X440

Contents

When you receive a brand-new device, it is strongly recommended that you download the most recent filesystem image from the Ettus Research website and write it to the NI Ettus USRP X4x0. Instructions on downloading the latest filesystem image and writing it to the X4x0 are described in the **USRP X4x0 Getting Started Guide**.

Note that if you are operating the device in Network Mode, then the versions of UHD running on the host computer and on the NI Ettus USRP X4x0 device must match.

The NI Ettus USRP X440 is the widest bandwidth USRP software defined radio device. It differs architecturally from most USRPs, utilizing a direct sampling architecture that provides balun-coupled access to the ADCs and DACs on the onboard Xilinx Zynq RFSoC. This makes it well suited to use as an intermediate frequency transceiver, connecting to external front ends for applications like satellite communications (SATCOM) prototyping, SATCOM ground station deployment, and mmWave or sub-THz 6G research. USRP X440 features high channel density ? 8 Tx and 8 Rx channels per device ? with phase coherency across channels by sharing sample clocks. Therefore, it is ideal for applications like direction finding and radar research and prototyping.

- High channel density
- Reliable and fault-tolerant deployment
- Stand-alone (embedded) or host-based (network streaming) operation
- Fully integrated and assembled (the USRP X440 does not support swappable daughtercards)
- 30 MHz to 4 GHz frequency range (tunable down to 1MHz)
- Up to 1600 MHz of instantaneous bandwidth per channel on 2 channels; up to 400 MHz IBW on 8 channels
- 8 RX, 8 TX in half-wide RU form factor
- Xilinx Zynq-Ultrascale+ ZU28DR RFSoC
- 12 bit ADC, 14 bit DAC
- IQ Sample Clock rates up to 2000 MS/s
- Onboard SD-FEC, DDC, DUC
- Quad-core ARM Cortex-A53 up to 1.2 GHz CPU
- Dual-core ARM Cortex-A5 MPCore up to 500 MHz
- Two QSFP28 ports (10 Gigabit Ethernet, 100 Gigabit Ethernet)
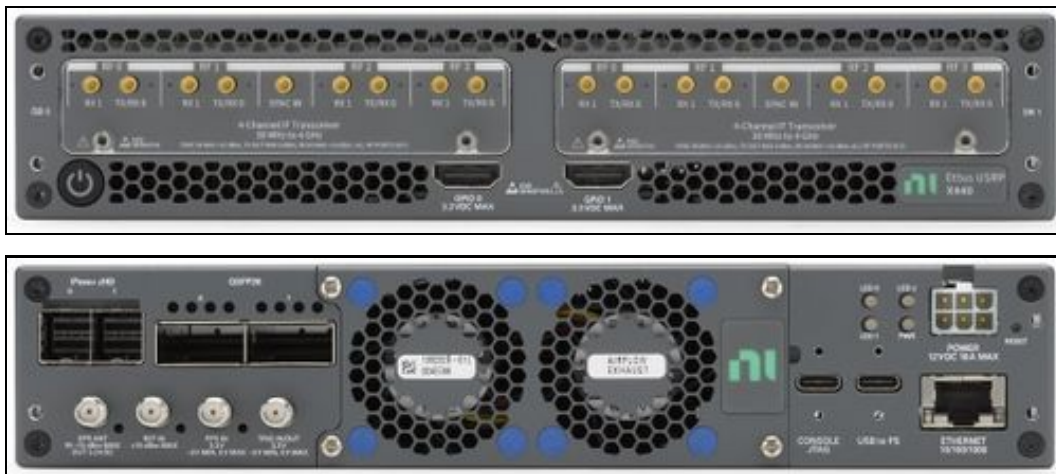- RJ45 (1 GbE)
- 10 MHz Clock reference

- PPS time reference
- Trig In/Out Interface
- Built-in GPSDO
- Two FPGA Programmable GPIO Interfaces (HDMI)
- 1 Type C USB host port
- 1 Type C USB port (serial console, JTAG)
- Watchdog timer
- OpenEmbedded Linux
- USRP Hardware Driver? (UHD) open-source software API version 4.5.0 or later
- RF Network on Chip (RFNoC?) FPGA development framework
- Xilinx Vivado® 2021.1 Design Suite (license not included)
- GNU Radio support maintained by Ettus Research? through GR-UHD, an interface to UHD distributed by GNU Radio

