

SPECIFICATIONS

mmWave Transceiver System

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Definitions

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

Characteristics 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 expected performance met by a majority of the models.
- *Nominal* specifications describe parameters and attributes that may be useful in operation.

Specifications are *Characteristics* unless otherwise noted.

Conditions

Specifications are valid under the following conditions unless otherwise noted.

- Ambient temperature of $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.
- The device is warmed up for 25 minutes.
- The PXI Express chassis fan speed is set to HIGH, the fan filters are clean if present, and the empty slots contain PXI chassis slot blockers and filler panels.

System Performance and Characteristics

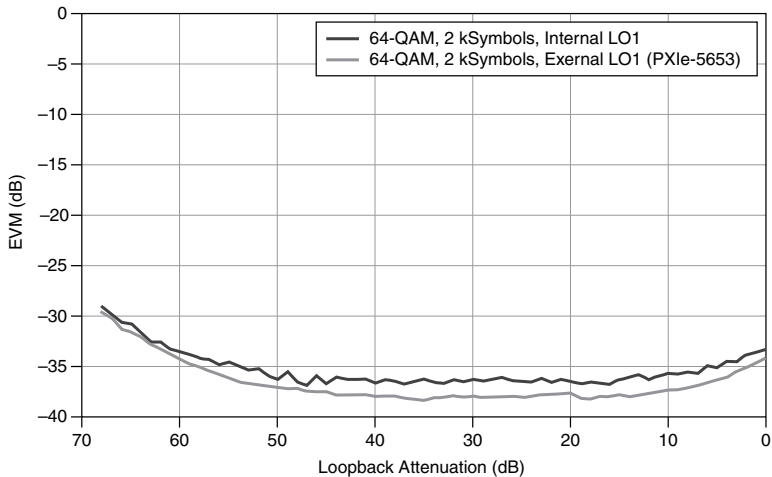


Note Single-point calibration is used to correct for image rejection, and an equalizer is used to correct for amplitude ripple and phase nonlinearity within the instantaneous bandwidth. The internal LO2 is utilized for all measurements. Separate LO1s are utilized for the transmitter and receiver in all measurements.

27.5 GHz to 29.5 GHz mmWave Transceiver System

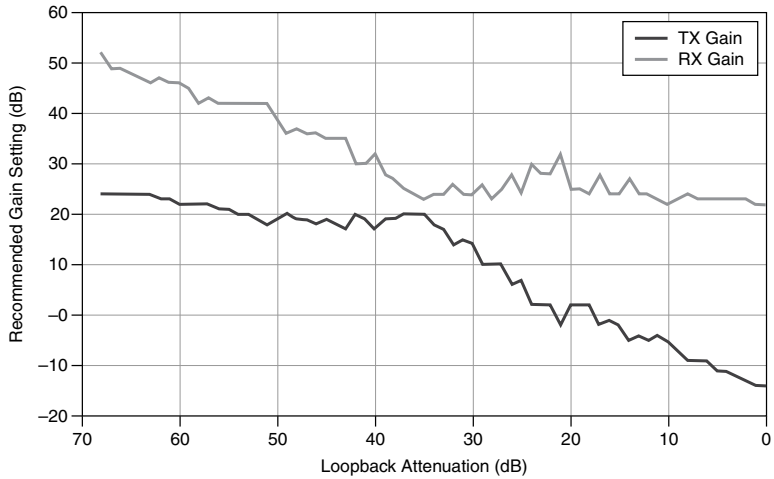
A variable attenuator is placed between the transmitter and receiver to simulate path loss at 28.5 GHz. The EVM of various single-carrier signals at a symbol rate of 768 MBaud (RRC filter $\alpha = 0.3$) is shown in the following figure.

Figure 1. EVM Versus Loopback Attenuation



The transmitter and receiver gain settings used for the EVM measurement are shown in the following figure.

