

Product Brochure

# FlexRIO Custom Instrumentation

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# FlexRIO Custom Instrumentation

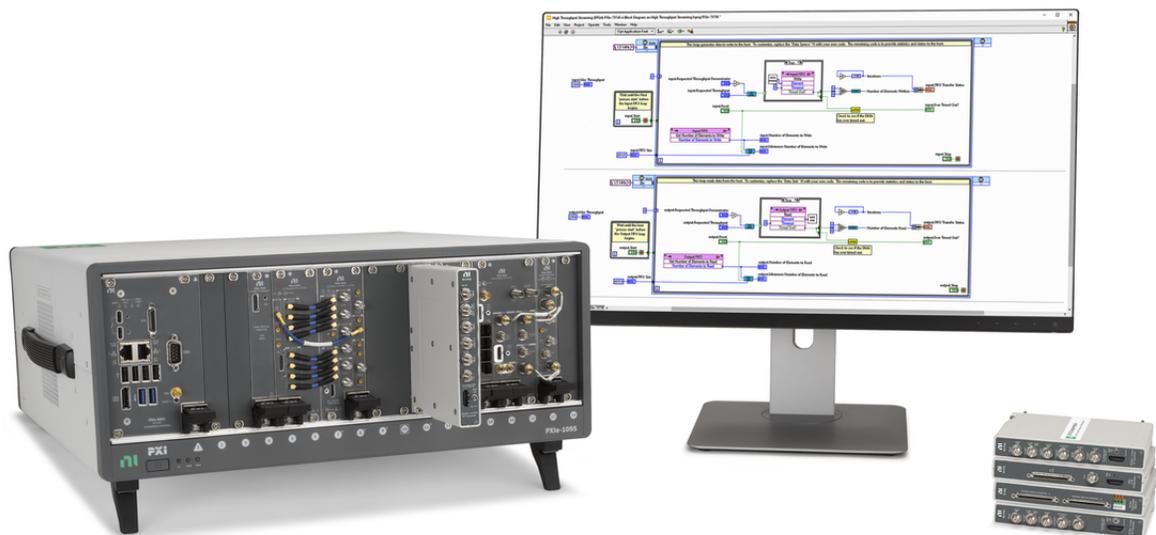


Figure 1. NI FlexRIO Family

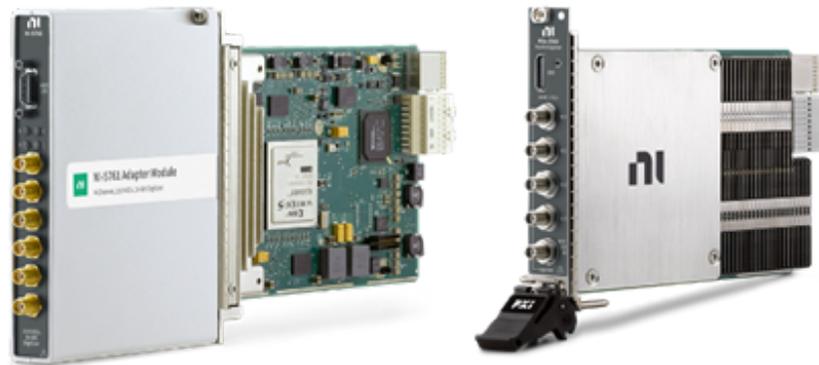
- Analog I/O up to 6.4 GS/s, digital I/O up to 1.25 Gbps, RF I/O up to 4.4 GHz
- Custom I/O with FlexRIO Module Development Kit (MDK)
- Data streaming up to 7 GB/s across the PXI backplane and multimodule synchronization with NI-TCIk
- Data streaming up to 169 GB/s for serial connectivity
- PXIe, PCIe, and stand-alone form factors are available
- Accelerate field-programmable gate array (FPGA) development using LabVIEW FPGA with example programs and detailed help files
- LabVIEW-programmable Xilinx Kintex UltraScale, Virtex UltraScale+, Kintex 7, and Virtex-5 FPGAs with up to 20 GB of onboard DRAM
- Host APIs for LabVIEW and C/C++
- I/O module specific shipping examples

## Customize Your Instrumentation without Building Custom Hardware

The FlexRIO product line was designed for engineers and scientists who need the flexibility of custom hardware without the cost of custom design. The FlexRIO platform combines hardware, software, and a library of IP for engineers to start building custom designs fast. FlexRIO provides a fully reconfigurable instrument that can be programmed with LabVIEW FPGA or with VHDL/Verilog. Engineers can even design their own custom I/O with the [FlexRIO Adapter Module Development Kit \(MDK\)](#).

# The Two FlexRIO Architectures

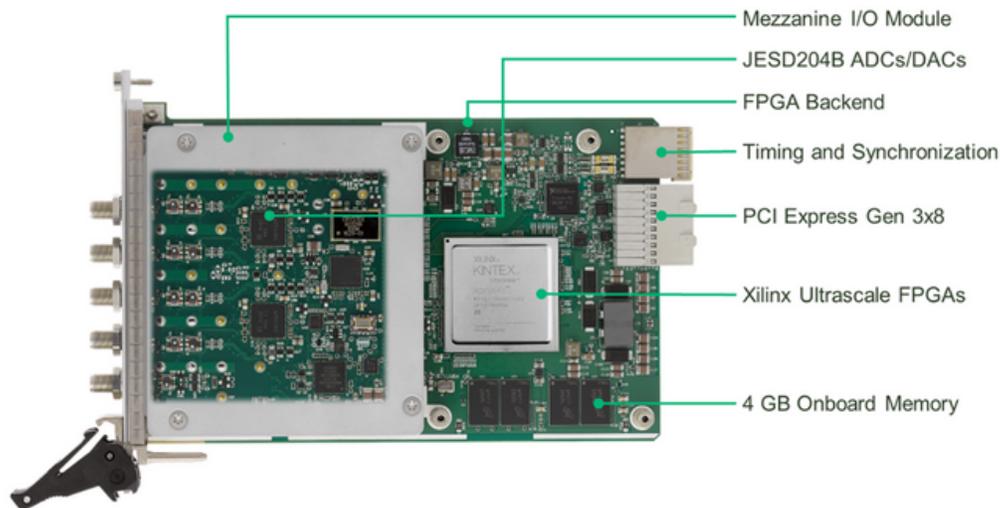
FlexRIO products are available in two different architectures: modular I/O modules and integrated I/O modules. The first FlexRIO architecture consists of two different components: the FPGA Module for FlexRIO and the FlexRIO Adapter Module, shown in Figure 2 on the left. The FlexRIO Adapter Modules are removable I/O modules that connect to the front of the FPGA Module through a card-edge connector, allowing the user to mix and match different adapter modules, such as digitizers, signal generators, or transceivers to one FPGA Module. The FPGA module connects directly to the PXI backplane and to the FlexRIO Adapter Module. The second architecture, shown in Figure 2 on the right, is built using high-speed serial converters, integrated I/O, and FPGA technology all within one module. These modules are referred to as FlexRIO with Integrated I/O.



