PXIe-5840 Specifications

2022-07-06

Contents

PXIe-5840 Specifications

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 performance met by a majority of models.
- **Typical-95** specifications describe the performance met by 95% (≈2σ) of models with a 95% confidence.
- **Nominal** specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Conditions

Warranted specifications are valid under the following conditions unless otherwise noted.

- Over ambient temperature range of 0 °C to 45 °C.
- 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.
- Calibration IP is used properly during the creation of custom FPGA bitfiles.

Typical specifications do not include measurement uncertainty and are measured immediately after a device self-calibration is performed.

Unless otherwise noted, specifications assume the PXIe-5840 is configured in the following default mode of operation:

- Reference Clock source: Internal
- RF IN reference level: 0 dBm
- RF IN preamplifier: AUTO
- RF OUT power level: 0 dBm
- LO tuning mode: Fractional
- LO PLL loop bandwidth: Low
- LO step size: 500 kHz
- LO frequency: 2.4 GHz
- LO source: Internal

Note Within the specifications, **self-calibration °C** refers to the recorded device temperature of the last successful self-calibration. You can read the self-calibration temperature from the device using the appropriate software functions.

Frequency

The following characteristics are common to both RF IN and RF OUT ports.

Frequency range	9 kHz to 6 GHz

Center Frequency	Instantaneous Bandwidth
9 kHz to <120 MHz	<120 MHz
120 MHz to 410 MHz	50 MHz
>410 MHz to 650 MHz	100 MHz
>650 MHz to 1.3 GHz	200 MHz
>1.3 GHz to 2.2 GHz	500 MHz
>2.2 GHz to 6 GHz	1 GHz

Center Frequency	Instantaneous Bandwidth
The PXIe-5840 uses the low frequency subsystem to directly acquire or generate the RF signal below 120 MHz.	

Table 1. PXIe-5840 Bandwidth

Tuning resolution[1]	888 nHz

LO step size

Fractional mode	Programmable step size, 500 kHz default

Integer mode[2]

LO ≤ 4 GHz	10 MHz, 25 MHz, 50 MHz, 100 MHz
LO > 4 GHz	20 MHz, 50 MHz, 100 MHz, 200 MHz

Frequency Settling Time

Settling Time	Maximum Time (ms)
$\leq 1 \times 10^{-6}$ of final frequency	0.38
$\leq 0.1 \times 10^{-6}$ of final frequency	0.40
This specification includes only frequency settling and excludes any residual amplitude settling.	

Table 2. Maximum Frequency Settling Time

Internal Frequency Reference

Initial adjustment accuracy	$\pm 200 \times 10^{-9}$
Temperature stability	$\pm 1 \times 10^{-6}$, maximum

Aging	$\pm 1 \times 10^{-6}$ per year, maximum
Accuracy	**Initial adjustment accuracy** ± **Aging** ± **Temperature stability**

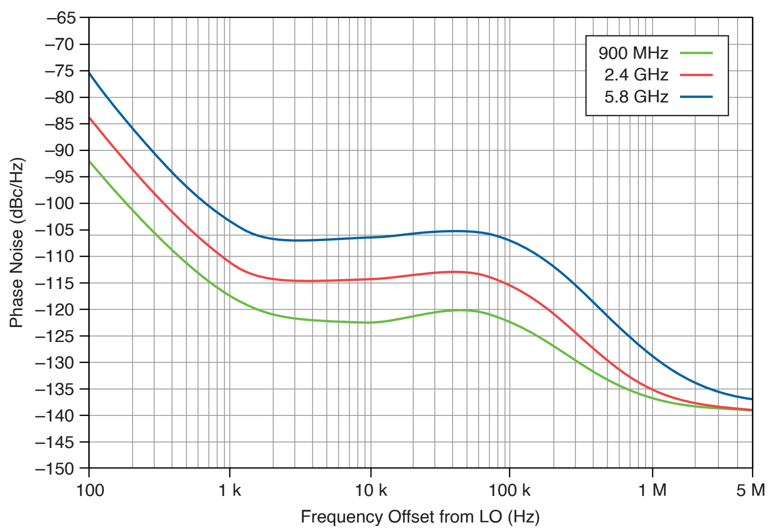
> **Note** For more information about using an external frequency reference or sharing the internal frequency reference, refer to the REF IN and REF OUT sections.

Spectral Purity

Frequency	Phase Noise (dBc/Hz, Single Sideband), 20 kHz Offset, Self-Calibration °C ± 10 °C
<3 GHz	-102
3 GHz to 4 GHz	-102
>4 GHz to 6 GHz	-96

Table 3. Single Sideband Phase Noise

Figure 1. Measured Phase Noise[3] at 900 MHz, 2.4 GHz, and 5.8 GHz



RF Input

RF Input Amplitude Range

Center Frequency	Preamp	RF Input (dB)
9 kHz to <120 MHz	Disabled	Average noise level to +15 dBm (CW RMS)
	Auto	
120 MHz to 6 GHz	Disabled	Average noise level to +30 dBm (CW RMS)
	Auto	
	Enabled	Average noise level to -10 dBm (CW RMS)

Table 4. Input Amplitude Range

RF gain resolution	1 dB, nominal

Center Frequency	RF Analog Gain Range (dB)
10 MHz to <120 MHz	≥35
120 MHz to 500 MHz	≥65
>500 MHz to 1.5 GHz	≥65
>1.5 GHz to 2.3 GHz	≥60
>2.3 GHz to 2.9 GHz	≥60
>2.9 GHz to 4.8 GHz	≥55
>4.8 GHz to 6 GHz	≥50

Table 5. Input RF Analog Gain Range, Preamp Auto, Nominal

Center Frequency	RF Analog Gain Range (dB)
120 MHz to 500 MHz	≥40
>500 MHz to 1.5 GHz	≥35
>1.5 GHz to 2.3 GHz	≥30
>2.3 GHz to 2.9 GHz	≥30
>2.9 GHz to 4.8 GHz	≥25
>4.8 GHz to 6 GHz	≥25

Table 6. Input RF Analog Gain Range, Preamp Enabled, Nominal

RF Input Amplitude Settling Time[4]

<0.5 dB of final value	40 µs, typical
<0.1 dB of final value	70 µs, typical

RF Input Absolute Amplitude Accuracy

Center Frequency	Specification	2σ	Typical
10 MHz to <120 MHz	±0.75	±0.55	±0.35
120 MHz to 500 MHz	±0.80	±0.65	±0.50
>500 MHz to 1.5 GHz	±0.70	±0.55	±0.40
>1.5 GHz to 2.3 GHz	±0.75	±0.60	±0.45
>2.3 GHz to 2.9 GHz	±0.65	±0.50	±0.35
>2.9 GHz to 4.8 GHz	±0.75	±0.55	±0.40
>4.8 GHz to 6 GHz	±0.90	±0.60	±0.45

Conditions: Reference level -30 dBm to +30 dBm; measured at 3.75 MHz offset from the configured center frequency; measurement performed after the PXIe-5840 has settled. Preamplifier mode set to automatic.

This specification is valid only when the module is operating within the specified ambient temperature range and within ±10 °C from the last self-calibration temperature, as measured with the onboard temperature sensors.

Table 16. Input Absolute Amplitude Accuracy (dB)

RF Input Frequency Response

Center Frequency	NI-RFSA Device Instantaneous Bandwidth	Frequency Response (dB)
≥250 MHz to 410 MHz	50 MHz	±0.90
		±0.50, typical
>410 MHz to 650 MHz	100 MHz	±0.75

Center Frequency	NI-RFSA Device Instantaneous Bandwidth	Frequency Response (dB)
		±0.50, typical
>650 MHz to 1.5 GHz	200 MHz	±1.00
		±0.65, typical
>1.5 GHz to 2.2 GHz	200 MHz	±1.30
		±0.70, typical
>2.2 GHz to 2.9 GHz	200 MHz	±1.00
		±0.55, typical
	1 GHz	±1.80, typical
>2.9 GHz to 4.8 GHz	200 MHz	±1.00
		±0.65, typical
	1 GHz	±2.00, typical
>4.8 GHz to 6 GHz	200 MHz	±1.00
		±0.65, typical
	1 GHz	±1.65, typical
Conditions: Reference level -30 dBm to +30 dBm; module temperature within ± 5 °C of last self-calibration temperature. Frequency response is defined as the maximum relative amplitude deviation from the reference offset frequency. For the PXIe-5840 RF Input the reference offset frequency is 3.75 MHz. For the absolute amplitude accuracy at the reference offset, refer to the RF Input Absolute Amplitude Accuracy section.		

