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## NI FlexRIO FPGA Modules



### Overview

The NI FlexRIO family consists of PXI and PXI Express field-programmable gate array (FPGA) modules coupled to I/O adapter modules. Programmed with the NI LabVIEW FPGA Module, these modules together provide high-performance I/O and user-defined hardware processing on the PXI platform. NI FlexRIO FPGA modules feature the latest in FPGA technology and high-performance bus interfaces. National Instruments and third parties offer NI FlexRIO adapter modules, and you can build your own adapter modules using the NI FlexRIO Adapter Module Development Kit (MDK). With custom adapter modules, you can implement the exact analog and digital I/O your application requires, along with graphical FPGA programming provided by LabVIEW. View a current list of NI and third-party adapter modules at [ni.com/flexrio](http://ni.com/flexrio).

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### Requirements and Compatibility

#### OS Information

- FPGA
- Real-Time OS
- Windows 2000/XP
- Windows 7
- Windows Vista

#### Driver Information

- NI FlexRIO Adapter Module Support
- NI-RIO

#### Software Compatibility

- LabVIEW
- LabVIEW FPGA Module

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### Application and Technology

Model	Bus/Form Factor	FPGA	FPGA Slices	FPGA DSP Slices	FPGA Memory (Block RAM)	Onboard Memory (DRAM)
NI PXIe-7965R/ 7966R <sup>1</sup>	PXI Express	Virtex-5 SX95T	14,720	640	8,784 kbit	512 MB
NI PXIe-7962R	PXI Express	Virtex-5 SX50T	8,160	288	4,752 kbit	512 MB
NI PXIe-7961R	PXI Express	Virtex-5 SX50T	8,160	288	4,752 kbit	0 MB
NI PXI-7954R	PXI	Virtex-5 LX110	17,280	64	4,608 kbit	128 MB
NI PXI-7953R	PXI	Virtex-5 LX85	12,960	48	3,456 kbit	128 MB
NI PXI-7952R	PXI	Virtex-5 LX50	7,200	48	1,728 kbit	128 MB
NI PXI-7951R	PXI	Virtex-5 LX30	4,800	32	1,152 kbit	0 MB

<sup>1</sup>These two devices have different speed grade FPGAs: (-1) for the NI PXIe-7965R and (-2) for the NI PXIe-7966R. For more information on Xilinx Virtex-5 FPGA speed grades, refer to the Virtex-5 FPGA Data Sheet: DC and Switching Characteristics at [xilinx.com](http://xilinx.com).

Table 1. NI FlexRIO FPGA Module Options

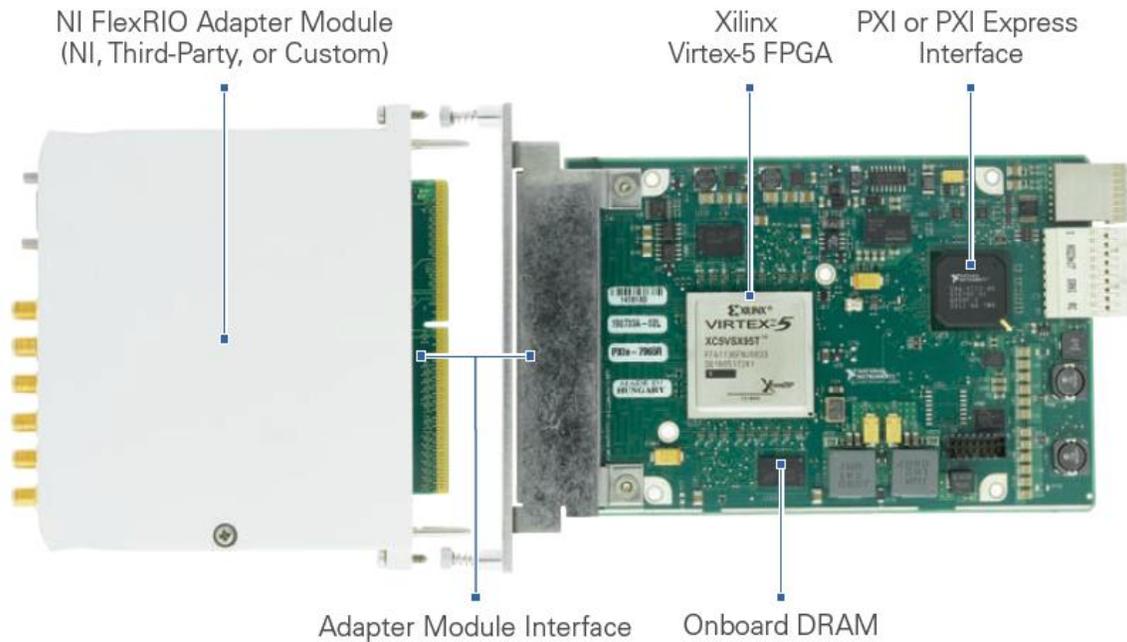


Figure 1. NI FlexRIO Architecture

Application	Example Algorithm
Inline signal processing	Continuous filtering, thresholding, peak detections, data reduction/compression, zero suppression, averaging
Custom triggering	Multievent, protocol-specific, variable hysteresis, logical AND/OR, data mask, multichannel
Software defined radio	Digital upconversion, downconversion, modulation, demodulation, packet assembly
"Protocol aware" semiconductor test systems	DUT-specific master and slave protocols
Custom RF communication scheme development and test	Custom modulation and demodulation, bit error rate test, fading profiles, additive noise
High-speed serial communication protocols	Serialization, deserialization, parallel algorithms
Deterministic analog or digital closed-loop control and interfacing	Frequency-based control loops, PID, emergency stop criteria evaluations, and assertion
High-performance and custom control or PXI-based test systems	Deterministic, low-latency instrument sequencing; high-performance DUT control
FPGA-based coprocessing/hardware acceleration	Algorithms exploiting FPGA throughput and parallelism, complementing host processing

