Product Brochure

NI Ettus USRP Software Defined Radios

Contents

USRP Software Defined Radios

USRP X4xx, USRP-2974, USRP-295x, USRP-294x, USRP-293x, USRP-292x, USRP-290x

- 1 MHz to 7.2 GHz frequency ranges (tunable up to 8 GHz)
- Up to 1.6 GHz/channel of bandwidth
- Up to eight transmit and eight receive channels per radio
- Local oscillator import/export synchronization
- GPS disciplined oscillator (GPSDO)

- Development tools such as LabVIEW, open-source UHD, GNU Radio, MathWorks MATLAB® software
- OS support in Windows, Linux, and OS X
- FPGA development using LabVIEW FPGA and RF Network on Chip (RFNoC) framework
- Onboard ARM and x86 processor available on some models
- Communication interfaces such as USB, Gigabit Ethernet, and PCI Express

Software Defined Radios for Any Use Case

The NI USRP (Universal Software Radio Peripheral) is a suite of fully user-programmable software defined radios (SDRs) that combine general-purpose processors, field-programmable gate arrays (FPGAs), and RF front-ends so that you rapidly can design, prototype, and deploy wireless systems. From low-cost, to high-performance, to rugged deployable, to multichannel, the NI USRP is the most popular and versatile SDR available.

Software is central to SDRs, and the NI USRP product line's roots lie in the designs of Ettus Research, an NI brand, since 2010. Whether you are a long-time LabVIEW programmer or you prefer open-source development tools, use the NI USRP product line to rapidly get up and going to build your custom wireless application. The NI USRP supports the popular GNU Radio framework with its open-source driver, USRP Hardware Driver (UHD).

Beyond software flexibility, with the NI USRP product line, you can take simulated inline digital signal processor (DSP) code and target it to the FPGA for real-time processing. You can do this with a prebuilt digital infrastructure using both LabVIEW FPGA and the powerful RF Network on Chip (RFNoC) framework compatible with popular open-source workflows.

NI Ettus Research SDR Hardware

From DC to 7.2 GHz, up to 1.6 GHz of real-time bandwidth, powerful DSP-focused FPGAs, and form factors ranging from handheld devices to high-channel-count systems, NI SDRs can meet your needs from design to deployment. Ettus Research provides detailed product information for B Series, N Series, E Series, and X Series devices at ettus.com.

NI Ettus USRP X440

The latest in performance in the X4 Series lineup, USRP X440 contains a Zynq UltraScale+ RFSoC, 8x8 MIMO, and up to 1.6 GHz per channel of bandwidth. It supports open-source software only.

NI Ettus USRP X410

The high-performance USRP X410 features a wide frequency range of 1 MHz to 7.2 GHz and a bandwidth of 400 MHz. Capable of 4x4 MIMO and including a powerful Zynq UltraScale+ RFSoC, the USRP X410 supports both LabVIEW and open-source software.

X310 Series/ USRP RIO

These high-performance PCI Express, 10 Gigabit Ethernet devices include a powerful Kintex-7 FPGA, a 2x2 MIMO transceiver, and up to 160 MHz of bandwidth. They support both LabVIEW and open-source software.

B Series/ USRP 290x

Cost-effective USB SDRs with a wide frequency range, these compact-form-factor devices offer up to 15 MHz of streaming bandwidth and support both LabVIEW and open-source software.

E Series

Conduction-cooled, portable, and stand-alone SDRs, these contain a Zynq System-on-Chip (SoC), a 2x2 MIMO transceiver, and 56 MHz of bandwidth. Compatible with open-source software only.

N Series

These high-performance, stand-alone SDRs contain a Zynq SoC, 2x2 MIMO, and up to 128 x 128 phase synchronous systems. They offer 200 MHz of bandwidth and are compatible with open-source software only.