Table 17. Input Frequency Response (dB), Equalized

Figure 2. Measured 200 MHz Input Frequency Response, 0 dBm Reference Level, Equalized

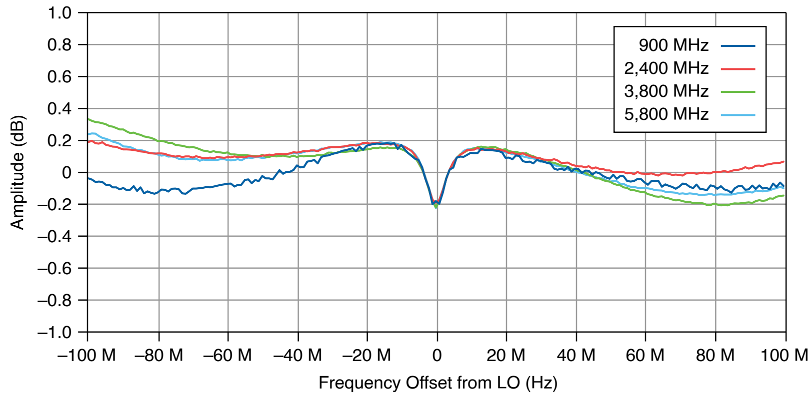
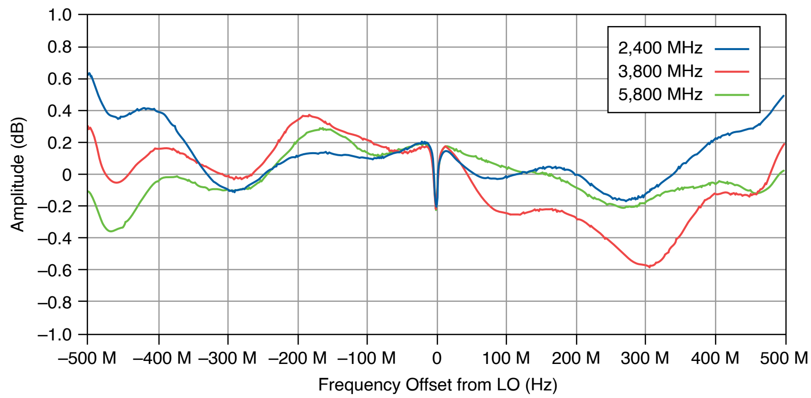


Figure 3. Measured 1 GHz Input Frequency Response, 0 dBm Reference Level, Equalized



RF Input Average Noise Density

Frequency Range	-50 dBm Reference Level	-10 dBm Reference Level
>120 MHz to 500 MHz	-161	-140
>500 MHz to 3.4 GHz	-164	-150
>3.4 GHz to 4.5 GHz	-163	-148
>4.5 GHz to 6.0 GHz	-161	-149
Conditions: Input terminated with a 50 Ω load; 50 averages; noise integrated and normalized to 1 Hz bandwidth. The -50 dBm reference level configuration has the preamplifier enabled for high sensitivity. The -10 dBm reference level configuration has the preamplifier disabled for optimized linearity.		

Table 18. Input Average Noise Density (dBm/Hz), Typical

RF Input Spurious Responses

RF Input Third-Order Input Intermodulation

Frequency Range	IIP_3 (dBm)
120 MHz to 600 MHz	23
>600 MHz to 1.4 GHz	20
>1.4 GHz to 4.0 GHz	22
>4.0 GHz to 5.1 GHz	19
>5.1 GHz to 6.0 GHz	16
Conditions: Two -10 dBm tones, 700 kHz separation at RF IN; preamp disabled; reference level: -5 dBm.	

Table 10. Third-Order Input Intercept Point (IIP_3), -5 dBm Reference Level, Typical

Frequency Range	IIP_3 (dBm)
120 MHz to 200 MHz	5
>200 MHz to 4.0 GHz	9
>4.0 GHz to 5.1 GHz	4
5.1 GHz to 6.0 GHz	1
Conditions: Two -25 dBm tones, 700 kHz separation at RF IN; preamp enabled; reference level: -20 dBm.	

Table 11. Third-Order Input Intercept Point (IIP_3), -20 dBm Reference Level, Typical

RF Input Nonharmonic Spurs

LO Frequency	10 kHz ≤ Offset < 100 kHz	100 kHz ≤ Offset < 1 MHz	1 MHz ≤ Offset[5]
>120 MHz to 410 MHz	-65	-64	-60
>410 MHz to 750 MHz	-65	-65	-66
>750 MHz to 2.2 GHz	-63	-63	-72
>2.2 GHz to 4.5 GHz	-57	-60	-68
>4.5 GHz to 6 GHz	-49	-50	-63

LO Frequency	10 kHz ≤ Offset < 100 kHz	100 kHz ≤ Offset < 1 MHz	1 MHz ≤ Offset[5]

Conditions: Reference level 0 dBm. Preamp disabled. Measured with a single tone, -6 dBr, where dBr is referenced to the configured RF reference level.

Note Offset refers to ± desired signal offset (Hz) around the current LO frequency.

Table 22. Input Nonharmonic Spurs (dBc), Typical

RF Input LO Residual Power

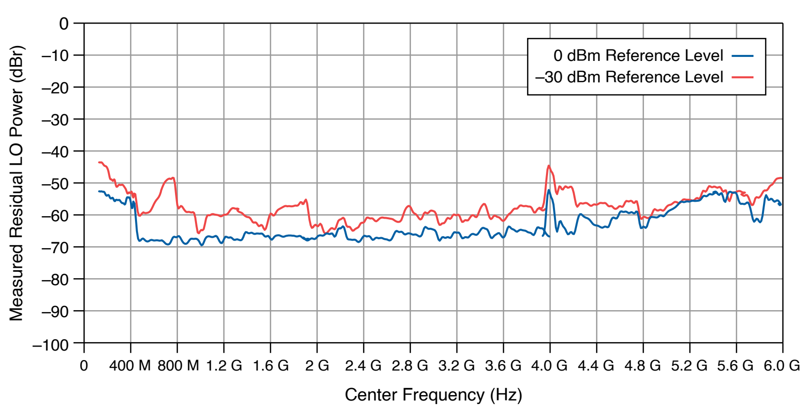
Center Frequency	Reference Level	
	-30 dBm to -20 dBm	-20 dBm to +30 dBm
≥120 MHz to 410 MHz	-42	-42
>410 MHz to 2.2 GHz	-47	-60
>2.2 GHz to 4 GHz	-55	-57
>4 GHz to 6 GHz	-45	-48

Conditions: LO Residual Power averaged across a maximum of 200 MHz bandwidth using the internal LO of the PXIe-5840. Input tone power at a maximum of -6 dBr.

The PXIe-5840 uses the low frequency subsystem to directly acquire the RF input signal below 120 MHz.

Table 23. Input LO Residual Power (dBr[6]), Typical

Figure 4. Input LO Residual Power, Typical



RF Input Residual Sideband Image

Center Frequency	NI-RFSA Device Instantaneous Bandwidth Setting	Input Bandwidth[7]	Residual Sideband Image (dBc)
≥120 MHz to 410 MHz	50 MHz	50 MHz	-50
>410 MHz to 650 MHz	100 MHz	100 MHz	-50
>650 MHz to 1.3 GHz	200 MHz	200 MHz	-55
>1.3 GHz to 2.2 GHz	200 MHz	200 MHz	-55
	500 MHz	200 MHz	-55
		500 MHz	-53
>2.2 GHz to 5 GHz	200 MHz	200 MHz	-57
	1 GHz	200 MHz	-50
		1 GHz	-45
>5 GHz to 6 GHz	200 MHz	200 MHz	-50
	1 GHz	200 MHz	-50
		1 GHz	-45
Conditions: Reference levels -30 dBm to +30 dBm. The PXIe-5840 uses the low frequency subsystem to directly acquire the RF signal below 120 MHz. This specification describes the maximum residual sideband image within the device bandwidth centered around a given RF center frequency.			