Figure 2. Transmitter and Receiver Gain Settings

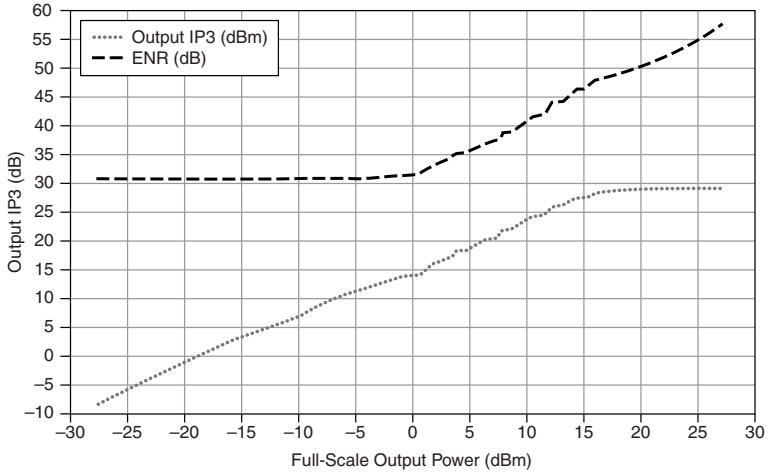


Transmitter

| | |
|------------------------------|------------------------|
| Tuning range | 27.5 GHz to 29.5 GHz |
| Instantaneous bandwidth | 2 GHz |
| Connector | 2.92 mm |
| Analog gain range | 55 dB |
| Saturated power ¹ | 26 dBm (approximately) |
| Output IP3 ¹ | 29 dBm |

¹ At maximum gain.

Figure 3. mmRH-3642 mmWave Radio Head Simulated Output IP3 and Excess Noise Ratio (ENR)²



Note mmRH-3602 mmWave Radio Head simulated output IP3 and ENR² is very similar to that of the mmRH-3642.

Receiver

| | |
|------------------------------------|----------------------|
| Tuning range | 27.5 GHz to 29.5 GHz |
| Instantaneous bandwidth | 2 GHz |
| Connector | 2.92 mm |
| Analog gain range | 50 dB |
| 1 dB gain compression ³ | -10 dBm to -15 dBm |
| Noise figure ¹ | 6 dB |

² Driven by the PXIe-3610 Waveform Generator and the PXIe-3620 RF Upconverter and Downconverter Module with a two-tone signal at -7 dBFS.

³ Near minimum gain. For lower gain settings, 1 dB compression is higher than full-scale.

Figure 4. mmRH-3652 mmWave Radio Head Simulated Input IP3 and Noise Figure⁴

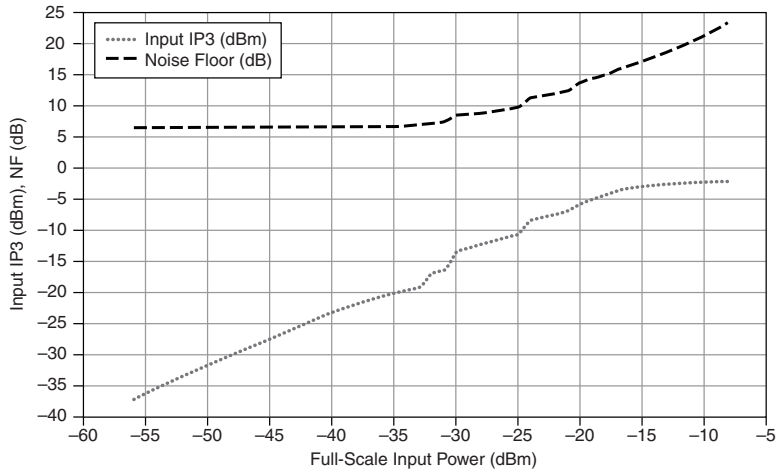
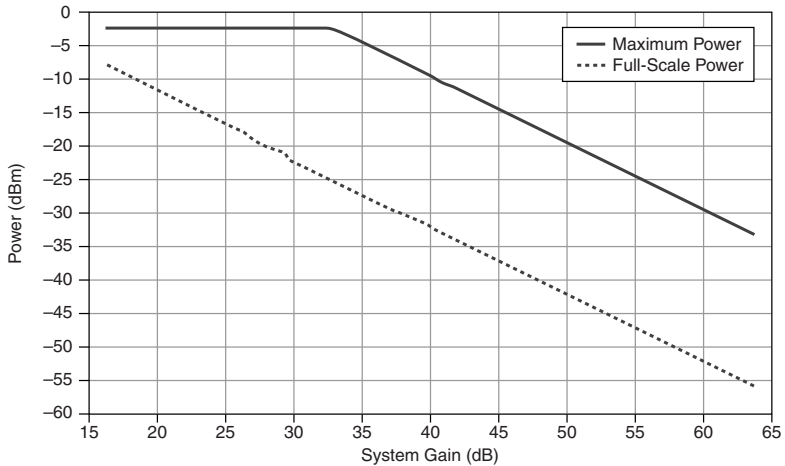