**FIGURE 2**  
On the left is an example of a modular I/O module with the NI-5761 Adapter Module and a FPGA Module for FlexRIO. On the right is an example of an integrated I/O module, the PXIe-5764 FlexRIO Digitizer.

## FlexRIO with Integrated I/O

NI's integrated FlexRIO architecture is based on high-speed serial communication between a mezzanine I/O module and an FPGA backend. This architecture was designed to interface with the industry's latest high-speed converters based on high-speed serial interfaces running protocols like JESD204B, which is particularly valuable in applications that continue to push requirements for sample rate, bandwidth, resolution, and channel count. The FPGA backend in the integrated I/O modules allows the user to develop FPGA code with LabVIEW FPGA or VHDL. LabVIEW FPGA gives user the ability to program FPGAs more efficiently and design FPGA-based systems without VHDL expertise through a highly integrated development environment, IP libraries, a high-fidelity simulator, and debugging features.



**FIGURE 3**  
PXIe-5764 FlexRIO Digitizer Module with Integrated I/O, 4 Ch, 16-bits, and 1 GS/s

## FlexRIO with Modular I/O

The modular FlexRIO products are comprised of two parts: a FlexRIO Adapter Module and a FlexRIO FPGA Module.

The FlexRIO Adapter Module is a modular, high-performance, I/O adapter that defines the physical inputs and outputs of a FlexRIO system and interfaces through the back with a card-edge connector to the FlexRIO FPGA Module. The FlexRIO FPGA Module provides the FPGA backend for the reconfigurable system. This FPGA Module is programmable with LabVIEW FPGA or VHDL. Each FPGA module has dedicated interfaces for data streaming, I/O, DRAM, and advanced clocking and triggering. Engineers can use FlexRIO Adapter Modules with user programmable FPGAs to solve a wide variety of test applications, from communications to medical imaging.

In applications where I/O needs may change through project phases or custom FPGA programming is needed for different applications, adapter modules are a great option. Multiple adapter modules can be paired with the same FlexRIO FPGA Module, which allows for quick and easy modifications to these systems. Additionally, LabVIEW FPGA gives users the ability to program FPGAs more efficiently and design FPGA-based systems without VHDL expertise through a highly integrated development environment, IP libraries, a high-fidelity simulator, and debugging features. FlexRIO Adapter Modules and FlexRIO FPGA Modules provide a customizable, reconfigurable instrument, for a lower cost. For even more customization than NI provides, there are additional FlexRIO Adapter Modules available from NI Partners and third parties, or you can customize your own I/O.

Each Adapter Module will need a compatible FlexRIO FPGA Module, which can be found in Table 1 or through the [NI FlexRIO Adapter and NI FlexRIO FPGA Module Compatibility](#) document. FlexRIO FPGA modules feature Kintex 7 FPGAs in PXI Express and stand-alone form factors with the FlexRIO Controller.

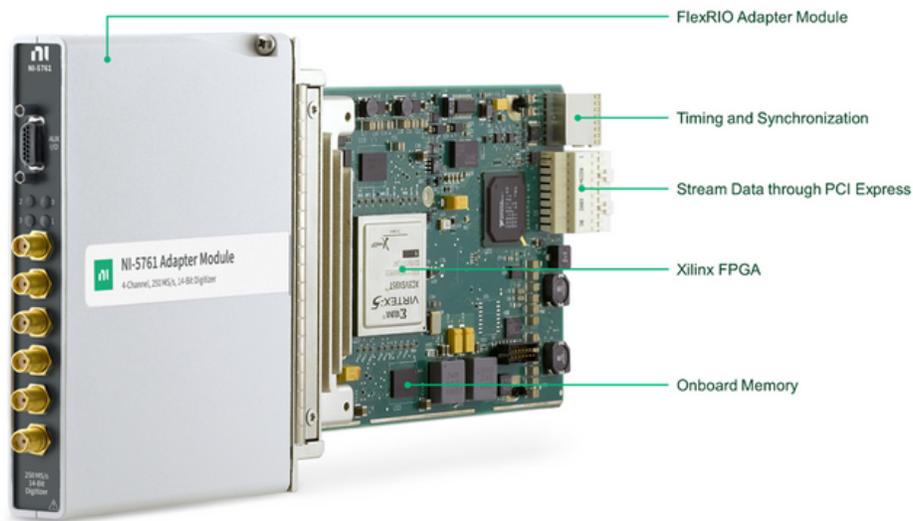


FIGURE 4

FlexRIO NI-5761 Adapter Module with a 4-Channel, 250 M/s, 14 Bit Digitizer, and a FlexRIO FPGA Module

## Custom I/O

The [FlexRIO Adapter Module Development Kit \(MDK\)](#) provides an avenue for you to create your own custom I/O for adapter modules or for integrated I/O modules. This process requires electrical, mechanical, analog, digital, firmware, and software design expertise. For a comparison and overview of the effort required, see [Advantages of Using FlexRIO Module Development Kits to Design Custom Instruments](#).

