

## SPECIFICATIONS

# PXIe-5651

## 3.3 GHz RF Analog Signal Generator

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# Definitions

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*Warranted* specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

The following characteristic specifications describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- *Typical* specifications describe the performance met by a majority of models.
- *Nominal* specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are *Warranted* unless otherwise noted.

# Conditions

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Minimum or maximum warranted specifications are valid under the following conditions unless otherwise noted.

- 30 minutes warm-up time
- Calibration cycle maintained
- Temperature of 0 °C to 55 °C

Typical specifications are valid under the following condition unless otherwise noted.

- Over ambient temperature ranges of 23 °C ± 5 °C

# Frequency

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Range <sup>1</sup>	500 kHz to 3.3 GHz
Resolution	
500 kHz to <1.3 GHz	<3 Hz
1.3 GHz to <3.3 GHz	<6 Hz
Accuracy	Refer to the <a href="#">Reference Clock</a> section.

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<sup>1</sup> Tunable down to 100 kHz with amplitude uncalibrated.

# Frequency Settling Time<sup>2</sup>

**Table 1.** Narrow Loop Bandwidth

Settling Time (ppm)	Median (ms)	Maximum (ms)
≤0.01	6.5	13
≤0.1	1.5	6.5 <sup>3</sup>

**Table 2.** Wide Loop Bandwidth

Settling Time (ppm)	Median (ms)	Maximum (ms)
0.01	1.0	5.0
0.1	0.3	1.0
1.0	0.2	0.7

## Reference Clock

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### Internal Clock

Initial accuracy	±3 ppm, maximum
Temperature (15 °C to 35 °C)	±1 ppm, maximum
Aging	±5 ppm per year, maximum

### Internal Reference Output (REF OUT and REF OUT2 connector)

Frequency	10 MHz
Amplitude	1 V <sub>pk-pk</sub> into 50 Ω
Coupling	AC
Output impedance	50 Ω

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<sup>2</sup> The frequency settling time specification includes only frequency settling and excludes any residual amplitude settling that may occur as the result of a large frequency change.

<sup>3</sup> Frequency steps that span the full range of a voltage-controlled oscillator (VCO) require more settling time than steps that remain close together within one VCO or steps that switch between VCOs. The maximum specification covers this worst-case frequency settling time.

## External Reference Input (REF IN connector)

Frequency	10 MHz $\pm$ 10 ppm
Amplitude	0.2 V <sub>pk-pk</sub> to 1.5 V <sub>pk-pk</sub> into 50 $\Omega$
Input impedance	50 $\Omega$
Lock time to external reference	<1 s

## Spectral Purity

**Table 3.** Single Sideband (SSB) Phase Noise at 10 kHz Offset<sup>4</sup>

Frequency	Phase Noise (dBc/Hz)
100 MHz	<-125, typical
500 MHz	<-111
1 GHz	<-105
2 GHz	<-98
3 GHz	<-95

### Residual FM (300 Hz to 3 kHz, RMS)

1 GHz	<0.8 Hz RMS, typical
2.4 GHz	<1.5 Hz RMS, typical

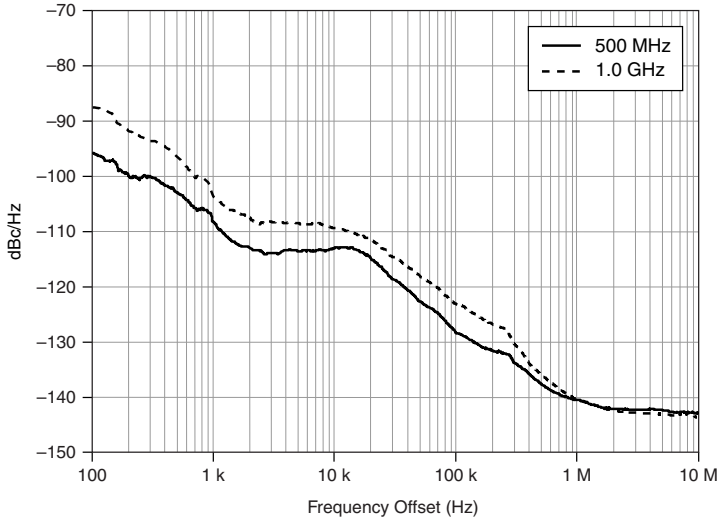
### Jitter<sup>5</sup> (seconds, RMS)

