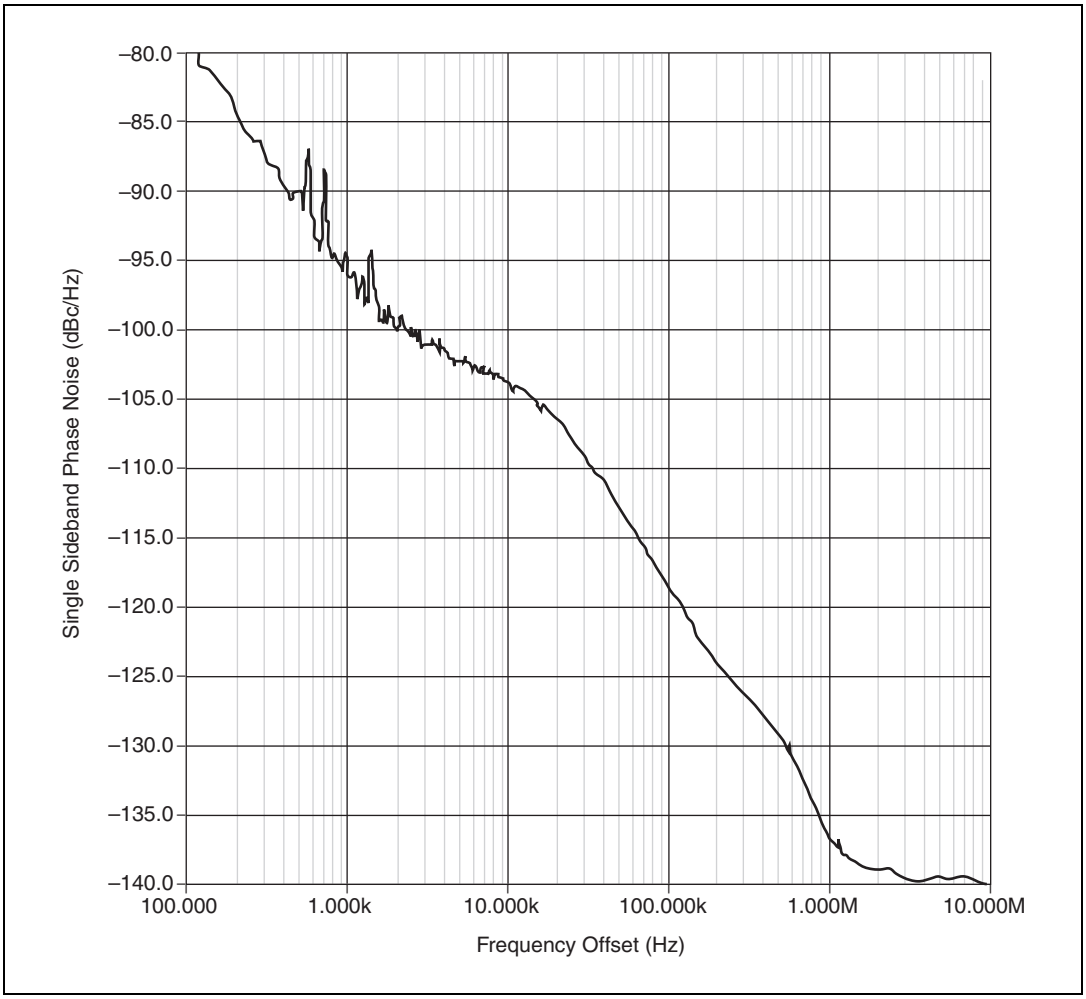


Figure 2. Typical Phase Noise at 2.4 GHz, Using NI 5652 LO Source and NI 5622 IF Digitizer