Table 2. Example Applications and Algorithms That Benefit From User-Defined FPGA Processing and High-Performance I/O on the PXI Platform

### NI FlexRIO FPGA Modules for PXI Express

PXI Express NI FlexRIO FPGA modules feature Xilinx Virtex-5 SXT FPGAs with up to 512 MB of onboard DRAM, which you can access at bandwidths up to 3.2 GB/s. In addition to general-purpose reconfigurable logic, SXT FPGAs are optimized for high-speed digital signal processing (DSP), with up to 640 DSP slices for single-cycle multiplication and filtering functions. PXI Express NI FlexRIO FPGA modules also feature the NI STC-3 application-specific integrated circuit (ASIC) to provide an optimized, high-bandwidth PCI Express x4 communications link to the backplane of the PXI Express chassis. This ASIC reduces the FPGA resources needed to implement host communication and enables new data transfer technology in the unique peer-to-peer streaming feature.

For multiadapter module synchronization, PXI Express NI FlexRIO FPGA modules include the I/O Module Synchronization Clock, which you can use to synchronize multiple adapter modules, provided the adapter module supports this signal.



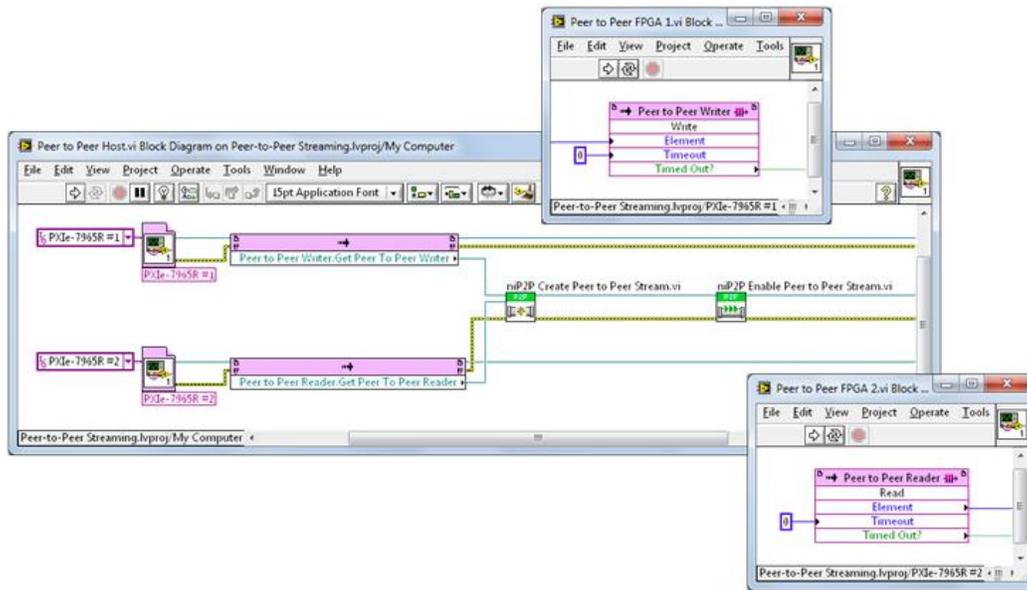


Figure 4. The NI-P2P driver offers simple, high-level access to the high-performance capabilities of peer-to-peer streaming, and intuitive nodes on the FPGA block diagram simplify data transfer.

### NI FlexRIO FPGA Modules for PXI

PXI NI FlexRIO FPGA modules feature Xilinx Virtex-5 LX FPGAs with up to 128 MB of onboard DRAM, which you can access at bandwidths up to 1.6 GB/s. They feature all of the benefits of the PXI platform including synchronization, triggering, and high-speed data transfer to and from their hosts.

Feature	PXI NI FlexRIO FPGA Modules	PXI Express NI FlexRIO FPGA Modules
Xilinx Virtex-5 FPGAs		
132-Line Adapter Module Interface		
I/O Module Synchronization		
Peer-to-Peer Data Streaming		

Table 3. PXI and PXI Express FPGA Module Comparison

### NI FlexRIO Adapter Modules

NI and National Instruments Alliance Partners offer NI FlexRIO adapter modules. You also can build your own with the NI FlexRIO Adapter MDK. View a list of NI FlexRIO adapter modules at [ni.com/flexrio](http://ni.com/flexrio).

### NI Adapter Modules

NI FlexRIO adapter modules provide high-performance I/O that you can customize with the NI FlexRIO FPGA module. With these adapter modules, National Instruments includes the module-specific Component-Level IP (CLIP) Node, which defines the interface between LabVIEW and the adapter module. This helps you begin programming your application immediately, without a low-level understanding of the adapter module design or functionality. Examples demonstrate how to effectively use the CLIP Node.

### Third-Party Adapter Modules

In addition to NI FlexRIO adapter modules built by National Instruments, NI Alliance Partners can build adapter modules with the same degree of performance, functionality, and integration. These modules are available as either standard or custom products.

### Custom Adapter Modules

If you cannot find an adapter module that meets your application needs from National Instruments or an NI Alliance Partner, you can build your own custom adapter module using the NI FlexRIO Adapter Module Development Kit (MDK).



Figure 5. The NI FlexRIO Adapter Module Development Kit (MDK) features the documentation, design files, and adapter module enclosures to build your own NI FlexRIO adapter module.

With the NI FlexRIO Adapter MDK, you receive the following:

- A comprehensive module development user manual
- Example adapter module support files
- Three blank adapter module enclosures
- One windowed adapter module enclosure for debugging
- Mechanical drawings for the adapter module PCB, card-edge connector, and front panel
- Direct support from NI R&D engineers, including a one-hour design review to help ensure electrical compatibility with NI FlexRIO FPGA modules

## Programming NI FlexRIO With the LabVIEW FPGA Module

### Graphical FPGA Programming

NI LabVIEW and the LabVIEW FPGA Module deliver graphical development for FPGA devices on NI reconfigurable I/O (RIO) hardware targets. You can create embedded FPGA VIs that combine direct access to I/O with user-defined LabVIEW logic to define custom hardware.