Table 24. Input Residual Sideband Image (dBc), Typical

Figure 5. Input Residual Sideband Image, 0 dBm Reference Level, Measured

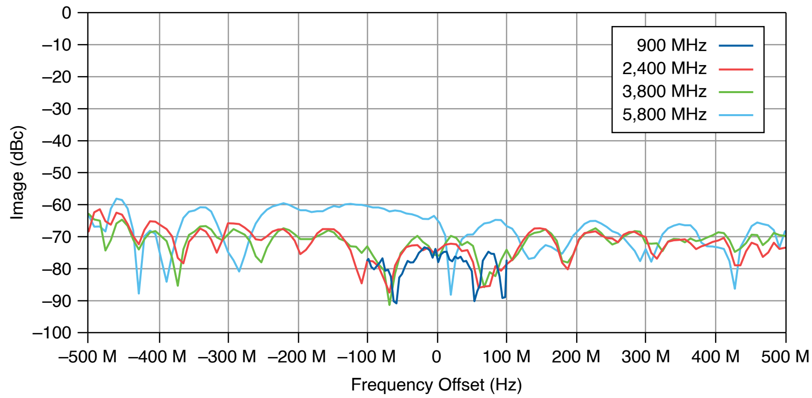
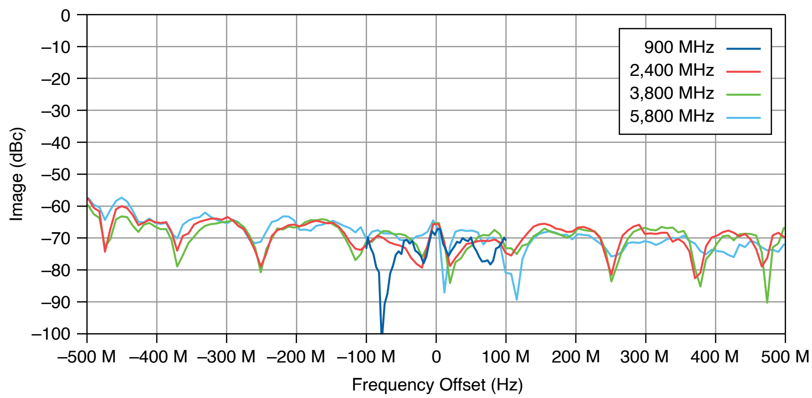


Figure 6. Input Residual Sideband Image, -30 dBm Reference Level, Measured



RF Output

RF Output Power Range

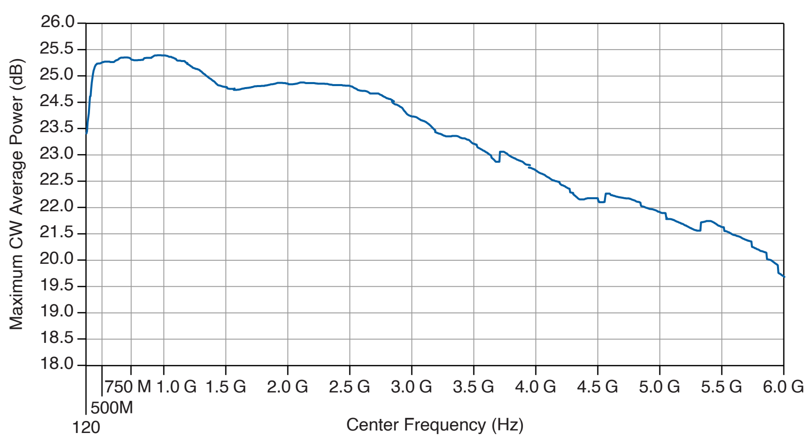
NI-RFSG Bandwidth Setting	Frequency	Power Range, CW, Average Power	
		Specification	Nominal
<120 MHz	9 kHz to <120 MHz	Noise floor to +5 dBm	Noise Floor to +8 dBm
≤200 MHz	120 MHz to 4 GHz	Noise floor to +18 dBm	Noise Floor to ≥+20 dBm
	>4 GHz to 6 GHz	Noise Floor to +15 dBm	Noise Floor to ≥+17 dBm
1 GHz	≥2.2 GHz to 4 GHz	Noise Floor to +18 dBm	Noise Floor to ≥+20 dBm

NI-RFSG Bandwidth Setting	Frequency	Power Range, CW, Average Power	
		Specification	Nominal
	>4 GHz to 6 GHz	Noise Floor to +10 dBm	Noise Floor to ≥+15 dBm
The power range refers to CW average power. For modulated signal generation, it is important to consider the impact of peak to average power ratio (PAPR). For example, a modulated 20 MHz signal between 120 MHz to 4 GHz with a 12 dB PAPR can be generated with up to +6 dBm (+8 dBm nominal) average modulated power.			

Table 15. Output Power Range

Output attenuator resolution	1 dB, nominal
Digital attenuation resolution[8]	<0.1 dB

Figure 7. Output Maximum CW Average Power (dB), Measured



RF Output Amplitude Settling Time[9]

<0.5 dB of final value	60 µs, typical
<0.1 dB of final value	85 µs, typical

RF Output Power Level Accuracy

Center Frequency	Specification	2σ	Typical
>200 MHz to 500 MHz	±0.8	±0.6	±0.45
>500 MHz to 1.5 GHz	±0.7	±0.6	±0.45
>1.5 GHz to 2.3 GHz	±0.7	±0.6	±0.45
>2.3 GHz to 2.9 GHz	±0.7	±0.6	±0.45
>2.9 GHz to 4.8 GHz	±0.85	±0.65	±0.5
>4.8 GHz to 6 GHz	±0.9	±0.7	±0.55
Conditions: For frequencies 2.3 GHz and below, Power Level -30 dBm to +15 dBm; for frequencies greater than 2.3 GHz, Power Level -50 dBm to +15 dBm; measured at 3.75 MHz offset from the configured center frequency; measurement performed after the PXIe-5840 has settled. This specification is valid only when the module is operating within the specified ambient temperature range and within ±10 °C from the last self-calibration temperature, as measured with the onboard temperature sensors. This specification requires that temperature correction is being performed. Temperature correction is applied automatically if NIRFSG_ATTR_AUTOMATIC_THERMAL_CORRECTION is enabled (default). Temperature correction is applied if necessary only when NI-RFSG settings are adjusted. If NIRFSG_ATTR_AUTOMATIC_THERMAL_CORRECTION is disabled, the niRFSG_PerformThermalCorrection must be explicitly called.			

Table 16. Output Power Level Accuracy (dB)

Figure 8. Output Relative Power Accuracy, 10 MHz to <120 MHz, -50 dBm to +5 dBm, Nominal[10]

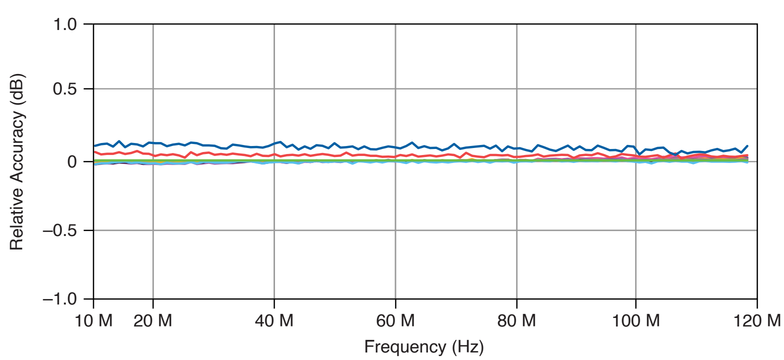
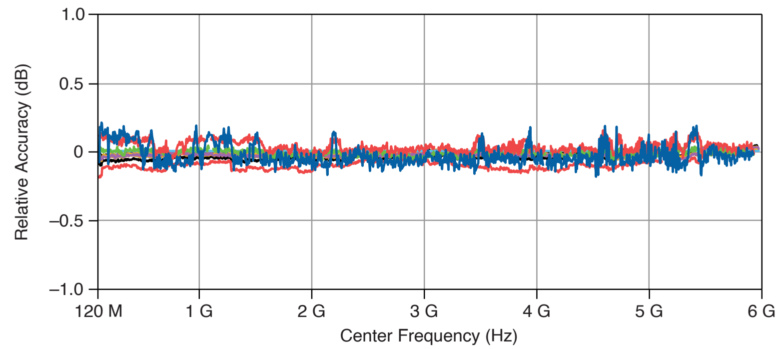


Figure 9. Output Relative Power Accuracy, 120 MHz to 6 GHz, -50 dBm to +15 dBm, Nominal[10]



RF Output Frequency Response

Center Frequency	NI-RFSG Signal Bandwidth Setting	Frequency Response (dB)
≥250 MHz to 410 MHz	50 MHz	±0.90
		±0.55, typical
>410 MHz to 650 MHz	100 MHz	±1.10
		±0.55, typical
>650 MHz to 1.5 GHz	200 MHz	±2.00
		±1.20, typical
>1.5 GHz to 2.2 GHz	200 MHz	±1.40
		±0.80, typical
>2.2 GHz to 2.9 GHz	200 MHz	±1.40
		±0.80, typical
	1 GHz	±2.00, typical
>2.9 GHz to 4.8 GHz	200 MHz	±2.20
		±1.20, typical
	1 GHz	±3.3, typical
>4.8 GHz to 6 GHz	200 MHz	±2.20
		±1.25, typical
	1 GHz	±3.00, typical
Conditions: Output peak power level -30 dBm to +15 dBm; module temperature within ±5 °C of last self-calibration temperature.		

