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Find the *National Instruments PXIe-5651* at our website: *Click HERE*

DEVICE SPECIFICATIONS

NI PXIe-5651

3.3 GHz RF Signal Generator

This document lists specifications for the NI PXIe-5651 (PXIe-5651) RF signal generator. Minimum or maximum specifications are warranted under the following conditions:

- 30 minutes warm-up time
- Calibration cycle maintained
- Temperature 0 °C to 55 °C unless otherwise noted

Typical values are used to define an average unit measured at ambient temperatures of 15 °C to 35 °C. Specifications that do not list a tolerance are typical values unless otherwise specified. Tolerance values represent the maximum variation that will be observed.

Specifications describe the warranted, traceable product performance over ambient temperature ranges of 0 ºC to 55 ºC, 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 PXIe-5651 specifications, visit *ni.com/manuals*.

To access PXIe-5651 documentation, navigate to **Start»All Programs»National Instruments»NI-RFSG»Documentation**.

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Frequency

Range[1]	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 *Reference Clock* section.

[1] Tunable down to 100 kHz with amplitude uncalibrated.

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Frequency Settling Time[2]

Table 1. Narrow Loop Bandwidth

Settling Time (ppm)	Median (ms)	Maximum (ms)
≤0.01	6.5	13
≤0.1	1.5	6.5[3]

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

Internal Clock

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

Internal Reference Output (REF OUT and REF OUT2 connector)

Frequency	10 MHz
Amplitude	1 $V_{pk\text{-}pk}$ into 50 Ω
Coupling	AC
Output impedance	50 Ω

[2] 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.

[3] 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.

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External Reference Input (REF IN connector)

Frequency	10 MHz ±10 ppm
Amplitude	0.2 V_{pk-pk} to 1.5 V_{pk-pk} into 50 Ω
Input impedance	50 Ω
Lock time to external reference	<1 s

Spectral Purity

Table 3. Single Sideband (SSB) Phase Noise at 10 kHz Offset[4]

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[5] (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

[4] 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.

[5] Measured at 0 dBm output power.

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

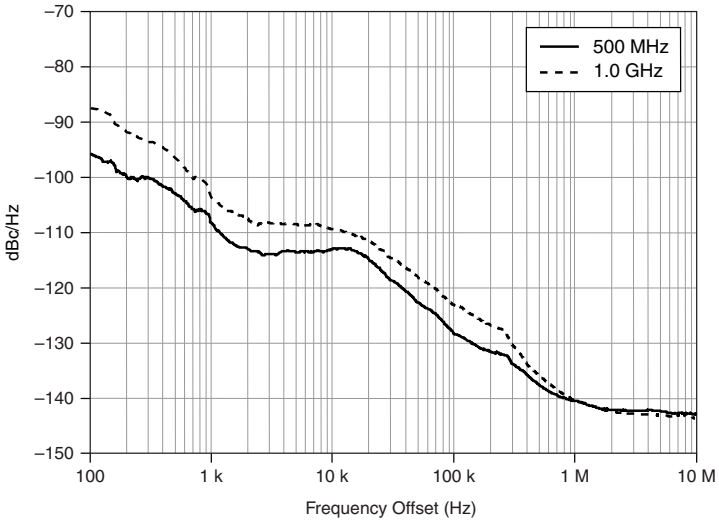
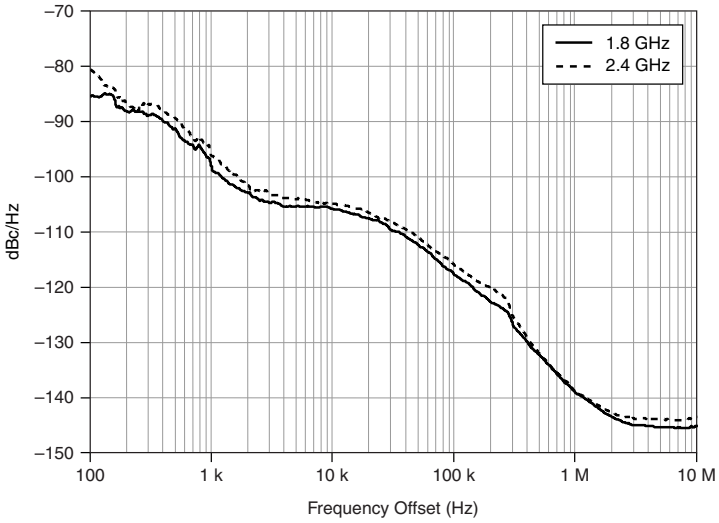