# NI FlexRIO Hardware

## FPGA Modules for FlexRIO

NI's FlexRIO FPGA Modules are paired with NI's Adapter Modules to create a fully reconfigurable instrument that can be programmed graphically with LabVIEW or with Verilog/VHDL. If you would like to use any of the adapter modules, you will need to choose a [compatible FPGA module](#). The FlexRIO FPGA Module portfolio is highlighted by the PXIe-7976, which features a large DSP-focused Xilinx Kintex 7 410T FPGA and 2 GB of onboard DRAM. With all 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.

Form Factor	Model	FPGA	FPGA Slices	FPGA DSP Slices	FPGA Block RAM (kbits)	Onboard Memory	Streaming Throughput
PXI Express	<a href="#">PXIe-7976</a>	Kintex 7 K410T	63,550	1,540	28,620	2 GB	3.2 GB/s
	<a href="#">PXIe-7975</a>	Kintex 7 K410T	63,550	1,540	28,620	2 GB	1.7 GB/s
	<a href="#">PXIe-7972</a>	Kintex 7 K325T	50,950	840	16,020	2 GB	1.7 GB/s
	<a href="#">PXIe-7971</a>	Kintex 7 K325T	50,950	840	16,020	0 GB	1.7 GB/s

Table 1: FPGA Modules for FlexRIO

<sup>1</sup> See documentation on [NI FlexRIO Adapter and NI FlexRIO FPGA Module Compatibility](#).

## Stand-Alone Controller for FlexRIO

The [Controller for FlexRIO](#) is a commercial off-the-shelf (COTS) solution designed for applications that require high-performance I/O and real-time signal processing in a compact, stand-alone form factor. The controller shares the same adapter modules, FPGAs, and software experience as the FlexRIO PXI modules, which makes it an ideal deployment target for solutions developed on the PXI platform. Although it has much in common with FlexRIO on PXI systems, it is aimed at embedded applications where smaller, lighter, lower power solutions are preferred.

Form Factor	Model	FPGA	FPGA Slices	FPGA DSP Slices	FPGA Block RAM (kbits)	Onboard Memory	Streaming Throughput
Stand-Alone	<a href="#">NI-7935</a>	Kintex 7 K410T	63,550	1,540	28,620	2 GB	2.4 GB/s (SFP+)
	<a href="#">NI-7931</a>	Kintex 7 K325T	50,950	840	16,020	2 GB	25 MB/s (GbE)

Table 2: Stand-Alone Controllers for FlexRIO

<sup>1</sup> See documentation on [NI FlexRIO Adapter and NI FlexRIO FPGA Module Compatibility](#).

# FlexRIO Digitizers

FlexRIO Digitizer Modules feature high-performance ADCs and are designed to maximize bandwidth and dynamic range. Digitizers are often used for time and frequency-domain applications as well as to build spectrum analyzers, transient recorders, and many-channel phenomena detection systems.

Family	Form Factor	Model	FPGA	Resolution	Channels	Maximum Sample Rate	Maximum Bandwidth	Coupling	Full-Scale Input Range	Connectivity
Adapter Module	PXI Express	<a href="#">NI-5734</a>	See <a href="#">Table 1</a>	16	4	120 MS/s	117 MHz	AC & DC	2 Vpp	BNC
		<a href="#">NI-5751B</a>	See <a href="#">Table 1</a>	14	16	50 MS/s	26 MHz	DC	2 Vpp	VHDCI
		<a href="#">NI-5752B</a>	See <a href="#">Table 1</a>	12	32	50 MS/s	14 MHz	AC	2 Vpp	VHDCI
		<a href="#">NI-5771</a>	See <a href="#">Table 1</a>	8	2	3 GS/s	900 MHz	DC	1.3 Vpp	SMA
		<a href="#">NI-5772</a>	See <a href="#">Table 1</a>	12	2	1.6 GS/s	2.2 GHz	AC or DC	2 Vpp	SMA
Integrated I/O Module	PXI Express	<a href="#">PXIe-5763<sup>1</sup></a>	KU035, KU040, KU060	16 bits	4	500 MS/s	225 MHz	AC or DC	AC 2.03 Vpp, DC 1.97 Vpp	SMA
		<a href="#">PXIe-5764<sup>1</sup></a>	KU035, KU040, KU060	16 bits	4	1 GS/s	1.15 GHz or 400 MHz	AC or DC	AC 2.05 Vpp, DC 2 Vpp	SMA
		<a href="#">PXIe-5774</a>	KU040, KU060	12 bits	2	6.4 GS/s-1 Ch 3.2 GS/s/ch-2 Ch	1.6 GHz or 3 GHz	DC	200 mVpp, 1 Vpp	SMA
	PCI	<a href="#">PCIe-5764</a>	KU035, KU040, KU060	16 bits	4	1 GS/s	1.15 GHz or 400 MHz	AC or DC	AC 2.05 Vpp, DC 2 Vpp	SMA
			KU035, KU060	12 bits	2	6.4 GS/s-1 Ch 3.2 GS/s/ch-2 Ch	1.6 GHz or 3 GHz	DC	200 mVpp, 1 Vpp	SMA
		<a href="#">PCIe-5763</a>	KU035, KU040, KU060	16 bits	4	500 MS/s	225 MHz	AC or DC	AC 2.03 Vpp, DC 1.97 Vpp	SMA
		<a href="#">PCIe-5775</a>	KU035, KU040, KU060	12 bits	2	6.4 GS/s-1 Ch 3.2 GS/s/ch-2 Ch	6 GHz	AC	1.25 Vpp	SMA

Table 3. Digitizer Adapter Modules for FlexRIO

<sup>1</sup> Requires the use of a chassis with slot cooling capacity  $\geq 58$  W, such as the PXIe-1095

## FlexRIO Signal Generator

Signal Generator Modules are well suited for custom signal generation. Whether you need to dynamically generate waveforms on the FPGA or stream them across the PXI backplane, these modules are ideal for applications in communications, hardware-in-the-loop (HIL) test, and scientific instrumentation.