Figure 5. Receiver Maximum Power (Damage)⁵



Note NI recommends keeping the incident power less than or equal to the full-scale power.

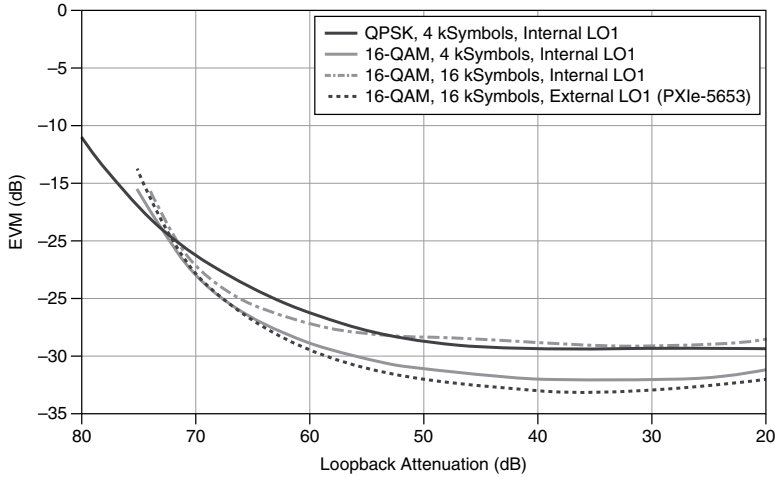
⁴ With the PXIe-3620 and the PXIe-3630 Digitizer.

⁵ Maximum power is the input power at which the receiver could be damaged.

71 GHz to 76 GHz mmWave Transceiver System

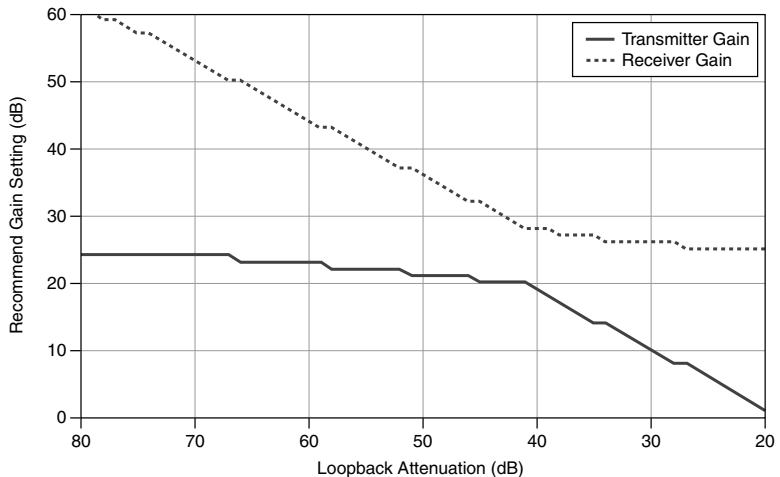
A variable attenuator is placed between the transmitter and receiver to simulate path loss at 73 GHz. The EVM of various single-carrier signals at a symbol rate of 1,536 MBaud (RRC filter $\alpha = 0.3$) is shown in the following figure.

Figure 6. EVM Versus Loopback Attenuation



The transmitter and receiver gain settings used for the EVM measurement are shown in the following figure.