622 MHz with 1 kHz to 5 MHz jitter bandwidth	<200 fs, typical
2.488 GHz with 5 kHz to 15 MHz jitter bandwidth	<50 fs, typical

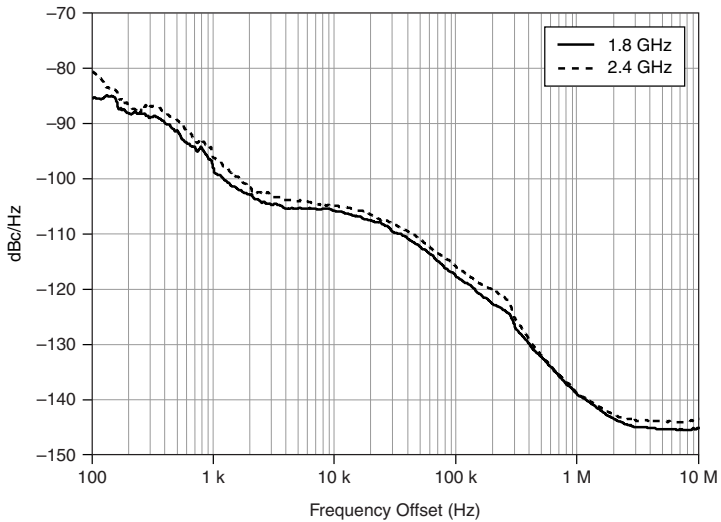
<sup>4</sup> Wide loop bandwidth has very similar phase noise performance at 10 kHz offset, but this noise level extends to approximately 300 kHz offset before it starts rolling down at approximately 20 dB per decade until it reaches the far out noise density.

<sup>5</sup> Measured at 0 dBm output power.

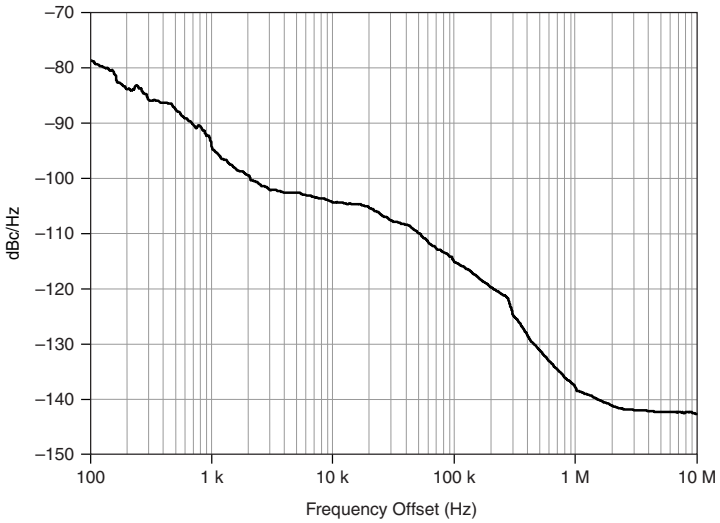
**Figure 1.** Measured Phase Noise at 500 MHz and 1 GHz (0 dBm Output Power)



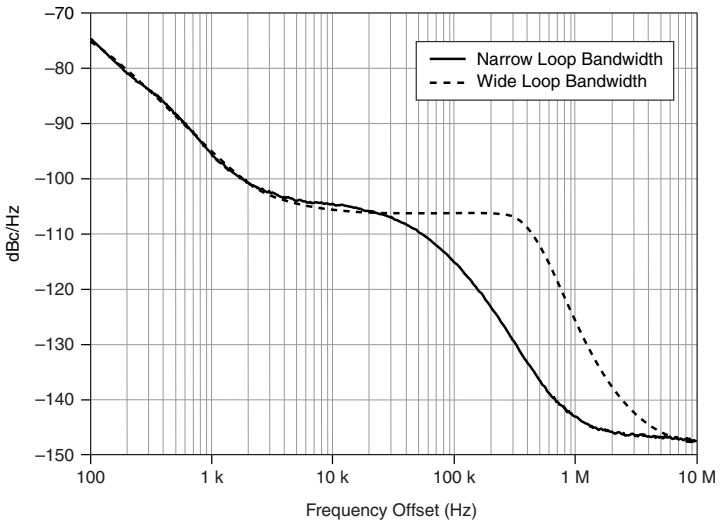
**Figure 2.** Measured Phase Noise at 1.8 GHz and 2.4 GHz (0 dBm Output Power)