Family	Form Factor	Model	FPGA	Resolution (Bits)	Channels	Maximum Sample Rate	Maximum Bandwidth	Coupling	Signaling	Connectivity
Adapter Module	PXI Express	<a href="#">AT-1120</a>	See <a href="#">Table 1</a>	14	1	2 GS/s	550 MHz	DC	Differential	SMA
		<a href="#">AT-1212</a>	See <a href="#">Table 1</a>	14	2	1.25 GS/s	400 MHz	DC	Differential	SMA
Integrated I/O Module	PXI Express	<a href="#">PXIe-5745<sup>1</sup></a>	KU035, KU040, KU060	12	2	3.2 GS/s per channel	2.9 GHz	AC	Single-ended	SMA

Table 4. FlexRIO Signal Generator Modules

<sup>1</sup> Requires the use of a chassis with slot cooling capacity  $\geq 58$  W, such as the PXIe-1095

## FlexRIO Digital Modules

Digital modules combined with their large, user-programmable FPGAs can help solve a variety of challenges, from high-speed communication with a device under test, emulating custom protocols in real time, real-time interfacing with standard protocols or implementing customized protocols.

Family	Form Factor	Model	FPGA	Channels	Logic Level and Range	Signaling Type	Maximum Data Rate
Adapter Module	PXI Express	<a href="#">NI-6581B</a>	See <a href="#">Table 1</a>	54	1.8 V, 2.5 V, 3.3 V	Single-ended (SE)	100 Mbps
		<a href="#">NI-6583</a>	See <a href="#">Table 1</a>	32 SE, 16 LVDS	mLVDS, LVDS, Programmable, 1.2 V–3.3 V	Single-ended, Differential	300 Mbps
		<a href="#">NI-6584</a>	See <a href="#">Table 1</a>	16	RS-422/RS-485	Differential	16 Mbps
		<a href="#">NI-6585B</a>	See <a href="#">Table 1</a>	32	LVDS	Differential	200 Mbps
		<a href="#">NI-6589</a>	See <a href="#">Table 1</a>	20	LVDS	Differential	1 Gbps
Integrated I/O Module	PXI Express	<a href="#">PXIe-6569</a>	Kintex UltraScale KU035, Kintex UltraScale KU060	32 digital input, 32 digital output	LVDS	Single-ended, Differential	LVDS 1.25 Gbps, Differential 300 Mbps
		<a href="#">PXIe-6569</a>	Kintex UltraScale KU035, Kintex UltraScale KU060	64 digital input	LVDS	Single-ended, Differential	LVDS 1.25 Gbps, Differential 300 Mbps
		<a href="#">PXIe-6569</a>	Kintex UltraScale KU035, Kintex UltraScale KU060	64 digital output	LVDS	Single-ended, Differential	LVDS 1.25 Gbps, Differential 300 Mbps

Table 5. FlexRIO Digital Modules

## FlexRIO Transceiver Modules

Transceiver Modules feature high-performance ADCs and DACs with lightweight analog front ends designed to maximize bandwidth and dynamic range. They can be used for applications including 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.

Family	Form Factor	Model	FPGA	Channels	Resolution	Max Input Sample Rate	Max Output Sample Rate	Bandwidth	Full-Scale Input Range	Full-Scale Output Range	Coupling	Signaling
Adapter Module	PXI Express	<a href="#">NI-5783</a>	See <a href="#">Table 1</a>	4 AI 4 AO	16	100 MS/s	400 MS/s	39.4 MHz	2 Vpp	1 Vpp	DC	Single-ended
Integrated I/O Module	PXI Express	<a href="#">PXIe-5785</a>	KU035, KU040, KU060	2 AI 2 AO	12	6.4 GS/s	3.2 GS/s	500 kHz to 6 GHz	1.25 Vpp	Dual channel mode 878 mVpp, Single channel mode 431 mVpp	AC	Single-ended
	PCI	<a href="#">PCIe-5785</a>	KU035, KU040, KU060	2 AI 2 AO	12	6.4 GS/s	3.2 GS/s	500 kHz to 6 GHz	1.25 Vpp	Dual channel mode 878 mVpp, Single channel mode 431 mVpp	AC	Single-ended

Table 6. FlexRIO Transceiver Modules

## FlexRIO RF Modules

RF modules for FlexRIO are only available as adapter modules. 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 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.

Family	Form Factor	Model	FPGA	Channel Count	Frequency Range	Bandwidth
Adapter Module	PXI Express	<a href="#">NI-5791</a>	See <a href="#">Table 1</a>	1 RX and 1 TX	200 MHz–4.4 GHz	100 MHz
		<a href="#">NI-5792</a>	See <a href="#">Table 1</a>	1 RX	200 MHz–4.4 GHz	200 MHz
		<a href="#">NI-5793</a>	See <a href="#">Table 1</a>	1 TX	200 MHz–4.4 GHz	200 MHz

Table 7. RF Adapter Modules for FlexRIO, which are available as a transceiver, receiver, or transmitter.

## FlexRIO Camera Link Modules

Camera Link modules for FlexRIO are only available as adapter modules. 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 to use 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 inline before sending the images to the CPU, enabling more advanced preprocessing architectures. The Camera Link Adapter Module for FlexRIO was designed to bring FPGA processing capabilities to a variety of Camera Link cameras.

