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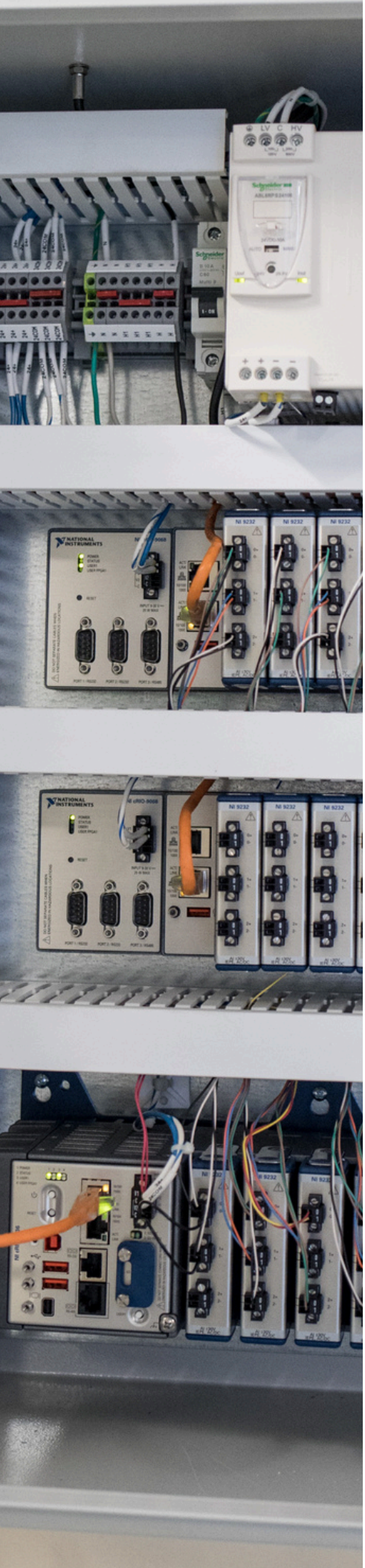
Product Brochure

CompactRIO

Summer 2024



NI CompactRIO

Contents

CompactRIO Overview

A rugged, embedded computing platform with modular I/O, programmable FPGA, and a real-time OS all powered by LabVIEW.

FIGURE 1.

The CompactRIO catalog has several controller options so you can design your system around size, storage, communication options, and compute performance.

Features

- NI Linux Real-Time OS
- Up to 1.91 GHz quad-core processors
- Xilinx FPGAs
- -40 °C to 70 °C operating temperature range
- 50 g shock and 5 g vibration operating range
- Over 200 modules for electrical signals, sensors, and communication protocols.
- Up to 16 GB of on-board SSD for data logging
- Computer ports including video out, USB, and Ethernet for peripherals and communication
- LabVIEW programmable main processor and FPGA

Benefits

Faster Development Time

Abstract low-level code and use a single toolchain to build and deploy time-critical applications on your CompactRIO system using LabVIEW.

Tailor the Platform to Your Needs

Harness the openness of the NI Linux Real-Time OS through thousands of open-source applications, IP, and examples, while collaborating with an active community of users and developers.

Combine DAQ and Control

Log data from over 70 modules for sensor and electrical measurements and add control using digital/analog output modules and industrial communication protocols.

Long-Term System Reliability

Use the integrated controller running a Linux Real-Time OS and LabVIEW-programmable FPGA to build and deploy robust applications with reliability for long-duration tests.

CompactRIO System Architecture

All CompactRIO hardware has three key components: a real-time processor (ARM/Intel), an FPGA, and connections to signal converters (analog-to-digital converters usually found in C Series modules). The core processor and FPGA are separate sub-systems that share data over a high-speed bus. I/O Modules are connected to the FPGA where data can be processed in-line and sent to the main processor, or the data can be part of a closed-loop control program running entirely on the FPGA. Both the main processor and the FPGA are programmed with LabVIEW.