Stand-Alone SDR

High-performing SDRs with an onboard processor and FPGA for stand-alone applications, these offer up to 160 MHz of bandwidth, and MIMO capability. They support both LabVIEW and open-source software.
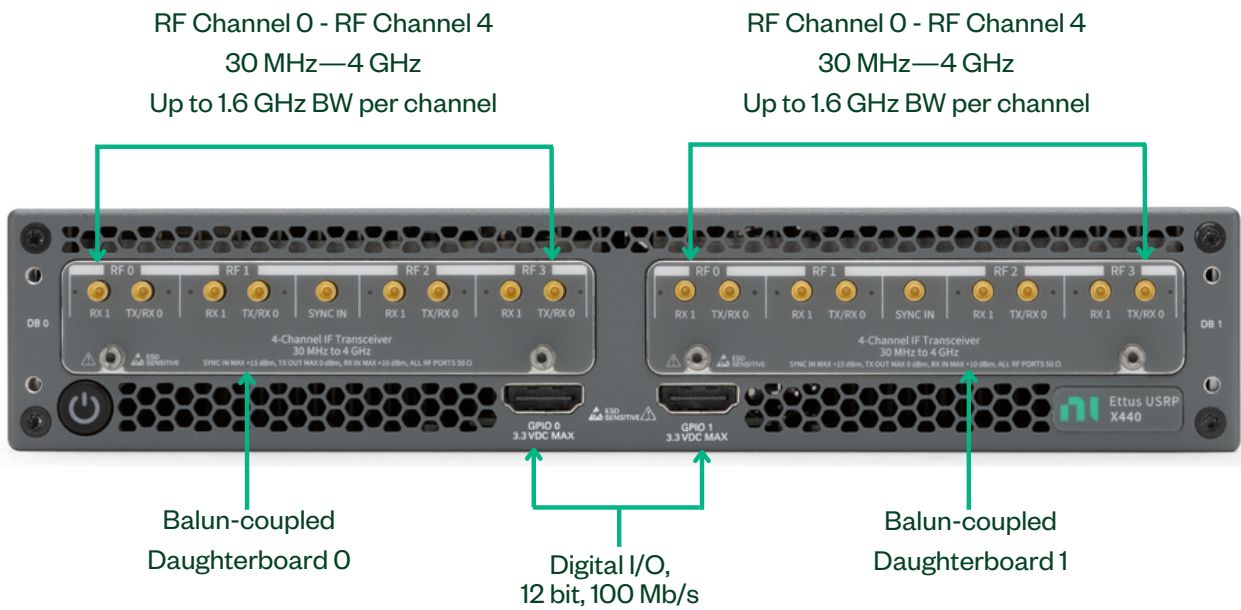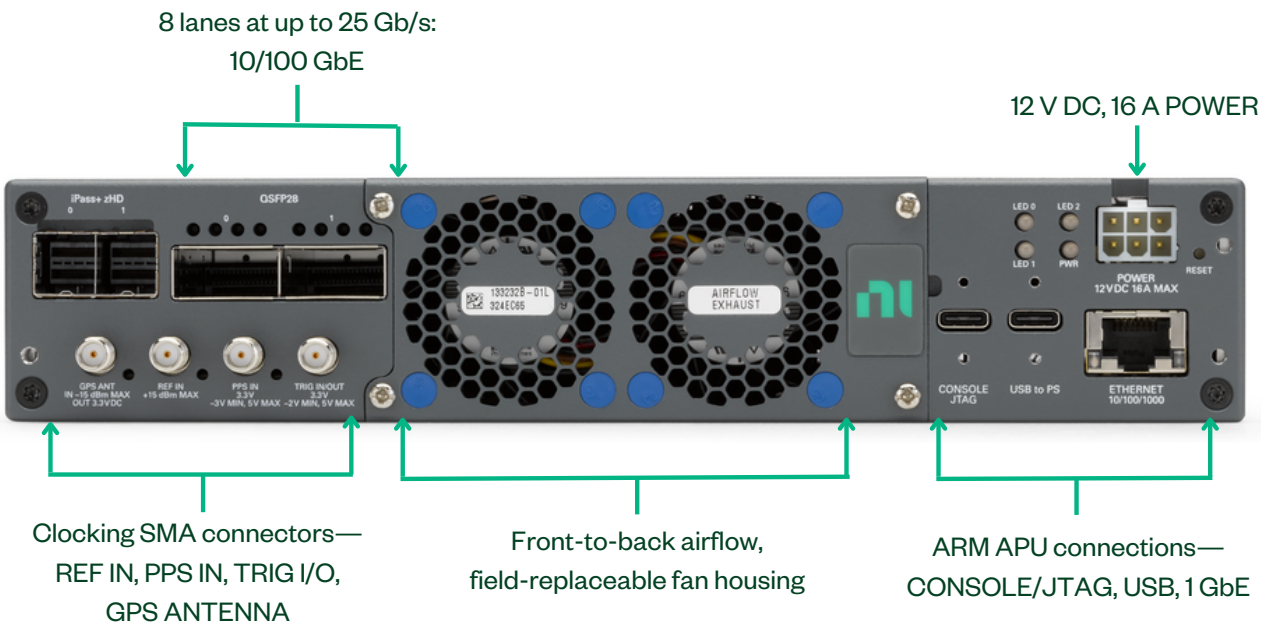
Table 1. The NI and Ettus Research USRP Family