- Current Hardware Revision: Module revision D and Motherboard revision F
- Minimum version of UHD required: 4.5.0
- USRP X440 is covered by Export Administration Regulations (EAR) NS2. Refer to US Department of Commerce for details and country chart.

https://www.ni.com/docs/en-US/bundle/ettus-usrp-x440-specs/page/specs.html https://github.com/EttusResearch/uhd/releases/tag/v4.5.0.0

If you want any CAD / STP models beyond those found here, please send an email to Ettus Support at support@ettus.com noting your request and your use case for any such model. We will determine on a case-by-case basis whether we have any such requested model and, if so, whether to release it -- possibly requiring an NDA for any such release. Note that we do not have models on all USRPs and daughterboards, and requesting any model does not guarantee that either Ettus Research or NI will honor any such request.

The Verilog code for the FPGA in the NI Ettus USRP X4x0 is open-source, and users are free to modify and customize it for their needs. However, certain modifications may result in either bricking the device, or even in physical damage to the unit. Specifically, changing the I/O interface of the FPGA in any way, or modifying the pin and timing constraint files, could result in physical damage to other components on the motherboard, external to the FPGA, and doing this will void the warranty. Also, even if the PCIe interface is not being used, you cannot remove or reassign these pins in the constraint file. The constraint files should not be modified. Please note that modifications to the FPGA are made at the risk of the user, and may not be covered by the warranty of the device.

An external 10 MHz reference clock may be used. The optimal signal is a square wave as created by the OctoClock/CDDA-2990. The input signal power level of the reference clock must not exceed +15 dBm.

Using a PPS signal for timestamp synchronization requires a square wave signal (a typical PPS signal has a 20%-25% duty cycle) with a 5 Vpp amplitude.

To test the PPS input, you can use the following tool from the UHD examples:

- `<args>` are device address arguments (optional if only one USRP device is on your machine)

```
cd <install-path>/lib/uhd/examples ./test_pps_input ?args=<args>
```

- https://files.ettus.com/manual/page_x400_gpio_api.html#x4x0gpio_fpanel

- https://kb.ettus.com/USRP_X410/X440_Getting_Started_Guide#Autoboot
- https://files.ettus.com/manual/page_usrp_x4xx.html#x4xx_usage_rearpanelleds_power

For datasheet, drawings, pricing, and purchasing please search for the Part Number listed below via https://www.ni.com/en-us/search.html

- Dual 100 Gigabit Ethernet PCIe Interface Kit For Ettus USRP X4xx
    - Part Number: 788216-01

- USRP X4xx Power Supply, 100-240VAC 50/60HZ 12VDC 24AMP
    - Part Number: 788204-01

- QSFP28 To 4xSFP28 Breakout Cable, 1M
    - Part Number: 788214-01

- QSFP28 Twinaxial Cable, 3M
    - Part Number: 788215-03

- USRP X4xx 19" Rack Mount Accessory, 1U, 2 USRP X4xx Devices, Shoulder to Shoulder
    - Part Number: 788147-01

- USRP X4xx Desktop Stack Accessory, Single USRP X4xx Device Fastened Buildup
    - Part Number: 788148-01

- USRP X4xx 19" Rack Mount Accessory, 1U, 1 USRP X4xx Device, w/Surrogate Extension
    - Part Number: 788149-01

- GPIO Communication Cable
    - SHH19-H19-AUX Shielded Single-Ended Cable, 1M
        - ◊ Part Number: 152629-01
    - SHH19-H19-AUX Shielded Single-Ended Cable, 2M
        - ◊ Part Number: 152629-02

- SCB-19 Noise Rejecting, Shielded Aux I/O Connector
    - Part Number: 782444-01

- Fan Replacement Cartridges
    - USRP X4xx Fan Cartridge Accessory, Exhaust
        - ◊ Part Number: 788164-01
    - USRP X4xx Fan Cartridge Accessory, Intake
        - ◊ Part Number: 788165-01

Recommended 10 Gigabit Ethernet Cards

- Dual 10 Gigabit Ethernet Interface for Ettus USRP
    - ni.com part number 788600-01
- Intel X710-DA2
    - Intel® Ethernet Converged Network Adapter X710-DA2
- Intel X710-DA4
    - Intel® Ethernet Converged Network Adapter X710-DA4

- Requires UHD 4.5 or later:?https://github.com/EttusResearch/uhd/releases/tag/v4.5.0.0
- 100GbE Streaming only supports Linux Hosts

