CompactRIO

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Features

- Small, rugged, industrial control and acquisition system
- Powered by reconfigurable I/O (RIO) FPGA technology for ultrahigh performance and customization
- Low-cost architecture with open access to low-level hardware resources
- High-productivity LabVIEW graphical programming tools for rapid development
- Real-time processor and reconfigurable FPGA for reliable stand-alone embedded or distributed applications
- Hot-swappable industrial I/O modules with built-in signal conditioning for direct connection to sensors and actuators
- Design your own custom control or acquisition circuitry in silicon with 25 ns timing/triggering resolution
- NI CompactRIO Extreme Industrial Certifications and Ratings
  - -40 to 70 °C (-40 to 158 °F) operating temperature
  - Up to 2,300 V_{rms} isolation (withstand)
  - 50 g shock rating
  - International safety, EMC, and environmental certifications
  - Class I, Division 2 rating for hazardous locations
  - Dual 11-30 VDC supply inputs, low power

For ordering information, see page 381.

Overview

National Instruments CompactRIO is an advanced reconfigurable embedded control and acquisition system powered by NI RIO technology for ultrahigh performance, user customization, and reconfigurability. It is designed to perform in the harshest industrial environments.



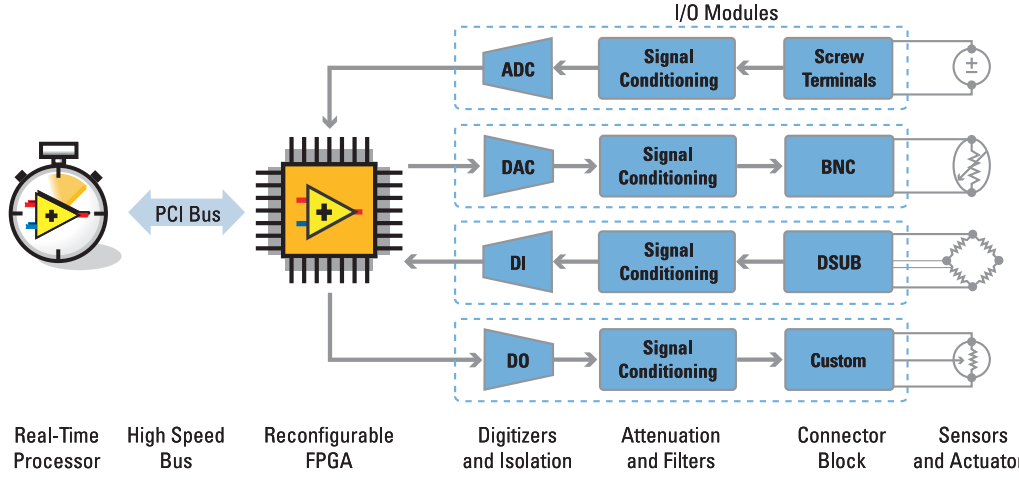
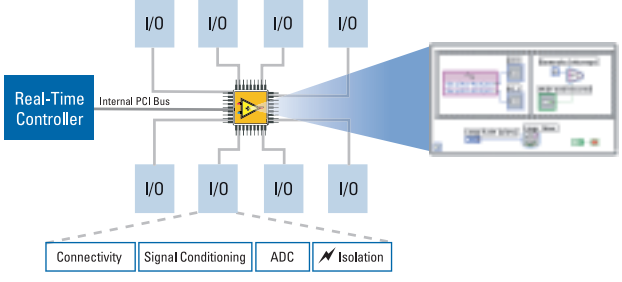


Figure 1. CompactRIO Architecture

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CompactRIO Overview

With NI CompactRIO, you can rapidly build embedded control or acquisition systems that rival the performance and optimization of custom-designed hardware circuitry. Now LabVIEW programmers can take advantage of reconfigurable FPGA technology to automatically synthesize a highly optimized electrical circuit implementation of their input/output, communication, or control applications. Field-programmable gate array (FPGA) devices are widely used by control and acquisition system vendors for their performance, reconfigurability, small size, and low engineering development costs. FPGA-based devices were traditionally vendor defined rather than user defined because of the complexity of the electronic design tools. Now you can take advantage of user-programmable FPGAs to create highly optimized reconfigurable control and acquisition systems with no knowledge of specialized hardware design languages such as VHDL.