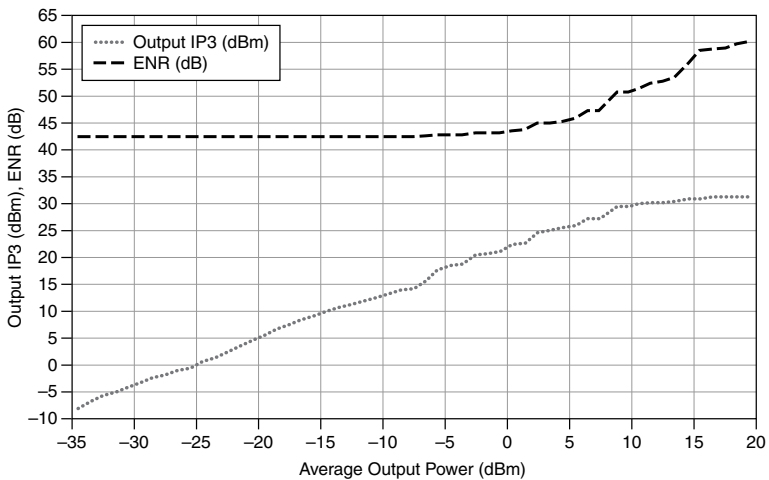
Figure 7. Transmitter and Receiver Gain Settings



Transmitter

| | |
|---|------------------|
| Tuning range | 71 GHz to 76 GHz |
| Instantaneous bandwidth | 2 GHz |
| Connector | WR-12 |
| Analog gain range | 55 dB |
| Saturated power ¹ | +24 dBm |
| Output third-order intercept (IP3) ¹ | +30 dBm |
| Local oscillator (LO) re-radiation ⁶ | <-90 dBm |

Figure 8. mmRH-3647 mmWave Radio Head Simulated Output IP3 and Excess Noise Ratio (ENR)²



Receiver

| | |
|------------------------------------|------------------|
| Tuning range | 71 GHz to 76 GHz |
| Instantaneous bandwidth | 2 GHz |
| Connector | WR-12 |
| Analog gain range | 55 dB |
| 1 dB gain compression ³ | -12 dBm |

⁶ Refers to super-heterodyne LO.

Noise figure¹

6 dB

Image rejection⁷

>80 dB

Figure 9. mmRH-3657 mmWave Radio Head Simulated Input IP3 and Noise Figure⁴

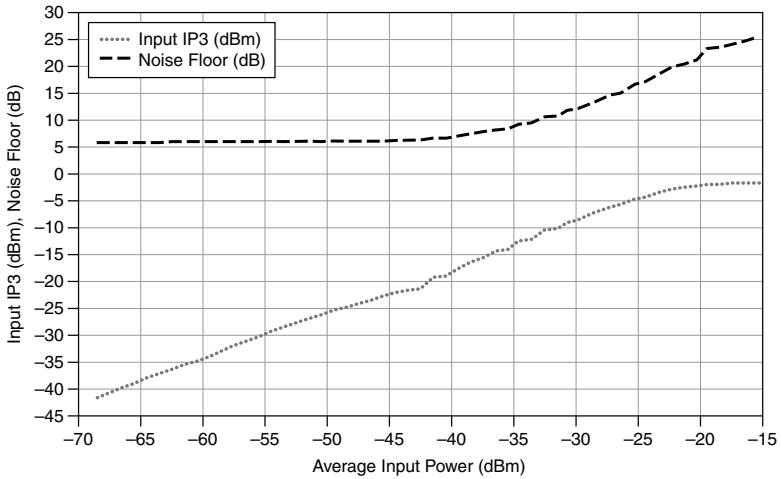
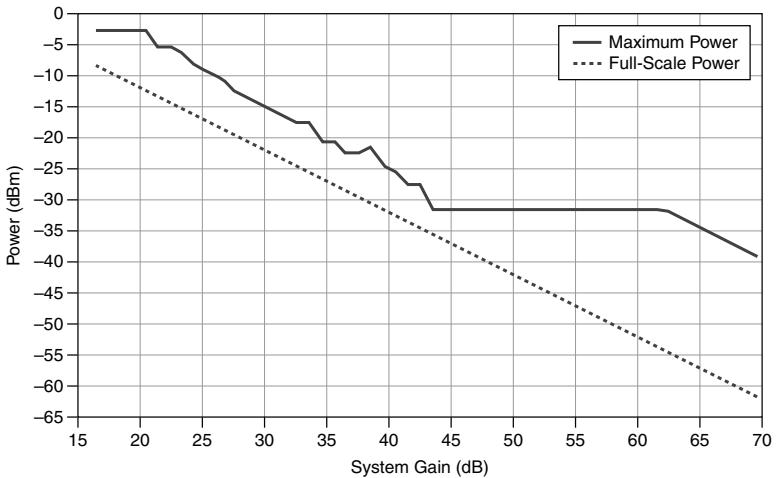


