Ettus USRP X440 Specifications

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Key Specifications

RF capabilities	8 TX, 8 RX, independently tunable Direct sampling transceiver 30 MHz to 4 GHz Up to 1.6 GHz bandwidth per channel Up to 3.2 GHz aggregated bandwidth per USRP
Processing system (PS)	Quad Core ARM Cortex-A53 (1200 MHz) 4 GB DDR4
Programmable logic (PL)	FPGA: RFSoC ZU28DR 2 × 4 GB DDR4
Software	UHD version 4.5 or later RFNoC GNU Radio C/C++ Python OpenEmbedded Linux on A53

Synchronization	REF IN (clock reference input) PPS IN (PPS time reference) TRIG IN/OUT GPSDO included OCXO included Sync In Port (for future use)
Digital interfaces	2 QSFP28 (10/100 GbE) Ethernet (1 GbE to PS) 2 USB-C (USB to PS, Console/JTAG) 2 HDMI (GPIO)
Power, form factor	12 V DC, 16 A maximum Half-wide RU 28.5 cm × 22.2 cm × 4.4 cm

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.
- ***Nominal*** specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are ***Characteristics*** unless otherwise noted.

Conditions

Unless otherwise noted, these specifications are valid under the following conditions:

- Converter Rate 2.94912 GSps
- Master Clock Rate 368.64 MHz
- FPGA Bitfile X440_X4_400
- IQ Mode
- UHD 4.5
- 23 °C ± 5 °C

Controller

Processing System

CPU	Quad Core ARM Cortex-A53 (1200 MHz)
Memory	4 GB DDR4, 2.4 GT/s
NVM	16 GB eMMC (Pseudo SLC)
RJ45	1 GbE host connection
USB-C	USB to PS (USB 2.0) USB Console/JTAG

Programmable Logic

FPGA	Xilinx RFSoC XCZU28DR Speed Grade -2
Memory	2 × 4 GB DDR4, 2.4 GT/s
SD-FEC	8 dedicated SD-FEC cores
QSFP28	2 × 4 lanes 10/100 GbE
GPIO	2 HDMI 12 I/O lines per connector Maximum data rate 100 Mbps Selectable I/O voltage (3.3 V, 2.5 V, or 1.8 V)
Trigger	SMA: Trigger In/Out (3.3 V I/O voltage)

DRAM Performance

Note The Replay Block allows users to record and playback RF data using the onboard DRAM. DRAM capabilities were validated with the maximum allowed Master Clock Rate for shipping bitfiles.

FPGA Bitfile	DRAM Throughput at 16-bit I/Q Samples	Application
X440_X4_400	8 channels at ~450 MSps each	Simultaneous Record and Playback

FPGA Bitfile	DRAM Throughput at 16-bit I/Q Samples	Application
	6 channels at 500 MSps each	Simultaneous Record and Playback
	8 channels at 500 MSps each	Record or Playback
X440_X4_1600	2 channels at 2 GSps each	Simultaneous Record and Playback

Baseband

Maximum I/Q sample rates[1]	2 GSps
Number of available channels	Up to 8
ADC resolution	12 bit
DAC resolution	14 bit

Transmitter

Number of channels	Up to 8
Analog frequency range	30 MHz to 4 GHz
Frequency step	< 1 Hz
Maximum output power[2]	0 dBm
TX/RX settling time	0.3 µs
Maximum instantaneous real-time bandwidth	Up to 1.6 GHz

1. The applicable maximum value depends on the Master Clock Rate selected in software.
2. Maximum output power varies by selected Master Clock Rate and frequency.

TX phase noise, 1 GHz carrier frequency, 23 °C, nominal	
1 kHz offset	-96 dBc/Hz
10 kHz offset	-114 dBc/Hz
100 kHz offset	-114 dBc/Hz

TX Measurements

Note The following figures depict the average TX Maximum Output Power and TX EVM based on two units with 16 channels total measured.