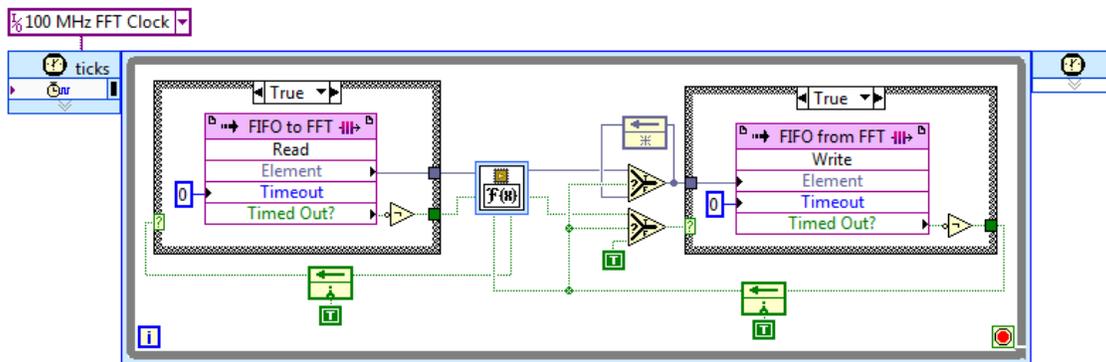
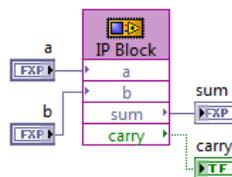


Figure 6. This LabVIEW code depicts a user-configurable, hardware-based FFT operation. It features fixed-point data processing, a dedicated 100 MHz clock domain in a single-cycle Timed Loop (100 MHz FFT clock), FIFOs to enter and exit the clock domain (FIFO to FFT and FIFO from FFT), flow control to ensure sample-accurate execution and account for multicycle IP latency, and a user-configurable FFT function (FFT).

### Integrating HDL

While LabVIEW is an effective tool for FPGA programming, you may have existing hardware description language (HDL) intellectual property (IP) that you must integrate into your NI FlexRIO hardware applications. You have three options for doing this. The first is the IP Integration Node. This node provides a simple, inline interface to HDL IP and Xilinx CORE Generator XCO files. It features automatic LabVIEW interface generation and the ability to generate cycle-accurate simulation models for host execution. Using the latter functionality, you can run your LabVIEW FPGA VI on the host to ensure proper functionality before compiling it for the FPGA.



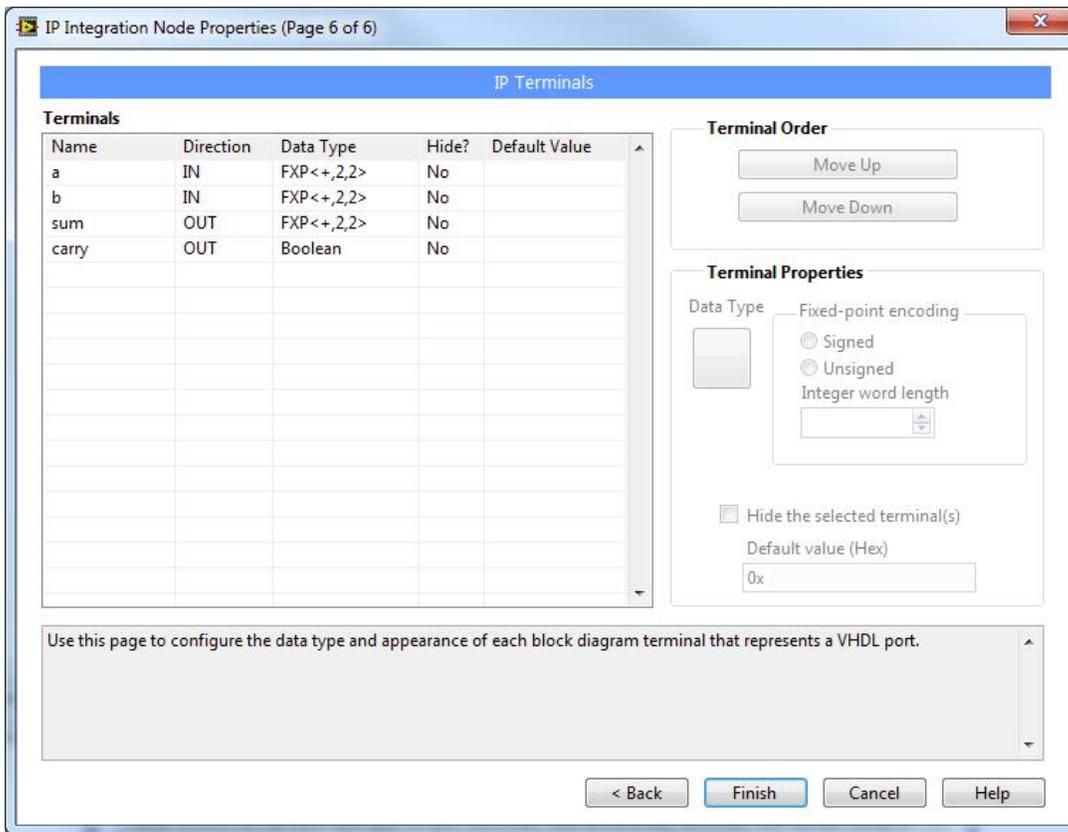
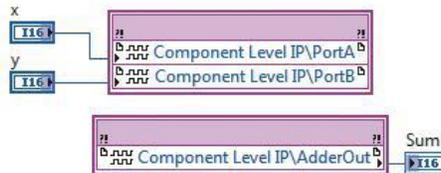


Figure 7. With the IP Integration Node, you can import VHDL and Xilinx CORE Generator XCO files. It automatically generates the LabVIEW interface (for use in a single clock domain) and creates a cycle-accurate simulation model for host PC code emulation.