NI USRP Model	Ettus Research Model	Frequency Range	Bandwidth	Transmitter/ Receiver Channels	Features
	USRP X440	30 MHz to 4 GHz	Up to 1.6 GHz	8 TX/8 RX	RFSoC-Based, Wideband, Multi-channel
	USRP X410	1 MHz to 7.2 GHz	400 MHz	4 TX/4 RX	
USRP-2974	n/a	10 MHz to 6 GHz	160 MHz	2 TX/2 RX	Stand-Alone, Intel Core i7 Processor
USRP-2955	X310 +TwinRX + GPSDO	10 MHz to 6 GHz	80 MHz	0 TX/4 RX	Configurable RF Front End, Programmable FPGA
USRP-2954	X310 + UBX + GPSDO	30 MHz to 6 GHz	160 MHz	2 TX/2 RX	
USRP-2953	X310 + CBX + GPSDO	1.2 GHz to 6 GHz	40 MHz/120 MHz	2 TX/2 RX	
USRP-2952	X310 + SBX + GPSDO	400 MHz to 4.4 GHz	40 MHz/120 MHz	2 TX/2 RX	
USRP-2950	X310 + WBX + GPSDO	50 MHz to 2.2 GHz	40 MHz/120 MHz	2 TX/2 RX	
USRP-2945	X310 + TwinRX	10 MHz to 6 GHz	80 MHz	0 TX/4 RX	
USRP-2944	X310 + UBX	10 MHz to 6 GHz	160 MHz	2 TX/2 RX	
USRP-2943	X310 + CBX	1.2 GHz to 6 GHz	40 MHz/120 MHz	2 TX/2 RX	
USRP-2942	X310 + SBX	400 MHz to 4.4 GHz	40 MHz/120 MHz	2 TX/2 RX	
USRP-2940	X310 + WBX	50 MHz to 2.2 GHz	40 MHz/120 MHz	2 TX/2 RX	
n/a	N321 / N320	3 MHz to 6 GHz	200 MHz	2 TX/2 RX	Stand-Alone, Wide Bandwidth, Multi-channel Sync Ready (N32x)
n/a	N310	10 MHz to 6 GHz	100 MHz	4 TX/4 RX	
n/a	N300	10 MHz to 6 GHz	100 MHz	2 TX/2 RX	
USRP-2932	N210 + SBX + GPSDO	400 MHz to 4.4 GHz	20 MHz	1 TX/1 RX	Low SWaP-C, Stand-Alone
USRP-2930	N210 + WBX + GPSDO	50 MHz to 2.2 GHz	20 MHz	1 TX/1 RX	
USRP-2922	N210 + SBX	400 MHz to 4.4 GHz	20 MHz	1 TX/1 RX	
USRP-2921	N210 + XCVR2450	2.4 GHz to 2.5 GHz, 4.9 GHz to 5.9 GHz	20 MHz	1 TX/1 RX	
USRP-2920	N210 + WBX	50 MHz to 2.2 GHz	20 MHz	1 TX/1 RX	
USRP-2901	B210	70 MHz to 6 GHz	56 MHz	2 TX/2 RX	Low SWaP-C, Highly Portable
USRP-2900	B200	70 MHz to 6 GHz	56 MHz	1 TX/1 RX	
n/a	E310 / E312 / E313 / E320	70 MHz to 6 GHz	56 MHz	2 TX/2 RX	Stand Alone, Low SWaP, Embedded Deployable