Figure 1. TX Maximum Output Power: 0 dBFS CW, 1 GSps Converter Rate, 0 Hz Waveform Frequency

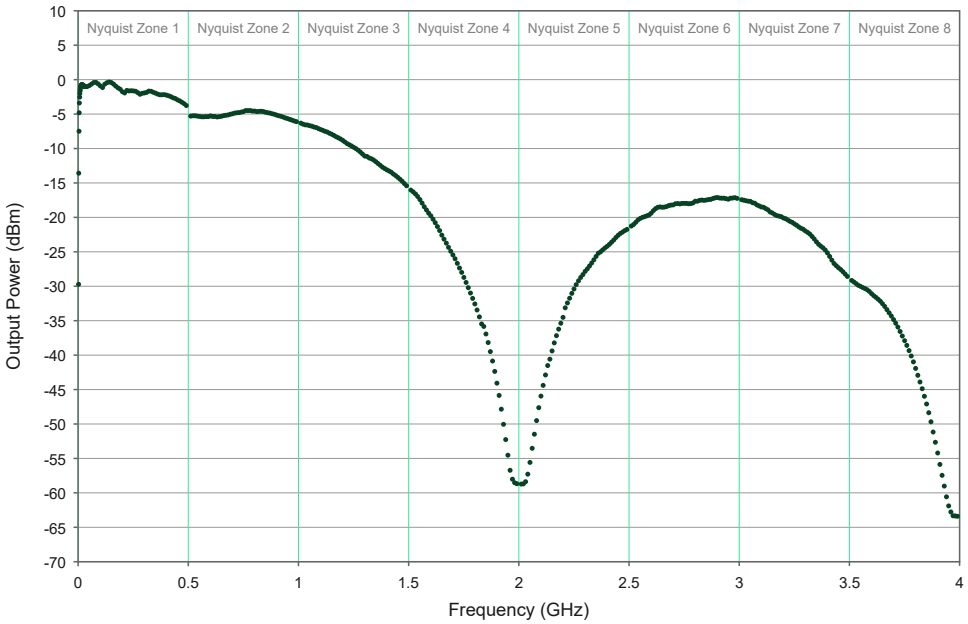


Figure 2. TX Maximum Output Power: 0 dBFS CW, 2.94912 GSps Converter Rate, 0 Hz Waveform

Frequency

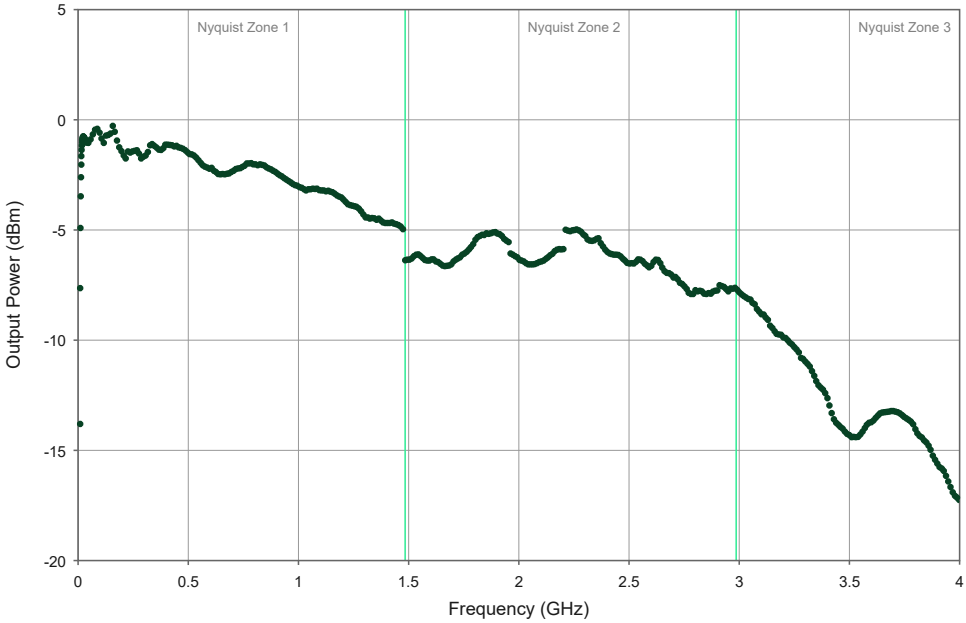
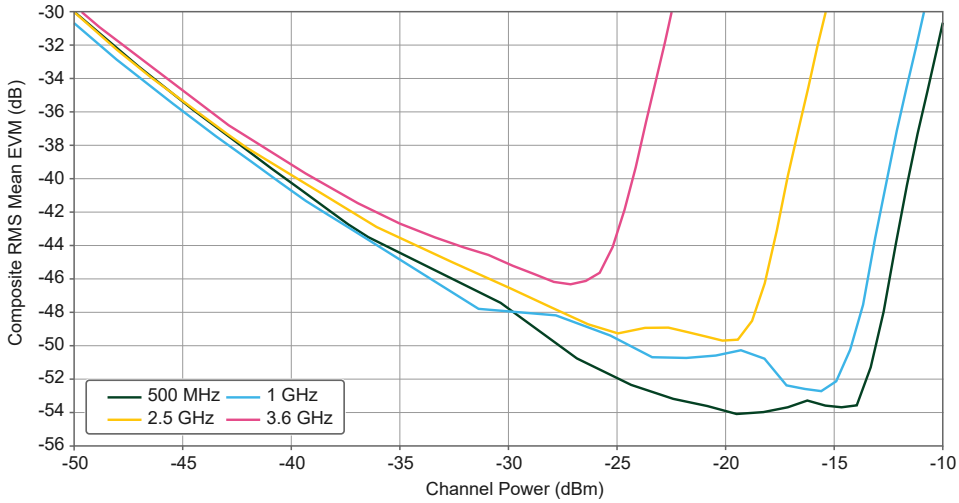