For more complex HDL that may use multiple clock domains and execute asynchronously, the CLIP Node offers an interface. Through an XML wrapper, you import the HDL into LabVIEW and access it through I/O nodes. You also use the CLIP Node to interface to the NI FlexRIO adapter module as well as the FPGA module onboard DRAM. The CLIP Node executes asynchronously to the LabVIEW block diagram, can support multiple clocks, and is required for customizing certain features of the hardware such as the adapter module interface. This is different from the IP Integration Node, which executes inline with the LabVIEW block diagram and can be accurately simulated with the LabVIEW host simulation.



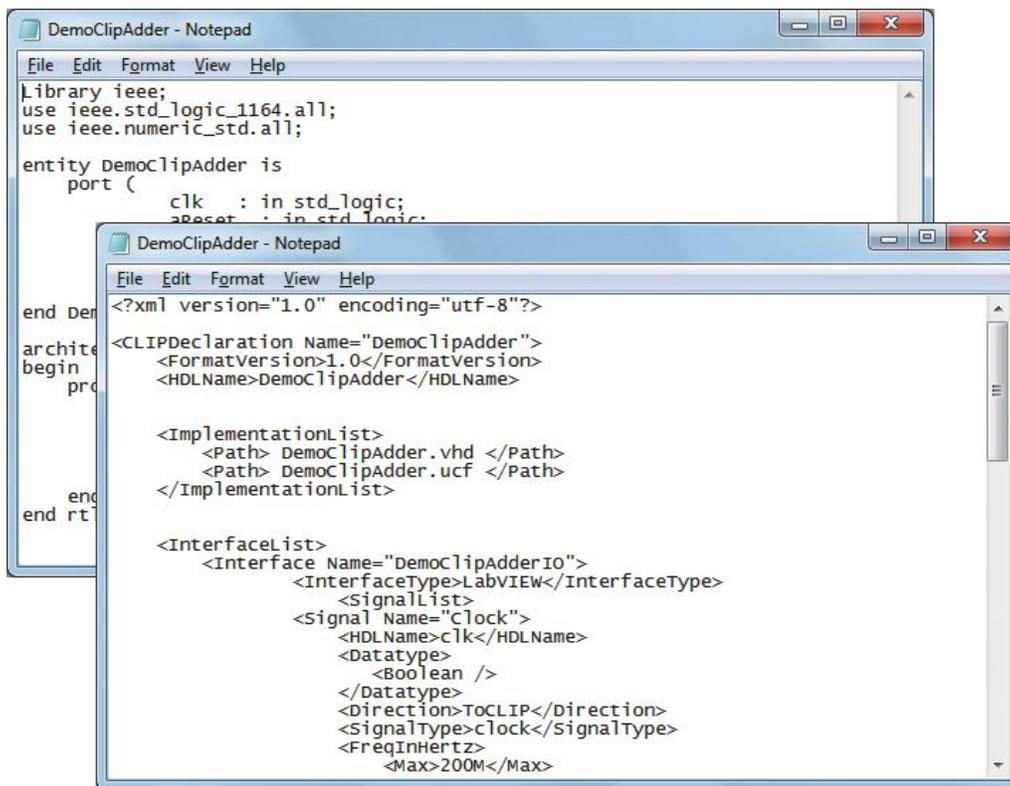
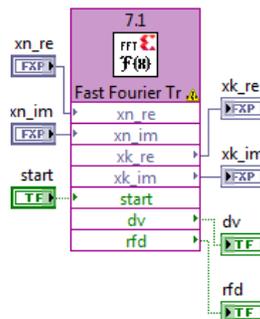


Figure 8. With the CLIP Node, you can import HDL or netlists through an XML wrapper file for asynchronous execution.

The Xilinx CORE Generator IP functions are designed to streamline the process for importing Xilinx CORE Generator files. The Xilinx CORE Generator uses the IP Integration Node to conveniently incorporate Xilinx CORE Generator IP into an FPGA VI by allowing you to configure the Xilinx CORE from within the LabVIEW environment.