USRP X440 Detailed View

NI USRP X440 Front Panel

RF Channel 0 - RF Channel 4
30 MHz—4 GHz
Up to 1.6 GHz BW per channel

RF Channel 0 - RF Channel 4
30 MHz—4 GHz
Up to 1.6 GHz BW per channel

Balun-coupled
Daughterboard 0

Digital I/O,
12 bit, 100 Mb/s

Balun-coupled
Daughterboard 1

NI USRP X440 Back Panel

8 lanes at up to 25 Gb/s:
10/100 GbE

12 V DC, 16 A POWER

Clocking SMA connectors—
REF IN, PPS IN, TRIG I/O,
GPS ANTENNA

Front-to-back airflow,
field-replaceable fan housing

ARM APU connections—
CONSOLE/JTAG, USB, 1 GbE

Key Features

Scalable, Multichannel Synchronized Systems

Use the NI USRP synchronization features to expand your RF channel count for phase-synchronous and massive multiple-input, multiple-output (MIMO) applications. Configure your multichannel system with shared reference clocks, triggers, and GPS synchronization using the GPSDO available on many units. Many models also have the option of Ethernet-based synchronization using the 'White Rabbit' standard. Or design a more advanced system for true phase-coherent operation using USRP N320/N321 local oscillator export, distribution, and import features.

For tight multidevice synchronization, you can share up to eight clocks using the 8-Channel Clock Distribution Accessory, or CDA-2990. This device accepts an external 10 MHz clock and a pulse per second (PPS) input signal and then amplifies and distributes each to eight output ports so that you can synchronize multiple modules to a common timing source. For systems with even higher channel counts, you can cascade multiple CDA-2990 devices. USRP users have built phase-coherent systems with up to 128 channels using this method.
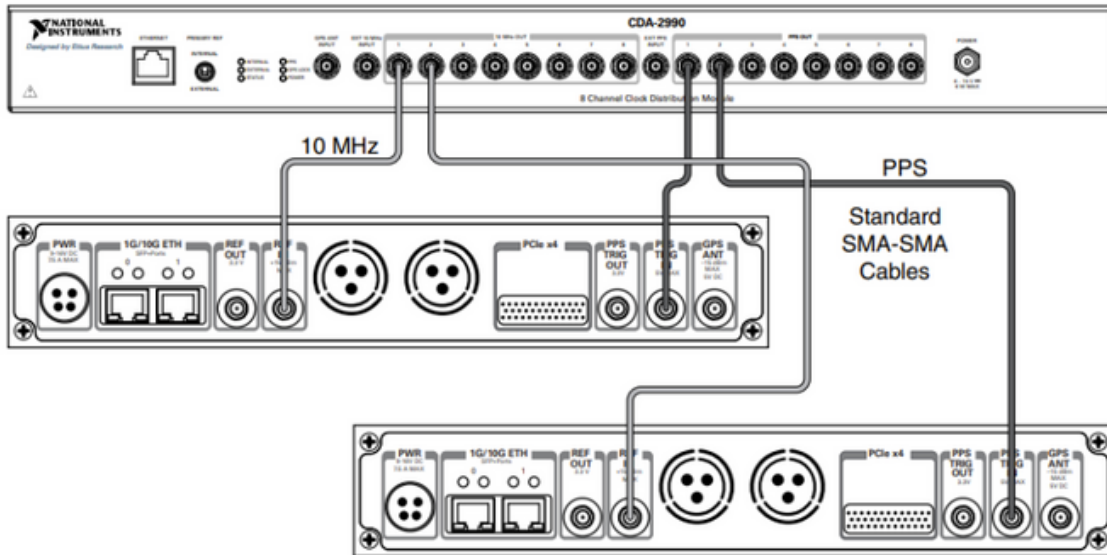