Center Frequency	NI-RFSG Signal Bandwidth Setting	Frequency Response (dB)
Frequency response is defined as the maximum relative amplitude deviation from the reference offset frequency. For the PXIe-5840 RF Input the reference offset frequency is 3.75 MHz. For the absolute amplitude accuracy at the reference offset, refer to the RF Output Power Level Accuracy section.		

Table 17. Output Frequency Response (dB) (Equalized)

Figure 10. Measured 200 MHz Output Frequency Response, 0 dBm Output Power Level, Equalized

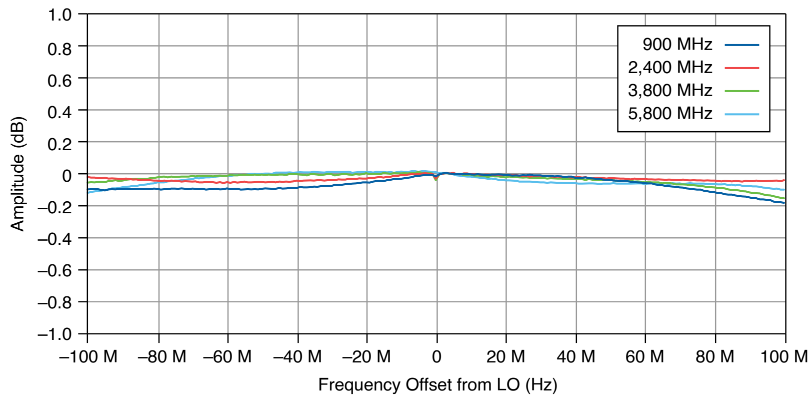
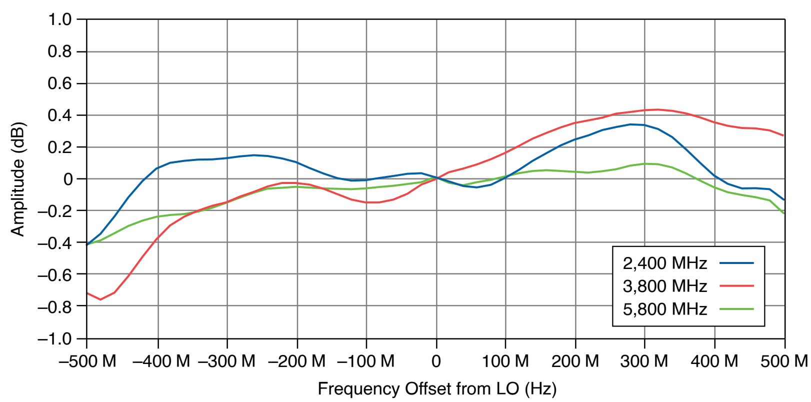


Figure 11. Measured 1 GHz Output Frequency Response, 0 dBm Output Power Level, Equalized



RF Output Average Noise Density

Center Frequency	Output Power Level (Peak)		
	-30 dBm	0 dBm	10 dBm
10 MHz to 120 MHz	-145	-147	—

Center Frequency	Output Power Level (Peak)		
	-30 dBm	0 dBm	10 dBm
>120 MHz to 600 MHz	-167	-149	-137
>600 MHz to 2.2 GHz	-165	-151	-140
>2.2 GHz to 3.0 GHz	-165	-143	-134
>3.0 GHz to 5.0 GHz	-164	-148	-138
>5.0 GHz to 6.0 GHz	-163	-142	-133
Conditions: 50 averages; -40 dB baseband signal attenuation; noise measurement frequency offset 4 MHz relative to output frequency.			

Table 18. Output Average Noise Density (dBm/Hz), Typical

RF Output Spurious Responses

RF Output Third-Order Intermodulation

Fundamental Frequency	Baseband DAC: -2 dBFS	Baseband DAC: -6 dBFS
1 MHz to 100 MHz	-72	-72
>100 MHz to 2.0 GHz	-45	-50
>2.0 GHz to 2.7 GHz	-49	-54
>2.7 GHz to 4.0 GHz	-46	-59
>4.0 GHz to 5.0 GHz	-42	-59
>5.0 GHz to 6.0 GHz	-50	-56
Conditions: -6 dBm tones with 700 kHz separation at RF OUT. Output power level set to achieve the desired output power per tone allowing specified digital headroom.		

Table 19. Third-Order Output Intermodulation Distortion (IMD_3) (dBc), -6 dBm Tones, Typical

Fundamental Frequency	Baseband DAC: -2 dBFS	Baseband DAC: -6 dBFS
1 MHz to 100 MHz	-71	-72
>100 MHz to 1.0 GHz	-52	-60
>1.0 GHz to 2.7 GHz	-56	-64
>2.7 GHz to 5.0 GHz	-54	-60
>5.0 GHz to 6.0 GHz	-53	-57

Fundamental Frequency	Baseband DAC: -2 dBFS	Baseband DAC: -6 dBFS
Conditions: -36 dBm tones with 700 kHz separation at RF OUT. Output power level set to achieve the desired output power per tone allowing specified digital headroom.		

Table 20. Third-Order Output Intermodulation Distortion (IMD_3) (dBc), -36 dBm Tones, Typical

RF Output Harmonics

	CW Average Power	
Frequency Range	6 dBm	15 dBm
10 MHz to 120 MHz	-50	N/A
>120 MHz to 200 MHz	-34	-32
>200 MHz to 1.4 GHz	-34	-32
>1.4 GHz to 2.7 GHz	-30	-32
>2.7 GHz to 6.0 GHz	-39	-32
Conditions: Measured using a -1 dBFS baseband signal with 1 MHz offset.		

Table 21. Output Second Harmonic Level (dBc), Typical

RF Output Nonharmonic Spurs

Frequency	10 kHz ≤ Offset < 100 kHz	100 kHz ≤ Offset < 1 MHz	1 MHz ≤ Offset[11]
>120 MHz to 460 MHz	<-80	<-80	<-60
>460 MHz to 1.35 GHz	<-75	<-75	<-65
>1.35 GHz to 2.25 GHz	<-75	<-70	<-63
>2.25 GHz to 4.5 GHz	<-65	<-63	<-62
>4.5 GHz to 6 GHz	<-55	<-56	<-61
Conditions : Output full scale level 0 dBm. Measured with a single tone at 0 dBFS.			

Note Offset refers to ± desired signal offset (Hz) around the current LO frequency.

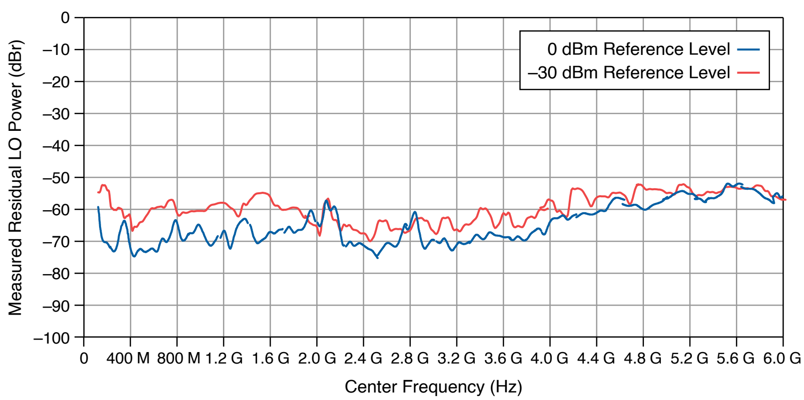
Table 22. Output Nonharmonic Spurs (dBc), Typical

RF Output LO Residual Power

Center Frequency	LO Residual Power
≥120 MHz to 410 MHz	-50
>410 MHz to 2.2 GHz	-52
>2.2 GHz to 4 GHz	-54
>4 GHz to 6 GHz	-51
Conditions: LO Residual Power averaged across a maximum of 200 MHz bandwidth using the internal LO of the PXIe-5840. Peak output power -30 dBm to +15 dBm; tone at -6 dBFS. The PXIe-5840 uses the low frequency subsystem to directly generate the RF signal below 120 MHz.	