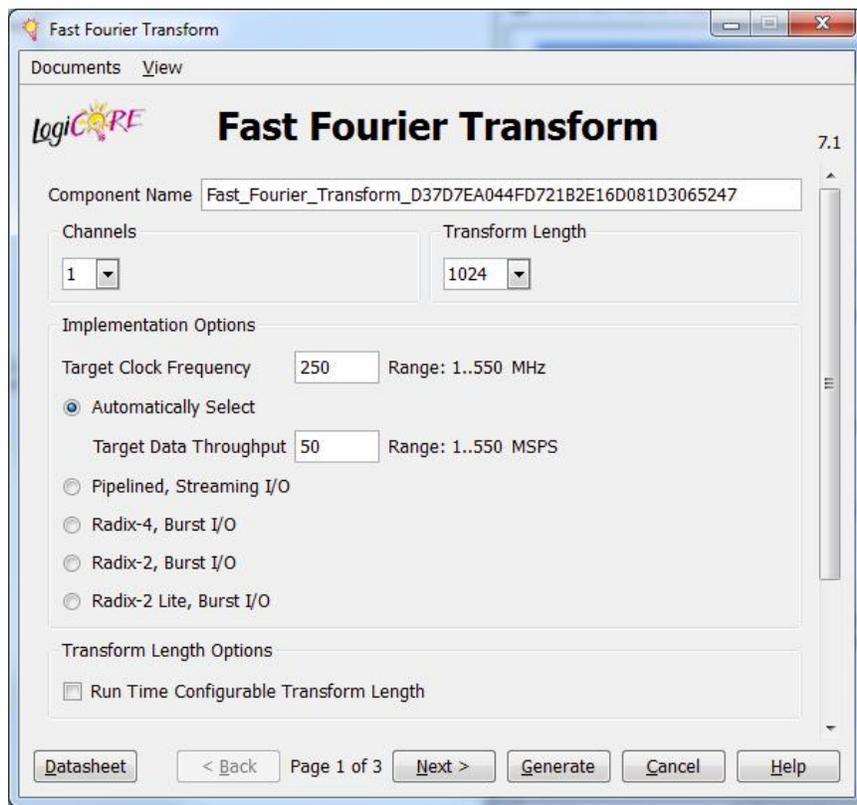


Figure 9. The Xilinx CORE Generator IP functions incorporate the IP Integration Node and Xilinx CORE Generator so you can configure the Xilinx CORE from within LabVIEW.

## NI FlexRIO Development Tools

NI FlexRIO development tools consist of the NI FlexRIO Instrument Development Library and the NI-573xR Example Instrument Driver. Both are available for download from [ni.com/labs](http://ni.com/labs).

### NI FlexRIO Instrument Development Library

The NI FlexRIO Instrument Development Library is a collection of LabVIEW Host and FPGA code designed to provide FPGA capabilities commonly found in instruments such as acquisition engines, DRAM interfaces, and trigger logic, along with the associated host APIs. This code is open and modular, so you can choose only the components you need, and it delivers efficient implementation. You also can use it to modify the code provided in the library, if necessary, to meet your unique application needs.

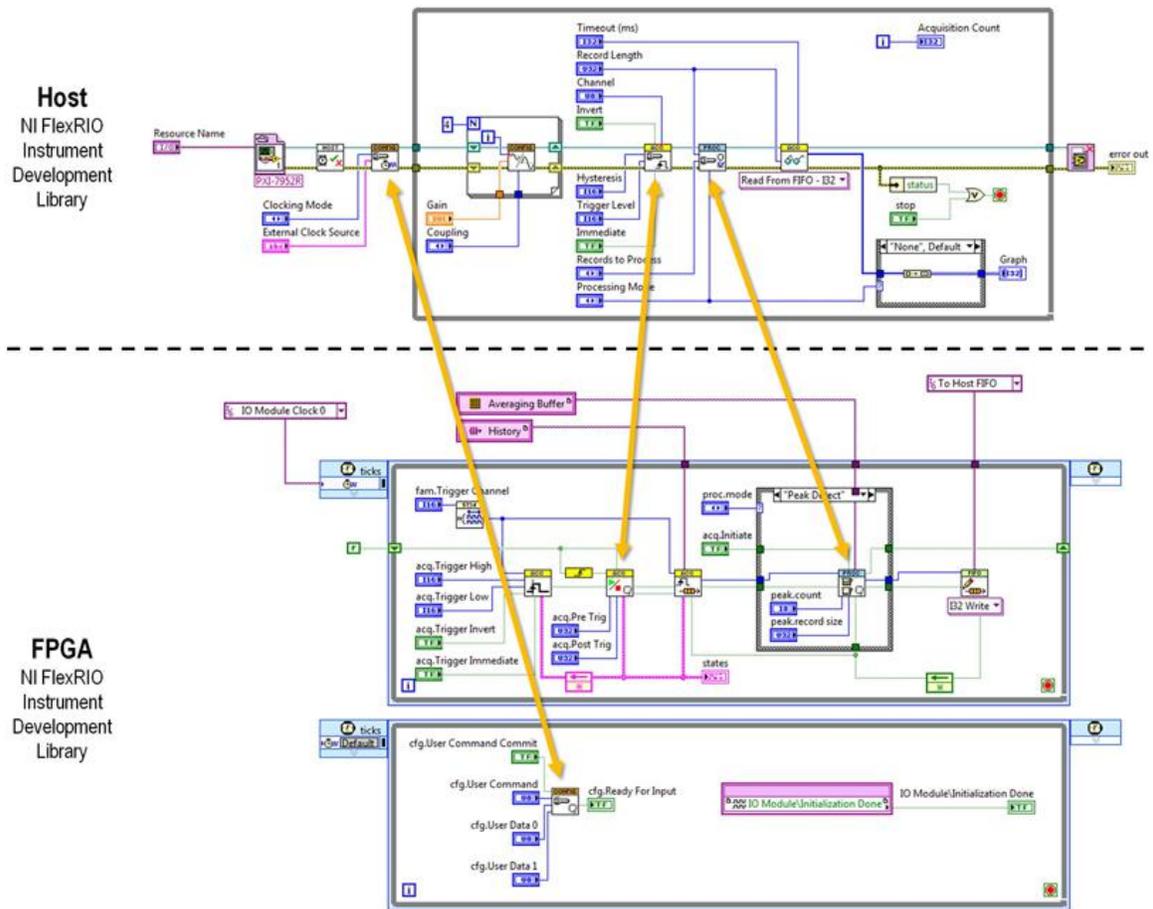


Figure 10. The NI FlexRIO Instrument Development Library provides LabVIEW Host and FPGA code building blocks for capabilities commonly found in instruments.

### NI-573xR Example Instrument Driver

The NI-573xR Example Instrument Driver builds on the NI FlexRIO Instrument Development Library to deliver a familiar software API and default FPGA personality for NI 573xR digitizer adapter modules. It helps you quickly begin taking measurements, modify both the LabVIEW Host and FPGA code to suit your application, and provides access to the full capabilities of user-customizable instrumentation hardware.