**Figure 3.** Measured Phase Noise at 3.0 GHz (0 dBm Output Power)



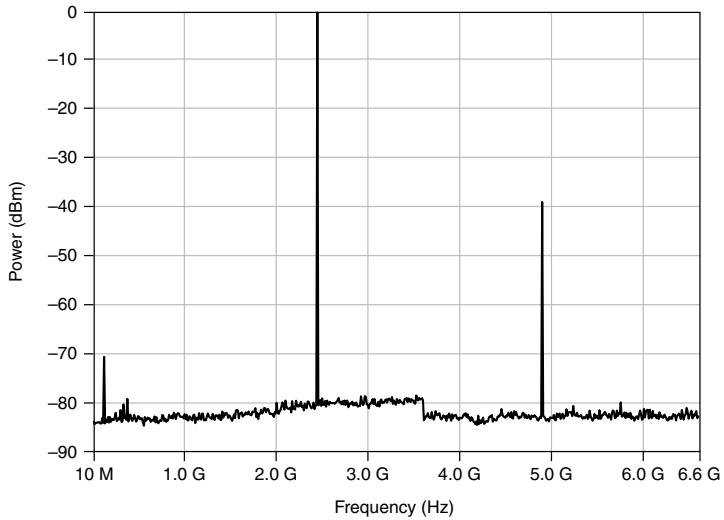
**Figure 4.** Measured Phase Noise at 3.0 GHz in Narrow and Wide Loop Bandwidth (0 dBm Output Power)



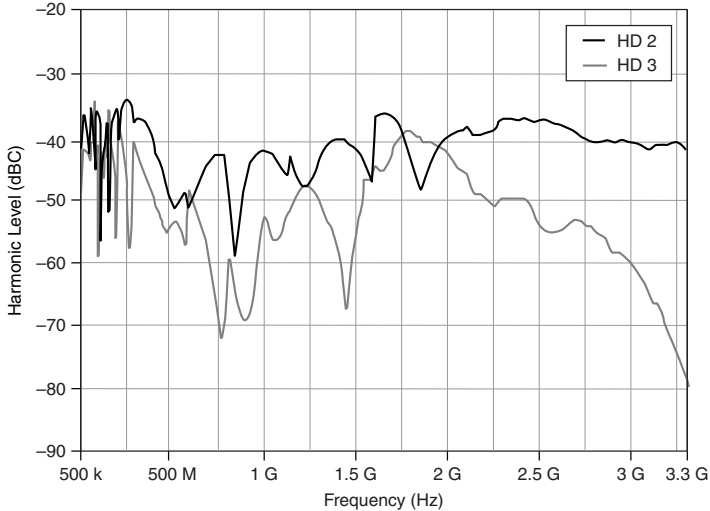
# Harmonics

500 kHz to 3.3 GHz (0 dBm to -40 dBm      -24 dBc  
output power)

**Figure 5.** Typical Spectrum at 2.45 GHz



**Figure 6.** Typical Second Harmonic (HD 2) and Third Harmonic (HD 3) Levels (0 dBm Output Power)



## Nonharmonics

### Narrow Loop Bandwidth

**Table 4.** Nonharmonic Products at 0 dBm to -20 dBm Output Power

Frequency	<3 kHz Offset (dBc), Typical	>3 kHz Offset (dBc)	>100 kHz Offset (dBc)
500 kHz to <50 MHz	<-57	<-57	<-57
50 MHz to <3.3 GHz	<-65	<-65	<-70



## Wide Loop Bandwidth

**Table 5.** Nonharmonic Products at 0 dBm to -20 dBm Output Power

Frequency	<3 MHz Offset (dBc), Typical	>3 MHz Offset (dBc), Typical
500 kHz to <50 MHz	<-57	<-57
50 MHz to <3.3 GHz	<-44	<-70