Figure 2. Measured Phase Noise at 1.8 GHz and 2.4 GHz (0 dBm Output Power)



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

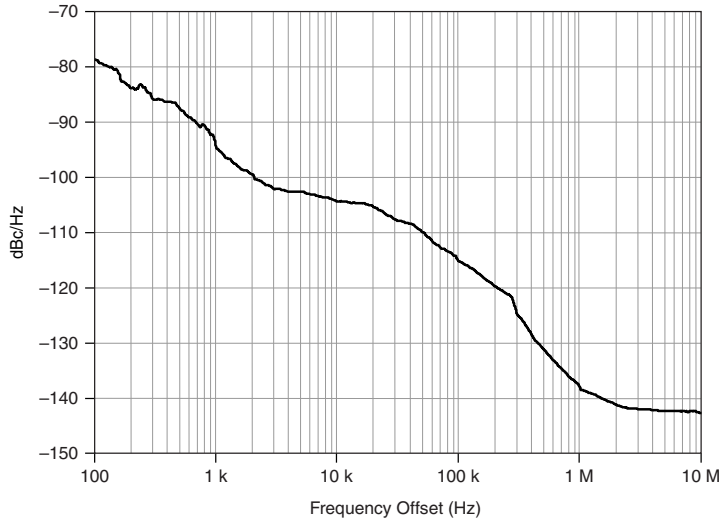
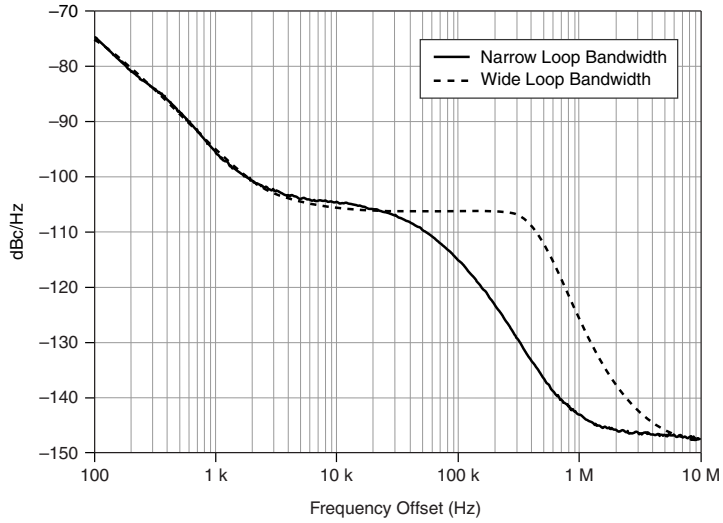


Figure 4. Measured Phase Noise at 3.0 GHz in Narrow and Wide Loop Bandwidth (0 dBm Output Power)