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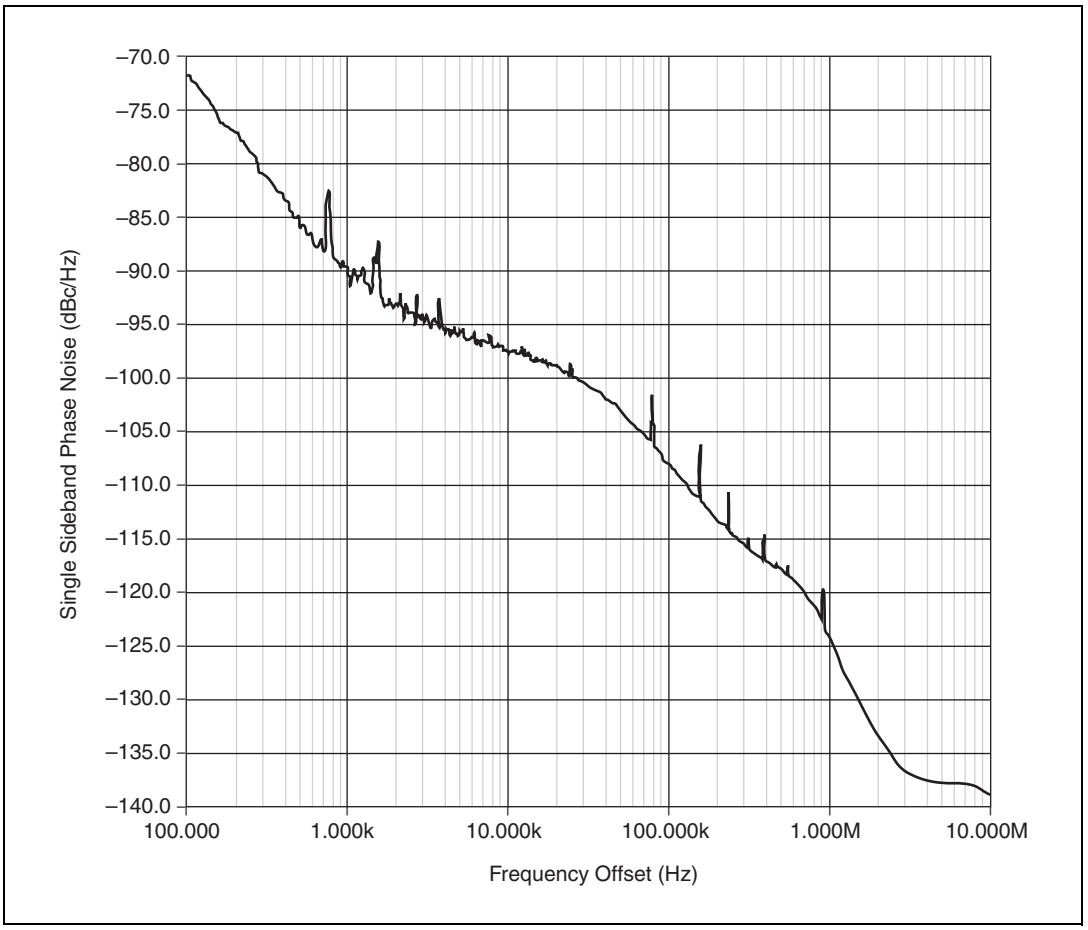


Figure 3. Typical Phase Noise at 5.8 GHz, Using NI 5652 LO Source and NI 5622 IF Digitizer

Amplitude

Range

Amplitude range..... *Average Noise Level* to +30 dBm

RF input attenuation..... 0 dB to 50 dB in 1 dB steps, nominal

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Average Noise Level

Frequency	23 °C ± 5 °C	0 °C to 55 °C
10 MHz to <30 MHz	<–159 dBm/Hz <–161 dBm/Hz, typical	<–158 dBm/Hz <–160 dBm/Hz, typical
30 MHz to <120 MHz	<–159 dBm/Hz <–163 dBm/Hz, typical	<–158 dBm/Hz <–162 dBm/Hz, typical
120 MHz to <3 GHz	<–155 dBm/Hz <–158 dBm/Hz, typical	<–154 dBm/Hz <–157 dBm/Hz, typical
3.0 GHz to <5.0 GHz	<–153 dBm/Hz <–156 dBm/Hz, typical	<–152 dBm/Hz <–155 dBm/Hz, typical
5.0 GHz to 6.6 GHz	<–151 dBm/Hz <–154 dBm/Hz, typical	<–150 dBm/Hz <–153 dBm/Hz, typical