Figure 10. Receiver Maximum Power (Damage)⁵



Note NI recommends keeping the incident power less than or equal to the full-scale power.

⁷ Refers to super-heterodyne image.

PXIe-3610 Waveform Generator

| | |
|--|--|
| Sample rate | 3,072 MS/s |
| DC offset | ±40 mV |
| Second harmonics | -60 dBc |
| Third harmonics | -65 dBc |
| Bandwidth | |
| Per I or Q | DC to 1 GHz |
| Complex | 2 GHz |
| I or Q Channels | |
| Connector | MMPX (100 Ω, differential) |
| Full-scale | +1 dBm; 1 V _{pk-pk} |
| Common-mode voltage | 0 VDC |
| Flatness | ±1.5 dB |
| Third-order intermodulation distortion (IMD3) ⁸ | -75 dBc at 100 MHz -65 dBc at 1,000 MHz |
| Noise density | -155 dBm/Hz |
| Amplitude mismatch ⁹ | ±0.2 dB |
| Phase mismatch ⁹ | ±0.5 degrees |
| REF IN | |
| Connector | MMPX (50 Ω) |
| Frequency | 10 MHz |
| Power | 0 dBm to +13 dBm |
| REF OUT | |
| Connector | MMPX (50 Ω) |
| Frequency | 10 MHz |
| Power | +10 dBm |
| Digital input | Mini-SAS HD |

⁸ Two-tone signal at -7 dBFS.

⁹ Calibrated.

PXle-3620 RF Upconverter and Downconverter Module

IF Interface

IF OUT

| | |
|--------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Tuning range | 8.5 GHz to 13.5 GHz |
| Linear power | -40 dBm to 7 dBm |

IF IN

| | |
|--------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Tuning range | 8.5 GHz to 13.5 GHz |
| Linear power | -25 dBm to +20 dBm |

LO1 Interface

LO1 TX/RX IN

| | |
|---------------------|----------------------------|
| Connector | MMPX female (50 Ω) |
| Frequency | 4 GHz to 8 GHz |
| Nominal input level | +9 dBm |
| Damage level | +18 dBm |

LO1 TX/RX OUT

| | |
|---------------|----------------------------|
| Connector | MMPX female (50 Ω) |
| Frequency | 4 GHz to 8 GHz |
| Maximum power | +8 dBm to +15 dBm |

LO1 TX/RX mmWave OUT

| | |
|---------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency | 4 GHz to 13.7 GHz |
| Maximum power | +10 dBm to +15 dBm |

Internal LO1 Frequency Resolution

| | |
|-------------------|-------|
| 4 GHz to 8 GHz | 1 MHz |
| 8 GHz to 13.7 GHz | 2 MHz |