Low-Cost Open Architecture

CompactRIO combines a low power consumption real-time embedded processor with a high-performance RIO FPGA chipset. The RIO core has built-in data transfer mechanisms to pass data to the embedded processor for real-time analysis, postprocessing, data logging, or communication to a networked host computer. CompactRIO provides direct hardware access to the input/output circuitry of each I/O module using LabVIEW FPGA elemental I/O functions. Each I/O module includes built-in connectivity, signal conditioning, conversion circuitry (ADC or DAC), and an optional isolation barrier. This represents a low-cost architecture with open access to low-level hardware resources.

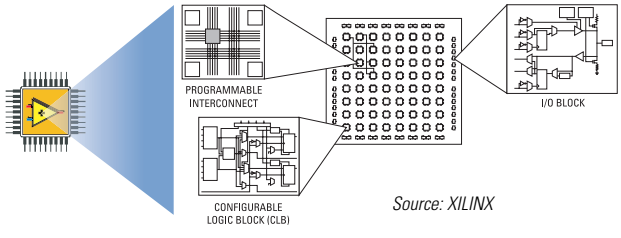
I/O Modules

Each CompactRIO I/O module contains built-in signal conditioning and screw terminal, BNC, or D-Sub connectors. By integrating the connector junction box into the modules, the CompactRIO system significantly reduces the space requirements and cost of field wiring. A variety of I/O types are available including ±80 mV thermocouple inputs, ±10 V simultaneous sampling analog inputs/outputs, 24 V industrial digital I/O with up to 1 A of current drive, differential/TTL digital inputs with 5 V regulated supply output for encoders, and 250 V_{rms} universal digital inputs. Because the modules contain built-in signal conditioning for extended voltage ranges or industrial signal types, you can usually make your wiring connections directly from the CompactRIO module to your sensors/actuators. Visit ***ni.com/compactrio*** for the latest information on module availability.



Real-Time Processor

The CompactRIO embedded system features an industrial 200 MHz Pentium class processor that reliably and deterministically executes your LabVIEW Real-Time applications. Choose from thousands of built-in LabVIEW functions to build your multithreaded embedded system for real-time control, analysis, data logging, and communication. The controller also features a 10/100 Mb/s Ethernet port for programmatic communication over the network (including email) and built in Web (HTTP) and file (FTP) servers. Using the remote panel Web server, you can automatically publish the front-panel graphical user interface of your embedded application for multiclient remote monitoring or control. The real-time processor also features dual 11 to 30 VDC supply inputs, a user DIP switch, LED status indicators, a real-time clock, watchdog timers, and other high-reliability features.



Source: XILINX

Performance

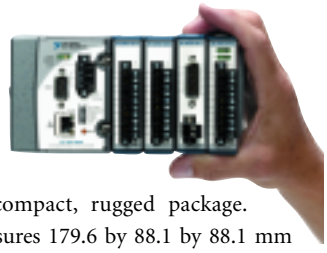
Using the LabVIEW FPGA Module and reconfigurable hardware technology, you can create ultrahigh performance control and acquisition systems with CompactRIO. The FPGA circuitry is a parallel processing reconfigurable computing engine that executes your LabVIEW application in silicon circuitry on a chip. The LabVIEW FPGA Module features built-in functions for analog closed-loop PID control, fifth-order FIR filters, 1D look-up tables, linear interpolation, zero crossing detection, and direct digital synthesis of sine waves. Using the embedded RIO FPGA hardware, you can implement multiloop analog PID control systems at loop rates exceeding 100 kS/s. Digital control systems can be implemented at loop rates up to 1 MS/s. Multiple rungs of Boolean logic can be evaluated using single-cycle while loops at 40 MHz (25 ns). Because of the parallel nature of the RIO core, adding additional computation does not necessarily reduce the speed of the FPGA application. CompactRIO offers 4 and 8-slot chassis with options for FPGA chips with either 1 million or 3 million gates.