Notes: Input terminated; no input signal; 0 dB RF attenuation; –10 dBm reference level at frequencies <100 MHz, –50 dBm reference level elsewhere

Accuracy

Absolute Gain Accuracy

≥–49 dBm Reference Levels		
	Accuracy	
Frequency	23 °C ±5 °C	0 °C to 55 °C
10 MHz to <300 MHz	±1.5 dB ±0.7 dB, typical	±1.5 dB ±0.7 dB, typical
300 MHz to <400 MHz	±1.4 dB ±0.7 dB, typical	±1.65 dB ±0.95 dB, typical
400 MHz to <5.5 GHz	±1.3 dB ±0.6 dB, typical	±1.4 dB ±0.7 dB, typical
5.5 GHz to 6.6 GHz	±1.3 dB ±0.65 dB, typical	±2.15 dB ±1.45 dB, typical

Notes: RF attenuation ≥8 dB; signal-to-noise ratio ≥20 dB; using calibration data stored internal to the NI 5601 RF downconverter.

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<–49 dBm Reference Levels		
Frequency	Accuracy	
	23 °C ± 5 °C	0 °C to 55 °C
10 MHz to <300 MHz	±1.5 dB ±0.7 dB, typical	±1.5 dB ±0.7 dB, typical
300 MHz to <400 MHz	±1.4 dB ±0.7 dB, typical	±1.4 dB ±0.7 dB, typical
400 MHz to <5.5 GHz	±1.3 dB ±0.6 dB, typical	±1.3 dB ±0.6 dB, typical
5.5 GHz to 6.6 GHz	±2.5 dB ±1.3 dB, typical	±2.7 dB ±1.5 dB, typical
Notes: RF attenuation ≥8 dB; signal-to-noise ratio ≥20 dB. Using calibration data stored internal to the NI 5601 RF downconverter.		

Conversion Gain

(Typical)

