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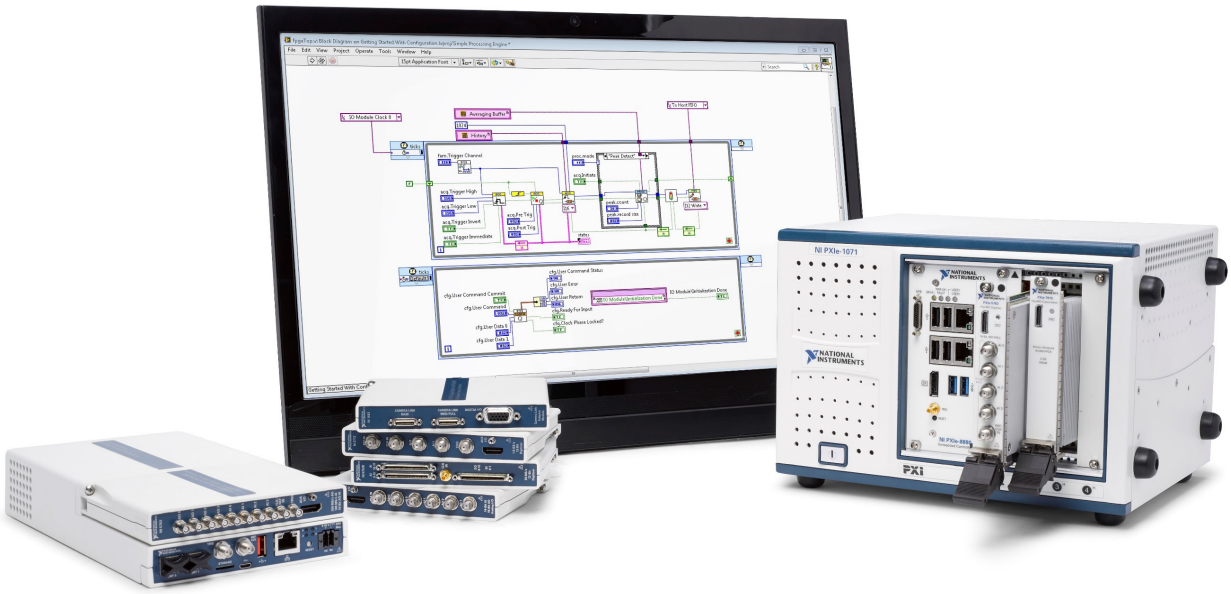
FlexRIO Custom Instrumentation

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FlexRIO Custom Instrumentation



- **Software:** Includes example programs for programming FPGAs with LabVIEW, Host APIs for LabVIEW and C/C++, I/O module specific shipping examples, and detailed help files
- LabVIEW-programmable Xilinx Kintex UltraScale, Kintex-7, and Virtex-5 FPGAs with up to 4 GB of onboard DRAM
- Analog I/O up to 3 GS/s, Digital I/O up to 1 Gbps, RF I/O up to 4.4 GHz
- Custom I/O with FlexRIO Module Development Kit (MDK)
- Data Streaming up to 7 GB/s and multi-module synchronization with NI-TClk

Custom Solutions Without Custom Design

The FlexRIO product line was designed for engineers and scientists who need the flexibility of custom hardware without the cost of custom design. Featuring large, user-programmable FPGAs and high-speed analog, digital, and RF I/O, FlexRIO provides a fully reconfigurable instrument that you can program graphically with LabVIEW or with VHDL/Verilog.

FlexRIO products are available in two architectures. The first architecture incorporates modular I/O modules that attach to the front of a PXI FPGA Module for FlexRIO and communicate over a parallel digital interface, and the second uses high-speed serial converters and features integrated I/O and Xilinx UltraScale FPGA technology in a single device.

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Target Applications

- Scientific and medical instrumentation
- RADAR/LIDAR
- Signals intelligence
- Communications
- Medical imaging
- Accelerator monitoring/control
- Automated test
- Custom protocol emulation

The Two FlexRIO Architectures

A key advantage of the FlexRIO product line is you can use the latest high-speed converter technologies before they are widely available in traditional commercial-off-the-shelf (COTS) instruments. This is particularly valuable in applications that continue to push requirements for sample rate, bandwidth, resolution, and channel count.

The original FlexRIO architecture relies on modular FlexRIO Adapter Modules that communicate with PXI FPGA Modules for FlexRIO over a wide, parallel digital interface capable of LVDS communication up to 1 Gbps on up to 66 differential pairs.

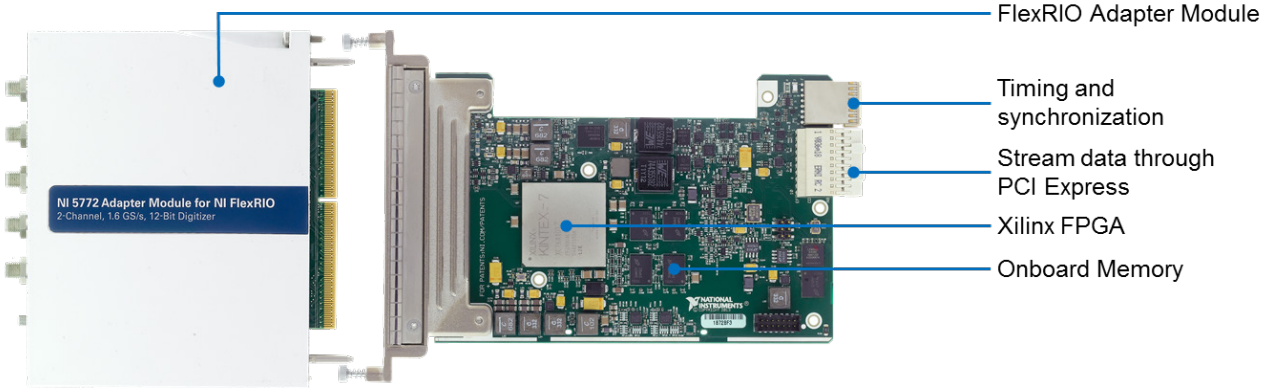


Figure 1. FlexRIO with modular I/O consists of a FlexRIO adapter module for analog, RF, or digital I/O, and a PXI FPGA Module for FlexRIO with LabVIEW-programmable Virtex-5 or Kintex-7 FPGAs.