Table 23. Output LO Residual Power (dBc), Typical

Figure 12. Output LO Residual Power, Typical



RF Output Residual Sideband Image

Center Frequency	NI-RFSG Signal Bandwidth Setting	Output Bandwidth[12]	Residual Sideband Image
≥120 MHz to 410 MHz	50 MHz	50 MHz	-40
>410 MHz to 650 MHz	100 MHz	100 MHz	-55
>650 MHz to 1.3 GHz	200 MHz	200 MHz	-48
>1.3 GHz to 2.2 GHz	200 MHz	200 MHz	-50
	500 MHz	200 MHz	-47

Center Frequency	NI-RFSG Signal Bandwidth Setting	Output Bandwidth[12]	Residual Sideband Image
		500 MHz	-45
>2.2 GHz to 5 GHz	200 MHz	200 MHz	-50
	1 GHz	200 MHz	-48
		1 GHz	-45
>5 GHz to 6 GHz	200 MHz	200 MHz	-45
	1 GHz	200 MHz	-45
		1 GHz[13]	-40

Conditions: Peak output power levels -30 dBm to +15 dBm.

The PXIe-5840 uses the low frequency subsystem to directly generate the RF signal below 120 MHz.

This specification describes the maximum residual sideband image within the device bandwidth centered around a given RF center frequency.

Table 24. Output Residual Sideband Image (dBc), Typical

Figure 13. Output Residual Sideband Image, 0 dBm Average Output Power, Measured

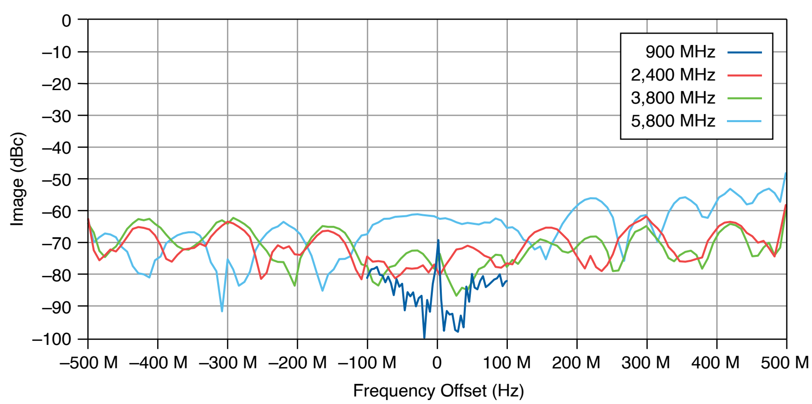
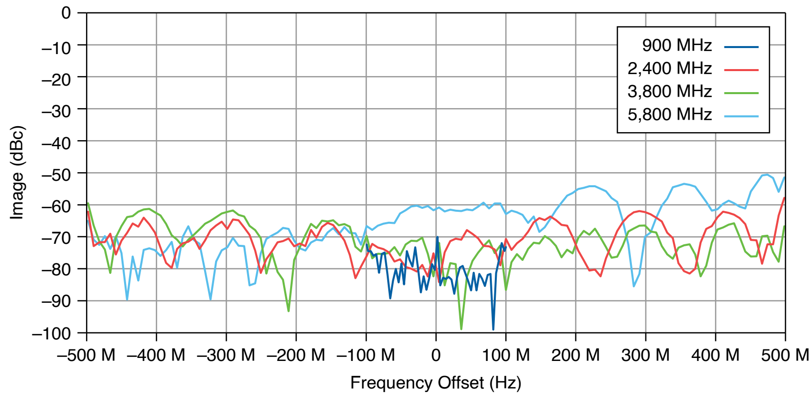


Figure 14. Output Residual Sideband Image, -30 dBm Average Output Power, Measured

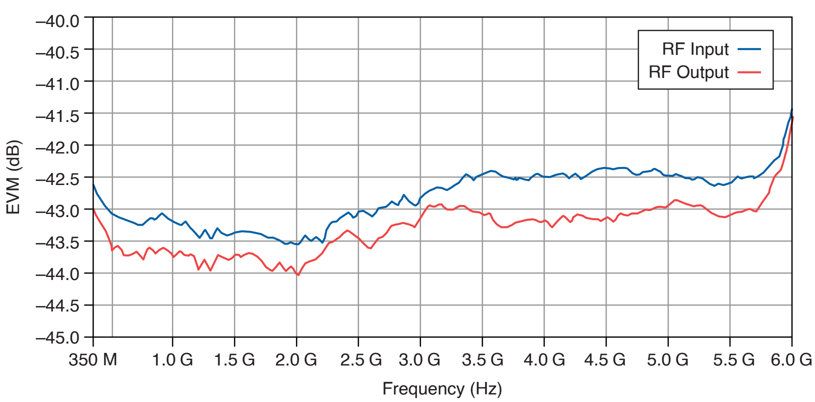


Error Vector Magnitude (EVM)

Center Frequency	RF Input	RF Output
350 MHz to 4 GHz	-41	-41
>4 GHz to 6 GHz	-40	-40
Conditions: 20 MHz bandwidth 64-QAM modulated signal. Pulse-shape filtering: root-raised cosine, alpha=0.25; PXIe-5840 RF Input reference level: 0 dBm, LO Offset: 10 MHz; PXIe-5840 RF Output average power level: -5 dBm; Reference Clock source: Onboard; Acquisition length: 300 µs.		

Table 25. Error Vector Magnitude, RMS (dB), Typical

Figure 15. Measured RMS EVM[14]



Application-Specific Modulation Quality

WLAN 802.11ax

Figure 16. WLAN 802.11ax Measured RMS EVM (dB) versus Frequency (Hz), External LO[15]

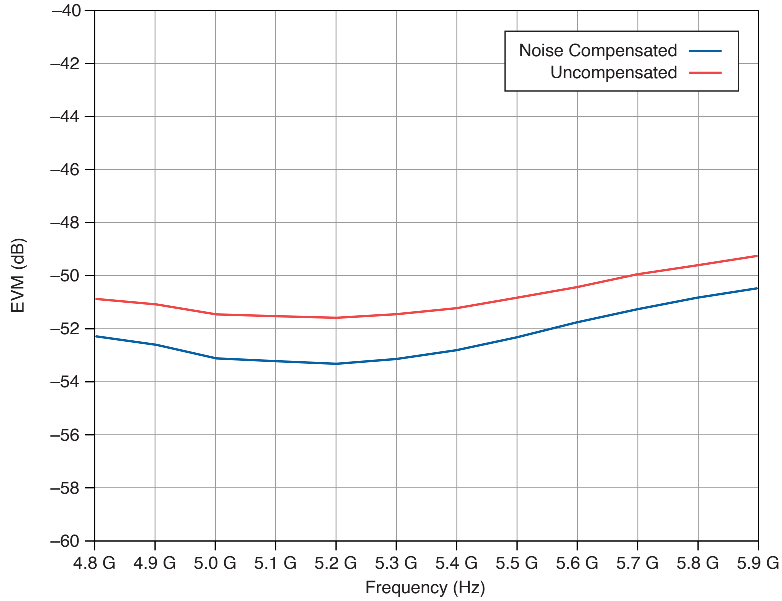


Figure 17. WLAN 802.11ax Measured RMS EVM (dB) versus Measured Average Power (dBm), External LO[16]