NI-573xR  
Example  
Instrument  
Driver

NI FlexRIO  
Instrument  
Development  
Library

NI-RIO

LabVIEW  
FPGA Bitfile

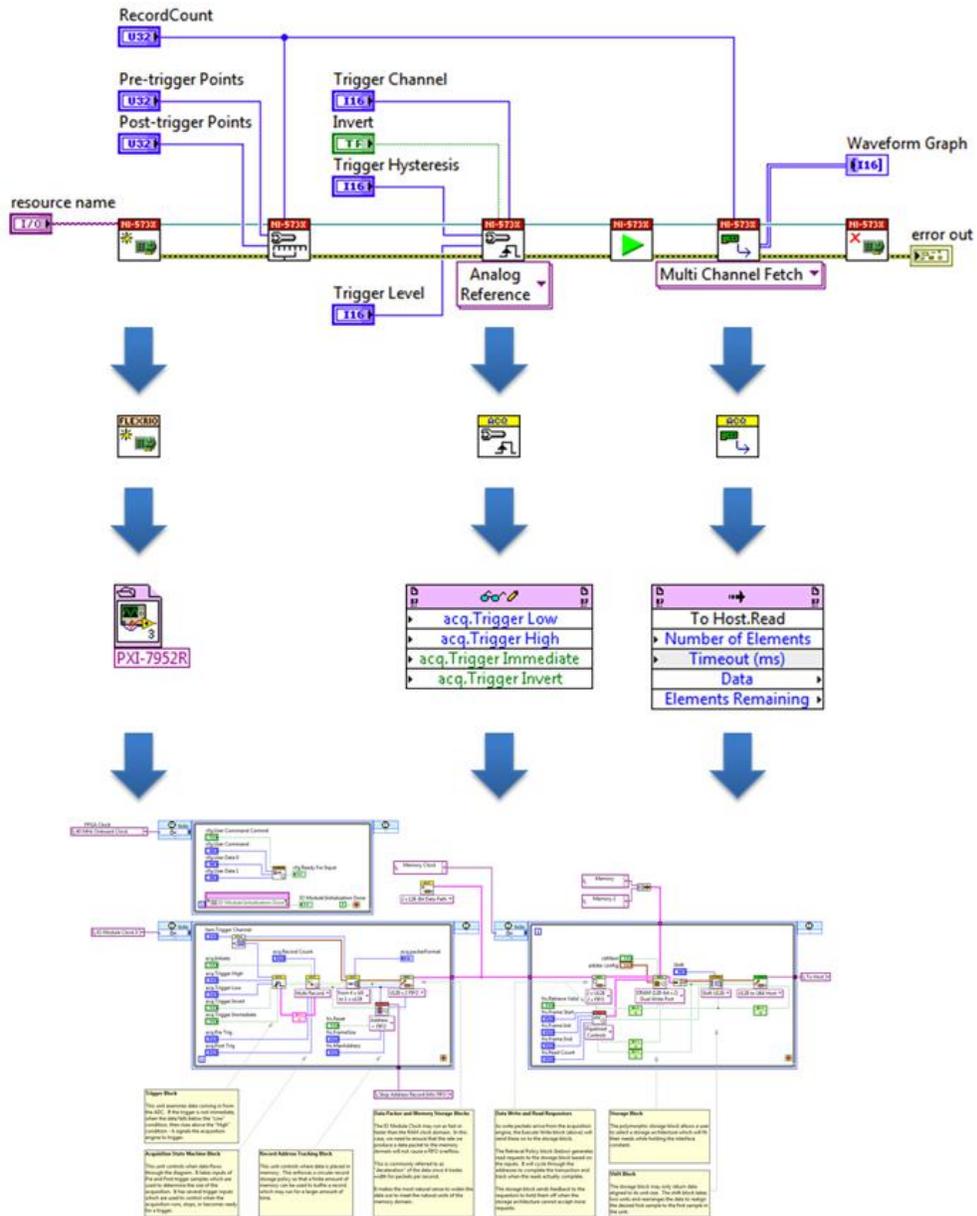


Figure 11. The NI-573xR Example Instrument Driver builds on the NI FlexRIO Instrument Development Library to provide a high-level Host API with an underlying FPGA acquisition engine.

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## Software Recommendations

### LabVIEW Professional Development System for Windows



- Advanced software tools for large project development
- Automatic code generation using DAQ Assistant and Instrument I/O Assistant
- Tight integration with a wide range of hardware
- Advanced measurement analysis and digital signal processing
- Open connectivity with DLLs, ActiveX, and .NET objects
- Capability to build DLLs, executables, and MSI installers

### NI LabVIEW FPGA Module



- Design FPGA applications for NI reconfigurable I/O (RIO) hardware targets
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx CORE Generator functions
- Included in the LabVIEW Embedded Control and Monitoring Suite

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## System Assurance Programs

NI system assurance programs are designed to make it even easier for you to own an NI system. These programs include configuration and deployment services for your NI PXI, CompactRIO, or Compact FieldPoint system. The NI Basic System Assurance Program provides a simple integration test and ensures that your system is delivered completely assembled in one box. When you configure your system with the NI Standard System Assurance Program, you can select from available NI system driver sets and application development environments to create customized, reorderable software configurations. Your system arrives fully assembled and tested in one box with your software preinstalled. When you order your system with the standard program, you also receive system-specific documentation including a bill of materials, an integration test report, a recommended maintenance plan, and frequently asked question documents. Finally, the standard program reduces the total cost of owning an NI system by providing three years of warranty coverage and calibration service. Use the online product advisors at [ni.com/advisor](http://ni.com/advisor) to find a system assurance program to meet your needs.

## Technical Support

Get answers to your technical questions using the following National Instruments resources.