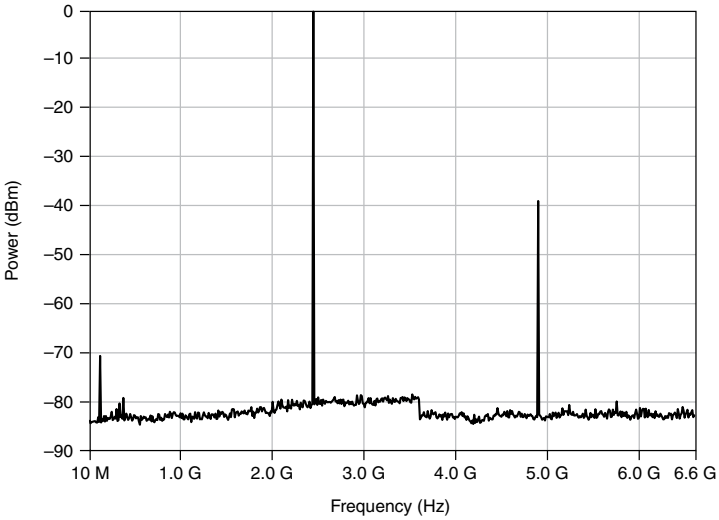


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Harmonics

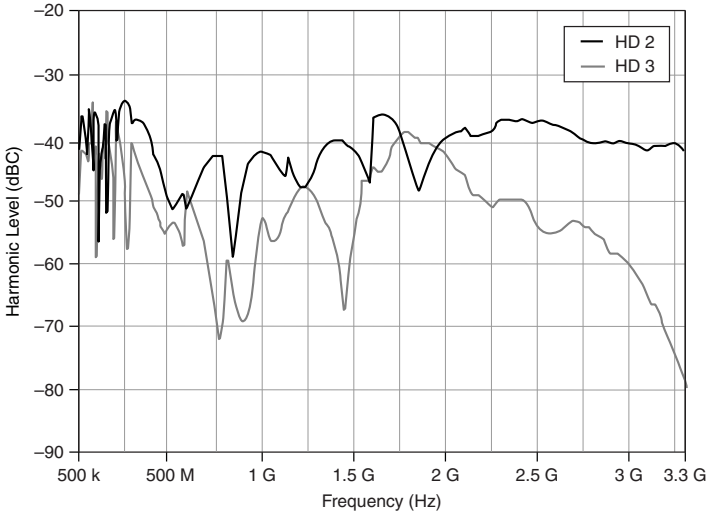
500 kHz to 3.3 GHz (0 dBm to -50 dBm output power)	-24 dBc

Figure 5. Typical Spectrum at 2.45 GHz



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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

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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[6]

Amplitude

Resolution	<0.1 dB

Table 6. Amplitude Range

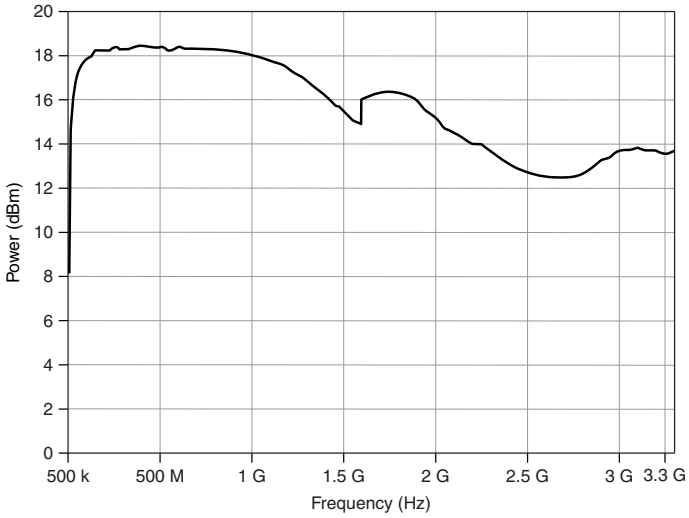
Frequency	Amplitude (dBm)
500 kHz to <10 MHz	-90 to 5
10 MHz to <50 MHz	-90 to 8
50 MHz to <500 MHz	-90 to 10
500 MHz to <1.3 GHz	-90 to 10
1.3 GHz to <1.6 GHz	-90 to 10
1.6 GHz to <2.9 GHz	-80 to 8
2.9 GHz to <3.3 GHz	-70 to 8

Maximum available power	2 dB above maximum specified amplitude, typical
Minimum available power	10 dB below minimum specified amplitude, typical

[6] No harmonic multiplication in this band.

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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

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

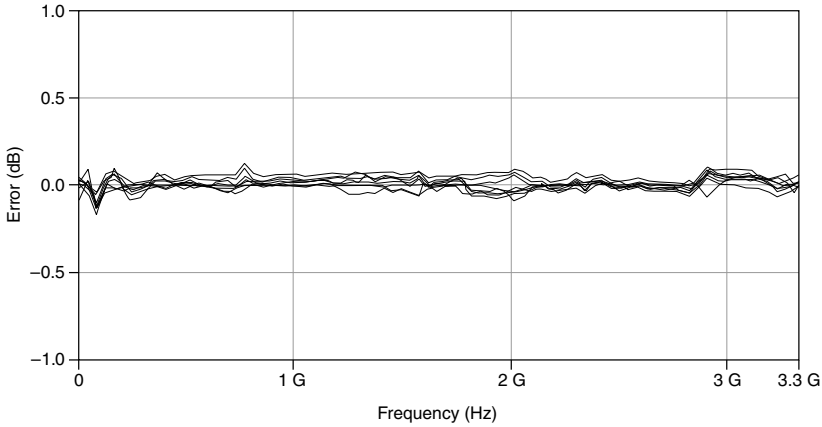
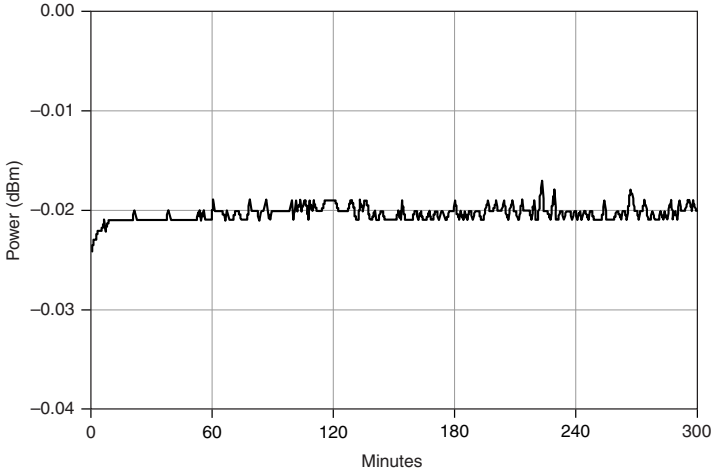