LO2 Interface

LO2 IN

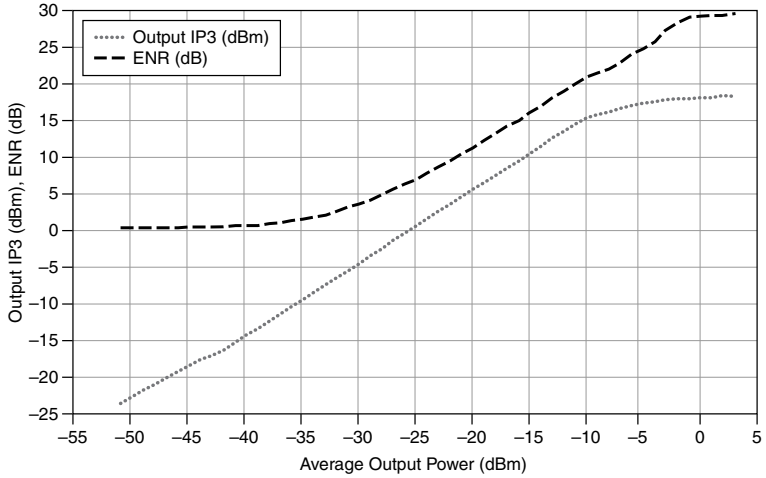
| | |
|-----------|----------------------------|
| Connector | MMPX female (50 Ω) |
| Frequency | 2.8 GHz to 4.5 GHz |

| | |
|-----------------------------------|---|
| Nominal input level | +9 dBm |
| Damage level | +18 dBm |
| LO2 OUT | |
| Connector | MMPX female (50 Ω) |
| Frequency | 2.8 GHz to 4.5 GHz |
| Maximum power | +11 dBm to +13 dBm |
| LO2 REF IN/OUT | |
| Connector | MMPX female (50 Ω) |
| Frequency | 10 MHz |
| Nominal level | 1.6 V _{pk-pk} |
| Damage level | 5 V _{pk-pk} |
| Internal LO2 frequency resolution | 1 MHz |
| Baseband Interface | |
| I/Q OUT | |
| Connector | MMPX female (100 Ω differential) |
| Frequency | DC to 1 GHz |
| Nominal level ¹⁰ | +5 dBm |
| Common-mode voltage | 0 V _{DC} |
| I/Q IN | |
| Connector | MMPX female (100 Ω) |
| Frequency | DC to 1 GHz |
| Nominal level ¹⁰ | +1 dBm |
| Damage level | +20 dBm |
| Common-mode voltage | 0 V _{DC} |

The following figure shows the simulated output IP3 and ENR of the PXIe-3620, when driven by the PXIe-3610 with a two-tone signal at -7 dBFS.

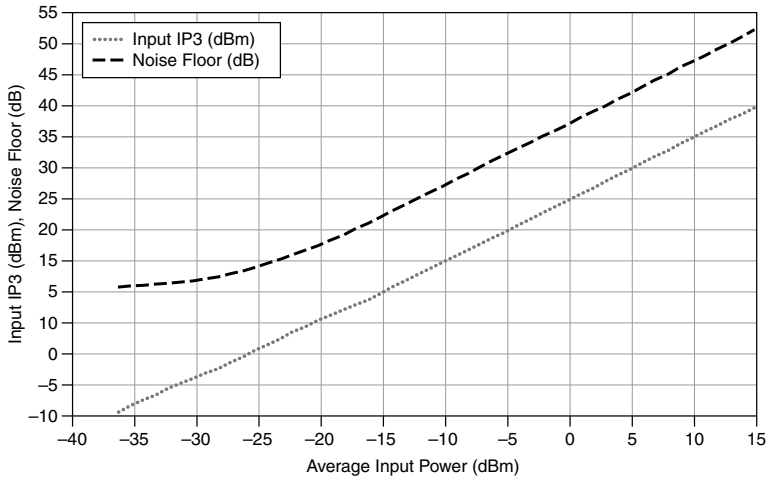
¹⁰ For a single I or Q differential port.

Figure 11. IF Transmitter Noise and Distortion



The following figure shows the simulated input IP3 and noise figure of the PXIe-3620 with the PXIe-3630.