Figure 3. TX EVM Bathtub Curves: 5GNR, UL, FDD, SISO, 100 MHz BW, 30 kHz SCS, 256 QAM



Note The following tables depict the isolation performance of the transmitter based on two units with a total of 16 channels at 23°C. The transmitter channel was set to 0 dBFS. Minimum represents the worst performing channel-to-channel combination measured. Average represents the mean value of all channel-to-channel combinations measured.

TX-TX Isolation

Frequency	Minimum	Average	Units
500 MHz	69	108	dBc
2 GHz	58	103	
3.5 GHz	49	92	

TX-RX Isolation

Frequency	Minimum	Average	Units
500 MHz	74	88	dBc
2 GHz	61	80	
3.5 GHz	51	68	

Receiver

Number of channels	Up to 8
Analog frequency range	30 MHz to 4 GHz
Frequency step	< 1 Hz
Maximum instantaneous real-time bandwidth	Up to 1.6 GHz
Maximum input power, damage level	
< 2.5 GHz	+13 dBm continuous
2.5 GHz – 3.6 GHz	+17 dBm continuous

3.6 GHz – 4 GHz	+20 dBm continuous

RX Measurements

Note The following figures depict the average RX input power to reach 0 dBFS and RX EVM based on two units with a total of 16 channels measured.

Figure 4. RX Input Power to Reach 0 dBFS: CW Input

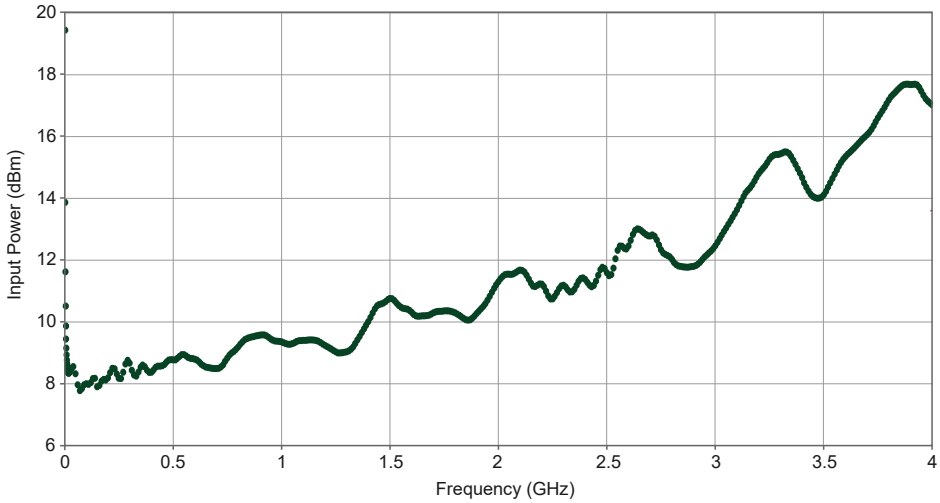
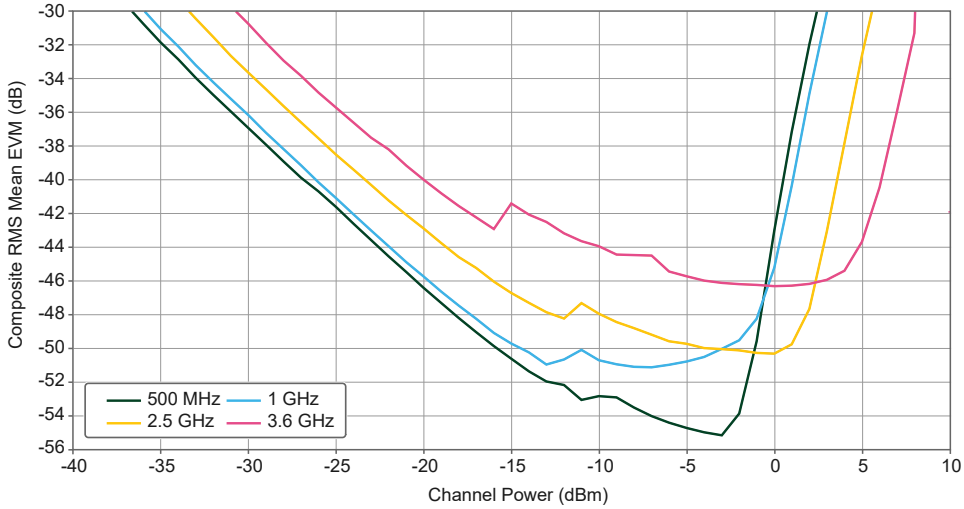