- **Support** - Visit [ni.com/support](http://ni.com/support) to access the NI KnowledgeBase, example programs, and tutorials or to contact our applications engineers who are located in NI sales offices around the world and speak the local language.
- **Discussion Forums** - Visit [forums.ni.com](http://forums.ni.com) for a diverse set of discussion boards on topics you care about.
- **Online Community** - Visit [community.ni.com](http://community.ni.com) to find, contribute, or collaborate on customer-contributed technical content with users like you.

## Repair

While you may never need your hardware repaired, NI understands that unexpected events may lead to necessary repairs. NI offers repair services performed by highly trained technicians who quickly return your device with the guarantee that it will perform to factory specifications. For more information, visit [ni.com/repair](http://ni.com/repair).

## Training and Certifications

The NI training and certification program delivers the fastest, most certain route to increased proficiency and productivity using NI software and hardware. Training builds the skills to more efficiently develop robust, maintainable applications, while certification validates your knowledge and ability.

- **Classroom training in cities worldwide** - the most comprehensive hands-on training taught by engineers.
- **On-site training at your facility** - an excellent option to train multiple employees at the same time.
- **Online instructor-led training** - lower-cost, remote training if classroom or on-site courses are not possible.
- **Course kits** - lowest-cost, self-paced training that you can use as reference guides.
- **Training memberships** and training credits - to buy now and schedule training later.

Visit [ni.com/training](http://ni.com/training) for more information.

## Extended Warranty

NI offers options for extending the standard product warranty to meet the life-cycle requirements of your project. In addition, because NI understands that your requirements may change, the extended warranty is flexible in length and easily renewed. For more information, visit [ni.com/warranty](http://ni.com/warranty).

## OEM

NI offers design-in consulting and product integration assistance if you need NI products for OEM applications. For information about special pricing and services for OEM customers, visit [ni.com/oem](http://ni.com/oem).

## Alliance

Our Professional Services Team is comprised of NI applications engineers, NI Consulting Services, and a worldwide National Instruments Alliance Partner program of more than 700 independent consultants and integrators. Services range from start-up assistance to turnkey system integration. Visit [ni.com/alliance](http://ni.com/alliance).

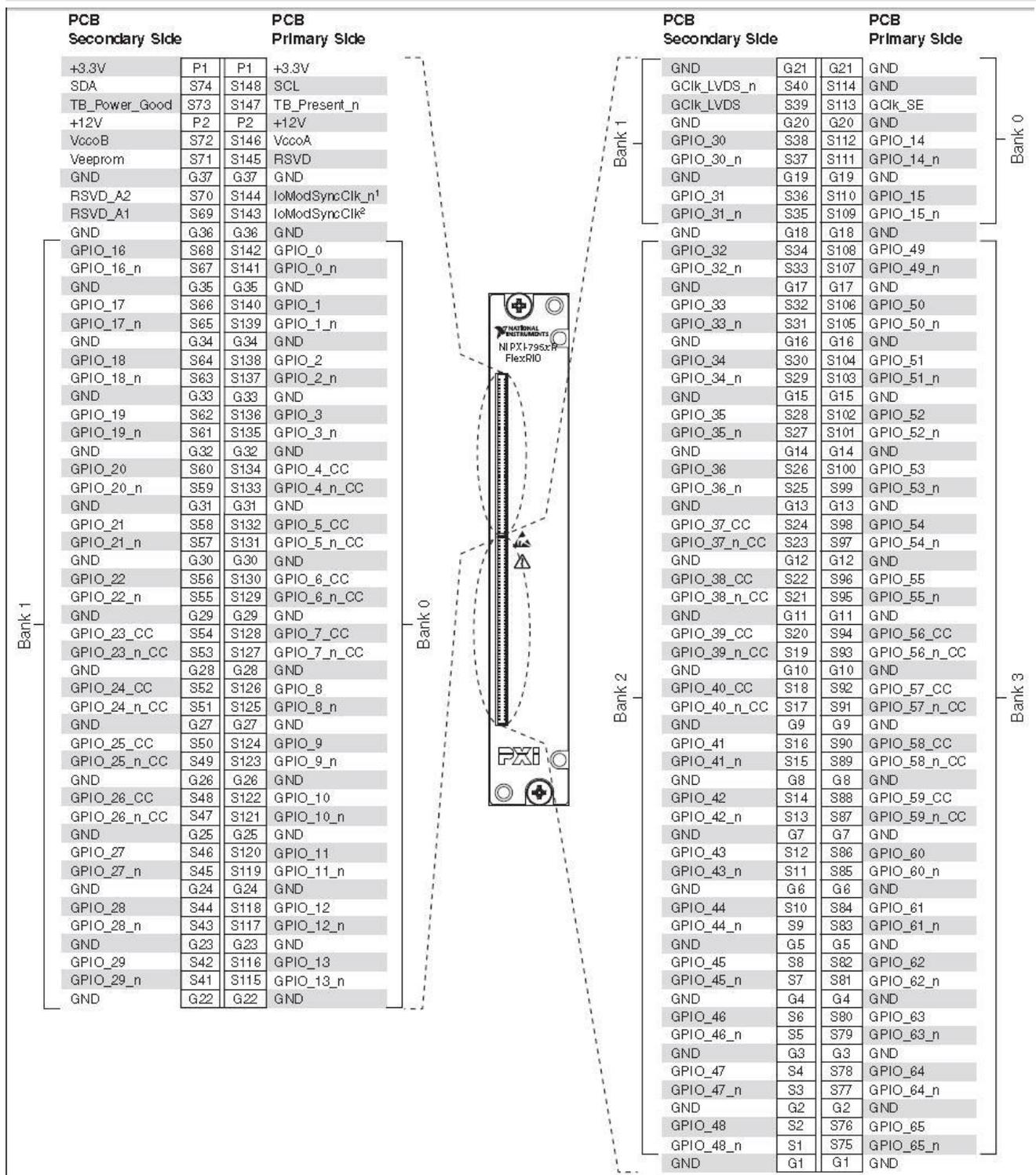
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## Detailed Specifications