Subharmonic products 500 kHz to 3.3 GHz

Not applicable<sup>6</sup>

## Amplitude

Resolution

<0.1 dB

**Table 6.** Amplitude Range

Frequency	Amplitude (dBm)
500 kHz to <10 MHz	-90 to 5
10 MHz to <50 MHz	-90 to 8
50 MHz to <500 MHz	-90 to 10
500 MHz to <1.3 GHz	-90 to 10
1.3 GHz to <1.6 GHz	-90 to 10
1.6 GHz to <2.9 GHz	-80 to 8
2.9 GHz to <3.3 GHz	-70 to 8

Maximum available power

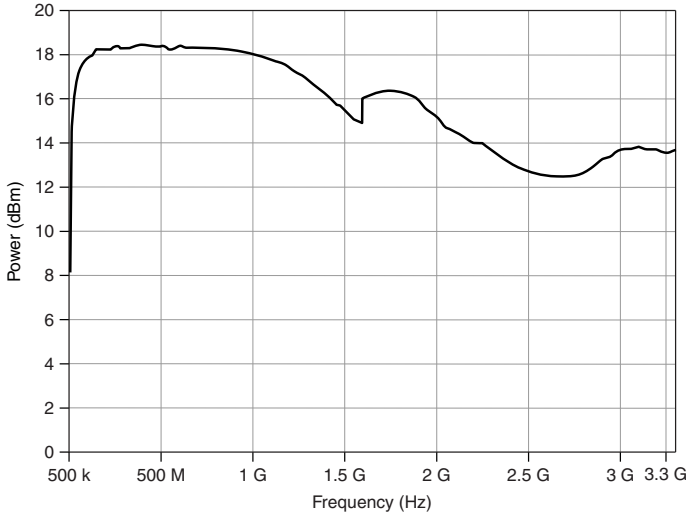
2 dB above maximum specified amplitude, typical

Minimum available power

10 dB below minimum specified amplitude, typical

<sup>6</sup> No harmonic multiplication in this band.

**Figure 7. Measured Maximum Available Power**

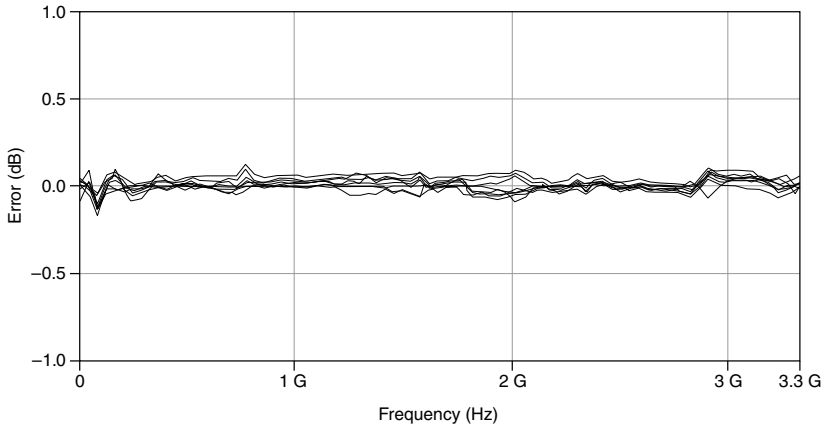


## Power Level Accuracy

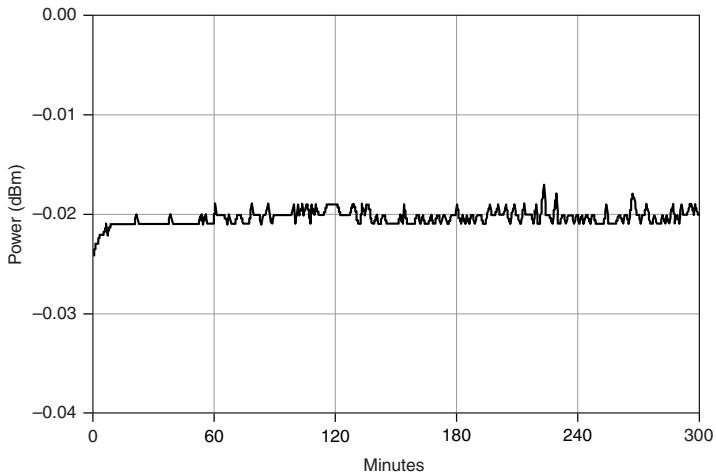
**Table 7. Power Level Accuracy (15 °C to 35 °C)**