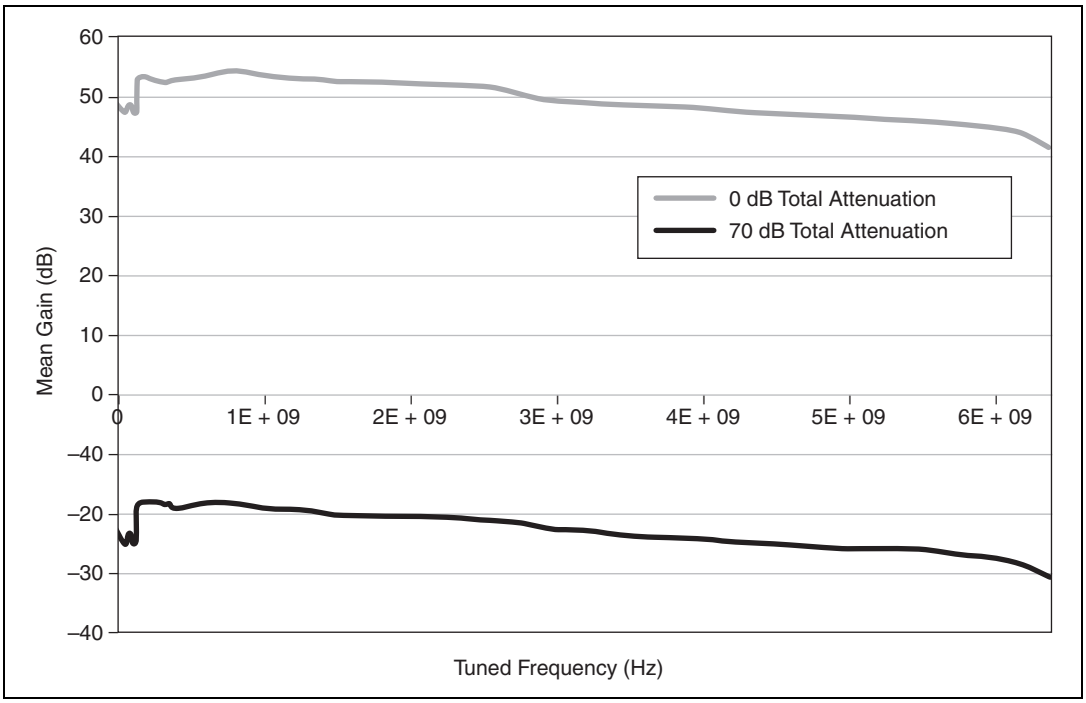


Figure 4. NI 5601 Conversion Gain

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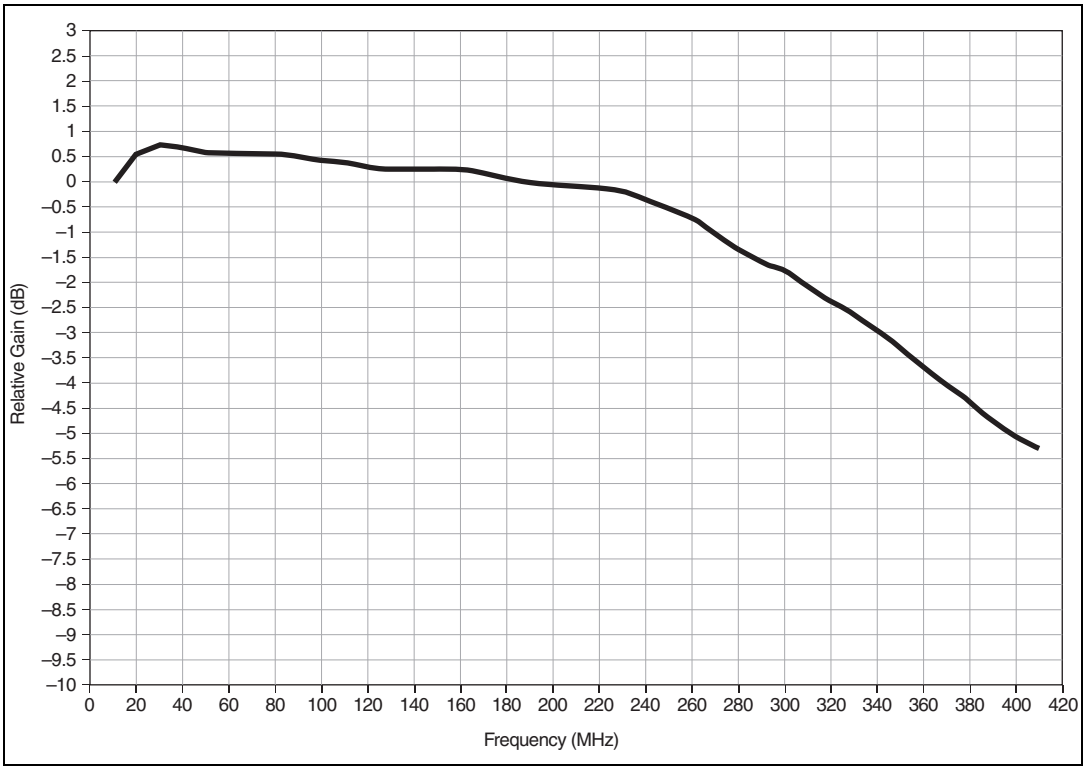


Figure 5. Typical Bypass Response

Gain step size.....1 dB

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Spurious Responses[1]

The single downconversion stage architecture does not provide RF image rejection.