While this architecture is well suited for digital interfacing and communication with converters over LVDS, converter technology is evolving to incorporate new standards. More specifically, converter manufacturers are moving toward high-speed serial interfaces for their highest performance parts to overcome common issues associated with parallel buses, including meeting static timing at higher clock rates.

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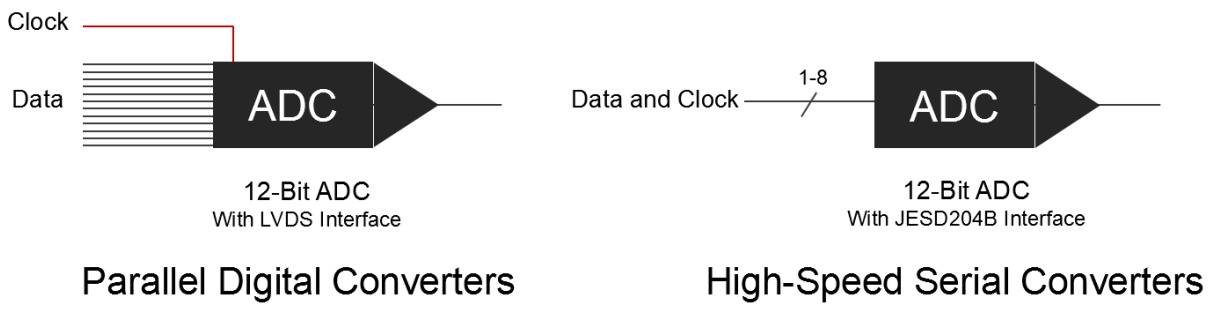


Figure 2. The original FlexRIO architecture was well suited for traditional converters with single-ended or LVDS interfaces for data communication. The new FlexRIO architecture was designed to interface with the industry's latest high-speed converters based on high-speed serial interfaces running protocols like JESD204B.

To stay ahead of this industry trend, a second FlexRIO architecture based on Xilinx UltraScale FPGAs and integrated I/O was created to support converters that leverage the JESD204B standard for data communication.

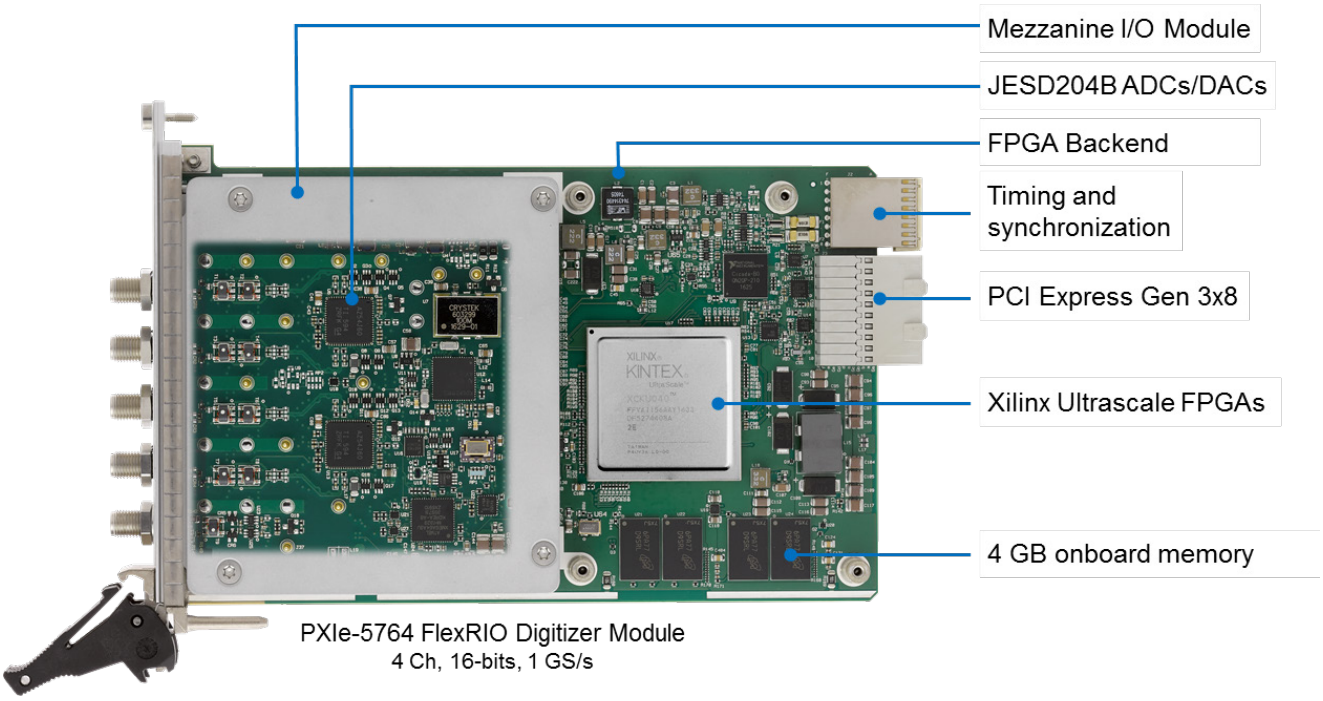


Figure 3. The new high-speed serial FlexRIO products are comprised of a mezzanine I/O module mated to a Xilinx UltraScale FPGA backend.

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FlexRIO With Integrated I/O

These FlexRIO modules consist of two integrated parts: mezzanine I/O module that contains high-performance analog-to-digital converters (ADCs), digital-to-analog converters (DACs), or high-speed serial connectivity, and an FPGA backend for user-defined signal processing. The mezzanine I/O module and FPGA backend communicate over a high-density connector that supports eight Xilinx GTH multigigabit transceivers, a dedicated GPIO interface for configuration of the I/O module, and several pins for routing clocks and triggers.

The products based on this architecture are identified by a model number corresponding to the mezzanine I/O module, and users can then choose the FPGA backend that best meets their requirements. For example, the PXIe-5764 is a 16-bit FlexRIO Digitizer that samples four channels simultaneously at 1 GS/s. You can pair the PXIe-5764 with one of the three FPGA backend options detailed in Table 1. The PXIe-5763 is another 16-bit FlexRIO Digitizer that samples four channels simultaneously at 500 MS/s, and the FPGA backend options are the same.

FPGA Backend Options

Table 1. When choosing a FlexRIO module with integrated I/O, you have a choice of three different FPGA backends, depending on the number of FPGA resources you need.