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CompactRIO Overview

Size and Weight

CompactRIO is designed for applications in harsh environments and small places. Size, weight, and I/O channel density are critical design requirements in many such embedded applications. By taking advantage of the extreme performance, small size, and lower power consumption of FPGA devices, CompactRIO is able to deliver unprecedented control and acquisition capabilities in a compact, rugged package.



A 4-slot embedded system measures 179.6 by 88.1 by 88.1 mm (7.07 by 3.47 by 3.47 in.) and weighs just 1.58 kg (3.47 lb). An 8-slot system filled with 32-channel I/O modules delivers a mass channel density of 9.7 g/ch (0.34 oz/ch), and a volumetric channel density of 8.2 cm^3/ch (0.50 $in.^3$/ch).

NI CompactRIO Extreme Industrial Certifications and Ratings

CompactRIO is a reconfigurable embedded system that combines reliable stand-alone embedded capability with extreme industrial certifications and ratings for operation in harsh industrial environments. CompactRIO is rated for a -40 to 70 °C (-40 to 158 °F) temperature range, 50 g shock, and hazardous locations or potentially explosive environments (Class I, Div 2). Most I/O modules feature up to 2,300 V_{rms} isolation (withstand), and 250 V_{rms} isolation (continuous). Each component comes with a variety of international safety, electromagnetic compatibility (EMC), and environmental certifications and ratings.

Hazardous Locations

(pending)

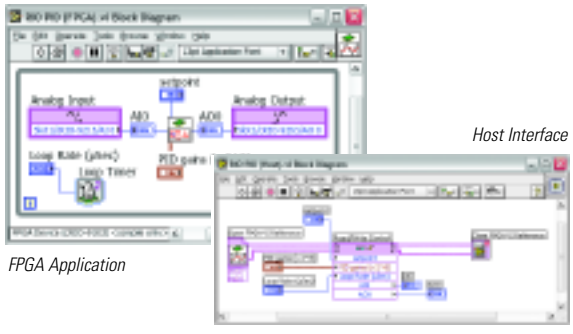
Description	Standard
Electromagnetic Compatibility (EMC)	89/336/EEC EN 55011 Class A at 10 m FCC Part 15A above 1 GHz Industrial levels per EN 61326-1:1997 + A2:2001, Table A.1 CE, C-Tick, and FCC Part 15 (Class A) Compliant
Product Safety	73/23/EEC EN 61010-1, IEC 61010-1 UL 61010-1 CAN/CSA C22.2 No. 61010-1
Hazardous Locations, Class I, Division 2	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nC IIC T4, EEx nC IIC T4
Shock and Vibration	IEC 60068-2-64, IEC 60068-2-27,IEC 60068-2-6
Mean Time Before Failure (MTBF)	Bellcore Issue 6, Method 1, Case 3 MIL-HDBK-217F

Typical Certifications – Actual specifications vary from product to product.
*Visit **ni.com/certification** for details.*



Key Developer Tools

The LabVIEW development environment, including the LabVIEW FPGA Module and LabVIEW Real-Time Module, provides an array of tools and technologies to accelerate the development of reliable reconfigurable embedded systems.

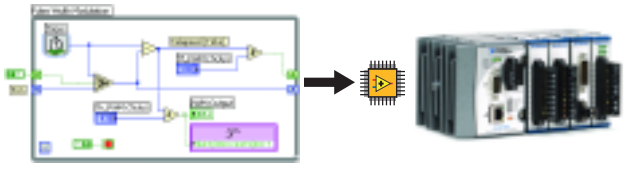


Host Interface

FPGA Application

Embedded Project Manager

- FPGA hardware target configuration and automatic module discovery
- CompactRIO module and I/O channel alias name management
- FPGA application flash memory download and autoload configuration