FIGURE 2

Synchronizing Multiple USRP Devices with the CDA-2990

FIGURE 3

University of Bristol and Lund University implemented the world's first 128-antenna, real time massive MIMO testbed using a combination of NI commercial-off-the-shelf hardware paired with LabVIEW software. Visit ni.com/Massive-MIMO to learn more about the solution.

Highly Portable, Highly Deployable

NI USRP SDRs offer a high level of performance while equally maintaining a high level of portability and deployability due to their small form factor. By combining the NI USRP driver with LabVIEW or UHD in conjunction with open-source software such as GNU Radio, and the ability to program to a flexible FPGA framework such as RFNoC, users can access the total RF and digital signal processing (DSP) power that these SDRs have to offer. The benefits and flexibility that NI USRPs offer make them ideal for emerging defense applications such as drone defense.

FIGURE 4

SkySafe has developed a system to defend against the growing threat of low-cost drones. Visit ni.com/SkySafe-Defeats-Commercial-Drone-Threats to learn more about the system that SkySafe developed utilizing the NI Ettus X310.

Wide Frequency Ranges and Bandwidths for More Applications

Demand for wide bandwidths and faster transmission rates over longer distances is growing. Wideband operations have become common in many applications, from military use in surveillance, radar, and EW prototyping to commercial use for cellular communications, Wi-Fi, and navigation. NI USRP SDRs feature many bandwidth options, varying from 20 MHz on the USRP N210 up to 1.6 GHz featured on the USRP X440.

The USRP X440 meets the growing need for wider bandwidth while operating over the ranges of 30 MHz to 4 GHz on a total of eight channels (TX/RX). Utilizing UHD in combination with RFNoC to program the onboard FPGA, users can conduct real-time spectral streaming with inline signal processing. With the ability to independently configure each channel, you can tune channels to different frequencies to monitor a greater proportion of the spectrum, or the same frequency for phase coherent acquisition or generation.

The USRP X440's wide bandwidth means that you can capture a broader spectrum when conducting signals intelligence or spectrum monitoring systems. Researchers can experiment with new radar or 5G NR algorithms that utilize wide bands for higher resolution or higher data rates, respectively. And because the direct sampling architecture is prepared for integration with external RF front ends, researchers can extend to higher frequencies for over-the-air mmWave communications or radar and EW testbeds.

Software Overview

Your Choice of Development Software

Regardless of your development tool preferences, USRP SDRs work with the broadest range of software workflows on the market. You can choose between two drivers—NI-USRP or USRP Hardware Driver (UHD)—based on your preferred development tools.

With NI-USRP, you can program your USRP SDR with LabVIEW, NI's flagship intuitive development environment, to rapidly develop measurement systems. You can program both the host and FPGA in a single development environment using the LabVIEW dataflow programming style. The abstracted design environment helps accelerate the design of wireless systems and makes FPGA programming accessible to those without HDL design expertise. If you have third-party IP that you want to incorporate, such as MathWorks MATLAB® or VHDL code, you can import this IP directly from LabVIEW. For a higher-level starting point, NI also offers LabVIEW Communications application frameworks for LTE, 802.11, and MIMO to accelerate application design.