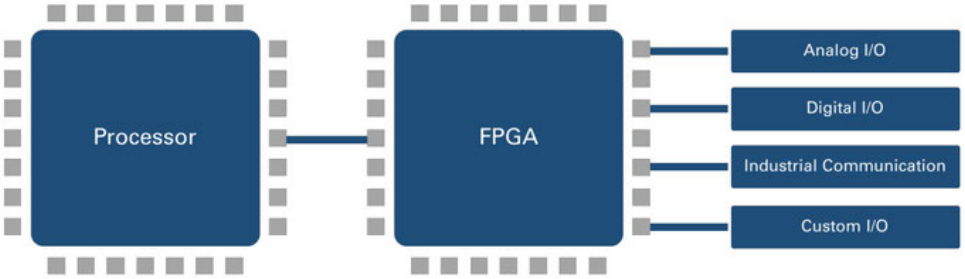


FIGURE 2.

The main processor (left) and FPGA (center) run separate LabVIEW VIs. You - the system designer - decide where the analysis and control logic happens based on your needs.

Main Processor

The main processor runs a real-time OS based on a standard kernel designed specifically for reliable and deterministic operation. LabVIEW VIs running on the main processor receive data from modules passed through the FPGA, networked systems, or peripherals connected to the controller ports such as HMIs. Host small web services, read/write to disk, or run deterministic PID loops on the main processor for an intelligent control and measurement system programmed with LabVIEW.

LabVIEW Programmable FPGA

Develop a LabVIEW VI for the FPGA to offload time-critical processes for advanced control, signal processing, filtering, or timing logic. NI uses FPGA technology from Xilinx for all LabVIEW-programmable targets, including CompactRIO.

Traditional development for FPGA-based systems requires low-level software tools, HDLs, or vendor-specific toolchains. LabVIEW and CompactRIO give you the benefits of custom measurement circuitry and FPGA processing technology without the burden of learning a separate development tool.

C Series Module Overview

Measurement and Signal Generation

Choose from over 70 I/O modules that measure electrical signals, read/write digital lines, connect to sensors, or generate output signals for simulation and control. Signal conditioning and conversion happen in the module after which the digital value is collected by the LabVIEW VI running on the FPGA. Engineers use LabVIEW FPGA VIs to design the timing, logic, and synchronization parameters specific to the application. Control logic running on the FPGA can interpret data and send it to the LabVIEW VI running on the main processor, or output data directly to modules without needing to involve the main processor for high-speed closed-loop control.

FIGURE 3.

C Series modules often have multiple options for connecting signal wires such as screw terminal (front left), BNC (front right), and DSUB (back row)

Communication Modules : CAN, LIN, RS 232/485

Use communication modules in a CompactRIO system to connect, control, or monitor other systems using common automotive networks or Serial protocols.

FIGURE 4.

Many CompactRIO controllers have built-in Serial ports on the main processor. Use C Series modules to expand the number of ports available.

GPS Timing and Synchronization Module

Connect GPS-accurate time data to your LabVIEW FPGA VI to time stamp data, gate acquisitions using the GPS pulse-per-second, or synchronize waveform acquisition between multiple CompactRIO systems installed over a large structure.

FIGURE 5.

The GPS module connects to standard antennas with an SMB connector. Note: the module is not designed for mobile applications and must be stationary.