LabVIEW FPGA Development Environment

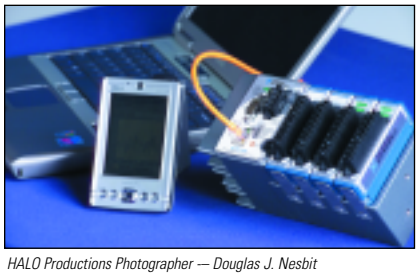
- FPGA device I/O for analog input/output, digital input/output, and I/O property nodes/methods
- Interrupt request (IRQ) generation and synchronization functions
- 40 MHz single-cycle timed loop for LabVIEW code execution in 25 ns timing interval
- Parallel processing with while loop, sequence, case, for loop, and other execution control structures
- FPGA FIFO data buffering and memory read/write
- Boolean logic, comparison, numeric math, saturation arithmetic functions, and bitwise data manipulation functions

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- HDL interface node for integration of non-LabVIEW IP cores
- Nonlinear system and discrete linear control functions including PID and fifth-order FIR filter
- 1D look-up table, linear interpolation, zero-crossing detection, and direct digital synthesis sine generator

LabVIEW Real-Time Development Environment

- Target configuration options including start-up application execution settings and development, Web, remote panel, and file server access
- Open FPGA VI Reference function for programmatic bit-stream download, communication interface reference, and application start
- Deterministic real-time while loop thread synchronization with FPGA-generated IRQ
- FPGA front panel control/indicator read/write for data transfer
- Data scaling/mapping functions for integer to floating-point engineering units conversion
- Real-Time FIFO data buffering for multithread communication
- Timed-loop structure for multirate deterministic control
- Floating-point PID, set-point profiling, gain scheduling, and rate limiter functions
- Point-by-point signal generation, time-domain analysis, frequency-domain transforms and spectrum analysis, filters, statistics, curve fitting/interpolation, linear algebra, array/vector operations
- SMTP E-mail, TCP/IP, UDP, IrDA, DataSocket, and VISA RS232 serial programmatic server/client communication (including 802.11 wireless Ethernet)
- Binary and text file I/O for embedded data logging and retrieval



HALO Productions Photographer — Douglas J. Nesbit

Application Modules and Toolkits

- LabVIEW PDA Module, LabVIEW Enterprise Connectivity Toolkit, LabVIEW Remote Panel License
- LabVIEW Execution Trace Toolkit
- LabVIEW Order Analysis Toolkit, LabVIEW Sound and Vibration Toolkit, LabVIEW Signal Processing Toolkit
- LabVIEW Simulation Module, LabVIEW Control Design Toolkit, LabVIEW System Identification Toolkit, LabVIEW Simulation Interface Toolkit, LabVIEW State Diagram Toolkit
- NI SoftMotion Development Module for LabVIEW

LabVIEW Networked Host Application Development

- Web browser remote panel graphical user interface plug-in for remote control/monitoring (Windows, Linux, Mac OS X, Solaris)
- Express spectral signal analysis, distortion/tone, amplitude/level, timing/transition, convolution/correlation, mask/limit, histogram functions
- Local or remote database connectivity, text/HTML/DIAdem report generation
- Handheld mobile/portable PDA user interface/ remote control (LabVIEW PDA Module)

The CompactRIO Platform is available in two configurations:



CompactRIO Embedded System

In this configuration, CompactRIO is a complete reconfigurable embedded system for rugged stand-alone or networked control and acquisition applications. The reconfigurable embedded system consists of a real-time controller, a reconfigurable chassis containing the user-programmable RIO FPGA, and a variety of hot-swappable industrial I/O modules.



CompactRIO R Series Expansion System

In this configuration, a CompactRIO expansion chassis connects to the digital port on a PCI or PXI R Series FPGA device. The R Series device can be installed in any desktop PC, industrial PC (IPC), or ruggedized PXI/CompactPCI computer system running Windows or one of the LabVIEW Real-Time OSs. The RIO FPGA resides on the R Series device while CompactRIO converts a digital port on the R Series device into a high-performance expansion I/O and signal conditioning system.