Figure 12. IF Receiver Noise and Distortion

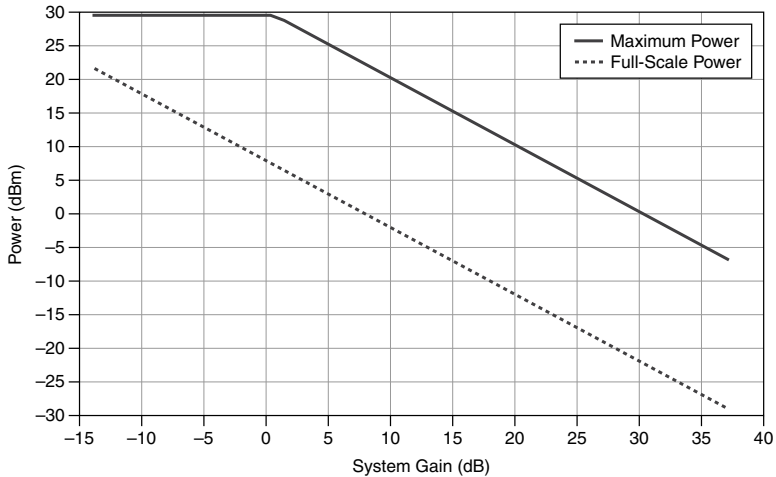


The phase noise added by the mmWave radio heads is nominally $20 \times \log_{10}(8)$ dB higher, due to the LO1 multiplication factor¹¹. Nominal single sideband (SSB) phase noise for the internal LO1 and internal LO2 on a PXIe-3620 module is shown in the following table.

Table 1. SSB Phase Noise

| Offset | LO1 (dBc/Hz) | LO2 (dBc/Hz) |
|---------|--------------|--------------|
| 100 Hz | -70 | -70 |
| 1 kHz | -92 | -92 |
| 10 kHz | -98 | -98 |
| 100 kHz | -104 | -104 |
| 1 MHz | -130 | -130 |

Figure 13. IF Receiver Maximum Power¹² (Damage)



Note NI recommends keeping the incident power less than or equal to the full-scale power.

¹¹ For mmRH-3647/3657 radio heads, the multiplication factor is 8. For mmRH-3602/3642/3652 radio heads, the overall multiplication factor is 8; a factor of 4 comes from the radio heads, and a factor of 2 comes from the LO1 doubler.

¹² Maximum power is the input power at which the receiver could be damaged.

PXIe-3630 Digitizer

| | |
|---------------------------------|--|
| Sample rate | 3,072 MS/s |
| DC offset | ±10 mV |
| Second harmonics | -60 dBc |
| Third harmonics | -60 dBc |
| Bandwidth | |
| Per I or Q | DC to 1 GHz |
| Complex | 2 GHz |
| I or Q Channels | |
| Connector | MMPX (100 Ω, differential) |
| Full-scale | +5 dBm, 1.59 V _{pk-pk} |
| Common-mode voltage | 0 VDC |
| Flatness | ±3.0 dB |
| IMD ³ ⁸ | -65 dBc at 100 MHz -60 dBc at 1,000 MHz |
| Noise density | -148 dBFS/Hz at 100 MHz -143 dBFS/Hz at 1,000 MHz |
| Amplitude mismatch ⁹ | ±0.2 dB |
| Phase mismatch ⁹ | ±1.5 degrees |
| REF IN | |
| Connector | MMPX (50 Ω) |
| Frequency | 10 MHz |
| Power | 0 dBm to +13 dBm |
| REF OUT | |
| Connector | MMPX (50 Ω) |
| Frequency | 10 MHz |
| Power | +10 dBm |
| Digital output | Mini-SAS HD |

PXIe-7902 High-Speed Serial Instrument



Note Refer to the *PXIe-7902 Specifications*, available online at ni.com/manuals, for specifications related to the PXIe-7902 High-Speed Serial Instrument.

mmRH-3602 mmWave Radio Head

RF IN/OUT

| | |
|--------------|----------------------|
| Connector | 2.92 mm |
| Tuning range | 27.5 GHz to 29.5 GHz |

IF IN/OUT

| | |
|-----------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 9.56 GHz to 11.56 GHz |