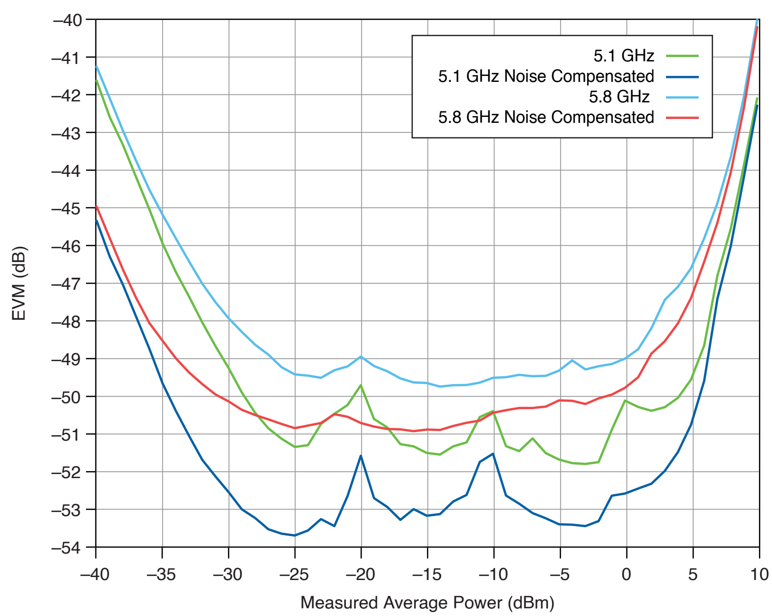


Figure 18. WLAN 802.11ax Measured RMS EVM (dB) versus Frequency (Hz), Internal LO[17]

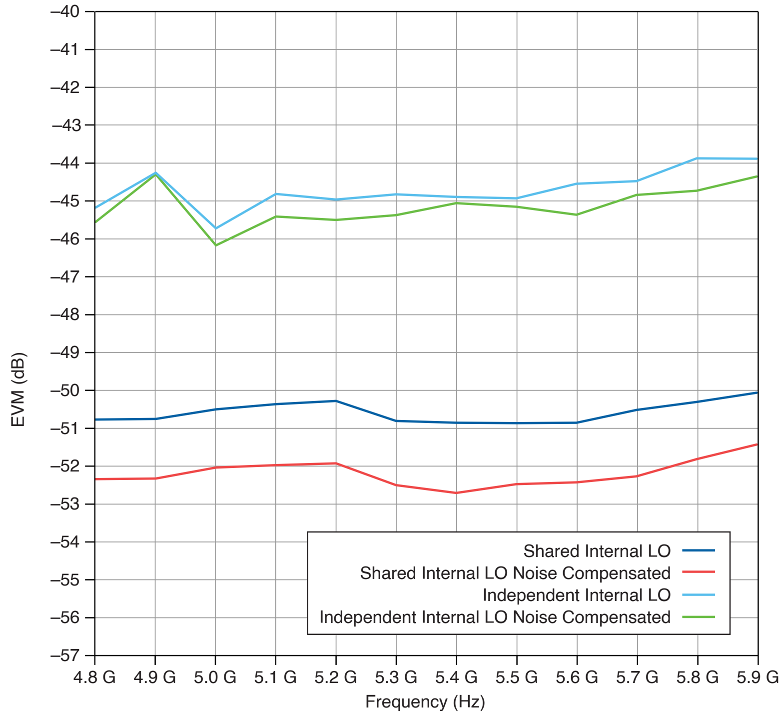
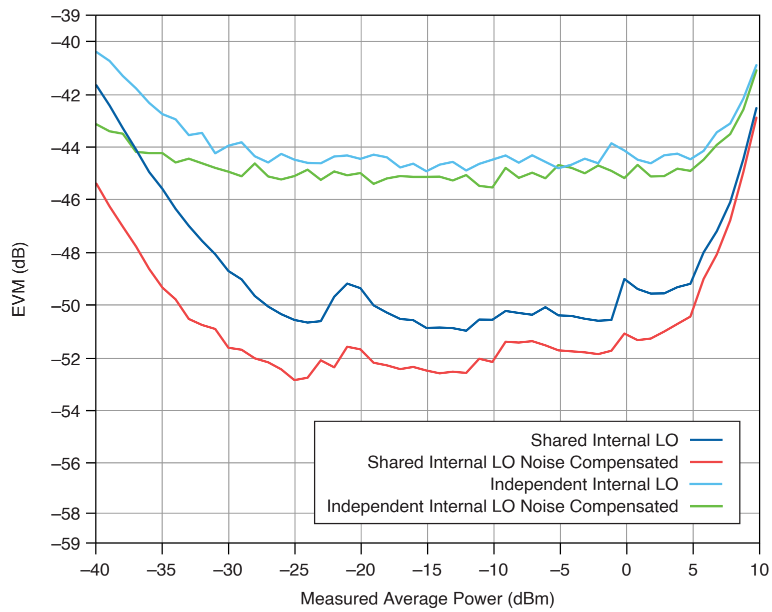


Figure 19. WLAN 802.11ax Measured RMS EVM (dB) versus Measured Average Power (dBm), Internal LO[18]



WLAN 802.11ac

Figure 20. WLAN 802.11ac Measured RMS EVM (dB) versus Frequency (Hz), 80 MHz Bandwidth[19]

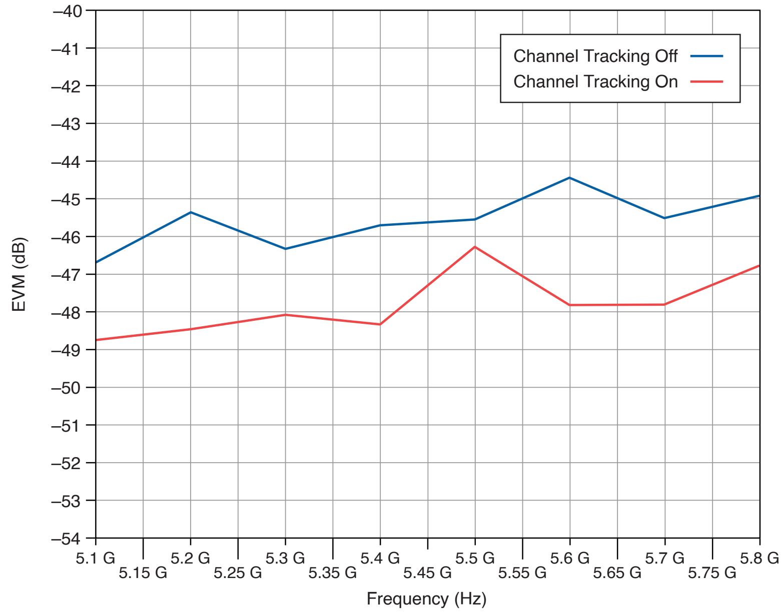
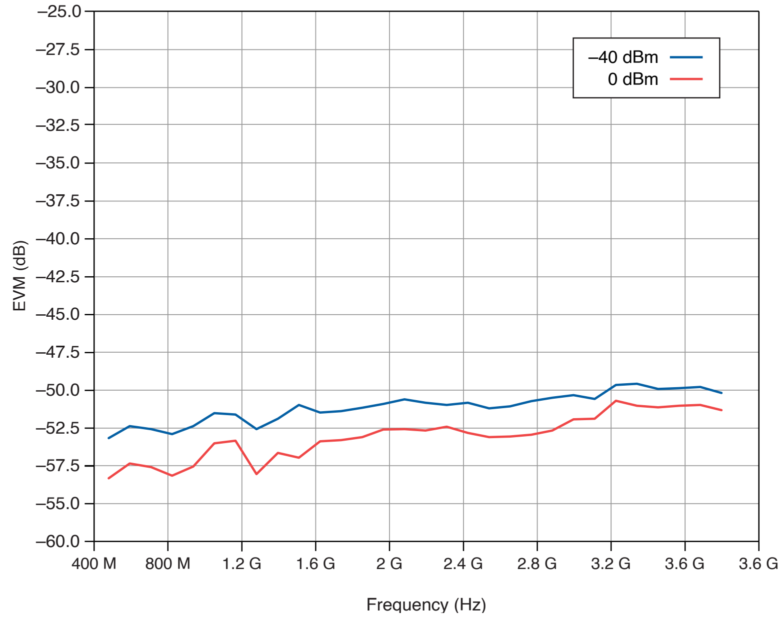


Figure 21. WLAN 802.11ac Measured RMS EVM (dB) versus Frequency (Hz), 160 MHz Bandwidth[20]