UHD works with all USRP SDRs, and NI's R&D organization publishes it under open-source licenses. It facilitates application development on USRP SDRs in C/C++ and offers cross-platform support for several industry-standard development environments and frameworks, such as RFNoC, GNU Radio, Python, and MathWorks MATLAB and Simulink®. As an active leader in open-source SDR communities such as the GNU Radio Foundation, NI consistently works to further wireless communications research through the open-source ecosystem.

Table 2. NI-USRP Driver and Ettus Research UHD Overview

	NI-USRP	UHD
Operating System	Windows NI Linux Real-Time	Windows Linux Mac OS
Host	LabVIEW 20XX	GNU Radio C/C++ MATLAB®/Simulink®/Wireless Testbench™ Python
FPGA	LabVIEW FPGA Module	VHDL Verilog HDL Coder RFNoC (Open-Source FPGA Framework)

Programming the Host

The NI USRP product family works with the broadest range of software workflows on the market. You can choose between NI-USRP and USRP RIO drivers based on LabVIEW or the flexible, open-source tools with the UHD with GNU Radio, Python, and C++.
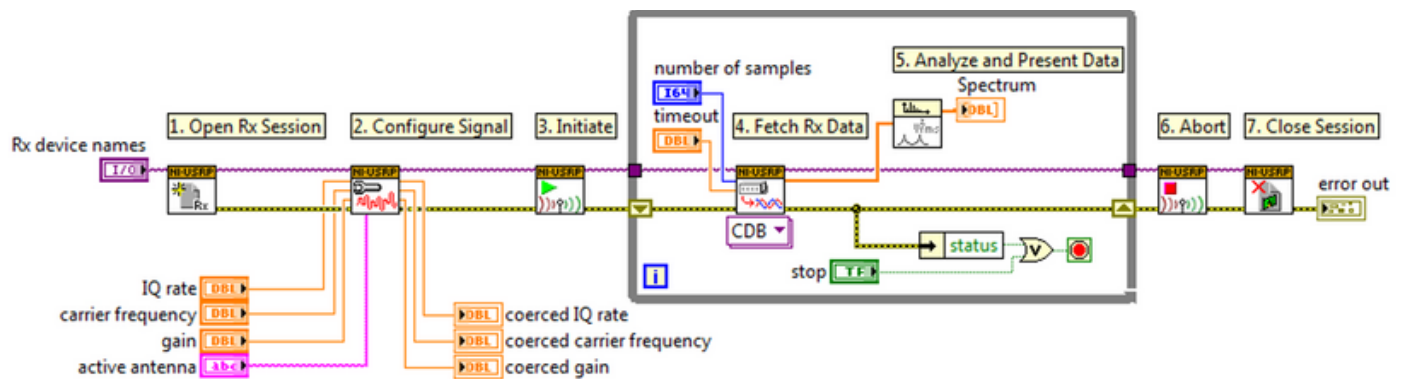

