

# Embedded Control and Monitoring

Productivity

Precision and Accuracy

Flexibility

Quality and Ruggedness







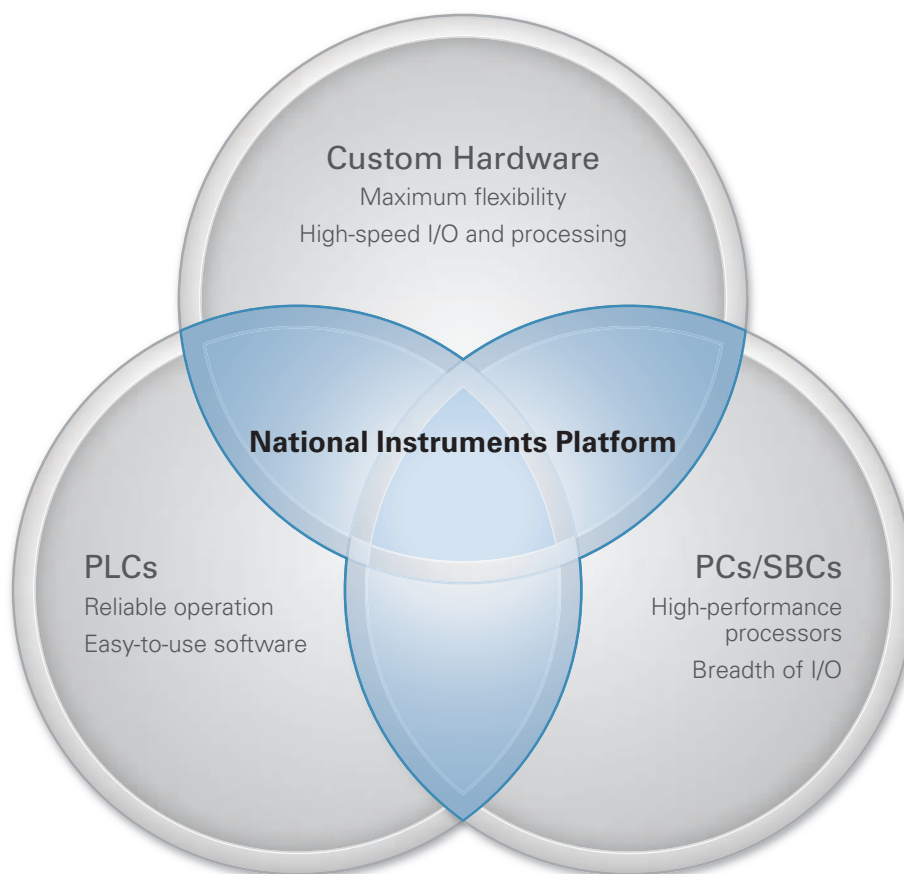
*“With its superior I/O and motion control capabilities and the flexibility and reliability of the FPGA, the CompactRIO system programmed with LabVIEW enabled us to create a high-performance embedded monitoring and control system that matches our rigorous requirements.”*