Figure 5. RX EVM Bathtub Curves: 5GNR, UL, FDD, SISO, 100 MHz BW, 30 kHz SCS, 256 QAM



Note The following tables depict the isolation performance of the receiver based on two units with 16 channels total measured at 23°C. The input power of the source channel was kept at a level of -2 dBFS. Minimum represents the

> worst performing channel-to-channel combination measured. Average represents the mean value of all channel-to-channel combinations measured.

RX-TX Isolation

Frequency	Minimum	Average	Units
500 MHz	93	117	dBc
2 GHz	83	107	
3.5 GHz	72	116	

RX-RX Isolation

Frequency	Minimum	Average	Units
500 MHz	71	95	dBc
2 GHz	56	93	
3.5 GHz	55	99	

Phase Coherency

Measurement Conditions

Master Clock Rate [Hz]	Converter Rate [GSps]	Carrier Frequency [GHz]	FPGA Bitfile
125e6	1	0.8	X440_X4_400
307.2e6	2.4576	1.69	X440_X4_400
360e6	2.88	1.95	X440_X4_400
368.64e6	2.94912	2.4	X440_X4_400
400e6	3.2	2.6	X440_X4_400
500e6	4	2.75	X440_X4_400
1000e6	4	3	X440_X4_1600

Master Clock Rate [Hz]	Converter Rate [GSps]	Carrier Frequency [GHz]	FPGA Bitfile
2000e6	4	3	X440_X4_1600

Configured Baseband Stimulus	
Wideband Signal	Carrier frequency in the second Nyquist Zone
Duration (Phase Stability)	2 hours
Iterations (Phase Repeatability)	100 times
Configuration	
Same Device	Stimulus simultaneously transmitted and received at up to four channels on the same USRP
Device-to-Device	Stimulus simultaneously transmitted and received at up to four channels on a separate USRP
Synchronization	
Shared 10 MHz Square Wave Reference	Sourced from OctoClock-G CDA-2990
Shared PPS	Sourced from OctoClock-G CDA-2990

Note The following table depicts channel-to-channel phase stability. Stability was measured on two units with up to eight channels total (up to four channels each) measured at 23°C after device warmup.

TX Phase Stability

Master Clock Rate [Hz]	Same Device		Device-to-Device	
	Peak-to-Peak [deg]	RMS [deg]	Peak-to-Peak [deg]	RMS [deg]
125e6	< 1	< 0.2	< 2	< 0.35
307.2e6	< 1.7	< 0.35	< 3.5	< 0.55
360e6	< 2	< 0.35	< 4	< 0.65
368.64e6	< 2.6	< 0.4	< 5	< 0.8
400e6	< 2.6	< 0.45	< 5.3	< 0.85
500e6	< 2.5	< 0.45	< 5.5	< 0.85
1000e6	< 1	< 0.15	< 3.8	< 0.6
2000e6	< 0.8	< 0.15	< 4	< 0.6

RX Phase Stability

Master Clock Rate [Hz]	Same Device		Device-to-Device	
	Peak-to-Peak [deg]	RMS [deg]	Peak-to-Peak [deg]	RMS [deg]
125e6	< 0.15	< 0.1	< 1.5	< 0.2
307.2e6	< 0.15	< 0.1	< 2.5	< 0.35
360e6	< 0.25	< 0.1	< 2.5	< 0.4
368.64e6	< 0.5	< 0.1	< 3.5	< 0.5
400e6	< 0.4	< 0.1	< 3.5	< 0.55
500e6	< 0.3	< 0.1	< 3.5	< 0.6
1000e6	< 0.35	< 0.1	< 4	< 0.6
2000e6	< 0.35	< 0.1	< 4	< 0.6

Phase Repeatability

Note The following table depicts channel-to-channel phase repeatability. Repeatability was measured on one unit with up to eight channels total measured at 23 °C after device warmup.