C Series I/O for Smaller, Rugged, Distributed Systems

Signal Type	Channel Count per Module	Measurement Types	Max Sample Rate	Special Features
Analog Input				
Voltage	Up to 32	Options for ±200 mV, ±500 mV, ±1 V, ±5 V, ±10 V, ±60 V, 3 Vrms, 400 Vrms, 800 Vrms, 300 Vrms	20 MS/s/ch	Up to channel-channel isolation, anti-aliasing, and configurable filtering
Current	Up to 16	Options for ±20 mA, 0 – 5 Arms, 0–20 Arms, 0–50 Arms	200 kS/s	Up to channel-channel isolation, built-in channel diagnostics
Voltage and Current	16	Options for ±20 mA and ±10 V	500 S/s	Channel-earth isolation, built-in noise rejection
Universal	Up to 4	V, mA, TC, RTD, Strain, Ω, IEPE	51.2 kS/s/ch	Up to channel-channel isolation, bridge completion, anti-aliasing filters, built-in shunt resistors, amplification
Thermocouple	Up to 16	J, K, T, E, N, B, R, and S types	95 S/s/ch	Up to channel-channel isolation, amplification, filtering, CJC
RTD	Up to 8	100 Ω, 1000 Ω	400 S/s	50/60 Hz filtering, bank isolation
Strain/ Bridge Based	Up to 8	¼, ½, full bridge (120 or 350 Ω)	50 kS/s/ch	External excitation, bridge completion, anti-aliasing filters
Sound and Vibration	Up to 8	±5 V, ±30 V	102.4 kS/s/ch	IEPE, anti-aliasing filters
Analog Outut				
Voltage	Up to 16	Options for 3 Vrms, ±10 V, ±40 V (stacked)	1 MS/s/ch	Up to bank isolation
Current	Up to 8	±20 mA	100 kS/s/ch	Channel-earth isolation, built-in open-loop detection
Digital I/O				
Input/Output	Up to 32	Options for TTL (3.3 V or 5 V) RS422, 5 V, 12 V, 24 V, 48 V, 72 V, 96 V, 120 V AC, 120 V DC, 240 V AC, 240 V DC	55 ns	Up to channel-channel isolation, sinking or sourcing input, bidirectional channel options
Relay Output	Up to 8	Options for 60 V DC, 30 Vrms, 250 Vrm	1 op/s	Up to channel-channel isolation, SPST, or SSR relays
Communication Buses				
CAN	1	HS/FD, LS/FT CAN	1 Mb/s	—
LIN	1	LIN	20 kb/s	—
Serial Interface	4 ports	RS232, RS485/RS422	921.6 kb/s	—

Developing a CompactRIO System with LabVIEW

LabVIEW abstracts the complex, low-level tasks required in embedded system programming so you can design your own advanced measurement and control system without a large team of developers or extensive experience with hardware design languages - HDLs.

Your LabVIEW VI for the main processor and the VI for the FPGA reside in the same LabVIEW project making it easier to develop a complete system.

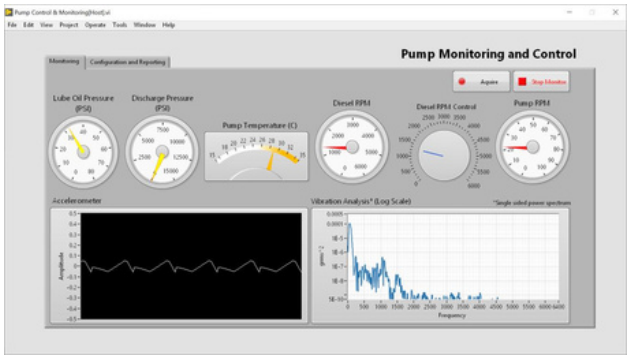


FIGURE 6.

LabVIEW VIs running on CompactRIO have front panels you can see while in development mode or when you connect to the chassis remotely. cRIO systems do not require a user interface and can operate as "headless" systems.

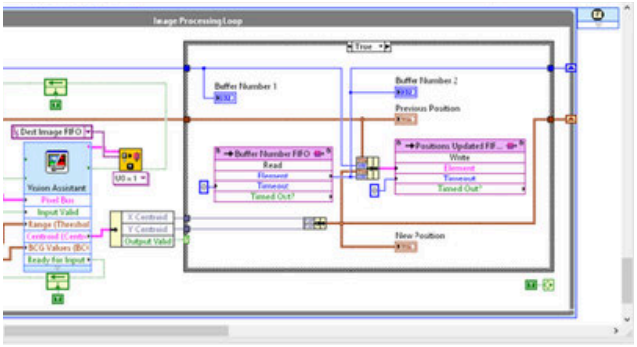


FIGURE 7.

Programming LabVIEW for CompactRIO requires the LabVIEW FPGA and LabVIEW Real-Time modules.

The Benefits of LabVIEW for Embedded System Design

Reduced Development Time

Focus on solving problems, not low-level programming tasks, with built-in constructs to manage timing and memory in an intuitive programming environment.

User-Programmable FPGA

Implement high-speed signal processing, custom timing and triggering, and control algorithms directly in hardware to maximize reliability and determinism.

Open Software Interoperability

Leverage other programming approaches alongside or with LabVIEW to reuse existing IP and take advantage of existing expertise.

Remote System Management

Transfer data between systems or remotely update hundreds of controllers at once with built in system management utilities.

Built-in Libraries

LabVIEW contains nearly 1,000 built-in signal processing, analysis, control, and mathematics functions to accelerate the development of embedded measurement systems.