—Pascal Wattellier, Serimax

# Experience the Difference

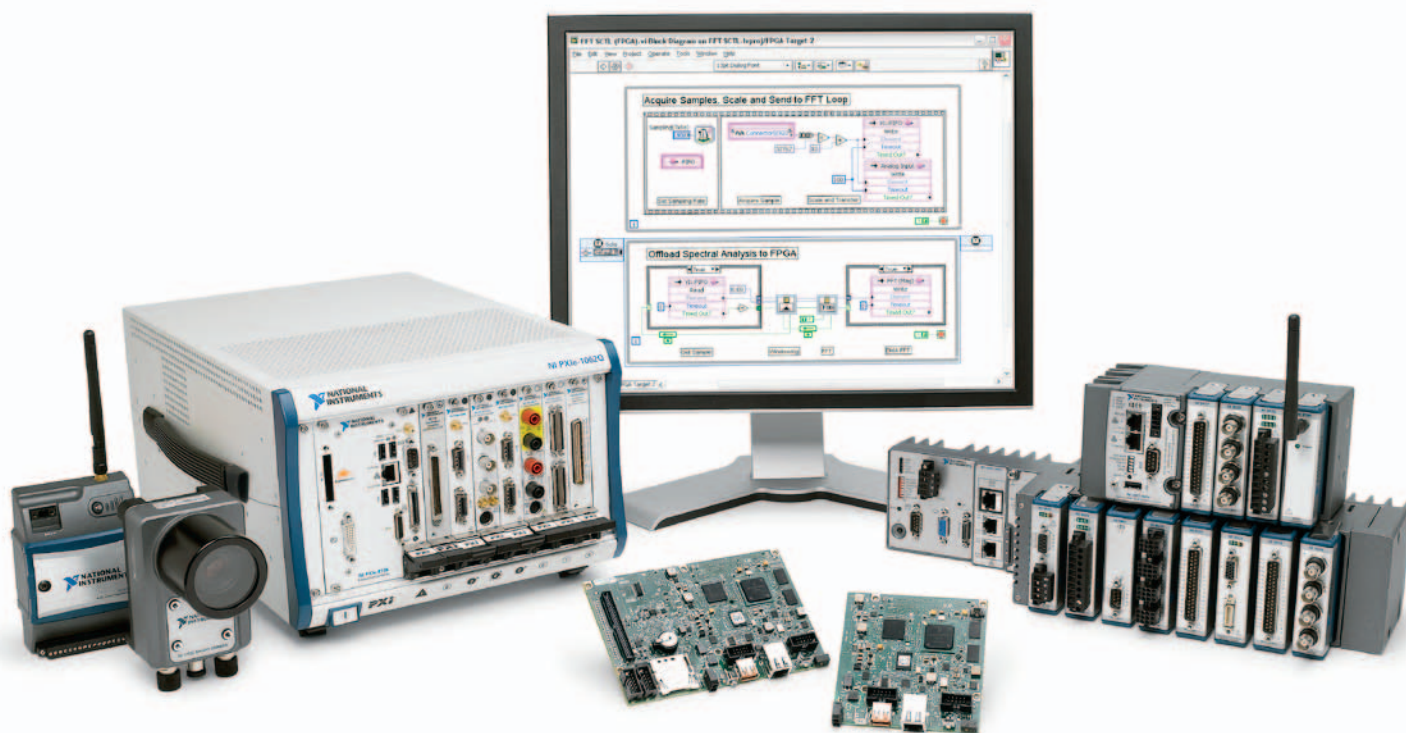
National Instruments transforms the way engineers and scientists around the world design, prototype, and deploy embedded control and monitoring systems. Using the graphical system design approach, which combines productive programming software with reconfigurable hardware, customers at more than 30,000 companies annually simplify development, increase productivity, and dramatically reduce time to market. NI provides the tools to help design teams build highly differentiated embedded systems for demanding applications in industries such as energy, industrial control, life sciences, and transportation.

NI embedded control and monitoring systems, including NI LabVIEW software and NI reconfigurable I/O (RIO) hardware, combine the ruggedness and ease of use of off-the-shelf systems like programmable logic controllers (PLCs), PC-based systems, and single-board computers (SBCs) with the specialization of custom hardware.



# A Superior Platform

NI embedded control and monitoring tools are the core component of the National Instruments graphical system design platform. LabVIEW software and reconfigurable hardware provide a superior method for design teams to complete demanding embedded control and monitoring tasks faster without requiring custom design.



*“LabVIEW and CompactRIO made it easy to implement critical parts of the control system with high-speed processing...without needing low-level tools, custom circuitry, or programming languages other than LabVIEW.”*

—Paolo Catterina, EUROelectronics



## NI Advantages

Our highly integrated platform provides key advantages, so you can be confident in meeting any control and monitoring challenge faster.



### Productivity

- LabVIEW system design software
- Single environment for programmable multicore processors and field-programmable gate arrays (FPGAs)
- Built-in I/O drivers and middleware



### Precision and Accuracy

- NI RIO FPGA-based hardware
- Custom, precise, and high-speed I/O timing, triggering, and synchronization
- High-accuracy analog and sensor inputs



### Flexibility

- Built-in control and signal processing algorithms
- Integration with existing code, IP, and models
- Easy connection to any sensor, actuator, or network



### Quality and Ruggedness

- Stringently built and tested embedded hardware
- Real-time and reliable software operation
- Reliability in extreme environments



### Support and Services

- More than 600 Alliance Partners around the globe
- Comprehensive maintenance for software and hardware
- End-to-end support, from planning to deployment

# Industries and Applications

NI transforms the way engineers and scientists, in a variety of industries, design, prototype, and deploy systems for embedded control and monitoring applications. The NI graphical system design platform reduces development costs and shortens time to market by helping you quickly develop embedded control, signal processing, diagnostic, and monitoring systems that can be deployed in a variety of demanding environments and application areas.





## Renewable and Electrical Power

Engineers and scientists around the world are using the graphical system design platform to make a positive impact on the global ecosystem. Rugged, high-performance hardware systems and LabVIEW software from NI can meet any control or monitoring challenge within the clean technology industry, including online monitoring systems for wind and solar applications, real-time control for power electronics, and embedded measurement and analysis systems for power quality.

### Remote Monitoring of Wind Turbines

T&M Solutions and ECN Wind Energy chose LabVIEW and NI CompactRIO hardware to replace measurement systems installed on remote wind turbines that could not be replaced or repaired easily. Using NI tools, they were able to develop reliable systems with the flexible module I/O configuration and software setup. The RIO systems acquire measurements, filter analog and digital signals, apply a timestamp, temporarily store data to prevent data loss, and transmit data to a database server.