FIGURE 5

NI-USRP API for LabVIEW

Take Advantage of the Power of FPGA

As bandwidths widen and latency requirements grow more stringent, the ability to implement high-speed digital signal processing in real-time is essential. Many NI USRP models feature a large user-programmable FPGA for those wireless applications that require the highest-performance SDR. The NI USRP gives you multiple options to take advantage of the power of FPGA programming for high-speed signal processing, such as inline fast Fourier transforms (FFTs) or finite impulse response filters. Program your USRP with the LabVIEW FPGA and the USRP RIO driver for specific models using LabVIEW.
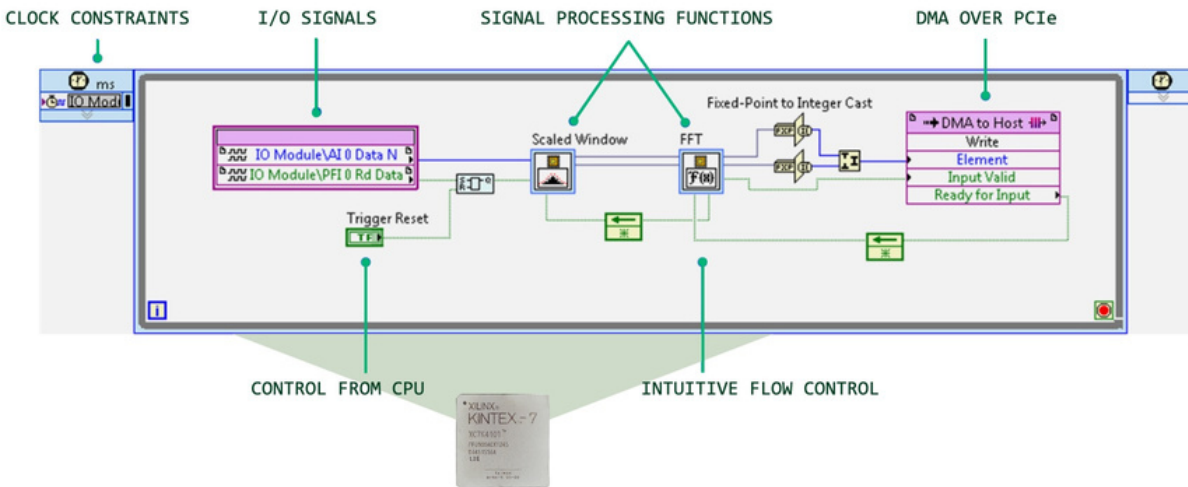

FIGURE 6

LabVIEW FPGA Graphical Abstraction of FPGA IP Integration

Get the most out of your USRP with the RF Network on Chip (RFNoC) framework—a prebuilt framework that gives you the infrastructure you need to build an SDR application with the FPGA—without having to develop the digital infrastructure and all—programmed with VHSIC Hardware Description Language and Verilog Hardware Description Languages with plug-ins for GNU Radio.

FIGURE 7

NI USRP RFNoC Framework
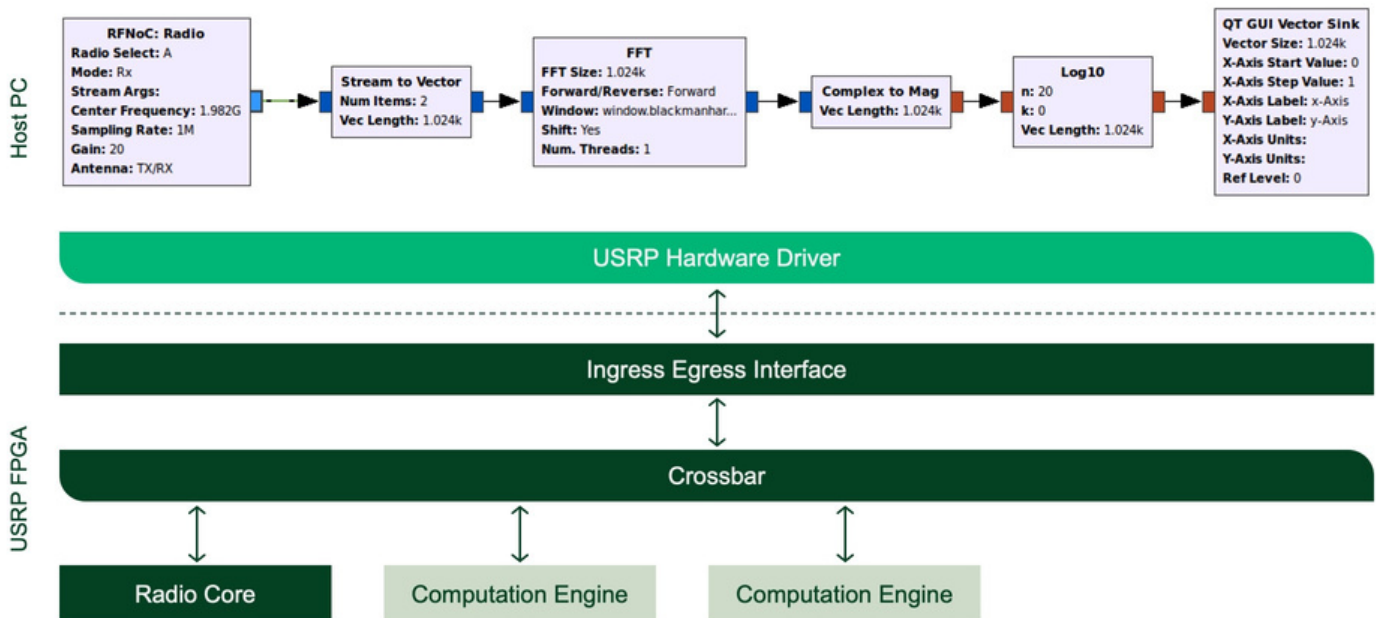
Supporting Documentation

