X410

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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 X410. Instructions on downloading the latest filesystem image and writing it to the X410 is described in the USRP X410 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 X410 device must match.

The NI Ettus USRP X410 is a high-performance, multi-channel software defined radio. The SDR is designed for frequencies from 1 MHz to 7.2 GHz, tunable up to 8 GHz and features a two-stage superheterodyne architecture with 4 independent TX and RX channels capable of 400 MHz of instantaneous bandwidth each. Digital interfaces for data offload and control include two QSFP28 interfaces capable of 100 GbE[1], a PCIe Gen3 x8 [3] interface, as well standard command, control, and debug interfaces: USB-C JTAG, USB-C console, Ethernet 10/100/1000. The USRP X410 is an all-in-one device built on the Xilinx Zynq Ultrascale+ ZU28DR RF System on Chip (RFSoC) with built-in digital up and down conversion and onboard Soft-Decision Forward Error Correction (SD-FEC) IP.

- High channel density
- Reliable and fault-tolerant deployment
- Stand-alone (embedded) or host-based (network streaming) operation
- Fully integrated and assembled (the USRP X410 does not support swappable daughtercards)
- 1 MHz to 7.2 GHz frequency range (tunable up to 8GHz)
- Up to 400 MHz of instantaneous bandwidth per channel
- 4 RX, 4 TX in half-wide RU form factor
- Xilinx Zynq-Ultrascale+ ZU28DR RFSoC
- 12 bit ADC, 14 bit DAC
- IQ Sample Clock rates up to 500 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, Aurora)
- Two iPass+? zHD® Interfaces (PCIe Gen3 x 8)
- RJ45 (1 GbE) [1]
- 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 4.1.0 or later
- RF Network on Chip (RFNoC?) FPGA development framework
- Xilinx Vivado® 2019.1 Design Suite (license not included)
- GNU Radio support maintained by Ettus Research? through GR-UHD, an interface to UHD distributed by GNU Radio
- [1] The RJ45 port is used for remote management of the device and does not support IQ streaming.

https://www.ni.com/pdf/manuals/378493a.pdf

- Current Hardware Revision: Module revision E and Motherboard revision G
- Minimum version of UHD required: 4.1.0.5

https://github.com/EttusResearch/uhd/releases/tag/v4.1.0.5

For detailed design files such as schematics and certain other more in-depth USRP documentation submit a request via the Support Request Manager.

The Verilog code for the FPGA in the NI Ettus USRP X410 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 5Vpp 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_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

- Intel X710-DA2
    - Intel® Ethernet Converged Network Adapter X710-DA2
- Intel X710-DA4
    - Intel® Ethernet Converged Network Adapter X710-DA4

- Requires UHD 4.2 or later: https://github.com/EttusResearch/uhd/releases/tag/v4.2.0.0
- 100GbE Streaming only supports Linux Hosts

Recommended 100 Gigabit Ethernet Bundles

- Dual 100 Gigabit Ethernet PCIe Interface Kit, NIC and Cable
    - ni.com part number 788216-01

Recommended 100 Gigabit Ethernet Cards

- Mellanox/NVIDIA ConnectX-5 EX 100 GbE NIC (MCX516A-CCAT (PCIe Gen3 x16))
- 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 15 CPU Cores
- At least 32 GB RAM
- Ubuntu 20.04 (5.4.0-89-generic kernel)

Validated Hardware and Software Configuration Examples

- Ubuntu 20.04 (5.4.0-89-generic kernel), DPDK 19.11, with Intel(R) Core(TM) i9-10920X CPU @ 3.50GHz - 24 CPU - 4.8 GHz Max CPU freq - 64 GB RAM. Mellanox/NVIDIA ConnectX-5 EX 100 GbE NIC (MCX516A-CCAT (PCIe Gen3 x16)). Mellanox/NVIDIA 3m QSFP28 MCP1600-C003E26N cables.

- Ubuntu 20.04 (5.4.0-89-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 X410 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 bitfile which does not include DUC/DDC resampling thus supports only rates of 491.52 MS/s and 500 MS/s

- Dual Port DPDK
    - 4 Rx + 4 Tx @ 491.52 MS/s
    - 4 Rx @ 491.52 MS/s
    - 4 Tx @ 491.52 MS/s
- Single Port DPDK
    - 2 Rx + 2 Tx @ 491.52 MS/s
    - 4 Rx @ 491.52 MS/s

        - 3 Tx @ 491.52 MS/s
- Dual Port Non-DPDK
        - 1 Rx + 1 Tx @ 491.52 MS/s
        - 4 Rx @ 491.52 MS/s
        - 2 Tx @ 491.52 MS/s
- Single Port Non-DPDK
        - 1 Rx + 1 Tx @ 491.52 MS/s
        - 3 Rx @ 491.52 MS/s
        - 2 Tx @ 491.52 MS/s

Ettus Research currently offers direct-connect, copper cabling accessories for the NI Ettus USRP X410. 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 X410 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 X410 devices with the listed hardware as noted in the above section https://kb.ettus.com/X410#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.

Found on the NI Product Certifications lookup tool here.

FPGA Resources

UHD Stable Binaries

UHD Source Code on Github