IF Rejection[2]

(Typical)

Tuned Frequency	Interference Frequency	Level
10 MHz to <120 MHz	187.5 MHz	<–75 dBc
120 MHz to <330 MHz	53 MHz	<–52 dBc
330 MHz to 6.6 GHz	187.5 MHz	<–52 dBc
Notes: –30 dBm input signal; –30 dBm reference level; 0 dB attenuation.		

Non-Input-Related Spurs (Residual Spurs)[3]

10 MHz to 6.6 GHz[4] ..... <–100 dBm, typical

Sideband Spurs[5]

(Typical)

>1 kHz to ≤100 kHz Offset

Tuned Frequency	Level
10 MHz to <3.3 GHz	<–65 dBc
3.3 GHz to 6.6 GHz	<–50 dBc
Notes: 0 dBm input level; 0 dBm reference level; automatic attenuation settings.	

[1] Spurious response specifications assume use of the NI 5652 as the LO source.

[2] IF rejection is the suppression of an input signal at the IF frequency when the RF vector signal analyzer is tuned elsewhere.

[3] Residual responses are the responses observed when no input signal is present.

[4] Input terminated; no input signal; 0 dB attenuation; ≤-60 dBm reference level; does not include LO leakage.

[5] Sideband spurs are due to system operation and appear on signals being observed.

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>100 kHz Offset

Tuned Frequency	Level
10 MHz to <50 MHz	<–75 dBc
50 MHz to <3.3 GHz	<–70 dBc
3.3 GHz to 6.6 GHz	<–65 dBc
Notes: 0 dBm input level; 0 dBm reference level; automatic attenuation settings.	

Input-Related Spurs

(Typical)

RF Frequency	Level
10 MHz to <120 MHz	–70 dBc
120 MHz to <330 MHz	–50 dBc
330 MHz to <410 MHz	–35 dBc
410 MHz to <3.3 GHz	–65 dBc
3.3 GHz to 6.6 GHz	–50 dBc
Notes: 0 dB input level; 0 dBm reference level; automatic attenuation settings.	

LO Leakage[1]

Port	Frequency	Level
RF	10 MHz to <3.0 GHz	<–60 dBm, typical
	3.0 GHz to 6.6 GHz	<–55 dBm, typical
IF	10 MHz to <120 MHz	<–25 dBm, typical
	120 MHz to 6.6 GHz	<–55 dBm, typical
Notes: 0 dB attenuation; –30 dBm reference level.		

[1] LO leakage is the local oscillator signal that appears at the RF input and IF output port.

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Linearity

Third-Order Intermodulation Distortion (Input IP_3, (IIP_3))

(Typical)

–20 dBm Reference Level	
Frequency Range	**Input IP_3**
10 MHz to <30 MHz	≥4 dBm
30 MHz to <330 MHz	≥8 dBm
330 MHz to <3.0 GHz	≥12 dBm
3.0 GHz to 6.6 GHz	≥11 dBm
Note: Two –30 dBm input tones = 200 kHz apart.	

10 dBm Reference Level	
Frequency Range	**Input IP_3**
10 MHz to <30 MHz	≥31 dBm
30 MHz to <330 MHz	≥30 dBm
330 MHz to <3.0 GHz	≥34 dBm
3.0 GHz to 6.6 GHz	≥25 dBm
Note: Two 0 dBm input tones = 200 kHz apart.	

Gain Compression

(Typical)

Frequency	1 dB Compression Point
10 MHz to <30 MHz	>0 dBm
30 MHz to <100 MHz	>4 dBm
100 MHz to 6.6 GHz	>8 dBm
Notes: At RF input port; –10 dBm reference level.	

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Dynamic Range

Compression (1 dB)-to-Noise Dynamic Range (DR)

(Typical)

Frequency	Compression-to-Noise DR
30 MHz to <100 MHz	>136 dB
100 MHz to 6.6 GHz	>138 dB
Notes: Noise normalized to 1 Hz bandwidth; 0 dB RF attenuation; –10 dBm reference level.	