Family	Form Factor	Model	FPGA	Supported Configurations	Connector	Supported Pixel Clock Frequency	Aux I/O
Adapter Module	PXI Express	<a href="#">NI-1483</a>	See <a href="#">Table 1</a>	Base, Medium, Full Camera Link	2x 26-pin SDR	20–85 MHz	4x TTL, 2x isolated digital inputs, 1x quadrature encoder

Table 8. Camera Link Adapter Module

## 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 high-speed serial ports on the front panel. These devices are typically paired with high-bandwidth acquisition or output devices (such as a PXI Vector Signal Transceiver) in applications that require substantial real-time signal processing.

Family	Form Factor	Model	FPGA	PCIe	Aux I/O
Integrated I/O Module	PXI Express	<a href="#">PXIe-7912</a>	Kintex UltraScale KU040	Gen 3 x8	8 GPIO, 4 HSS
		<a href="#">PXIe-7915</a>	Kintex UltraScale KU060	Gen 3 x8	8 GPIO, 4 HSS

Table 9. Coprocessor Modules with Integrated I/O

## FlexRIO FPD-Link™ Interface Modules

The PXI FlexRIO FPD-Link Interface Module provides a high-speed digital interface for using and testing modern advanced driver assistance systems (ADAS), autonomous drive (AD) camera sensors, and electronic control units (ECUs). The PXIe-1486 is ideal for applications such as in-vehicle data logging, lab-based playback, or hardware in the loop (HIL).

Family	Form Factor	Model	FPGA	Deserializer	Digital Output Channels	Serializer	Digital Input Channels Only	Serial Link
Integrated I/O module	PXI Express	<a href="#">PXIe-1486</a>	Kintex UltraScale+ KU11P	-	8	DS90UB9702	0	FPD-LINK III
		<a href="#">PXIe-1486</a>	Kintex UltraScale+ KU11P	DS90UB954	4	DS90UB953	4	FPD-LINK III
		<a href="#">PXIe-1486</a>	Kintex UltraScale+ KU11P	DS90UB954	0	-	8	FPD-LINK III

Table 10. FlexRIO GMSL Interface Module with Integrated I/O

## FlexRIO High-Speed Serial Modules

PXI High-Speed Serial Instruments are designed for engineers who need to validate, interface through, and test high-speed serial protocols. Select high-speed serial devices, such as the PXIe-7903 and PXIe-7902, were designed for engineers who need high-performance FPGA co-processing capabilities to achieve high volume data movement along with real-time signal processing.

All High-Speed Serial Instruments are programmable in LabVIEW FPGA for maximum application-specific customization and reuse. These instruments take advantage of FPGA multigigabit transceivers (MGTs) to support line rates up to 28.2 Gbps, up to 48 TX and RX lanes, and up to a combined data rate more than 1 Tb/s. As part of the PXI platform, they benefit from PXI clocking, triggering, and high-speed data movement capabilities, including streaming to and from disk, as well as peer-to-peer (P2P) streaming at rates up to 7 GB/s.

Family	Form Factor	Model	FPGA	Line Rate	Channels	DRAM	Host Streaming Bandwidth	Connector	Cabling Options	Aux DIO
Integrated I/O Module	PXI Express	<a href="#">PXIe-6591</a>	Kintex 7 K410T	500 Mbps -12.5 Gbps <sup>1</sup>	8 TX/RX	2 GB	3.2 GB/sec	Mini-SAS HD	Copper or Optical	20 SE
		<a href="#">PXIe-6592</a>	Kintex 7 K410T	500 Mbps -10.3125 Gbps <sup>1</sup>	4 TX/RX	2 GB	3.2 GB/sec	SFP+	Copper or Optical	4 SE
		<a href="#">PXIe-6593</a>	Kintex UltraScale KU040, Kintex UltraScale KU060	500 Mbps - 16.3 Gbps	8 TX/RX	4 GB	7 GB/sec	QSFP28	Copper or Optical	8 GPIO
		<a href="#">PXIe-6594</a>	Kintex UltraScale + KU15P	500 Mbps -28.2 Gbps	8 TX/RX	8 GB	7 GB/sec	QSFP28	Copper or Optical	8 GPIO
		<a href="#">PXIe-7902</a>	Virtex 7 485T	500 Mbps -12.5 Gbps <sup>1</sup>	24 TX/RX	2 GB	3.2 GB/sec	Mini-SAS HD	Copper or Optical	N/A
		<a href="#">PXIe-7903<sup>2</sup></a>	Virtex UltraScale + XCVU11P	500 Mbps -28.2 Gbps	48 TX/RX	20 GB	7 GB/sec	Mini-SAS HD	Copper or Optical	8 GPIO

Table 11. FlexRIO High Speed Serial Modules

<sup>1</sup> Gap in achievable line rates between 8 Gbps and 9.8 Gbps

<sup>2</sup> Module requires two PXI slots

## FlexRIO GMSL™ Interface Modules

The PXI FlexRIO GMSL™ Interface Module combines the Maxim Integrated Gigabit Multimedia Serial Link™ (GMSL™) interface with the Xilinx FPGA for high-throughput vision and imaging applications. This module provides a high-speed digital interface for using and testing modern advanced driver assistance systems (ADAS) and autonomous drive (AD) camera sensors and electronic control units (ECUs). Additionally, the PXIe-1487 makes use of a combination of GMSL serializers and deserializers with a Xilinx FPGA to provide a high-throughput and customizable GMSL interface on PXI. The PXIe-1487 is ideal for applications such as in-vehicle data logging, lab-based playback, or hardware in the loop (HIL).