LabVIEW Tools Network

Extend the capabilities of your system with a vast ecosystem of certified, application-specific add-ons.

Connect to Industrial Systems

Industrial Communications

With native support for common industrial protocols like PROFINET, OPC UA, EtherCAT and more, CompactRIO can connect to a variety of devices, equipment, and infrastructure. Have a brownfield application that requires support for numerous protocols? CompactRIO is an ideal Industrial Internet of Things gateway that can act as the translator between any of the nearly 20 supported protocols, and even custom communication protocols through the FPGA.

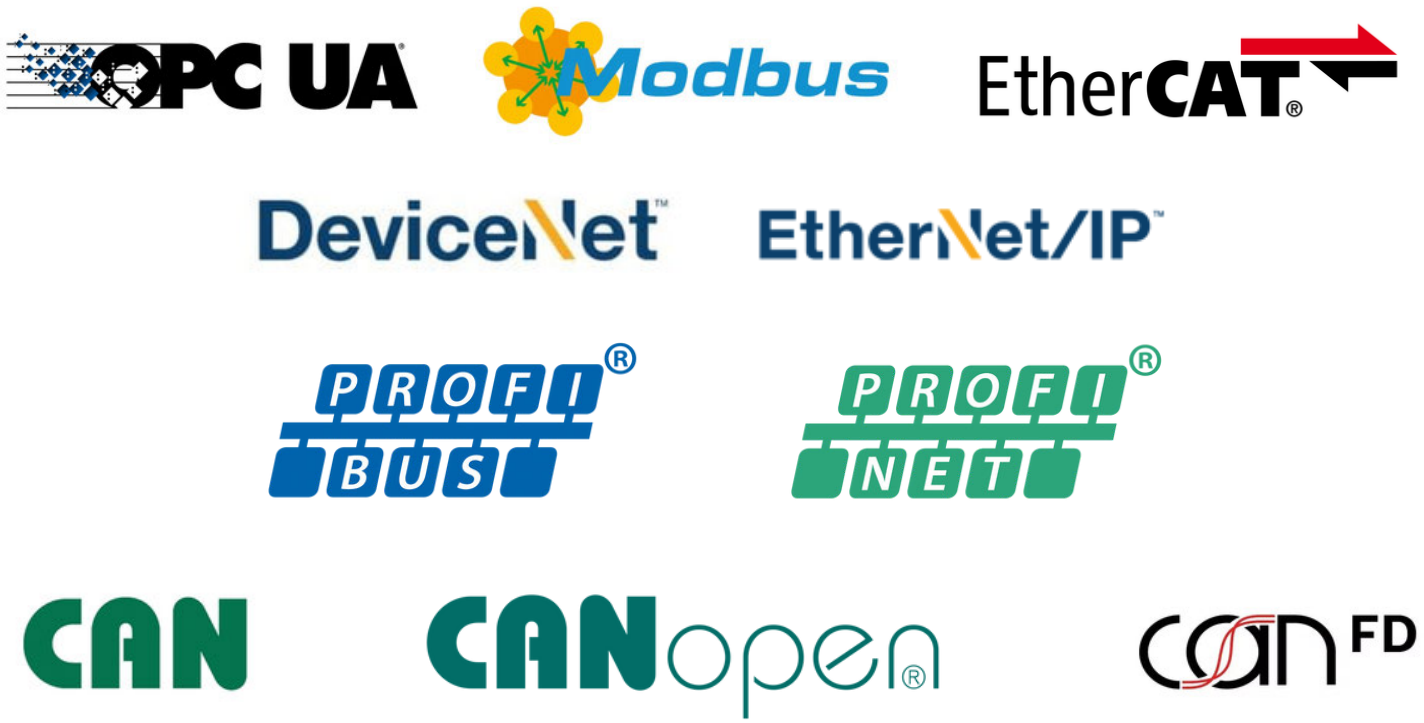


FIGURE 8.

Options for industrial communication include ports connected to the main processor, C Series modules, and communication APIs available for LabVIEW either as add-ons or as free community IP.