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CompactRIO Overview





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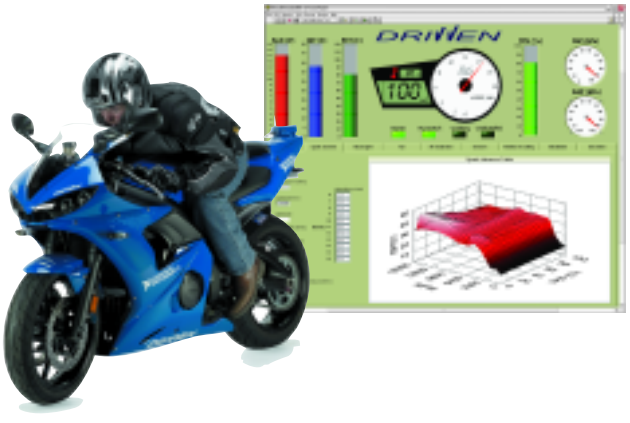
Photo courtesy of NASA



Application Examples

Due to its low cost, reliability, and suitability for high-volume embedded measurement and control applications, CompactRIO can be adapted to solve the needs of a wide variety of industries and applications. Examples include heavy industrial machine control, in-vehicle data acquisition, machine condition monitoring, and rapid control prototyping (RCP):

- Batch control
- Discrete control
- Motion control
- In-vehicle data acquisition
- Machine condition monitoring
- Rapid control prototyping (RCP)
- Industrial data acquisition
- Distributed data acquisition and control
- Mobile/portable noise, vibration, and harshness (NVH) analysis



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CompactRIO Configuration Guide

Build your CompactRIO reconfigurable control and acquisition system in three easy steps:

Step 1. Choose your CompactRIO real-time embedded controller, PXI controller, or industrial PC.

Type of Controller	Reconfigurable Embedded System	R Series Expansion System
Standard real-time	cRIO-9002 embedded controller, 64 MB storage	PXI-8145 RT, PXI-1031 (real-time PXI)
Premium real-time	cRIO-9004 embedded controller, 512 MB storage	PXI-8186 RT, PXI-1031 (real-time PXI)
Windows PXI		NI PXI-8186, PXI-1031
Windows PCI		Any desktop or industrial PC
PCI real-time (ETS)		Certified desktop PC (Dell Optiplex, model GX270)
		or industrial PC

Step 2. Select a reconfigurable chassis or R Series device and expansion chassis.

Type of Chassis	Reconfigurable Embedded System	R Series Expansion System
Standard real-time	cRIO-9101 4-slot 1 M gate RIO chassis	PXI-7831R or PXI-7811R, and
	cRIO-9102 8-slot 1 M gate RIO chassis	cRIO-9151 expansion chassis
Premium real-time	cRIO-9103 4-slot 3 M gate RIO chassis	PXI-7831R or PXI-7811R, and
	cRIO-9104 8-slot 3 M gate RIO chassis	cRIO-9151 expansion chassis
Windows PXI		PXI-7831R or PXI-7811R and
		cRIO-9151 expansion chassis
Windows PCI		PCI-7831R and
		cRIO-9151 expansion chassis
PCI real-time (ETS)		PCI-7831R and
		cRIO-9151 expansion chassis

Step 3. Choose your I/O modules.