Frequency	>-40 dBm Output Power (dB)	≤-40 dBm Output Power (dB)
500 kHz to <10 MHz	±1.6	±2.2
10 MHz to <3.3 GHz	±0.75	±1.8

**Figure 8. Typical Power Accuracy, -40 dBm to 0 dBm, 5 dB Steps**



**Figure 9. Typical Power (0 dBm) at 2.4 GHz Over Time<sup>7</sup>**



## Amplitude Settling Time

0.05 dB of final value	<500 ms, typical
0.25 dB of final value	<10 ms, typical

<sup>7</sup> Calling the niRFSG Perform Thermal Correction VI or niRFSG\_PerformThermalCorrection function once per minute.

# Signal-to-Noise Ratio

≥0 dBm output power

<-140 dBc/Hz, typical

# Voltage Standing Wave Ratio (VSWR)

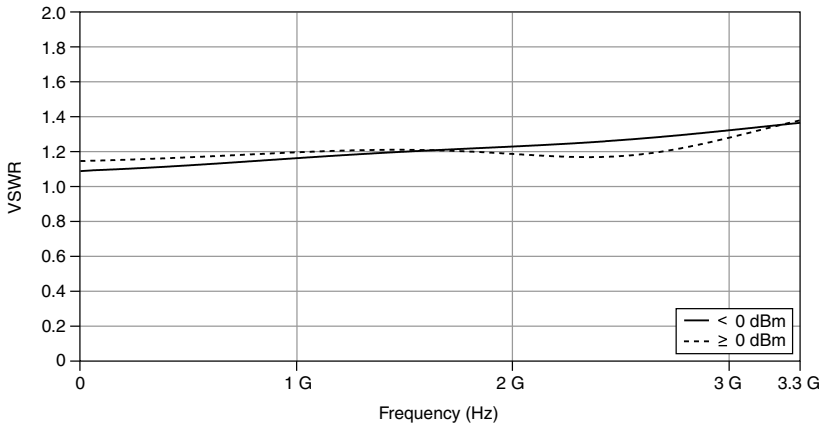
500 kHz to 3.3 GHz

<1.8:1, typical

Output impedance

50 Ω

**Figure 10.** Measured VSWR



# Reverse Power Handling

RF

0.5 watts, +27 dBm<sup>8</sup>

DC

25 volts

# Modulation

## Frequency Modulation (FM)

Modulation waveform types

Sine, triangle, square

External modulation source

Not supported

<sup>8</sup> If the requested output power is less than -3 dBm, the RF reverse power handling is +15 dBm for signals ≤10 MHz.

**Table 8. FM Typical Maximum Deviation**

Frequency Range	Typical Maximum Deviation (Sine Wave)
500 kHz to <50 MHz	500 kHz
50 MHz to <100 MHz	125 kHz
100 MHz to <200 MHz	250 kHz
200 MHz to <400 MHz	500 kHz
400 MHz to <800 MHz	1 MHz
800 MHz to <1.6 GHz	2 MHz
1.6 GHz to <3.3 GHz	4 MHz

Modulation waveform frequency 1 Hz to 100 kHz

Characteristic deviation accuracy<sup>9</sup> <±3.5%

Typical distortion<sup>9</sup> <0.1%

SINAD<sup>9</sup> >65 dB

## Frequency Shift Keying (FSK)

Modulation waveform types

PRBS 5-order to 31-order

User-defined Up to 1,022 bit

Modulation format 2-FSK

**Table 9. FSK Typical Maximum Deviation**

Frequency Range	Typical Maximum Deviation
500 kHz to <50 MHz	250 kHz
50 MHz to <100 MHz	31.25 kHz
100 MHz to <200 MHz	62.5 kHz
200 MHz to <400 MHz	125 kHz
400 MHz to <800 MHz	250 kHz

<sup>9</sup> 1 kHz sine wave, 10% of maximum deviation; noise bandwidth of 10 kHz.