Table 3. NI Ettus USRP Documentation

Document Type	Model #Number
Getting Started Guide	USRP X440, USRP X410, USRP-2974, USRP-295X, USRP-294X, USRP-293X, USRP-292X, USRP-290X
Specifications	USRP X440, USRP X410, USRP-2974, USRP-2955, USRP-2954, USRP-2953, USRP-2952, USRP-2950, USRP-2945, USRP-2944, USRP-2943, USRP-2942, USRP-2940, USRP-2932, USRP-2930, USRP-2922, USRP-2921, USRP-2920, USRP-2901, USRP-2900
Features	USRP X440, USRP X410, USRP-2974, USRP-2955, USRP-2954, USRP-2953, USRP-2952, USRP-2950 (40 MHz), USRP-2950 (120 MHz), USRP-2945, USRP-2944, USRP-2943, USRP-2942, USRP-2940, USRP-2932, USRP-2930, USRP-2922, USRP-2921, USRP-2920, USRP-2901, USRP-2900

NI Hardware Services

All NI hardware includes a one-year warranty for basic repair coverage and calibration in adherence to NI specifications prior to shipment. PXI systems also include basic assembly and a functional test. NI offers additional entitlements to improve uptime and lower maintenance costs with service programs for hardware. Learn more at ni.com/services/hardware.

	Hardware	Standard	Premium	Description
Duration at Point of Sale	1 year; included	3 years; optional	3 years; optional	NI enhances warranty coverage with additional service benefits provided with a hardware service program.
Maximum Duration with Renewal	≤3 Years w/ Service Program	≤3 Years	≤3 Years	NI maintains the high performance and availability of your hardware for up to three years with a hardware service program.
Extended Repair Coverage	•	•	•	NI restores your device's functionality and includes firmware updates and factory calibration within <10 working days [4] plus standard shipping time.
System Configuration, Assembly, and Test [1]		•	•	NI technicians assemble, install software in, and test your system per your custom configuration prior to shipment.
Advanced Replacement [2]			•	NI stocks replacement hardware that can be shipped immediately if a repair is needed.
System Return Material Authorization (RMA) [1]			•	NI accepts the delivery of fully assembled systems when performing repair services.
Technical Support	•	•	•	NI provides access to support resources for your hardware.
Calibration Plan (Optional)		Standard	Expedited [3]	NI performs the requested level of calibration at the specified calibration interval for the duration of the service program.

1 This option is only available for PXI, CompactRIO, and CompactDAQ systems.
2 This option is not available for all products in all countries. Contact your local NI sales engineer to confirm availability.
3 Expedited calibration is only available for the Traceable calibration level.
4 This applies to non-RF products only. Standard extended repair coverage for RF products is <15 working days plus standard shipping time.

PremiumPlus Service Program

NI can customize the offerings listed above or offer additional entitlements such as on-site calibration, custom sparing, and life-cycle services through a PremiumPlus Service Program. Contact your NI sales representative to learn more.

Technical Support

NI hardware service programs and warranty include access to technical support provided by NI Support Agents during local business hours. Service requests can be managed online. Additionally, take advantage of NI's award winning online resources and communities.

ni.com/usrp