Dynamic Range (Noise and Third-Order Intermodulation Distortion (IMD3))

(Nominal)

Maximum Dynamic Range (Spurious-Free Dynamic Range (SFDR))		
Frequency	**+10 dBm Reference Level***	**–20 dBm Reference Level†**
30 MHz to <330 MHz	105 dB	105 dB
330 MHz to <3.3 GHz	106 dB	105 dB
3.3 GHz to 6.6 GHz	105 dB	104 dB

Notes: SFDR = $^2/_3$(IIP$_3$ – *Average Noise Level*); noise normalized to 1 Hz.

* Signal level = 0 dBm for +10 dBm reference level

† Signal level = –30 dBm for –20 dBm reference level

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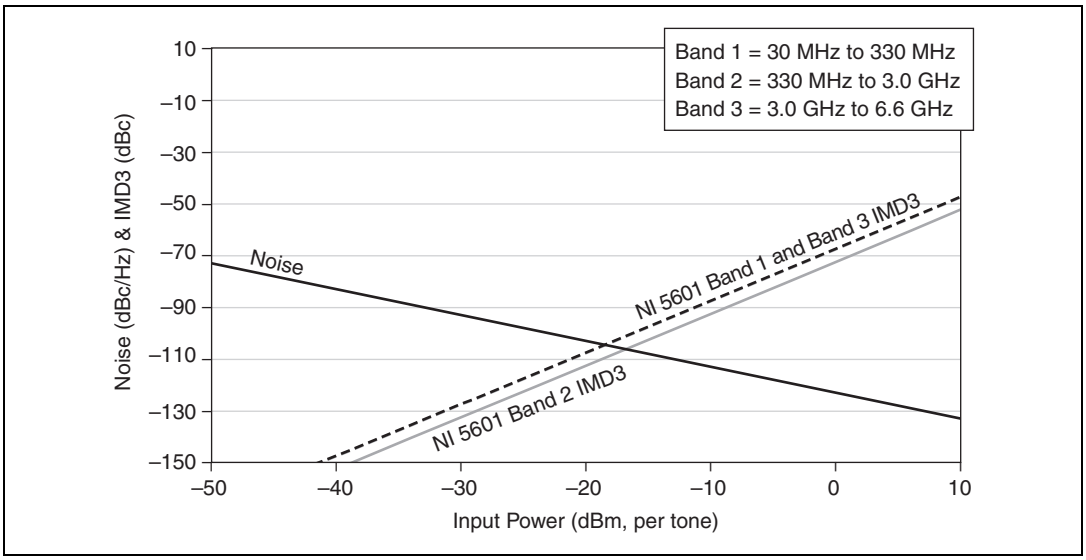