FPGA	LUTs/FFs	DSP48s	BRAM (Mb)	DRAM (GB)	PCIe	Aux I/O
Xilinx Kintex UltraScale KU035	406,245	1700	19	0	Gen 3 x8	8 GPIO
Xilinx Kintex UltraScale KU040	484,800	1920	21.1	4	Gen 3 x8	8 GPIO, 4 HSS
Xilinx Kintex UltraScale KU060	663,360	2760	38	4	Gen 3 x8	8 GPIO, 4 HSS

Auxiliary I/O

All three backends feature front-panel auxiliary digital I/O through a Molex Nano-Pitch I/O connector for triggering or digital interfacing. On the larger FPGAs, four additional GTH multigigabit transceivers, each capable of data streaming up to 16 Gbps, are routed to the Nano-Pitch I/O connector. These transceivers can be used for high-bandwidth communication with other devices over high-speed serial protocols such as Xilinx Aurora, 10 Gigabit Ethernet UDP, 40 Gigabit Ethernet UDP, or Serial Front Panel Data Port (SFPDP).

PCI Express Gen 3 x8 Connectivity

The new FlexRIO modules are equipped with PCI Express Gen 3 x8 connectivity, making them capable of streaming up to 7 GB/s via DMA to/from CPU memory. Or, with NI peer-to-peer streaming technology, you can stream data between two modules in a chassis without passing data through host memory. Learn more about peer-to-peer technology.

Synchronization

Synchronizing multiple modules in a system is often the most difficult part of designing high-channel-count solutions. Many COTS vendors have solutions for synchronization that don’t scale and, with custom designs, it can take significant expertise to meet common requirements for repeatable phase alignment across channels. FlexRIO modules take advantage of the inherent timing and synchronization capabilities of the PXI platform, directly accessing the clocks and trigger routes shared with other instruments. PXI enables you to synchronize an entire chassis full of FlexRIO devices with subsample timing jitter between samples from different modules. This is achieved through sharing reference clocks on the backplane and a patented NI technology called NI-TClk, which orchestrates synchronization to ensure all modules are aligned to the same start trigger. Learn more about NI-TClk technology.

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Streaming Driver

FlexRIO modules with integrated I/O modules are supported in the FlexRIO streaming driver, which was designed to support basic digitizer and arbitrary waveform generator functionality without requiring FPGA programming. The driver supports finite or continuous acquisition/generation on any high-speed serial FlexRIO products with analog I/O and is intended as a high-level starting point before further customization on the FPGA. In addition to basic streaming functionality, you can use the driver for configuration of the I/O module's analog front end, clocking, and even direct register reads/writes to the ADCs or DACs.

FlexRIO Coprocessor Modules

FlexRIO Coprocessor Modules add signal processing capability to existing systems and are capable of high-bandwidth streaming over the backplane or through four high-speed serial ports on the front panel. When paired with another PXI instrument such as the PXIe-5840 vector signal transceiver, FlexRIO Coprocessor Modules provide the FPGA resources necessary to run complex algorithms in real-time.

Table 2. There are three dedicated UltraScale coprocessor modules available for applications requiring additional DSP capability.

Model	FPGA	PCIe	Aux I/O
PXIe-7911	Kintex UltraScale KU035	Gen 3 x8	None
PXIe-7912	Kintex UltraScale KU040	Gen 3 x8	8 GPIO, 4 HSS
PXIe-7915	Kintex UltraScale KU060	Gen 3 x8	8 GPIO, 4 HSS

FlexRIO Digitizer Modules

FlexRIO Digitizer Modules feature high-performance ADCs with lightweight analog front-ends designed to maximize bandwidth and dynamic range. All digitizer modules also feature an auxiliary I/O connector with eight GPIO for triggering or digital interfacing and the option for high-speed serial communication.

Table 3. The first two FlexRIO Digitizer modules feature 16-bit of resolution, at either 500 MS/s or 1 GS/s.

Model	Channels	Sample Rate	Resolution	Coupling	Bandwidth	Connectivity	FPGA Options
PXIe-5763	4	500 MS/s	16 bits	AC or DC	227 MHz	SMA	KU035, KU040, KU060
PXIe-5764	4	1 GS/s	16 bits	AC or DC	400 MHz	SMA	KU035, KU040, KU060

FlexRIO Module Development Kit

With the FlexRIO Adapter Module Development Kit (MDK), you can build your own FlexRIO I/O module that is tailored to your application. This process requires electrical, mechanical, analog, digital, firmware, and software design expertise. Learn more about the NI FlexRIO Adapter Module Development Kit.

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FlexRIO With Modular I/O

These FlexRIO products are comprised of two parts: modular, high-performance I/O called FlexRIO Adapter Modules, and powerful FlexRIO FPGA Modules. Together, these parts form a fully reconfigurable instrument that can be programmed graphically with LabVIEW or with Verilog/VHDL. FlexRIO FPGA Modules can also be used with NI Peer-to-Peer streaming to add inline digital signal processing (DSP) capability to a traditional instrument.



Figure 4: Adapter modules can be used with either a PXI FPGA Module for FlexRIO or Controller for FlexRIO.

PXI FPGA Modules for FlexRIO

NI's FlexRIO FPGA Module portfolio is highlighted by the PXIe-7976R and the NI 7935R Controller for FlexRIO, which both feature large DSP-focused Xilinx Kintex-7 410T FPGAs and 2 GB of onboard DRAM. With all of the benefits of the PXI platform, PXI FPGA Modules for FlexRIO are ideal for systems requiring high-performance data streaming, synchronization, processing, and high channel density. For applications that require reduced size, weight, and power for deployment, the Controller for FlexRIO utilizes the same modular I/O and FPGA in a stand-alone package with high-speed serial connectivity and an integrated dual-core ARM processor running NI Linux Real-Time.

Table 4. NI offers FPGA Modules for FlexRIO with a variety of different FPGAs and form factors.