Figure 9. Typical Power (0 dBm) at 2.4 GHz Over Time[7]



Amplitude Settling Time

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

[7] Calling the niRFSG Perform Thermal Correction VI or `niRFSG_PerformThermalCorrection` function once per minute.

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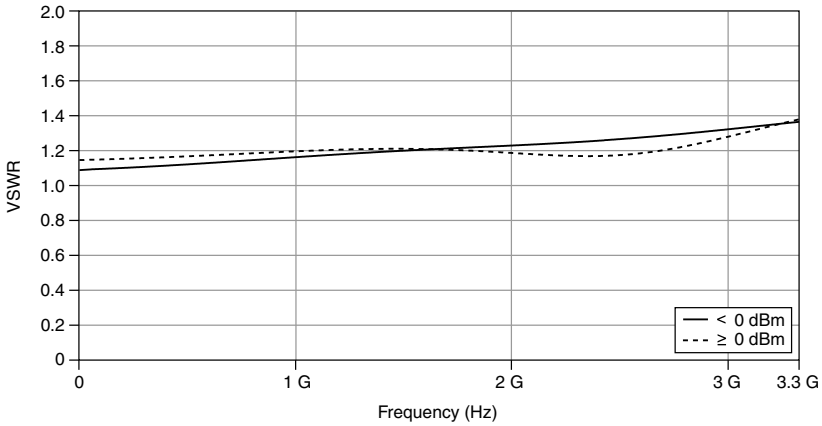
Signal-to-Noise Ratio

≥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[8]
DC	25 volts

Modulation

Frequency Modulation (FM)

Modulation waveform types	Sine, triangle, square
External modulation source	Not supported

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

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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[9]	<±3.5%
Typical distortion[9]	<0.1%
SINAD[9]	>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

[9] 1 kHz sine wave, 10% of maximum deviation; noise bandwidth of 10 kHz.

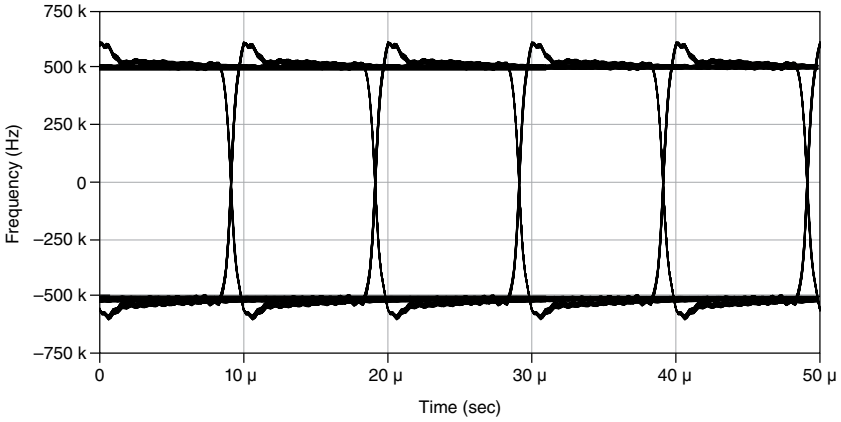
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Table 9. FSK Typical Maximum Deviation (Continued)