Family	Form Factor	Model	FPGA	Digital Input Channels	Digital Output Channels	Serializer	Deserializer	Supported Modes	Serial Link
Integrated I/O module	PXI Express	<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	0	8	MAX96717	-	Pixel, Tunneling	GMSL2
		<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	8	0	-	MAX9296 A	Pixel	GMSL2
		<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	4	4	MAX96717	MAX96716 A	Pixel, Tunneling	GMSL2
		<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	0	8	MAX9295 A	-	Pixel	GMSL2
		<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	8	0	-	MAX96716 A	Pixel, Tunneling	GMSL2
		<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	4	4	MAX96717 F	MAX96716 A	Pixel, Tunneling	GMSL2
		<a href="#">PXIe-1487</a>	Kintex UltraScale + KU11P	4	4	MAX9295 A	MAX9296 A	Pixel	GMSL2

Table 12. FlexRIO GMSL Interface Module with Integrated I/O

# Key Features

## Leverage Rapidly Evolving Technology

FlexRIO provides you with the latest high-speed converter and FPGA technologies before they are widely available in commercial instruments. You can use FlexRIO to develop applications that push the requirements for sample rate, bandwidth, resolution, and channel count.

## Synchronize Multiple Modules

FlexRIO uses the inherent timing and synchronization capabilities of PXI, which means you can synchronize multiple modules with subsample jitter between channels. FlexRIO modules with integrated I/O also work with NI-TCIkl technology, making it simple to program this synchronization.

## Process Signals in Real Time

FlexRIO can help you keep up with faster converters. Modules with Xilinx Kintex UltraScale FPGA ranging up to the Xilinx Virtex UltraScale+ VU11P FPGA paired with LabVIEW FPGA provide the resources you need to engineer complex algorithms, process data in real time between the I/O and CPU, and deploy your designs to hardware.

# FlexRIO Software

## Programming FPGAs with LabVIEW

LabVIEW FPGA is a software tool developed by NI that allows engineers and scientists to program FPGAs using graphical programming. LabVIEW FPGA is a powerful tool for designing and implementing custom hardware circuits that can provide high-speed and low-latency processing for a wide range of applications, including industrial automation, robotics, aerospace, and scientific research. With LabVIEW FPGA, you can design custom hardware circuits that run in real time, so you can implement high-speed, low-latency, and deterministic control and signal processing systems.

LabVIEW FPGA provides an intuitive graphical programming environment that abstracts away many of the low-level details of FPGA programming, making it accessible to users with little or no experience in digital design. The tool includes a library of pre-built FPGA IP blocks that can be used to implement common signal processing and control functions, such as filtering, FFT, PID control, and pulse-width modulation. Traditional methods of programming FPGAs require intimate knowledge of hardware design and years of experience working with low-level hardware description languages. LabVIEW can integrate VHDL to reuse existing IP or for additional programming needs.

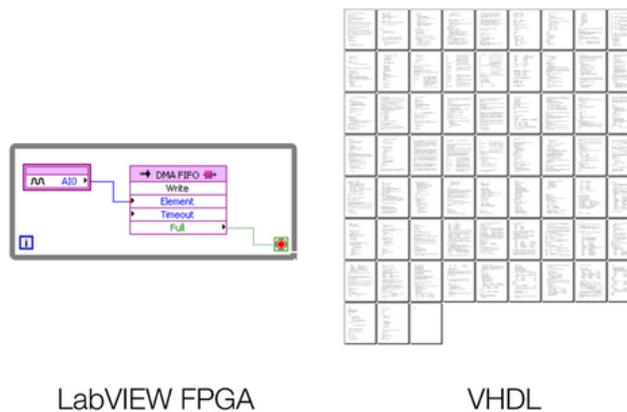


FIGURE 5

Side-by-side comparison of LabVIEW FPGA and VHDL code to implement a FIFO to transfer data from an FPGA to a processor. This example requires more than 4,000 lines of VHDL code. In LabVIEW FPGA, this can be implemented with one graphical while loop.

## FlexRIO Examples

The FlexRIO driver includes dozens of LabVIEW examples that quickly interface with I/O to help users 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. In addition to the examples included with the FlexRIO driver, NI has published several application reference examples that are available through the [online community](#) or in the VI Package Manager.

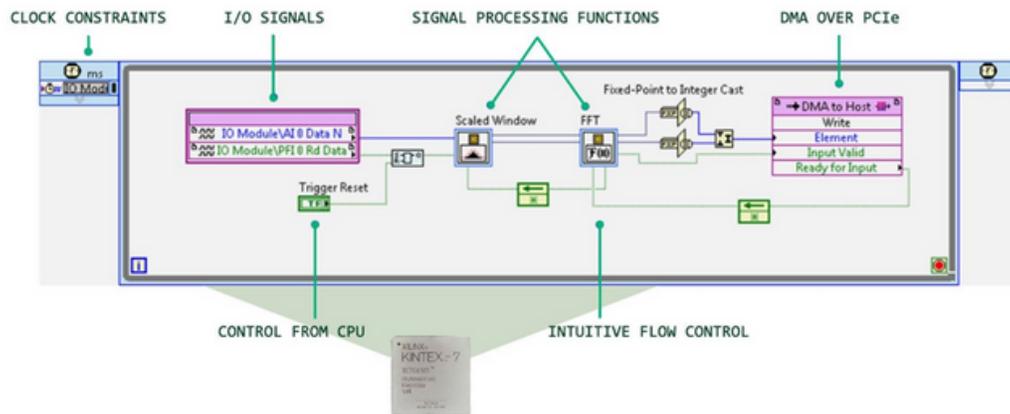


FIGURE 6

LabVIEW FPGA provides a graphical programming approach that simplifies the task of interfacing to I/O and processing data, greatly improving design productivity and shortening time to market.

## Extensive Library of LabVIEW 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 Partners, and Xilinx. Table 13 highlights just some of the NI-provided functions that are commonly used in FlexRIO applications.

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		

Table 13. LabVIEW FPGA IP Commonly Used with FlexRIO FPGA Modules

# Instrument Design Libraries

The FlexRIO examples described in Table 13 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 include:

- 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
  - 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.