Model	FPGA	FPGA Slices	FPGA DSP Slices	FPGA Block RAM (Kbits)	Onboard Memory	Streaming Throughput	Form-Factor
PXIe-7976R	Kintex-7 K410T	63,550	1,540	28,620	2 GB	3.2 GB/s	PXI Express
PXIe-7975R	Kintex-7 K410T	63,550	1,540	28,620	2 GB	1.7 GB/s	PXI Express
PXIe-7972R	Kintex-7 K325T	50,950	840	16,020	2 GB	1.7 GB/s	PXI Express
PXIe-7971R	Kintex-7 K325T	50,950	840	16,020	0 GB	1.7 GB/s	PXI Express
NI 7935R	Kintex-7 K410T	63,550	1,540	28,620	2 GB	2.4 GB/s (SFP+)	Stand-alone
NI 7932R	Kintex-7 K325T	50,950	840	16,020	2 GB	2.4 GB/s (SFP+)	Stand-alone
NI 7931R	Kintex-7 K325T	50,950	840	16,020	2 GB	25 MB/s (GbE)	Stand-alone
PXIe-7966R	Virtex-5 SX95T	14,720	640	8,784	512 MB	800 MB/s	PXI Express

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PXIe-7962R	Virtex-5 SX50T	8,160	288	4,752	512 MB	800 MB/s	PXI Express
PXIe-7961R	Virtex-5 SX50T	8,160	288	4,752	0 MB	800 MB/s	PXI Express
PXI-7954R	Virtex-5 LX110	17,280	64	4,608	128 MB	800 MB/s	PXI
PXI-7953R	Virtex-5 LX85	12,960	48	3,456	128 MB	130 MB/s	PXI
PXI-7952R	Virtex-5 LX50	7,200	48	1,728	128 MB	130 MB/s	PXI
PXI-7951R	Virtex-5 LX30	4,800	32	1,152	0 MB	130 MB/s	PXI

Digitizer Adapter Modules for FlexRIO

Digitizer Adapter Modules for FlexRIO can be used with a PXI FPGA Module for FlexRIO or the Controller for FlexRIO to create a high-performance instrument with customizable firmware. With sampling rates from 40 MS/s to 3 GS/s and up to 32 channels, these modules cover a wide range of requirements for both time and frequency domain applications. Digitizer Adapter Modules also provide digital I/O capability for interfacing with external hardware.

Table 5. NI offers Digitizer Adapter Modules for FlexRIO with up to 3 GS/s, up to 32 channels, and up to 2 GHz of bandwidth.

Model	Resolution (bits)	Channels	Maximum Sample Rate	Maximum Bandwidth	Coupling	Full-scale Input Range	Connectivity
NI 5731	12	2	40 MS/s	120 MHz	AC & DC	2 Vpp	BNC
NI 5732	14	2	80 MS/s	110 MHz	AC & DC	2 Vpp	BNC
NI 5733	16	2	120 MS/s	117 MHz	AC & DC	2 Vpp	BNC
NI 5734	16	4	120 MS/s	117 MHz	AC & DC	2 Vpp	BNC
NI 5751(B)	14	16	50 MS/s	26 MHz	DC	2 Vpp	VHDCI
NI 5752(B)	12	32	50 MS/s	14 MHz	AC	2 Vpp	VHDCI
NI 5753	16	16	120 MS/s	176 MHz	AC or DC	1.8 Vpp	MCX
NI 5761	14	4	250 MS/s	500 MHz	AC or DC	2 Vpp	SMA
NI 5762	16	2	250 MS/s	250 MHz	AC	2 Vpp	SMA
NI 5771	8	2	3 GS/s	900 MHz	DC	1.3 Vpp	SMA
NI 5772	12	2	1.6 GS/s	2.2 GHz	AC or DC	2 Vpp	SMA

Signal Generator Adapter Modules for FlexRIO

Signal Generator Adapter Modules for FlexRIO feature either high or low-speed analog output and can be paired with a PXI FPGA Module for FlexRIO or the Controller for FlexRIO for custom signal generation. Whether you need to dynamically generate waveforms on the FPGA or stream them across the PXI backplane, these adapter modules are well suited for applications in communications, hardware-in-the-loop (HIL) test, and scientific instrumentation.

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Table 6. NI offers Signal Generator Adapter Modules for FlexRIO for both low-speed control and high-speed generation.

Model	Resolution (bits)	Channels	Maximum Sample Rate	Maximum Bandwidth	Coupling	Full-scale Output Range	Signaling	Connectivity
NI 5741	16	16	1 MS/s	500 kHz	DC	5 Vpp	Single-ended	VHDCI
NI 5742	16	32	1 MS/s	500 kHz	DC	5 Vpp	Single-ended	VHDCI
AT 1120	14	1	2 GS/s	550 MHz	DC	4 Vpp	Differential	SMA
AT 1212	14	2	1.25 GS/s	400 MHz	DC	4 Vpp	Differential	SMA

Digital Adapter Modules for FlexRIO

Digital I/O Adapter Modules for FlexRIO offer up to 54 channels of configurable digital I/O that can interface with single-ended, differential, and serial signals at a variety of voltage levels. When combined with a large, user-programmable FPGA, you can use these modules to solve a variety of challenges, from high-speed communication with a device under test to emulating custom protocols in real-time.

Table 7. NI offers adapter modules for high-speed digital interfacing over both single-ended and differential interfaces.

Model	Channels	Type of Signaling	Maximum Data Rate	Voltage Levels (V)
NI 6581(B)	54	Single-ended (SE)	100 Mbps	1.8, 2.5, 3.3, or external reference
NI 6583	32 SE, 16 LVDS	SE, and LVDS or mLVDS	300 Mbps	1.2 to 3.3 V SE, LVDS
NI 6584	16	RS-485/422 Full/Half-Duplex	16 Mbps	5 V
NI 6585(B)	32	LVDS	200 Mbps	LVDS
NI 6587	20	LVDS	1 Gbps	LVDS
NI 6589	20	LVDS	1 Gbps	LVDS

Transceiver Adapter Modules for FlexRIO

Transceiver Adapter Modules for FlexRIO feature multiple inputs, outputs, and digital I/O lines for applications that require the acquisition and generation of IF or baseband signals with inline, real-time processing. Example applications include RF modulation and demodulation, channel emulation, signals intelligence, real-time spectrum analysis, and software defined radio (SDR). Transceiver Adapter Modules also provide digital I/O capability for interfacing with external hardware.

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Table 8. Transceiver Adapter Modules are ideal for applications that require high-speed acquisition and generation on the same instrument. Transceiver Adapter Modules are available in both single-ended and differential configurations, with up to 250 MS/s analog input and 1 GS/s analog output.