Deploy to Rugged Environments

Contained within a compact, rugged package, CompactRIO Controllers feature operating temperature ranges as wide as -40 °C to 70 °C (-40 °F to 158 °F), up to 50 g shock and 5 g vibration ratings, redundant power supply inputs, and a variety of international safety, Hazloc, and environmental certifications and ratings for operation in harsh industrial environments.

FIGURE 9.

Rugged operating specifications and a variety of certifications make CompactRIO well suited for applications in oil and gas and industrial or factory automaton environments.

Structural Health Monitoring Case Studies

Monitoring the Xiamen Jimei Bridge in China (10 km)

Building a Large Bridge Structural Monitoring System Based on CompactRIO and LabVIEW

CCCC Highway Consultants used CompactRIO hardware and LabVIEW to create a distributed signal acquisition system for the Xiamen Jimei Bridge. This intelligent solution ensures safety and durability by monitoring various aspects, including load, wind, temperature, humidity, and structural dynamics.

Structural Academic Research (In the field)

Discovering the Dynamic Properties of Civil Structures with Wirelessly Synchronized, Highly Distributed Data Loggers

The University of Exeter's Vibration Engineering Section (VES) developed bespoke vibration data loggers. These loggers, using LabVIEW and CompactRIO, enabled sub-microsecond synchronization across large structures without long cables or RF transmissions. By measuring ambient vibrations of the Jiangyin Suspension Bridge in China, they estimated its modal properties and created a novel monitoring system for civil structures.

Structural Academic Research (In the classroom)

Using LabVIEW and CompactRIO to Continuously Monitor a Footbridge

Tufts University deployed a CompactRIO-based continuous monitoring system on the Dowling Hall Footbridge. The system collects eight acceleration channels and ten temperature channels. The university uses remote access to the system as a live lavatory for research and as a teaching tool for vibration analysis courses.

Embedded Test Systems with Control Case Studies

Safety Testing of London's Underground

Thales UK Tests London's Underground Rail Network with CompactRIO and LabVIEW

Thales UK revolutionized rail testing for the London Underground system by leveraging NI CompactRIO hardware and NI LabVIEW system design software. They automated rail testing using virtual test trains (VTTs), saving time and costs compared to traditional methods. The VTTs, powered by CompactRIO, mimic passenger trains and provide efficient, bidirectional testing.

High-Voltage Transient Root Cause Analysis

Siemens Uses CompactRIO, LabVIEW, and DIAdem to Determine the Root Cause of Damaging High-Voltage Transients

Siemens addressed recurring issues with light-rail transit vehicles by developing a rugged monitoring system using NI CompactRIO (cRIO) hardware and LabVIEW software. They identified voltage transients - missed by earlier equipment - as the root cause, significantly reducing costly failures and operating delays for their customer.

Railway Lab Test Benches

Creating Railway Laboratory Test Benches Based on NI LabVIEW, PXI, and CompactRIO

CETEST S.L. developed railway rolling stock integral laboratory solutions, focusing on conducting structural integrity and fatigue resistance tests. They used NI LabVIEW software and cRIO hardware to monitor critical parameters, ensuring safety, performance, and durability.

NI Partner Network

The NI Partner Program offers domain, application, and overall test development expertise to help your team get ahead and stay ahead.

Innovate faster with proven scalable solutions Reduce development time and cost through Integration and Consulting assistance

Types of Partners

Solution Partners

Experts in delivering products and solutions to solve your specific automated test or automated measurement application challenges.

System Integrators

Specialists in integrating and deploying test and measurement systems, based on your specific requirements and their mature industry capabilities.

Consultants

Consultants offer expert project services in areas such as software development, engineering, science, analytics, regulatory compliance, or other specialized skills to support complex systems.

Connect with our global community of trusted NI Partners ready to give your business a competitive edge.

Find a Partner or Solution at **ni.com/findapartner**

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. NI offers additional entitlements to improve uptime and lower maintenance costs with service programs for hardware. Learn more at ni.com/services/hardware.

	Hardware	Standard	Premium	Description
Duration at Point of Sale	1 year; included	3 years; optional	3 years; optional	NI enhances warranty coverage with additional service benefits provided with a hardware service program.
Maximum Duration with Renewal	≤3 years 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.

Premium Plus Service Program

NI can customize the offerings listed above or offer additional entitlements such as on-site calibration, custom sparing, 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.