Type of Signal	Signal	Module	Channels	Special Features[1]
Analog Input	Thermocouple	cRIO-9211	4	24-bit delta-sigma, 15 S/s, differential (J, K, R, S, T, N, E, and B thermocouple types)
	IEPE[2] (±5 V)	cRIO-9233	4	24-bit delta-sigma, 50 kS/s per ch, simultaneous, antialiasing, nonisolated, TEDS
	Small voltage (±80 mV)	cRIO-9211	4	24-bit, 15 S/s, differential
	Medium voltage (±10 V)	cRIO-9215	4	16-bit, 100 kS/s per ch, simultaneous, differential
		cRIO-9201	8	12-bit, 800 kS/s
	High voltage (±60 V)	cRIO-9221	8	12-bit, 800 kS/s
Analog Output	Medium voltage (±10 V)	cRIO-9263	4	16-bit, 100 kS/s per ch, simultaneous
Digital Input	24 V sinking	cRIO-9421	8	100 µs, 24 V logic, 40 V protection
		cRIO-9423	8	1 µs, high-speed, 24 V logic, 35 V protection
	250 AC/DC universal	cRIO-9435	4	3 ms, ±5 to 250 VDC, 10 to 250 VAC, universal, sink/source
	Differential or TTL	cRIO-9411	6	1 µs, ±5 to 24 V, single-ended TTL or differential, regulated 5 V supply output
Digital Output	24 V sourcing	cRIO-9472	8	100 µs, 24 V logic, 750 mA max per ch, 30 V protection, short-circuit-proof
		cRIO-9474	8	1 µs, high-speed, 24 V logic, 1 A max per ch, 30 V protection, short-circuit-proof
Relay Output	Form A (SPST)	cRIO-9481	4	1 s, 30 VDC (2 A), 60 VDC (1 A), 250 VAC (2 A) electromechanical form A (SPST)
Counter, Pulse	Counter/timer (24 V)	cRIO-9423	8	1 µs, high-speed, 24 V logic, 35 V protection
	Counter/timer (TTL)	cRIO-9411	6	1 µs, ±5 to 24 V, single-ended TTL or differential, regulated 5 V supply output
	Quadrature encoder (differential)	cRIO-9411	6	1 µs, ±5 to 24 V, single-ended TTL or differential, regulated 5 V supply output
	PWM	cRIO-9474	8	1 µs, high-speed, 24 V logic, (5 to 30 V)1 A max per ch, 30 V protection,short-circuit-proof

[1]NI CompactRIO Extreme Industrial Certifications and Ratings. All modules except cRIO-9233 feature 2,300 V_{rms} withstand isolation, 250 V_{rms} continuous isolation channel-to-earth ground.
[2]Integrated electronic piezoelectric (IEPE) sensors include accelerometers, strain gages, load cells, and microphones.

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CompactRIO Reconfigurable Chassis

NI cRIO-910x *NEW!*

- Design hardware using LabVIEW programming skills
- 4 or 8-slot chassis for any CompactRIO I/O modules
- 1 M or 3 M gate RIO FPGA core for normal or extended RIO processing power
- DIN-rail mounting, 19 in. rack mount, and panel mounting options
- NI CompactRIO Extreme Industrial Certifications and Ratings[1]
- Program in easy-to-use LabVIEW FPGA graphical development environment to automatically synthesize an optimized high-performance electrical circuit implementation of your application
- RIO FPGA core executes LabVIEW control logic at rates up to 40 MS/s using single-cycle timed loops



Product	Module Slots	FPGA System Gates	RAM (KB)	Default Timebase (MHz)	Maximum Power Consumption (W)	Built-In Panel Mounting Holes
cRIO-9101	4	1 M	82	40	2.3	✓
cRIO-9102	8	1 M	82	40	2.3	✓
cRIO-9103	4	3 M	196	40	3	✓
cRIO-9104	8	3 M	196	40	3	✓

Overview and Applications

The National Instruments CompactRIO reconfigurable chassis are the heart of the CompactRIO system because they contain the reconfigurable I/O (RIO) core. The RIO FPGA core, which has an individual connection to each I/O module, is programmed with easy-to-use elemental I/O functions to read or write signal information from each module. Because there is no shared communication bus between the RIO FPGA core and the I/O modules, I/O operations on each module can be precisely synchronized with 25 ns resolution. The RIO core can perform local integer-based signal processing and decision-making and directly pass signals from one module to another.

The RIO core is also connected to the CompactRIO real-time controller through a local PCI bus interface. The real-time controller can retrieve data from any control or indicator on the front-panel of the RIO FPGA application through an easy-to-use FPGA Read/Write function. The RIO FPGA can also generate interrupt requests (IRQs) to synchronize the real-time software execution with the RIO FPGA. Typically, the real-time controller is used to convert the integer based I/O data to scaled floating-point numbers. In addition, the real-time controller typically performs single-point control, waveform analysis, data logging, and Ethernet/serial communication.