Reconfigurable FPGA				
Device	FPGA	LUTs/Flip-Flops	DSP48 Slices (25 x 18 Multiplier)	Embedded Block RAM (kbits)
NI PXI-7951R	Virtex-5 LX30	19,200	32	1,152
NI PXI-7952R	Virtex-5 LX50	28,800	48	1,728
NI PXI-7953R	Virtex-5 LX85	51,840	48	3,456
NI PXI-7954R	Virtex-5 LX110	69,120	64	4,608
NI PXI-7961R	Virtex-5 SX50T	32,640	288	4,752
NI PXI-7962R	Virtex-5 SX50T	32,640	288	4,752
NI PXI-7965R	Virtex-5 SX95T	58,880	640	8,784

Default timebase	40MHz
Timebase reference sources	
NI PXI-795xR	PXI 10 MHz
NI PXI-796xR	PXIe 100 MHz
Timebase accuracy	
NI PXI-795xR	±100 ppm, 250 ps

	peak-to-peak jitter
NI PXI-796xR	±50 ppm, 250 ps peak-to-peak jitter
Data transfers	DMA, interrupts, programmed I/O
Number of DMA channels	
NI PXI-795xR	3
NI PXI-796xR	16
<b>FPGA Digital Input/Output</b>	
Number of general-purpose channels	132, configurable as 132 single-ended, 66 differential, or a combination of both <sup>1</sup>
Channels per bank	
Bank 0/Bank 2	32, single-ended per bank
Bank 1/Bank 3	34, single-ended per bank
Compatibility	Configured via FPGA, 1.2 V to 3.3 V I/O standards (refer to <a href="http://www.xilinx.com">www.xilinx.com</a> )
Protection	Refer to <a href="http://www.xilinx.com">www.xilinx.com</a>
Current	Refer to <a href="http://www.xilinx.com">www.xilinx.com</a>
Maximum I/O data rates	
Single-ended	400 Mb/s for LVDCI25
Differential	1 Gb/s for LVDS
Global clock inputs	1 LVTTTL, 1 LVDS
Connection resources	
NI PXI-795xR	PXI triggers, Clk10, and PXI star trigger
NI PXI-796xR	PXI triggers, Clk10, PXI star trigger, DStarA, DStarB, DStarC, and Sync100
<b>Device Signals</b>	



1 RSVD\_B2 on the NI PXI-795xR

2 RSVD\_B1 on the NI PXI-795xR

Figure 1. NI FlexRIO FPGA Module Front Connector Pin Assignments and Locations

### Onboard DRAM

#### Memory size

NI PXI-795xR	2 banks; 64 MB per bank
NI PXI-796xR	2 banks; 256 MB per bank

#### Maximum theoretical data rate

NI PXI-795xR	800 MB/s per bank
NI PXI-796xR	1.6 GB/s per bank

## Bus Interface

PXI	Master, slave
PXI Express	
Form factor	x4 PXI Express, specification v1.0 compliant
Slot compatibility	x4, x8, and x16 PXI Express or PXI Express hybrid slots

## Maximum Power Requirement

PXI	Master, slave
NI PXI-795xR	
+5 VDC (±5%)	2 A
+3.3 VDC (±5%)	2 A
+12 V	0.5 A
-12 V	0 A
NI PXI-796xR	
+5 VDC (±5%)	3 A
+3.3 VDC (±5%)	2 A

## Physical

Dimensions (not including connectors)

NI PXI-795xR	18.8 cm × 12.9 cm (7.4 in. × 5.1 in.)
NI PXI-796xR	16.1 cm × 10.8 cm (6.3 in. × 4.3 in.)

Weight

NI PXI-795xR	190 g (6.7 oz)
NI PXI-796xR	213 g (7.5 oz)

I/O connector High-density card edge

## Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth	0 V to 3.3 V, Measurement Category I
Channel-to-channel	0 V to 3.3 V, Measurement Category I



**Caution** Do not use this device for connection to signals in Measurement Categories II, III, or IV.

## Environmental

This device is intended for indoor use only.

Operating environment	0°C to 55°C, tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.
Relative humidity range	10% to 90%, noncondensing, tested in accordance with IEC-60068-2-56.
Altitude	2,000 m at 25°C ambient temperature
Pollution Degree	2
Storage environment	
Ambient temperature range	-40°C to 70°C, tested in accordance with IEC-60068-2-1 and IEC-60068-2-2.
Relative humidity range	5% to 95%, noncondensing, tested in accordance with IEC-60068-2-56.

## Shock and Vibration

Operational shock	30 g peak, half-sine, 11 ms pulse, tested in accordance with IEC-60068-2-27. Test profile developed in accordance with MIL-PRF-28800F.
Random vibration	
Operating	5 Hz to 500 Hz, 0.3 grms
Nonoperating	5 Hz to 500 Hz, 2.4 grms, tested in accordance with IEC-60068-2-64. Nonoperating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.

## Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1



**Note** For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

## Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326 (IEC 61326): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions



**Note** For the standards applied to assess the EMC of this product, refer to the *Online Product Certification* section.



**Note** EMC compliance evaluated with a wrapback adapter module and general purpose I/O (GPIO) signals configured to LVTTTL I/O standard, slew rate set to slow, and drive strength set to 6 mA. EMC compliance of other I/O standards, faster slew rates, and greater drive strength is not guaranteed.

## CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

## Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit [ni.com/certification](http://ni.com/certification), search by module number or product line, and click the appropriate link in the Certification column.

## Environmental Management

National Instruments is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the *NI and the Environment* Web page at [ni.com/environment](http://ni.com/environment). This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

## Waste Electrical and Electronic Equipment (WEEE)



**EU Customers** At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste Electrical and Electronic Equipment, visit [ni.com/environment/weee.htm](http://ni.com/environment/weee.htm).

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