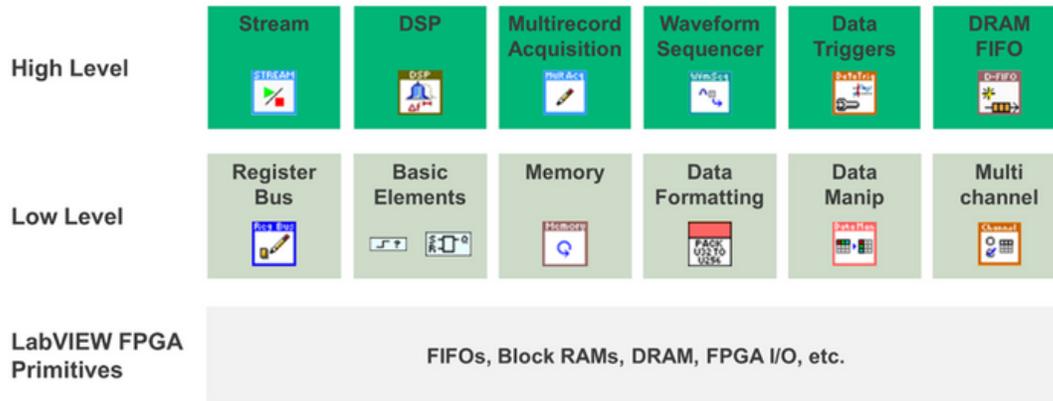


FIGURE 7

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.

# Programming FPGAs with Vivado

Experienced digital engineers can use the Vivado Project Export feature included with LabVIEW FPGA 2017 and later to develop, simulate, and compile for FlexRIO hardware with 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 Vivado Project Export on all FlexRIO and high-speed serial devices with Kintex 7 or newer FPGAs.

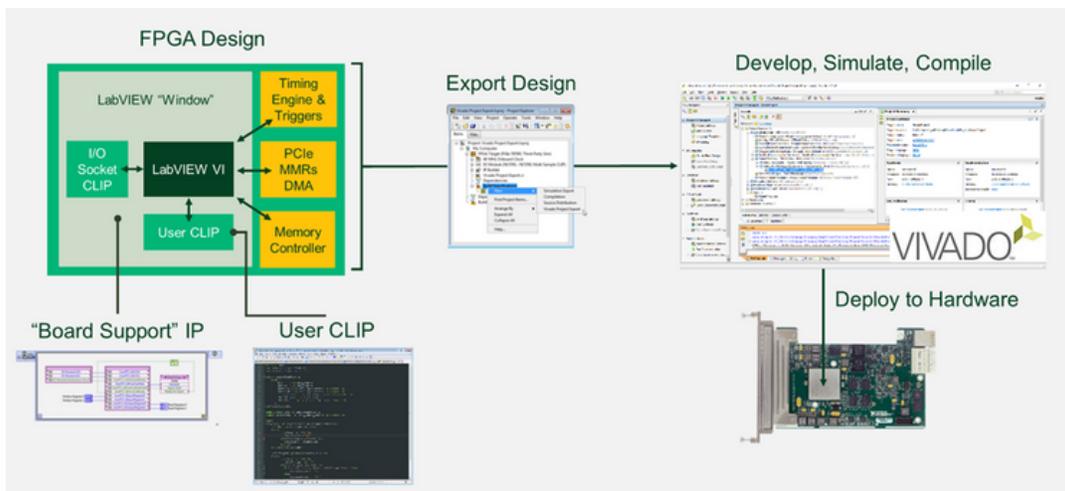


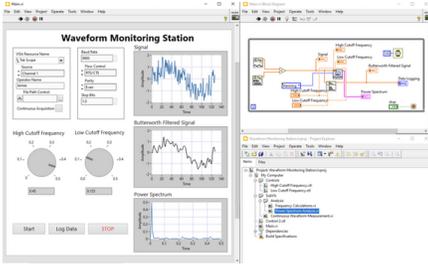
FIGURE 8

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.

# NI Software - The Right Tool for the Job

NI has a variety of software for engineers working on research, validation, and production test applications. Learn more about our software that helps engineers perform quick ad-hoc tests, build an automated test system, automate data analysis and reporting, develop test sequences, and more.

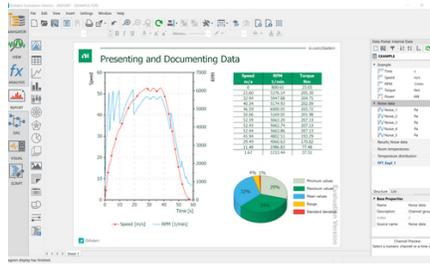
## LabVIEW



Graphical programming environment that engineers use to develop automated research, validation, and production test systems.

- Acquire data from NI and third-party hardware and communicate using industry protocols
- Use configurable, interactive display elements
- Take advantage of available analysis functions

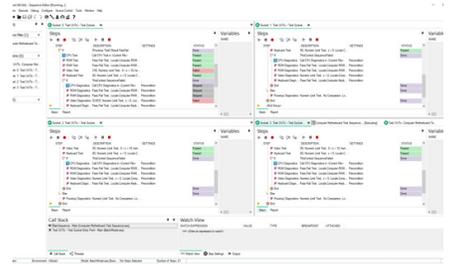
## DIAdem



Data analytics software for measurement data search, inspection, analysis, and automated reporting.

- Display data in multiple 2D-axis systems
- Perform calculations with a simple point-and-click interface
- Automate your measurement data analysis workflow, from import to analysis

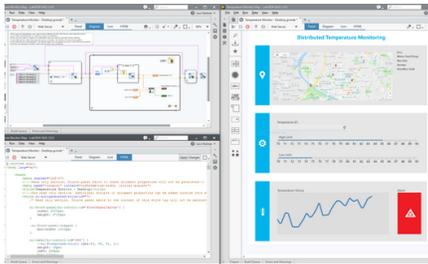
## TestStand



Test executive software that accelerates system development for engineers in validation and production.