Note Within the device, the phase relationship between channels is repeatable over sessions, retunes, and reboots. Across multiple devices, the phase relationship between channels is not preserved over retunes and reboots.

Master Clock Rate [Hz]	Same Device [TX]	Same Device [RX]
	Peak-to-Peak [deg]	Peak-to-Peak [deg]
125e6	< 1.15	< 0.45
307.2e6	< 2	< 0.7
360e6	< 2.8	< 0.5
368.64e6	< 2.8	< 1
400e6	< 2.6	< 1.6
500e6	< 2.8	< 1
1000e6	< 2.5	< 0.5
2000e6	< 1.8	< 0.5

GPS Disciplined Oscillator (GPSDO)

Frequency accuracy[3]	
OCXO (not locked to GPS)[4]	2.5 ppm
OCXO (locked to GPS)	5 ppb

3. ***Frequency accuracy*** is based on oven-controlled crystal oscillator (OCXO) vendor specifications and is not measured. Alternatively, you can incorporate an external reference source to provide a

Active antenna	
Voltage	3.3 V
Power	0.19 W
Frequency band(s)	L1, C/A 1.574 GHz

Power

Notice The protection provided by this product may be impaired if it is used in a manner not described in this document.

Voltage rating	12 V
Frequency rating	DC
Current/power rating	3 A to 16 A (bitfile dependent)
Power supply	190 W, minimum

Caution The product must be powered with an AC adapter offered by NI that meets the power requirements for the product and has appropriate safety certification marks for country of use.

Physical Characteristics

Dimensions

Enclosure	26.7 cm × 22.2 cm × 4.4 cm (10.5 in. × 8.7 in. × 1.7 in.)
Enclosure and connectors	28.5 cm × 22.2 cm × 4.4 cm (11.2 in. × 8.7 in. ×

more precise frequency Reference Clock and to achieve better frequency accuracy.

4. Factory default accuracy. Contact NI if your application requires tuning the OCXO output frequency.

	1.7 in.)
Weight	2.7 kg (6 lb)

Ventilation Clearance and Cooling

This product is designed to operate on a bench or in an instrument rack. Fan vents are located at the back of the product. Standard airflow provision of the product is set up as front to back cooling with option to change the airflow direction in the interest for directing back to front cooling using a fan cartridge accessory.

Adequate clearance is required at the front and back of the product and surrounding equipment, inclusive of indiscriminate heat generating devices, and any potential air flow blockages must be maintained to ensure proper cooling.

Minimum cooling clearances	51 mm (2 in.) at the front and back

Note Benchtop and rack mount applications may require additional cooling clearances for optimal airflow and to reduce any unexpected hot air recirculation in either direction of the air inlet fans.

Environment

Environmental Characteristics

Operating temperature range	0 °C to 55 °C
Storage temperature range	-40 °C to 71 °C
Maximum altitude	2,000 m (800 mbar) (at 25 °C ambient temperature)
Operating humidity range	10% to 90%, noncondensing
Storage humidity range	5% to 95%, noncondensing
Pollution Degree	2

Environmental Standards

This product meets the requirements of the following environmental standards for electrical equipment.

- IEC 60068-2-1 Cold
- IEC 60068-2-2 Dry heat
- IEC 60068-2-78 Damp heat (steady state)
- IEC 60068-2-64 Random vibration
- IEC 60068-2-27 Shock

Note To verify marine approval certification for a product, refer to the product label or visit ***ni.com/certification*** and search for the certificate.

Shock and Vibration

Operating vibration	5 Hz to 500 Hz, 0.3 g RMS
Non-operating vibration	5 Hz to 500 Hz, 2.4 g
RMS operating shock	30 g, half-sine, 11 ms pulse
Non-operating shock	50 g, half-sine, 11 ms pulse