Figure 6. NI 5601 RF Downconverter Dynamic Range, +10 dBm Reference Level

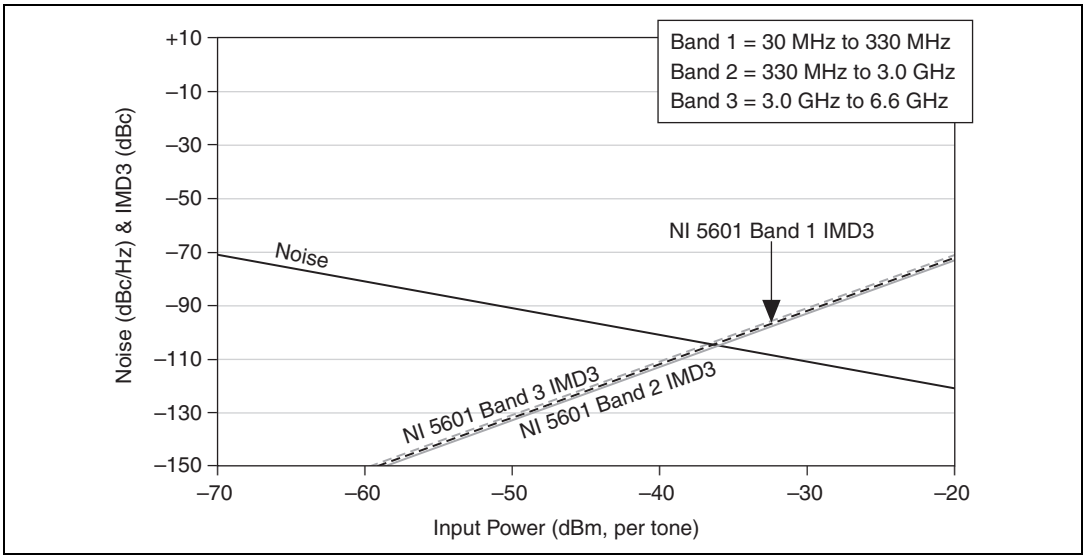


Figure 7. NI 5601 RF Downconverter Dynamic Range, –20 dBm Reference Level

The dynamic range plots in the two preceding figures show nominal performance with NI-RFSA automatic coupled settings that are optimized for noise performance. If you use the RF attenuation manual settings, IMD3 performance can improve with minimal degradation in noise floor, thus increasing the effective SFDR in the power per tone signal range of –10 dB to 0 dB below reference level.

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Measurement Speed

Frequency Settling Time[1]

(Nominal)

Accuracy	Frequency Settling Time*
0.1×10^{-6} of final frequency	1.5 ms
0.01×10^{-6} of final frequency	6.5 ms
*Typical for tuning between any two frequencies. Settling time can be reduced using a wide downconverter loop bandwidth.	

Amplitude Settling Time[1]

(Nominal)

Accuracy	Amplitude Settling Time
0.1 dB of final amplitude	62.5 µs*, 1.2 ms
*Mechanical attenuator not used.	

Input and Output Characteristics

NI 5601 Front Panel Connectors

RF IN

Connector .....SMA female

Impedance.....50 Ω, nominal

Coupling .....AC

Maximum safe DC input voltage ....±5 V

Maximum Safe Continuous RF Power

RF Attenuation	Level
Enabled (≥8 dB)	+30 dBm
Disabled (0 dB)	+20 dBm

[1] Frequency and amplitude settling times partially overlap.

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Voltage Standing Wave Ratio (VSWR)

(Nominal)

Attenuation	Frequency	VSWR
Enabled (≥8 dB)*	10 MHz to <1.3 GHz	1.4:1
	1.3 GHz to <5.0 GHz	2.0:1
	5.0 GHz to 6.6 GHz	3.0:1
Disabled (0 dB)	10 MHz to <5.0 GHz	2.0:1
	5.0 GHz to 6.6 GHz	3.0:1
* Available in 1 dB steps.		

IF OUT

Connector ..... SMA female

Impedance ..... 50 Ω, nominal

Coupling ..... AC

Amplitude ..... –6 dBm, nominal, with reference level input

Maximum IF output level ..... +23 dBm

Maximum reverse power level ..... +20 dBm

Maximum safe DC voltage ..... ±5 V

Frequency ..... 53 MHz,187.5 MHz[1], or Bypass[2], nominal

VSWR

53 MHz 2.1:1

187.5 MHz 1.65:1

Bypass ..... 1.4:1[2]

[1] Dependent on frequency range of RF input signal.

[2] 10 MHz to 300 MHz

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LO IN and LO OUT

- Connector .....SMA female
- Impedance.....50 Ω, nominal
- Coupling .....AC
- Frequency .....153 MHz to 6.6 GHz, nominal
- Amplitude.....0 dBm, nominal
- Maximum safe RF input level .....+20 dBm
- Maximum reverse power level .....+20 dBm
- Maximum safe DC voltage.....±5 V
- LO input to output noise figure .....15 dB, nominal

Power Requirements[1]

+3.3 VDC.....640 mA

–12 VDC.....740 mA

Calibration

Interval.....1 year

[1] Voltages ±5%.