- Call and execute tests in LabVIEW, Python, C/C++, or .NET
- Conduct complex tasks, such as parallel testing
- Create customer operator interfaces and robust tools for deployment and debugging

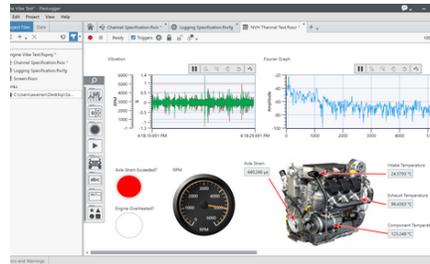
## G Web



Development software that helps engineers create web-based user interfaces without the need for traditional web development skills.

- Data transfer APIs for connecting to systems written in LabVIEW, Python, or C#
- Pre-built objects for data display and user input
- Included hosting on SystemLink™ Cloud

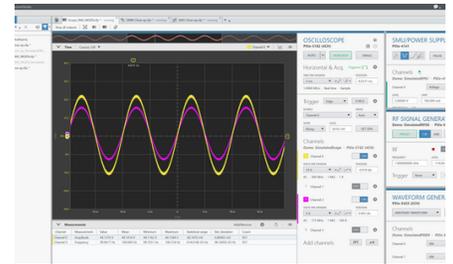
## FlexLogger™



No-code data acquisition software engineers use to build validation and verification test applications.

- Interactive visualization tools for monitoring tests with drag-and-drop charts, graphs, and controls
- Ability to set alarms that monitor single channels or groups for unexpected behavior

## InstrumentStudio™



Application software that simplifies setup and configuration of NI PXI hardware

- Customizable layouts for monitoring multiple instruments at once
- Interactively debug in tandem with code
- TDMS file export containing instrument settings, measurements, and raw data

# Supporting Documentation

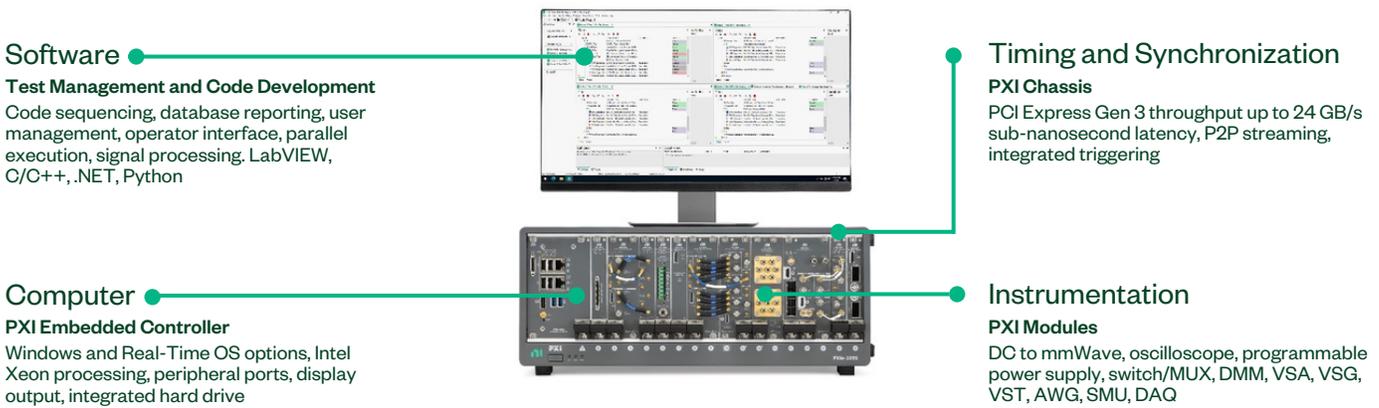
Table 14. Supporting Documentation for Individual Models

Document Type	Model #
Getting Started Guide	<a href="#">NI FlexRIO FPGA Module Installation Guide and Specifications, PXIe-1486, PXIe-1487, PXIe-5745, NI 5751/5751B, NI 5752/5752B, PXIe-5763, PCIe-5763, PXIe-5764, PXIe-5774, PXIe-5775, PCIe-5775, NI 5783, PXIe-5785, PCIe-5785, PXIe-6569, NI 6585/6585B, NI 6589, PXIe-6591, PXIe-6592, PXIe-6593, PXIe-6594, PXIe-7902, PXIe-7903, PXIe-7911/7912/7915</a>
Specifications	<a href="#">PXIe-1486, PXIe-1487, PXIe-5745, NI 5751/5751B, PXIe-5763, PCIe-5763, PXIe-5764, PCIe-5764, PXIe-5774, PCIe-5774, PXIe-5775, PCIe-5775, NI 5781, NI 5783, PXIe-5785, PCIe-5785, NI 5793, PXIe-6569, NI 6583, NI 6584, NI 6585B, PXIe-6591, PXIe-6592, PXIe-6593, PXIe-6594, PXIe-7902, PXIe-7903, PXIe-7911, PXIe-7912, PXIe-7915, NI 7935, PXIe-7971, PXIe-7972, PXIe-7975, PXIe-7976</a>

# What Is PXI?

## A Platform Approach to Test and Measurement

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.



## Integrated with 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.

<b>HIGHER DATA THROUGHPUT</b>  <b>PCI Express Gen 3</b>	<b>PARALLEL TEST EXECUTION</b>  <b>Multicore Processors</b>	<b>MEASUREMENT ACCELERATION</b>  <b>FPGAs</b>	<b>INCREASED MEASUREMENT RANGE</b>  <b>Data Converters</b>
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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

# 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](https://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 with 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; <10 working days [4] + standard shipping.
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 + standard shipping.

## PremiumPlus Service Program

NI can customize the offerings listed above or offer additional entitlements such as on-site calibration, custom sparring, and lifecycle 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](#).