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

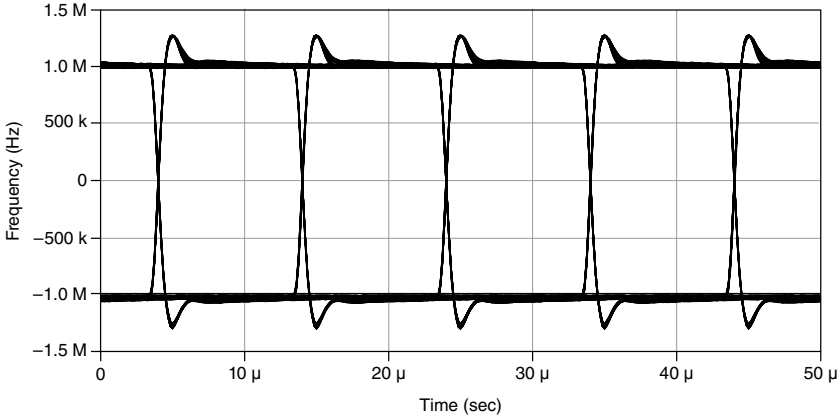
FSK characteristic deviation accuracy (100 kHz rate, 10% of maximum deviation)	<±10%
Symbol rate	
PRBS	763 Hz to 100 kHz
User-defined	763 Hz to 100 kHz
Pulse shaping	Not supported

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



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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

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

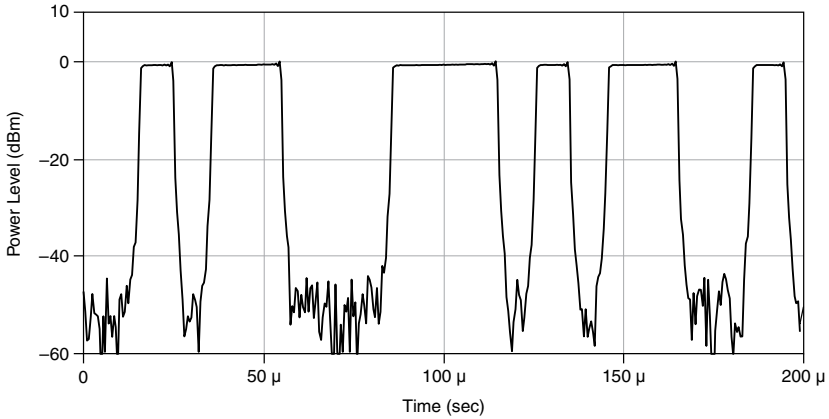
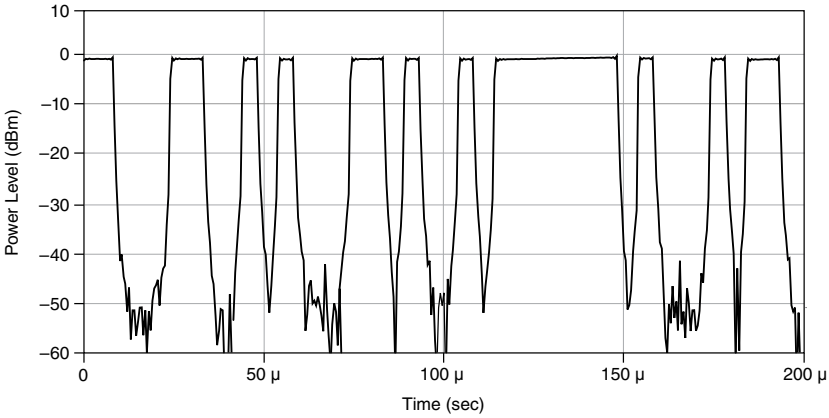


Figure 14. OOK Diagram, 1.0 GHz Carrier, 200 kHz Symbol Rate, Ninth-Order PRBS



DC Power Requirements

Table 11. DC Power Requirements

Voltage (V_{DC})	Maximum Current (A)	Typical Current (A)
+3.3	1.00	0.90
+12	1.00	0.80

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Calibration

Interval	1 year

Physical Dimensions

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.)
Weight	415 g (14.6 oz)

Environment

Maximum altitude	2,000 m (800 mbar) (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	-40 °C to 70 °C (Tested in accordance with IEC 60062-2-1 and IEC 60068-2-2.)
Relative humidity range	5% to 95%, noncondensing (Tested in accordance with IEC 60068-2-56.)

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Shock and Vibration

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_{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 generate radio frequency energy for the treatment of material or inspection/analysis purposes.

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

CE Compliance CE

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

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; 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*, 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*. 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*.

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