LO IN

| | |
|-----------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 9,515 MHz to 10,015 MHz |
| Power | +5 dBm |

| | |
|----------|----------------|
| DC Power | 2.5 A at +12 V |
|----------|----------------|

| | |
|--------|---------|
| Weight | 2.4 lbs |
|--------|---------|

| | |
|--------------------------------------|---|
| Dimensions (L \times W \times H) | 5.5 in. \times 5.0 in. \times 3.1 in. |
|--------------------------------------|---|

mmRH-3642 mmWave Radio Head

RF IN/OUT

| | |
|--------------|----------------------|
| Connector | 2.92 mm |
| Tuning range | 27.5 GHz to 29.5 GHz |

IF IN/OUT

| | |
|-----------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 9.56 GHz to 11.56 GHz |

LO IN

| | |
|-----------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 9,515 MHz to 10,015 MHz |
| Power | +5 dBm |

| | |
|----------|----------------|
| DC Power | 2.0 A at +12 V |
|----------|----------------|

| | |
|--------|---------|
| Weight | 1.8 lbs |
|--------|---------|

| | |
|--------------------------------------|---|
| Dimensions (L \times W \times H) | 5.5 in. \times 5.0 in. \times 3.1 in. |
|--------------------------------------|---|

mmRH-3647 mmWave Radio Head

RF IN/OUT

| | |
|--------------|------------------|
| Connector | WR-12 |
| Tuning range | 71 GHz to 76 GHz |

IF IN/OUT

| | |
|-----------------|-------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 11 GHz to 13 GHz |

LO IN

| | |
|-----------------|------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 7,375 MHz to 8,000 MHz |
| Power | +5 dBm |

| | |
|----------|----------------|
| DC Power | 1.8 A at +12 V |
|----------|----------------|

| | |
|--------|---------|
| Weight | 4.8 lbs |
|--------|---------|

| | |
|------------------------|-----------------------------|
| Dimensions (L × W × H) | 7.5 in. × 4.6 in. × 2.4 in. |
|------------------------|-----------------------------|

mmRH-3652 mmWave Radio Head

RF IN/OUT

| | |
|--------------|----------------------|
| Connector | 2.92 mm |
| Tuning range | 27.5 GHz to 29.5 GHz |

IF IN/OUT

| | |
|-----------------|-----------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 9.56 GHz to 11.56 GHz |

LO IN

| | |
|-----------------|-------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 9,515 MHz to 10,015 MHz |
| Power | +5 dBm |

| | |
|----------|----------------|
| DC Power | 1.5 A at +12 V |
|----------|----------------|

| | |
|--------|---------|
| Weight | 1.8 lbs |
|--------|---------|

| | |
|------------------------|-----------------------------|
| Dimensions (L × W × H) | 5.5 in. × 5.0 in. × 3.1 in. |
|------------------------|-----------------------------|

mmRH-3657 mmWave Radio Head

RF IN/OUT

| | |
|--------------|------------------|
| Connector | WR-12 |
| Tuning range | 71 GHz to 76 GHz |

IF IN/OUT

| | |
|-----------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 11 GHz to 13 GHz |

LO IN

| | |
|-----------------|---------------------------|
| Connector | SMA female (50 Ω) |
| Frequency range | 7,375 MHz to 8,000 MHz |
| Power | +5 dBm |

| | |
|----------|----------------|
| DC Power | 1.2 A at +12 V |
|----------|----------------|

| | |
|--------|---------|
| Weight | 4.8 lbs |
|--------|---------|

| | |
|--------------------------------------|---|
| Dimensions (L \times W \times H) | 7.5 in. \times 4.6 in. \times 2.4 in. |
|--------------------------------------|---|

Environment

| | |
|------------------|---|
| Maximum altitude | 2,000 m (800 mbar) (at 25 $^{\circ}$ C ambient temperature) |
|------------------|---|

| | |
|------------------|---|
| Pollution Degree | 2 |
|------------------|---|

Indoor use only.

Operating Environment

| | |
|---------------------------|--|
| Ambient temperature range | 0 $^{\circ}$ C to 40 $^{\circ}$ 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 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.) |

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 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, 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.

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