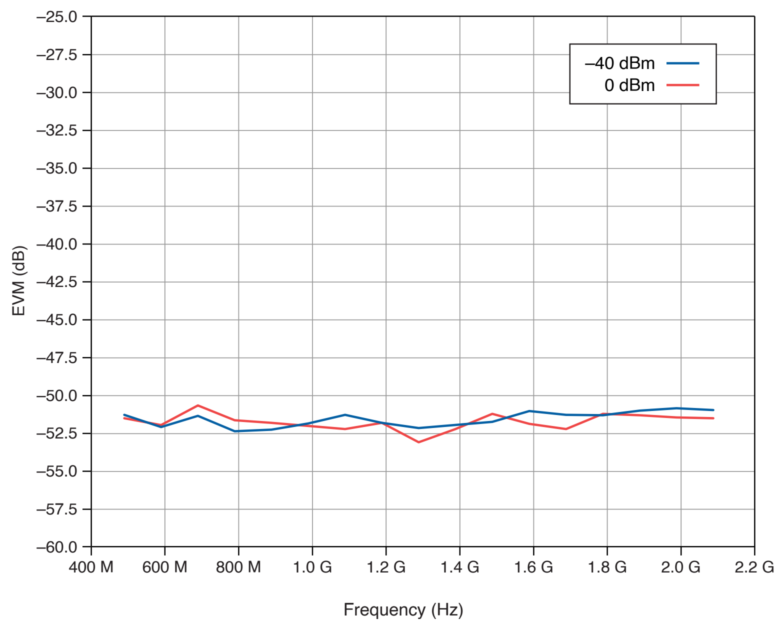
LTE

Figure 22. LTE Measured RMS EVM (dB) versus Frequency (Hz)[21]



WCDMA

Figure 23. WCDMA Measured RMS EVM (dB) versus Frequency (Hz)[22]



Baseband Characteristics

Analog-to-digital converters (ADCs)	
I/Q data rate[23]	19 kS/s to 1.25 GS/s
Digital-to-analog converters (DACs)	
I/Q data rate[24]	19 kS/s to 1.25 GS/s

Onboard FPGA

FPGA	Xilinx Virtex-7 X690T
LUTs	433,200
Flip-flops	866,400
DSP48 slices	3,600
Embedded block RAM	52.9 Mbits
Data transfers	DMA, interrupts, programmed I/O
Number of DMA channels	56

Onboard DRAM

Memory size	2 banks, 2 GB per bank
Theoretical maximum data rate	12 GB/s per bank

Onboard SRAM

Memory size	2 MB
Maximum data rate (read)	31 MB/s
Maximum data rate (write)	29 MB/s

Front Panel I/O

> **Note** Measurement Categories CAT I and CAT O (Other) are equivalent. These test and measurement circuits are not intended for direct connection to the MAINs building installations of Measurement Categories CAT II, CAT III, or CAT IV.

RF IN

Connector	SMA (female)
Input impedance	50 Ω, nominal, AC coupled
Maximum DC input voltage without damage	±10 VDC

Absolute maximum input power

<120 MHz	+24 dBm (CW RMS)
≥120 MHz	+33 dBm (CW RMS)

Input Return Loss (VSWR)

Frequency	Preamp Disabled	Preamp Enabled, Auto
100 kHz to <500 MHz	13.5 (1.51:1)	13.5 (1.51:1)
500 MHz to <1.2 GHz	15.0 (1.43:1)	13.5 (1.51:1)
1.2 GHz to <3.8 GHz	15.0 (1.43:1)	15.0 (1.43:1)
3.8 GHz to <4.2 GHz	15.0 (1.43:1)	13.5 (1.51:1)
4.2 GHz to <5.8 GHz	15.0 (1.43:1)	15.0 (1.43:1)
5.8 GHz to 6.0 GHz	13.5 (1.51:1)	13.5 (1.51:1)

Table 27. Input Return Loss (dB) (Voltage Standing Wave Ratio), Typical

RF OUT

Connector	SMA (female)
Output impedance	50 Ω, nominal, AC coupled

Absolute maximum reverse power

<120 MHz	+24 dBm (CW RMS)
≥120 MHz	+33 dBm (CW RMS)

Output Return Loss (VSWR)

Frequency	Typical
100 kHz to <500 MHz	12.0 (1.67:1)
500 MHz to <2.8 GHz	17.0 (1.33:1)
2.8 GHz to <4.5 GHz	14.5 (1.46:1)
4.5 GHz to <5.8 GHz	16.0 (1.38:1)
5.8 GHz to 6.0 GHz	15.0 (1.43:1)

Table 27. Output Return Loss (dB) (Voltage Standing Wave Ratio), Typical

LO OUT (RF IN and RF OUT)

Connectors	MMPX (female)
Frequency range	120 MHz to 6 GHz
Output power	0 dBm ± 2 dB, typical
Output power resolution[25]	0.25 dB, nominal
Output impedance	50 Ω, nominal, AC coupled

Output return loss

120 MHz to 2 GHz	>15 dB (VSWR < 1.43:1), nominal
>2 GHz to 6 GHz	>12 dB (VSWR < 1.67:1), nominal

LO IN (RF IN and RF OUT)

Connectors	MMPX (female)
Frequency range	120 MHz to 6 GHz
Input power range[26]	-4 dBm to 0 dBm, nominal
Input impedance	50 Ω, nominal, AC coupled

Input return loss (LO IN Enabled)

120 MHz to 2 GHz	>20 dB (VSWR <1.22:1), nominal

>2 GHz to 6 GHz	>15 dB (VSWR <1.43:1), nominal
Input return loss (LO IN Disabled) 120 MHz to 6 GHz	>18 dB (VSWR <1.22:1), nominal
Absolute maximum input power	+15 dBm
Maximum DC voltage	±5 VDC

REF IN

Connector	MMPX (female)
Frequency	10 MHz
Tolerance[27]	$\pm 10 \times 10^{-6}$
Amplitude[28]	0.7 $V_{pk\text{-}pk}$ to 3.3 $V_{pk\text{-}pk}$ into 50 Ω, typical
Input impedance	50 Ω, nominal
Coupling	AC

REF OUT

Connector	MMPX (female)
Frequency[29]	10 MHz, nominal
Amplitude	1.65 $V_{pk\text{-}pk}$ into 50 Ω, nominal

Output impedance	50 Ω, nominal
Coupling	AC

PFI 0

Connector	MMPX (female)
Voltage levels[30]	
Absolute maximum input range	-0.5 V to 5.5 V
V_{IL}, maximum	0.8 V
V_{IH}, minimum	2.0 V
V_{OL}, maximum	0.2 V with 100 µA load
V_{OH}, minimum	2.9 V with 100 µA load
Input impedance	10 kΩ, nominal
Output impedance	50 Ω, nominal
Maximum DC drive strength	24 mA

DIGITAL I/O

Connector	Molex Nano-Pitch I/O
5.0 V Power	±5%, 50mA maximum, nominal

Signal	Type	Direction
MGT Tx± <3..0>	Xilinx Virtex-7 GTH	Output
MGT Rx± <3..0>	Xilinx Virtex-7 GTH	Input
MGT REF±	Differential	Input
DIO <1..0>[31]	Single-ended	Bidirectional
DIO <7..2>	Single-ended	Bidirectional
5.0 V	DC	Output
GND	Ground	—

Table 29. DIGITAL I/O Signal Characteristics

Digital I/O Single-Ended Channels

Number of channels	8
Signal type	Single-ended
Voltage families	3.3 V, 2.5 V, 1.8 V, 1.5 V, 1.2 V
Input impedance	
DIO <1..0>	10 kΩ, nominal
DIO <7..2>	100 kΩ, nominal
Output impedance	50 Ω, nominal
Direction control	Per channel
Minimum required direction change latency	200 ns
Maximum output toggle rate	60 MHz with 100 µA load, nominal

Voltage Family	V_{IL} Max	V_{IH} Min	V_{OL} Max (100µA load)	V_{OH} Min (100µA load)	Maximum DC Drive Strength
3.3 V	0.8 V	2.0 V	0.2 V	3.0 V	24 mA
2.5 V	0.7 V	1.6 V	0.2 V	2.2 V	18 mA
1.8 V	0.62 V	1.29 V	0.2 V	1.5 V	16 mA
1.5 V	0.51 V	1.07 V	0.2 V	1.2 V	12 mA
1.2 V	0.42 V	0.87 V	0.2 V	0.9 V	6 mA

Table 29. DIGITAL I/O Single-Ended DC Signal Characteristics[32]