Model	Channels	Analog Input Resolution (bits)	Maximum Analog Input Sample Rate	Analog Output Resolution (bits)	Maximum Analog Output Sample Rate	Transceiver Bandwidth	Voltage Range	Coupling	Signaling
NI 5781	2 AI, 2 AO	14	100 MS/s	16	100 MS/s	40 MHz	2 Vpp	DC	Differential
NI 5782	2 AI, 2 AO	14	250 MS/s	16	1 GS/s	100 MHz	2 Vpp	DC or AC	Single-ended
NI 5783	4 AI, 4 AO	16	100 MS/s	16	400 MS/s	40 MHz	1 Vpp	DC	Single-ended

RF Adapter Modules for FlexRIO

RF Adapter Modules for FlexRIO feature frequency coverage from 200 MHz to 4.4 GHz, with up to 200 MHz instantaneous bandwidth. When paired with a PXI FPGA Module for FlexRIO or the Controller for FlexRIO, you can program the FPGA using LabVIEW to implement custom signal processing, including modulation and demodulation, channel emulation, spectral analysis, and even closed-loop control. These modules are all based on a direct conversion architecture and feature an onboard local oscillator which can be shared with adjacent modules for synchronization. RF adapter modules also provide digital I/O capability for interfacing with external hardware.

Table 9. RF Adapter Modules for FlexRIO are available as a transceiver, receiver, or transmitter, covering from 200 MHz to 4.4 GHz.

Model	Channel Count	Frequency Range	Bandwidth
NI 5791	1 Rx and 1 Tx	200 MHz – 4.4 GHz	100 MHz
NI 5792	1 Rx	200 MHz – 4.4 GHz	200 MHz
NI 5793	1 Tx	200 MHz – 4.4 GHz	200 MHz

Camera Link Adapter Module for FlexRIO

The Camera Link Adapter Module for FlexRIO supports 80-bit, 10-tap base-, medium-, and full-configuration image acquisition from Camera Link 1.2 standard cameras. You can pair the Camera Link Adapter Module for FlexRIO with a PXI FPGA Module for FlexRIO for applications that require bit-level processing and very low system latency. With the Camera Link Adapter Module for FlexRIO, you can use the FPGA to process images from the camera in-line before sending the images to the CPU, enabling more advanced preprocessing architectures.

Table 10. The NI 1483 Camera Link Adapter Module for FlexRIO was designed to bring FPGA processing capabilities to a variety of Camera Link cameras.

Model	Supported Configurations	Connector	Supported Pixel Clock Frequency	Aux I/O
NI 1483	Base, Medium, Full Camera Link	2 x 26-pin SDR	20 to 85 MHz	4 x TTL, 2 x Isolated digital inputs, 1 x Quadrature encoder

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Key Advantages of FlexRIO

Process Signals in Real-Time

As converter technologies advance, data rates continue to increase, putting pressure on streaming infrastructure, processing elements, and storage devices to keep up. While CPUs are generally accessible and easy to program, they are not reliable for real-time, continuous signal processing, especially at higher data rates. Adding an FPGA between the I/O and the CPU provides the opportunity to process the data as it is acquired/generated in a point-by-point fashion, greatly reducing the load on the rest of the system.

Table 11. Example applications and algorithms that can benefit from real-time, FPGA-based processing with high-performance I/O.

Use-case	Example Algorithms
Inline signal processing	Filtering, thresholding, peak detection, averaging, FFT, equalization, zero suppression, fractional decimation, interpolation, correlation, pulse measurements
Custom triggering	Logical AND/OR, waveform mask, frequency mask, channel power level, protocol-based
RF Acquisition/Generation	Digital upconversion/downconversion (DDC/DUC), modulation and demodulation, packet assembly, channel emulation, channelization, digital pre-distortion, pulse compression, beamforming
Control	PID, digital PLLs, assertion, emergency condition monitoring/response, hardware-in-the-loop test, simulation
Digital interfacing	Custom protocols emulation, command parsing, test sequencing

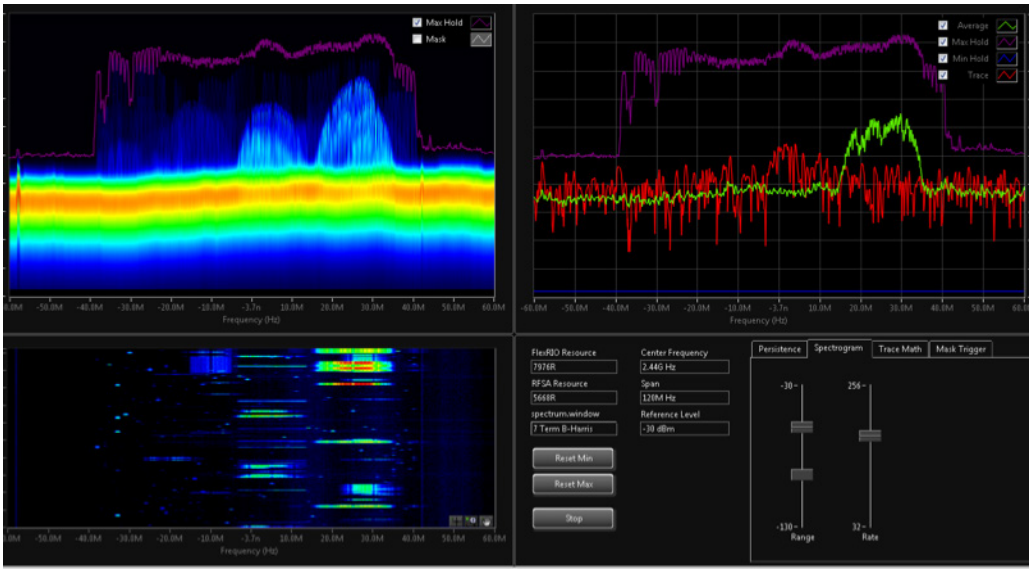


Figure 5. NI's Real-Time Spectrum Analyzer Reference Example processes 3.2 GB/s of data continuously on the FPGA, computing over 2 Million FFTs per second.

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Program FPGAs with LabVIEW

The LabVIEW FPGA module is an add-on to LabVIEW that extends graphical programming to FPGA hardware and provides a single environment for algorithm capture, simulation, debugging, and compilation of FPGA designs. Traditional methods of programming FPGAs require intimate knowledge of hardware design and years of experience working with low-level hardware description languages. Whether you come from this background or you have never programmed an FPGA, LabVIEW offers substantial productivity improvements that allow you to focus on your algorithms, not the complex glue that holds your design together. For more information on programming FPGAs with LabVIEW, see LabVIEW FPGA Module.