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Hardware Front Panel

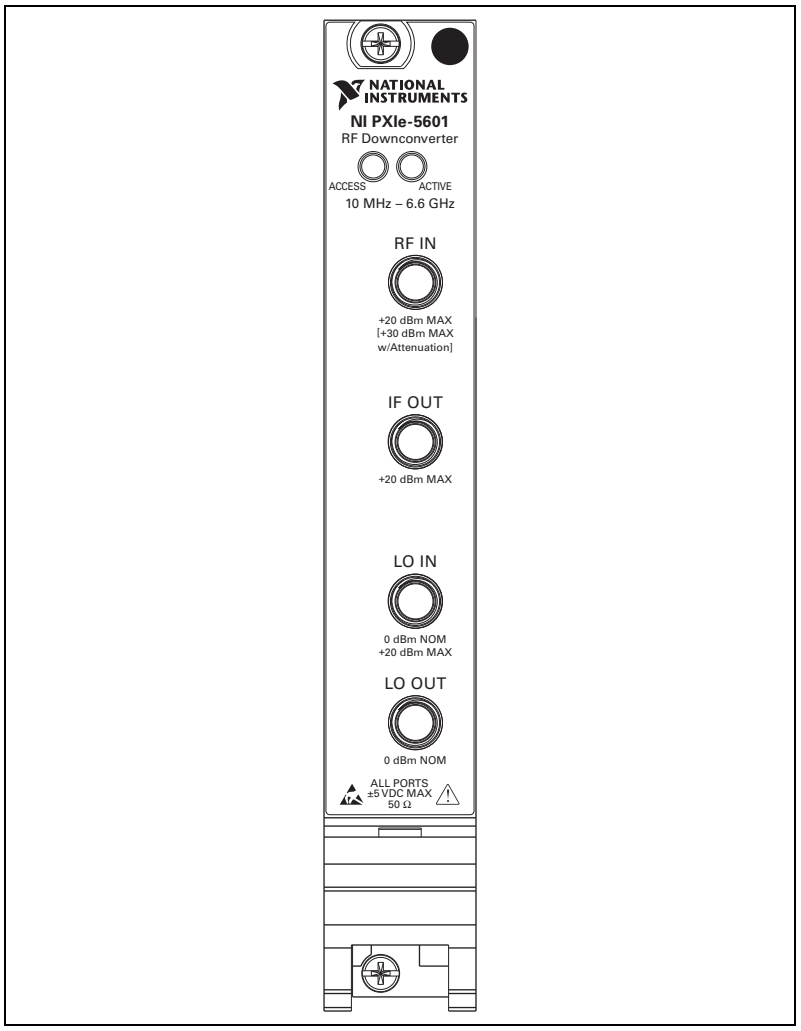


Figure 8. NI 5601 Module Front Panel

Physical Dimensions

NI 5601 (1 PXIe slot)..... 3U, One Slot,
PXI Express module
21.6 cm × 2.0 cm × 13.0 cm
(8.5 in. × 0.8 in. × 5.1 in.)

Weight..... 454 g (16.0 oz)

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Environmental

Specifications in this document are guaranteed under the following specified environmental conditions unless otherwise stated.

Altitude .....0 m to 2,000 m (at 25 °C ambient temperature)

Pollution Degree 2

Indoor use only.

Operating Environment

Warm-up time.....30 minutes

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.)

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Shock and Vibration

Operating Shock..... 30 g peak, half-sine, 11 ms pulse (Tested in accordance with IEC 60068-2-27. Meets MIL PRF-28800F Class 2 limits.)

Random Vibration

Operating ..... 5 Hz to 500 Hz, 0.3 g_{rms}

Non-operating ..... 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.)

Safety, Electromagnetic Compatibility, and CE Compliance

This product is designed to meet the requirements of the following standards of safety for electrical equipment 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 visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

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

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For EMC compliance, operate this device according to product documentation.

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CE Compliance CE

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)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain 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.

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