Recommended 100 Gigabit Ethernet Cards

- Mellanox/NVIDIA ConnectX-5 EX 100 GbE NIC (MCX516A-CDAT (PCIe Gen4 x16))

Recommended 100 Gigabit Ethernet Cables

- Mellanox/NVIDIA 3m QSFP28 MCP1600-C003E26N
    - Shorter length variants also recommended

Recommended Host PC

- At least 32 CPU Cores
- At least 64 GB RAM
- Ubuntu 20.04 (5.13.0-44-generic)

Validated Hardware and Software Configuration Examples

- Ubuntu 20.04 (5.13.0-44-generic kernel), DPDK 20.11, with AMD Ryzen Threadripper 3960X 24-Core Processor - 48 CPU - 3.6 GHz CPU freq - 64 GB RAM. Mellanox/NVIDIA ConnectX-5 EX 100 GbE NIC (MCX516A-CDAT (PCIe Gen4 x16)). Mellanox/NVIDIA 3m QSFP28 MCP1600-C003E26N cables.

Data Throughput Rates

Testing was completed with the following conditions

- Hardware and Software Configurations listed above
- CPU configured for performance mode: https://kb.ettus.com/USRP_Host_Performance_Tuning_Tips_and_Tricks#CPU_Governor
- DPDK Setup: https://files.ettus.com/manual/page_dpdk.html and https://kb.ettus.com/Getting_Started_with_DPDK_and_UHD#UHD_4.0
- Enabling Tx pause Frames on X4x0 for the SFP port(s) utilized for streaming:
    https://files.ettus.com/manual/page_transport.html#transport_udp_linux
    - `ethtool -A sfp0 tx on`
    - `ethtool -A sfp1 tx on`

- uhd.conf: See https://files.ettus.com/manual/page_dpdk.html#dpdk_nic_config

Executing benchmark_rate over multiple iterations as well as over an extended continuous time period (>12 Hours) without data loss resulted in the following maximum rates and channel counts

- Usage of the `--priority` argument set to `high` in benchmark_rate which requires benchmark rate to be executed with root privileges via `sudo`
- Usage of single versus multiple threads in the benchmark_rate utility - controlled by using the `--multi_streamer` argument. Specifying this argument assigns one thread per channel being streamed.
- Utilizing the CG_400 and CG_1600 bitfile.

- CG_400
  - Dual Port DPDK
    - 6 Rx @ 500 MS/s
    - 8 Rx @ 400 MS/s
    - 6 Tx @ 500 MS/s
    - 8 Tx @ 450 MS/s
    - 4 Rx + 4 Tx @ 500 MS/s
    - 8 Rx + 8 Tx @ 250 MS/s
- CG_1600
  - Dual Port DPDK
    - 2 Rx @ 1000 MS/s
    - 2 Tx @ 1800 MS/s
    - 2 Rx + 2 Tx @ 1000 MS/s

All testing was done using dual 100GbE ports. For a single port, expect around half the number of channels as compared to the dual port equivalent configuration at the same streaming rate.

Ettus Research currently offers direct-connect, copper cabling accessories for the NI Ettus USRP X4x0. However, it is also possible to use multi-mode fiber instead of copper connections for these devices. In this section, we will provide general guidance on the types of fiber adapters and cables that can be used with these products.

The NI Ettus USRP X4x0 is compatible with most brands of SFP+ fiber adapters. In some cases, other equipment in the systems such as 1/10/100 Gigabit Ethernet switches are only compatible with specific brands of SFP+ adapters and cables. As a general rule, we recommend checking compatibility with the switches and network cards in your system before purchasing an adapter.

Ettus Research does test the NI Ettus USRP X4x0 devices with the listed hardware as noted in the above section
https://kb.ettus.com/X440#100_Gigabit_Ethernet

As of December 1st, 2010 all Ettus Research products are RoHS compliant unless otherwise noted. More information can be found at
http://ettus.com/legal/rohs-information

Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation

Chinese Customers

National Instruments is in compliance with the Chinese policy on the Restriction of Hazardous Substances (RoHS) used in Electronic Information Products. For more information about the National Instruments China RoHS compliance, visit ni.com/environment/rohs_china.

Certifications will soon be findable on the NI Product Certifications lookup tool.

The Letter of Volatility Link.

FPGA Resources

UHD Stable Binaries

UHD Source Code on Github