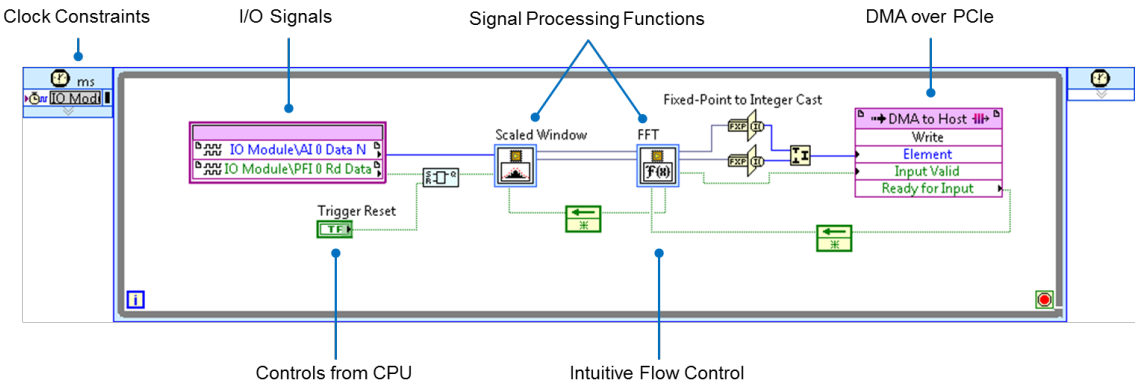


Figure 6. Program how you think. LabVIEW FPGA provides a graphical programming approach that simplifies the task of interfacing to I/O and processing data, greatly improving design productivity, and reducing time to market.

Program FPGAs with Vivado

Experience digital engineers can use the Xilinx Vivado Project Export feature included with LabVIEW FPGA 2017 to develop, simulate, and compile for FlexRIO hardware with Xilinx Vivado. You can export all the necessary hardware files for a FlexRIO design to a Vivado Project that is pre-configured for your specific deployment target. Any LabVIEW signal processing IP used in the LabVIEW design will be included in the export; however, all NI IP is encrypted. You can use Xilinx Vivado Project Export on all FlexRIO and high-speed serial devices with Kintex-7 or newer FPGAs.

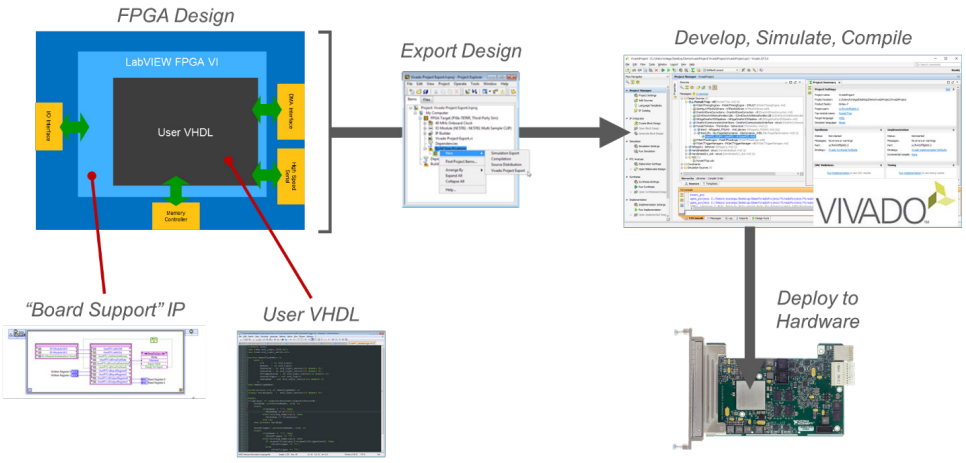


Figure 7. For experienced digital engineers, the Vivado Project Export feature allows for exporting all necessary hardware design files to a Vivado project for development, simulation, and compilation.

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Extensive Libraries of FPGA IP

LabVIEW's extensive collection of FPGA IP gets you to a solution faster, whether you're looking to implement a completely novel algorithm or you just need to perform common tasks in real-time. LabVIEW FPGA includes dozens of highly optimized functions designed for use with high-speed I/O and if you can't find what you're looking for in LabVIEW, IP is also available through the online community, NI Alliance Partners, and Xilinx. The table below highlights just some of the NI-provided functions that are commonly used in FlexRIO applications.

Table 12. A list of LabVIEW FPGA IP most commonly used with FlexRIO FPGA Modules.

LabVIEW FPGA IP for FlexRIO		
10 Gigabit Ethernet UDP	Edge detection	Persistence display
3-Phase PLL	Equalization	PFT channelizer
Accumulator	Exponential	PID
All-digital PLL	FFT	Pipeline frequency transform (PFT)
Area measurements	Filtering	Polar to X/Y conversion
Bayer decoding	FIR compiler	Power level trigger
Binary morphology	Fixed-point filter design	Power servoing
Binary object detection	Fractional interpolator	Power spectrum
BRAM delay	Fractional resampler	Programmable filter
BRAM FIFO	Frequency domain measurements	Pulse measurements
BRAM packetizer	Frequency mask trigger	Reciprocal
Butterworth filter	Frequency shift	RFFE
Centroid calculation	Halfband decimator	Rising/falling edge detect
Channel emulation	Handshake	RS-232
Channel power	Hardware test sequencer	Scaled window
CIC compiler	I2C	Shading correction
Color extraction	Image operators	Sin & Cos
Color space conversion	Image transforms	Spectrogram
Complex multiply	Instruction sequencer	SPI
Corner detection	IQ impairment correction	Square root
Counters	Line detection	Streaming controller
D latch	Linear interpolation	Streaming IDL
Delay	Lock-in amplifier filter	Synchronous latch
Digital gain	Log	Trigger IDL
Digital pre-distortion	Matrix multiply	Unit delay
Digital pulse processing filter	Matrix transpose	VITA-49 data packing
Discrete delay	Mean, Var, Std deviation	Waveform generation
Discrete normalized integrator	Memory IDL	Waveform match trigger
Divide	Moving average	Waveform math
Dot product	N channel DDC	X/Y to polar conversion
DPO	Natural log	Xilinx Aurora
DRAM FIFO IDL	Noise generation	Zero crossing
DRAM packetizer	Normalized square	Zero order hold
DSP48 node	Notch filter	Z-Transform delay
DUC/DDC compiler		



Figure 8. Just one of the palletes of FPGA IP included with LabVIEW FPGA.