The reconfigurable chassis, real-time controller, and I/O modules combine to create a complete stand-alone embedded system. Application development consists of three steps:

1. Target the reconfigurable chassis to automatically detect the I/O modules and develop the RIO FPGA application,
2. Compile the RIO application to automatically synthesize an optimized high-performance electrical circuit implementation of your application,
3. Develop the real-time controller application to add floating-point control, signal processing, data logging, and communication

[1]See CompactRIO Overview on page 366 for details.

Key Features

- Create any local or multichassis timing, triggering, and synchronization scheme with 25 ns resolution
- Use multiple while loops to create a parallel processing application for high-performance signal processing or multirate control systems
- Built-in PID control functions for control system loop rates greater than 100 kHz
- Generate waveforms or implement nonlinear look-up tables (LUTs) using LabVIEW FPGA express VIs
- Integrate widely available third-party HDL cores using the LabVIEW FPGA Module HDL Node
- Enforce critical logic and interlocks in silicon hardware circuitry, or use the parallel RIO architecture to create dual, triple, or quadruple redundant systems

Visit *ni.com/compactrio* for example programs, application notes, and other developer tools.

For ordering information, see page 381.

North American Hazardous Locations

(pending)

For more information, see page 379.

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CompactRIO Ordering Information

Ordering Information

Developer Kits

NI cRIO-9961 Embedded System Developer
Hardware Evaluation Kit 779107-01

NI Reconfigurable I/O
Software Development Kit 779149-03

Reconfigurable Embedded Systems

Real-Time Controllers

NI cRIO-9002 779000-01
NI cRIO-9004 779055-01

Reconfigurable Chassis

NI cRIO-9101 779052-01
NI cRIO-9102 779007-01
NI cRIO-9103 779053-01
NI cRIO-9104 779054-01

Power Supplies

NI PS-1 777567-01
NI PS-2
Japan 100 VAC/US 120 VAC 777584-01
North American 240 VAC 777584-05
NI PS-3
Japan 100 VAC/US 120 VAC 777585-01
North American 240 VAC 777585-05
NI PS-4 778586-90
NI PS-5 778805-90

R Series Expansion Systems

Expansion Chassis

NI cRIO-9151 chassis.....779008-01
SH68-C68-S cable, 2 m 186381-02

R Series Devices

NI PXI-7811R Digital I/O 778800-01
NI PXI-7831R Multifunction I/O 778668-01
NI PCI-7831R Multifunction I/O 778797-01

Input/Output Modules[1]

Analog Input Modules

NI cRIO-9201 779013-01
NI cRIO-9211 779001-01
NI cRIO-9215 779011-01
NI cRIO-9221 779014-01
NI cRIO-9233 779015-01

Analog Output Module

NI cRIO-9263 779012-01

Digital Input and Counter/Timer Modules

NI cRIO-9411 779005-01
NI cRIO-9421 779002-01
NI cRIO-9423 779009-01
NI cRIO-9435 779010-01

Digital Output and Relay Modules

NI cRIO-9472 779004-01
NI cRIO-9474 779003-01
NI cRIO-9481 779006-01

Accessories

NI cRIO-9912 779019-01
NI cRIO-9915 779018-01
NI cRIO-9932 779017-01
NI cRIO-9933 779103-01
NI cRIO-9934 779104-01
NI cRIO-9935 779016-01
NI cRIO-9936 779105-01
NI cRIO-9937 779106-01

Ethernet Cables

CAT5
5 m 182219-05
CAT5 Crossover
5 m 187375-05

[1]Visit *ni.com/compactrio* for up-to-date information on module availability.

BUY NOW!

For complete product specifications, pricing, and accessory information, call (866) 265-9891 (U.S. only) or go to ni.com and search on a four-digit model number listed above.