**Table 9. FSK Typical Maximum Deviation (Continued)**

Frequency Range	Typical Maximum Deviation
800 MHz to <1.6 GHz	500 kHz
1.6 GHz to <3.3 GHz	1 MHz

FSK characteristic deviation accuracy  $\leq \pm 10\%$   
 (100 kHz rate, 10% of maximum deviation)

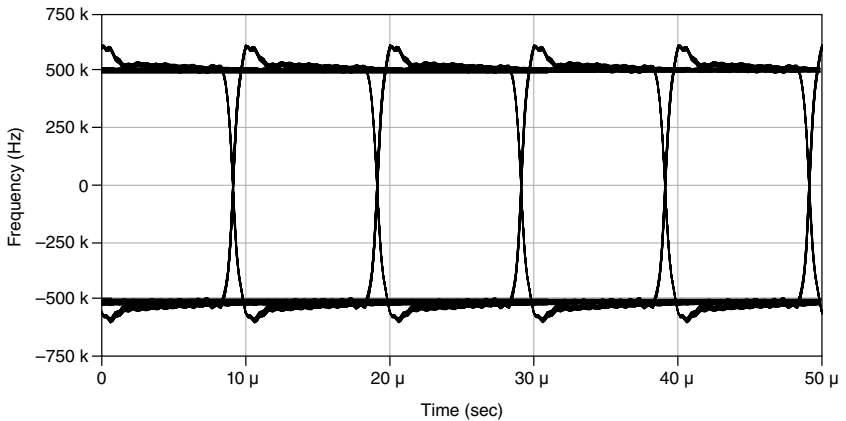
Symbol rate

PRBS 763 Hz to 100 kHz

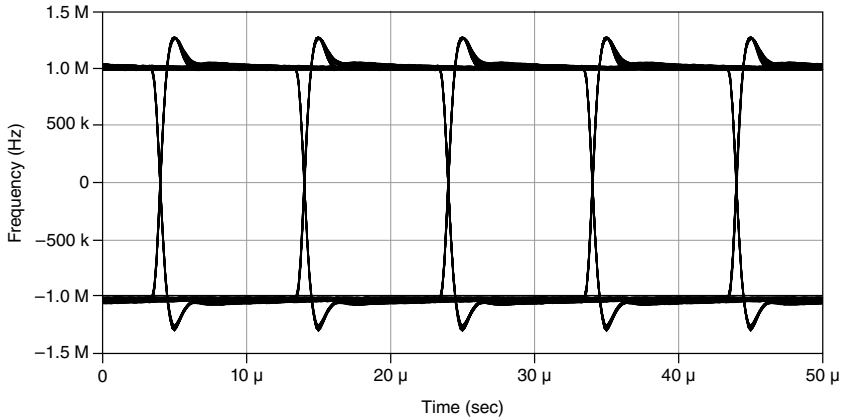
User-defined 763 Hz to 100 kHz

Pulse shaping Not supported

**Figure 11. FSK Modulation Eye Diagram, 1.0 GHz Carrier, 100 kHz Symbol Rate, 500 kHz Deviation, Ninth-Order PRBS**



**Figure 12. FSK Modulation Eye Diagram, 2.4 GHz Carrier, 100 kHz Symbol Rate, 1.0 MHz Deviation, Ninth-Order PRBS**



## On-Off Keying (OOK)

Modulation waveform types

PRBS	5-order to 31-order
User-defined	Up to 1,024 bit

**Table 10. OOK Typical Amplitude**

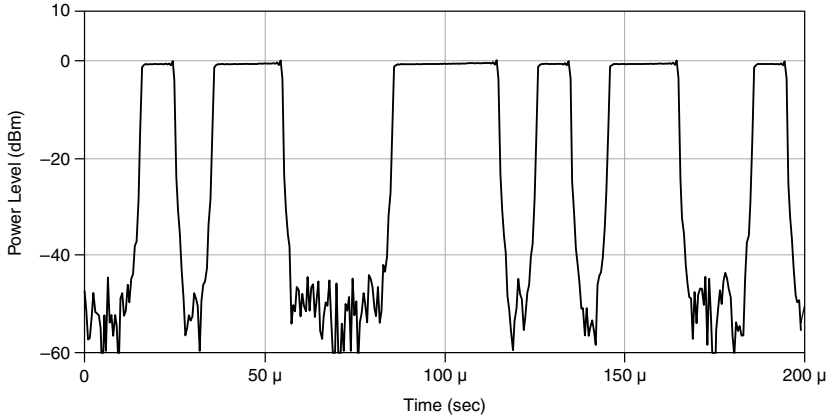
Frequency Range	Typical Amplitude (dBm)
500 kHz to <10 MHz	-3 to 5
10 MHz to <50 MHz	-3 to 8
50 MHz to <1.6 GHz	-3.5 to 10
1.6 GHz to <3.3 GHz	-2.5 to 8

Symbol rate

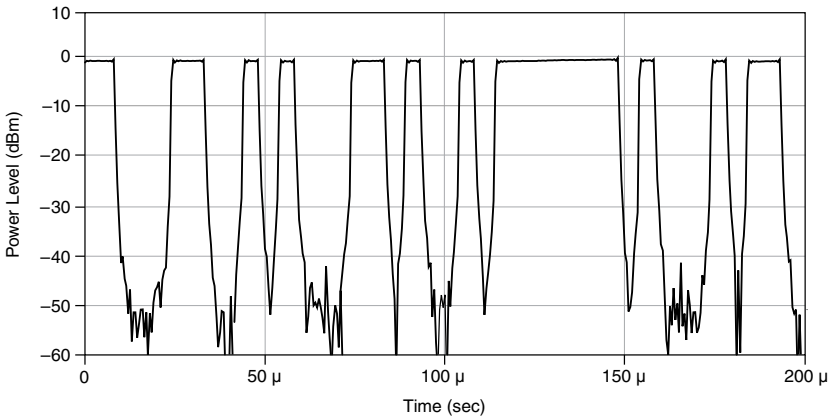
PRBS	153 Hz to 100 kHz
User-defined	153 Hz to 100 kHz

Pulse shaping Not supported

**Figure 13.** OOK Diagram, 1.0 GHz Carrier, 100 kHz Symbol Rate, Ninth-Order PRBS



**Figure 14.** OOK Diagram, 1.0 GHz Carrier, 200 kHz Symbol Rate, Ninth-Order PRBS



## DC Power Requirements

**Table 11.** DC Power Requirements

Voltage (V <sub>DC</sub> )	Maximum Current (A)	Typical Current (A)
+3.3	1.00	0.90
+12	1.00	0.80



# Calibration

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Interval	1 year
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# Physical Dimensions

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PXIe-5651 module	3U, one slot, PXI Express module 2.0 cm × 13.0 cm × 21.6 cm (0.8 in. × 5.1 in. × 8.5 in.)
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Weight	415 g (14.6 oz)
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# Environment

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Maximum altitude	2,000 m (800 mbar) (at 25 °C ambient temperature)
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Pollution Degree	2
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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.)
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Relative humidity range	10% to 90%, noncondensing (Tested in accordance with IEC 60068-2-56.)
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# Storage Environment

Ambient temperature range	-40 °C to 70 °C (Tested in accordance with IEC 60062-2-1 and IEC 60068-2-2.)
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Relative humidity range	5% to 95%, noncondensing (Tested in accordance with IEC 60068-2-56.)
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# Shock and Vibration

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Nonoperational 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 nonoperating	5 Hz to 500 Hz, 2.4 g <sub>rms</sub> (Tested in accordance with IEC 60068-2-64. Nonoperating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.)

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## Compliance and Certifications

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### 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 C22.2 No. 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
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: 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 generate radio frequency energy for the treatment of material or inspection/analysis purposes.



**Note** For EMC declarations, certifications, and additional information, refer to the [Online Product Certification](#) section.

## CE Compliance

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)

## Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit [ni.com/certification](https://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 to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at [ni.com/environment](https://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 NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit [ni.com/environment/weee](https://ni.com/environment/weee).

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