Digital I/O High Speed Serial MGT[33]

Data rate	500 Mbps to 12 Gbps, nominal
Number of Tx channels	4
Number of Rx channels	4
I/O AC coupling capacitor	100 nF

MGT Tx± <3..0> Channels

Minimum differential output voltage[34]	800 mV_{pk-pk} into 100 Ω, nominal

MGT Rx± <3..0> Channels

Differential input voltage range	
≤ 6.6 GB/s	150 $mV_{pk\text{-}pk}$ to 2000 $mV_{pk\text{-}pk}$, nominal
> 6.6 GB/s	150 $mV_{pk\text{-}pk}$ to 1250 $mV_{pk\text{-}pk}$, nominal
Differential input resistance	100 Ω, nominal

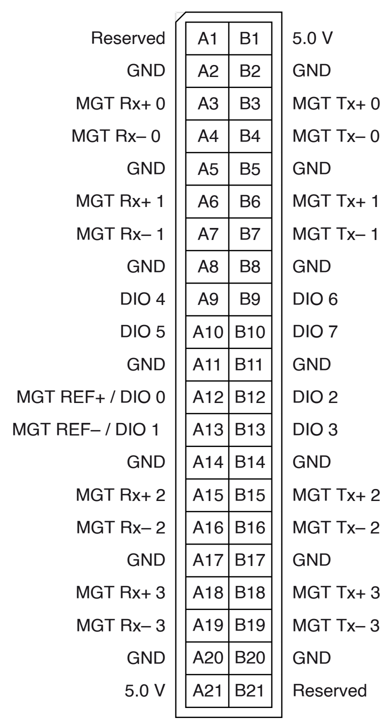
MGT Reference Clock

Clocking Resources	
Internal MGT reference[35]	78.125 MHz to 625 MHz
Data Clock	156.25 MHz
MGT REF± Input	60 MHz to 820 MHz, nominal

MGT REF± Input

AC coupling capacitors	100 nF
Differential input resistance	100 Ω, nominal
Differential input $V_{pk\text{-}pk}$ range	350 mV to 2000 mV, nominal
Absolute maximum input range	-1.25 V to 4.5 V[36]

Figure 24. DIGITAL I/O Nano-Pitch Connector



Power Requirements

Voltage (V_{DC})	Typical Current (A)
+3.3	3.3
+12	5.8
Power is 80 W, typical. Consumption is from both NI PXI Express backplane power connectors. Conditions: Simultaneous generation and acquisition using NI-RFSG and NI-RFSA at 1.25 GS/s IQ rate, 45 °C ambient temperature. Power consumption depends on FPGA image being used.	

Table 30. Power Requirements

Calibration

Interval	1 year

Note For the two-year calibration interval, add 0.2 dB to one year specifications for RF Input Absolute Amplitude Accuracy, RF Input Frequency Response, RF Output Power Level Accuracy, and RF Output Frequency Response.

Physical Characteristics

PXIe-5840 module	2U, two slot, PXI Express module 4.1 cm × 12.9 cm × 21.1 cm (1.6 in. × 5.6 in. × 8.3 in.)
Weight	794 g (28.0 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 45 °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 4 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.)

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} (Tested in accordance with IEC 60068-2-64.)
Nonoperating	5 Hz to 500 Hz, 2.4 g_{rms} (Tested in accordance with IEC 60068-2-64. Test profile exceeds the requirements of MIL-PRF-28800F, Class 3.)

Compliance and Certifications

Safety Compliance Standards

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
- CAN/CSA-C22.2 No. 61010-1

Note For UL and other safety certifications, refer to the product label or the Product Certifications and Declarations 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.

Note For EMC declarations, certifications, and additional information, refer to the Product Certifications and Declarations section.

CE Compliance CE

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

2014/30/EU; Electromagnetic Compatibility Directive (EMC)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, 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.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

[1] Tuning resolution combines LO step size capability and frequency shift DSP implemented on the FPGA.

[2] Larger step sizes in integer mode improves phase noise performance.

[3] Conditions: Measured Port: LO OUT; Reference Clock: internal, phase noise spurs not shown.

[4] Constant RF input signal, varying input reference level.

[5] The maximum offset is limited to within the equalized bandwidth of the referenced LO Frequency.

[6] dBr is relative to the full scale of the configured RF reference level.

[7] The Input Bandwidth describes the occupied bandwidth of the input signal centered at the center frequency.

[8] Average output power ≥ -100 dBm.

[9] Varying RF output power range.

[10] RF Front end configured to maximum +5 dBm (<120 MHz) and +15 dBm (120 MHz to 6 GHz). Signal level attenuated digitally.

[11] The maximum offset is limited to within the equalized bandwidth of the referenced LO Frequency.

[12] Output Bandwidth describes the occupied bandwidth of the generated signal centered at the center frequency.

[13] Image performance degrades for center frequencies greater than 5.9 GHz for reference levels above 0 dBm.

[14] Conditions: 20 MHz bandwidth 64-QAM modulated signal. Pulse-shape filtering: root-raised cosine, alpha=0.25; PXIe-5840 RF Input reference level: 0 dBm, LO Offset: 10 MHz; PXIe-5840 RF Output average power level: -5 dBm; Reference Clock source: Onboard; acquisition length: 300 µs.

[15] Conditions: RF Output loopback to RF Input; waveform bandwidth: 80 MHz; MCS Index: 11; 16 OFDM Symbols; 10 Packet Averages; LO Offset: -250 MHz; device instantaneous bandwidth: 1 GHz; RF Output power level: -15 dBm; External LO: PXIe-5653. Channel Estimation Method is Preamble.

[16] Conditions: RF Output loopback to RF Input; waveform bandwidth: 80 MHz; MCS Index: 11; LO Offset: -250 MHz; device instantaneous bandwidth: 1 GHz; External LO: PXIe-5653. Channel Estimation Method is Preamble.

[17] Conditions: RF Output loopback to RF Input; waveform bandwidth: 80 MHz; MCS Index: 11; LO Offset: -250 MHz; device instantaneous bandwidth: 1 GHz; RF Output power level: -15 dBm. Channel Estimation Method is Preamble.

[18] Conditions: RF Output loopback to RF Input; waveform bandwidth: 80 MHz; MCS index: 11; LO Offset: -250 MHz; device instantaneous bandwidth: 1 GHz; carrier frequency: 5.5 GHz.

[19] Conditions: RF Output loopback to RF Input; MCS Index: 9; 16 OFDM Symbols; 10 Packet Averages; LO Offset: -250 MHz; device instantaneous bandwidth: 500 MHz; RF Output power level: 0 dBm; Internal LO.

[20] Conditions: RF Output loopback to RF Input; MCS Index: 9; LO Offset: -250 MHz; device instantaneous bandwidth: 500 MHz; RF Output power level: 0 dBm; Internal LO.

[21] Conditions: RF Output loopback to RF Input; Single LTE channel; LO Leakage Avoidance disabled.

[22] Conditions: RF Output loopback to RF Input; Single WCDMA channel; LO Leakage Avoidance enabled

[23] I/Q data rates lower than 1.25 GS/s are achieved using fractional decimation.

[24] I/Q data rates lower than 1.25 GS/s are achieved using fractional interpolation.

[25] Output power resolution refers to the RF attenuator step size used to compensate for the LO output frequency response.

[26] The PXIe-5840 supports receiving an external LO with a range of signal power levels. To properly configure the PXIe-5840 LO signal path for the provided level, set NIRFSA_ATTR_LO_IN_POWER or NIRFSG_ATTR_LO_IN_POWER.

[27] **Frequency Accuracy** = **Tolerance** × **Reference Frequency**

[28] Jitter performance improves with increased slew rate of input signal.

[29] Refer to the Internal Frequency Reference section for accuracy.

[30] Voltage levels are guaranteed by design through the digital buffer specifications.

[31] Pins are multiplexed with MGT REF±.

[32] Voltage levels are guaranteed by design through the digital buffer specifications.

[33] For detailed FPGA and High Speed Serial Link specifications, refer to Xilinx documentation.

[34] When transmitter output swing is set to the maximum setting.

[35] Internal MGT Reference is derived from the Sample Clock PLL. Available frequencies are 2.5 GHz / **N**, where $4 \le N \le 32$. Set via MGT component level IP (CLIP).

[36] Absolute maximum levels at input, prior to AC coupling capacitors.