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FlexRIO Software Experience

FlexRIO Examples

The FlexRIO driver includes dozens of LabVIEW examples to quickly interface with FlexRIO Adapter Modules and learn FPGA programming concepts. Each example consists of two parts: LabVIEW code that runs on the FlexRIO FPGA Module, and code that runs on the CPU communicating with the FPGA. These examples serve as a foundation for further customization, and are a great starting point for new applications.

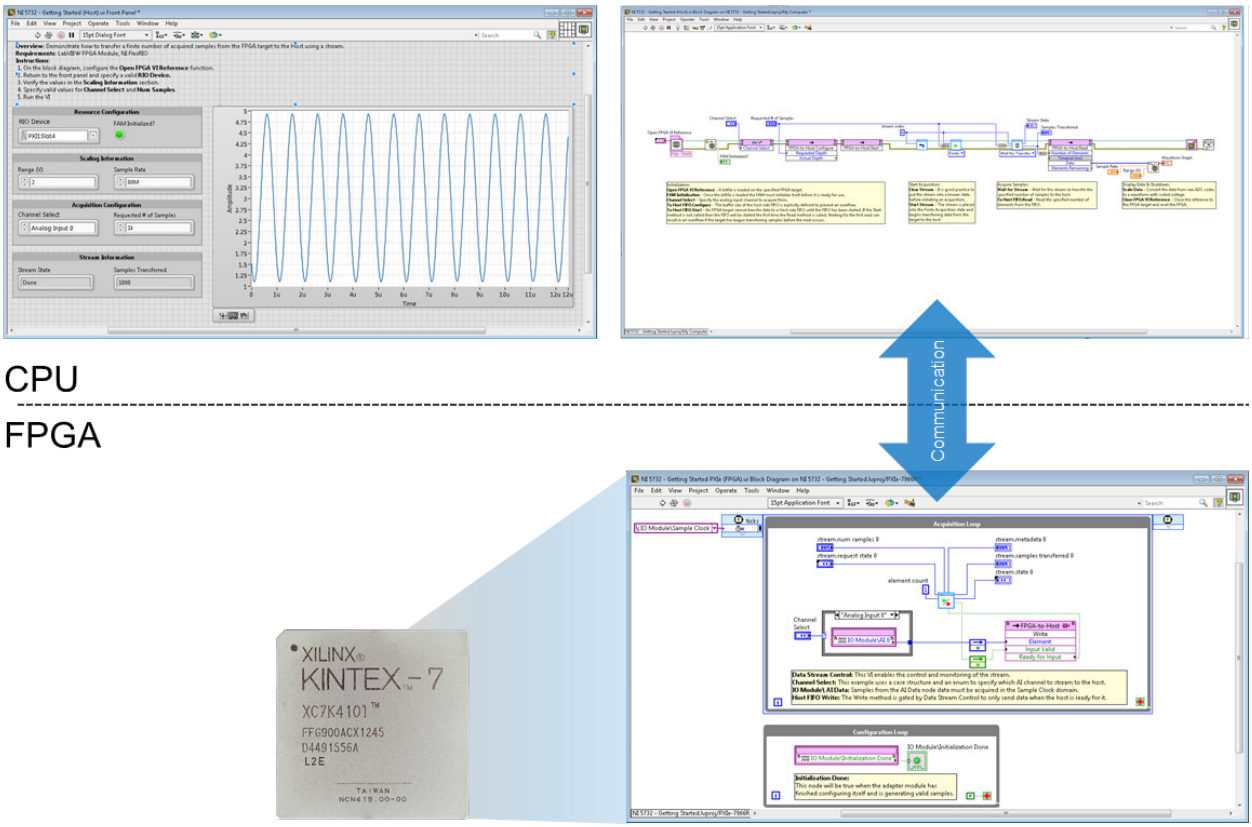


Figure 9. The shipping examples included with the FlexRIO driver are the best place to get started when programming FlexRIO FPGA Modules.

In addition to the examples included with the FlexRIO driver, National Instruments has published a number of application reference examples that are available through the online community or through VI Package Manager.

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Instrument Design Libraries

The FlexRIO examples described above are built on common libraries called Instrument Design Libraries (IDLs). IDLs are basic building blocks for common tasks you may want to perform on the FPGA and save you valuable time during development. Some of the most valuable IDLs are the Streaming IDL which provides flow control for DMA transfers of data to the host, the DSP IDL which includes highly optimized functions for common signal processing tasks, and the Basic Elements IDL which abstracts everyday functions like counters and latches. Many libraries also contain functions that run on the CPU and interface with their corresponding FPGA counterparts.

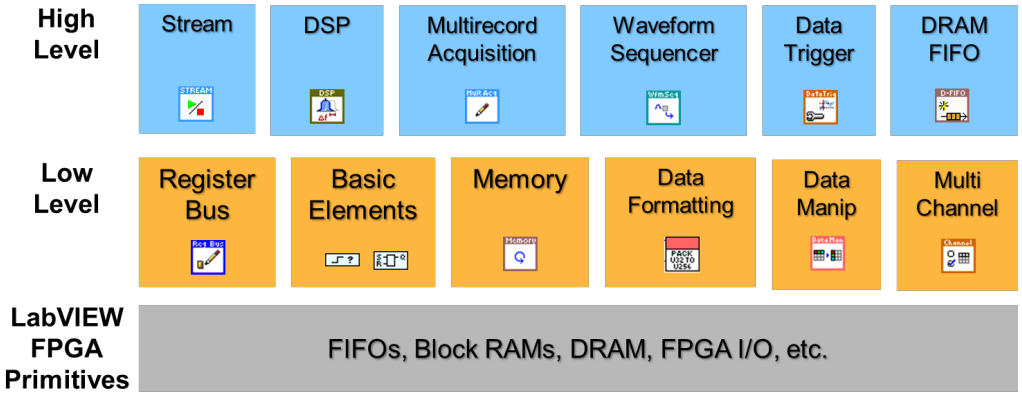


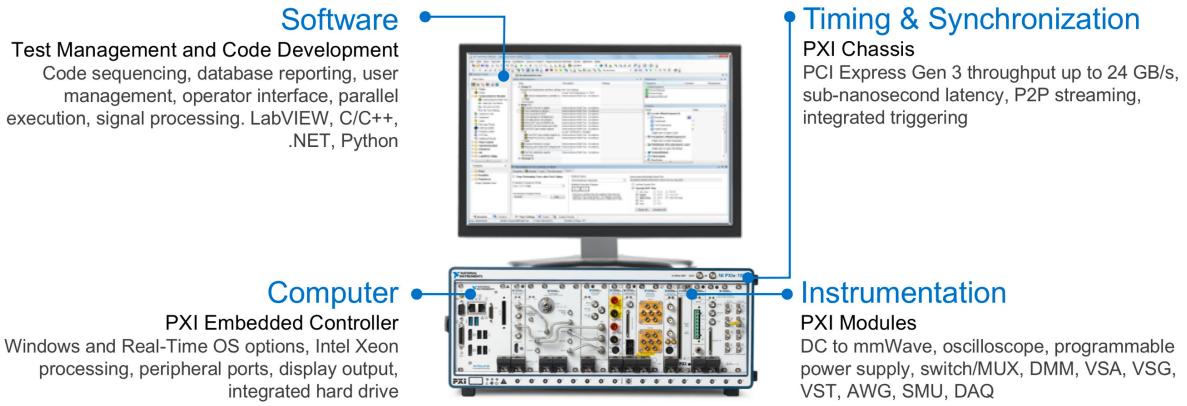
Figure 10. The Instrument Design Libraries (IDLs) for LabVIEW FPGA are included with FPGA-based instrument drivers and provide basic building blocks common to many FPGA designs.

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Platform-Based Approach to Test and Measurement

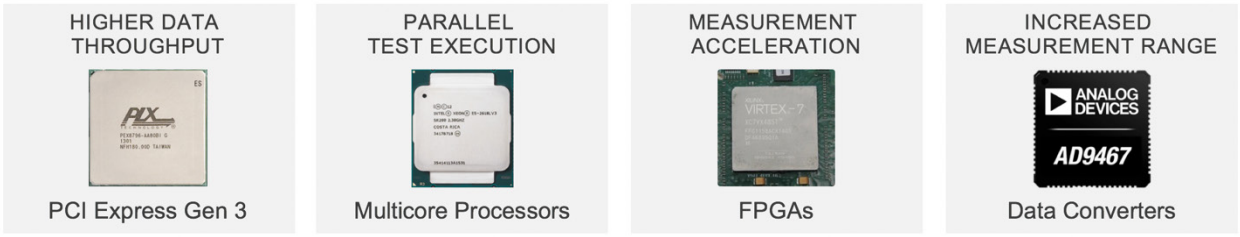
What Is PXI?

Powered by software, PXI is a rugged PC-based platform for measurement and automation systems. PXI combines PCI electrical-bus features with the modular, Eurocard packaging of CompactPCI and then adds specialized synchronization buses and key software features. PXI is both a high-performance and low-cost deployment platform for applications such as manufacturing test, military and aerospace, machine monitoring, automotive, and industrial test. Developed in 1997 and launched in 1998, PXI is an open industry standard governed by the PXI Systems Alliance (PXISA), a group of more than 70 companies chartered to promote the PXI standard, ensure interoperability, and maintain the PXI specification.



Integrating the Latest Commercial Technology

By leveraging the latest commercial technology for our products, we can continually deliver high-performance and high-quality products to our users at a competitive price. The latest PCI Express Gen 3 switches deliver higher data throughput, the latest Intel multicore processors facilitate faster and more efficient parallel (multisite) testing, the latest FPGAs from Xilinx help to push signal processing algorithms to the edge to accelerate measurements, and the latest data converters from TI and ADI continually increase the measurement range and performance of our instrumentation.



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PXI Instrumentation

NI offers more than 600 different PXI modules ranging from DC to mmWave. Because PXI is an open industry standard, nearly 1,500 products are available from more than 70 different instrument vendors. With standard processing and control functions designated to a controller, PXI instruments need to contain only the actual instrumentation circuitry, which provides effective performance in a small footprint. Combined with a chassis and controller, PXI systems feature high-throughput data movement using PCI Express bus interfaces and sub-nanosecond synchronization with integrated timing and triggering.



Oscilloscopes

Sample at speeds up to 12.5 GS/s with 5 GHz of analog bandwidth, featuring numerous triggering modes and deep onboard memory



Digital Multimeters

Perform voltage (up to 1000 V), current (up to 3A), resistance, inductance, capacitance, and frequency/period measurements, as well as diode tests



Digital Instruments

Perform characterization and production test of semiconductor devices with timing sets and per channel pin parametric measurement unit (PPMU)



Waveform Generators

Generate standard functions including sine, square, triangle, and ramp as well as user-defined, arbitrary waveforms



Frequency Counters

Perform counter timer tasks such as event counting and encoder position, period, pulse, and frequency measurements



Source Measure Units

Combine high-precision source and measure capability with high channel density, deterministic hardware sequencing, and SourceAdapt transient optimization



Power Supplies & Loads

Supply programmable DC power, with some modules including isolated channels, output disconnect functionality, and remote sense



FlexRIO Custom Instruments & Processing

Provide high-performance I/O and powerful FPGAs for applications that require more than standard instruments can offer



Switches (Matrix & MUX)

Feature a variety of relay types and row/column configurations to simplify wiring in automated test systems



Vector Signal Transceivers

Combine a vector signal generator and vector signal analyzer with FPGA-based, real-time signal processing and control



GPIB, Serial, & Ethernet

Integrate non-PXI instruments into a PXI system through various instrument control interfaces



Data Acquisition Modules

Provide a mix of analog I/O, digital I/O, counter/timer, and trigger functionality for measuring electrical or physical phenomena

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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.

	Standard	Premium	Description
Program Duration	3 or 5 years	3 or 5 years	Length of service program
Extended Repair Coverage	•	•	NI restores your device's functionality and includes firmware updates and factory calibration.
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 RMA[1]		•	NI accepts the delivery of fully assembled systems when performing repair services.
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 only includes traceable levels.

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

Every NI system includes a 30-day trial for phone and e-mail support from NI engineers, which can be extended through a Software Service Program (SSP) membership. NI has more than 400 support engineers available around the globe to provide local support in more than 30 languages. Additionally, take advantage of NI's award winning online resources and communities.

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