### Quality Monitoring of a Grid-Tied Energy Storage System

Xtreme Power has created a scalable control system to manage megawatt-sized energy storage and provide digital power management systems called Dynamic Power Resources (DPRs) for independent power producers, transmission and distribution utilities, and commercial and industrial end users. Within these systems, LabVIEW and NI Single-Board RIO devices continuously measure the power and power quality of the energy grid and control a network of power inverters and battery cells to manage the energy flow.







## Oil and Gas

NI is a leader in advanced control and monitoring for all segments of the oil and gas industry, from drilling and production to pipeline leak, fault, safety, and inspection technologies. Through a single architecture, exploration and production (E&P) companies can achieve a systematic view of operation and address the different data requirements of various departments and job functions.



### Oil Well Fracture Pump Monitoring and Analysis

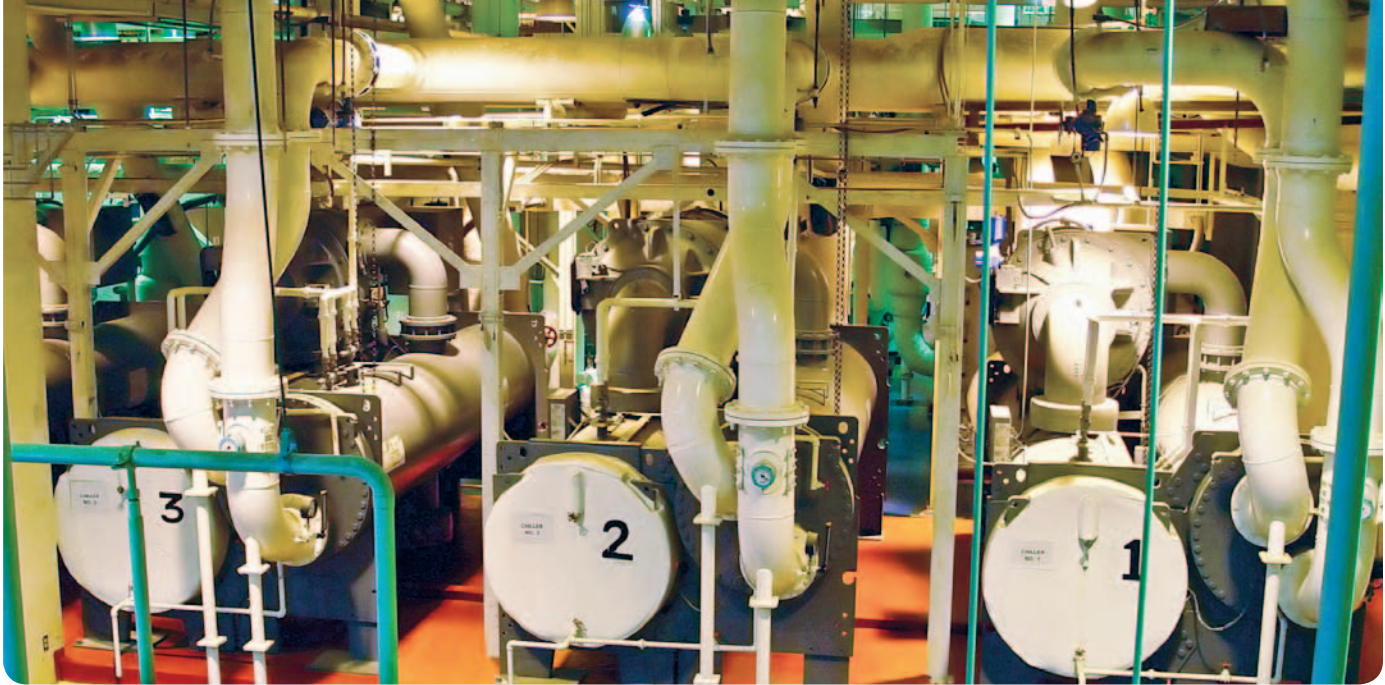
LIME Instruments built an advanced monitoring system that can survive being mounted directly to an oil well servicing pump in a rugged environment while performing advanced analysis on sensor data. NI RIO hardware and LabVIEW were used to design a pump monitoring system that monitors the operating parameters of a reciprocating pump used in well servicing applications. The RIO platform provided the optimal solution for LIME Instruments' application needs and is used as the backbone to the entire control system.



### High-Performance Systems for Automated Pipe Welding

Serimax developed a rugged, cutting-edge, automated pipeline welding system that adapts to address various customer requirements, provides maximum uptime, and meets reliability and quality standards. Using LabVIEW for all motion control, condition monitoring, and logic tasks and CompactRIO hardware as a deployment target, Serimax built a high-performance embedded monitoring and control system ideal for its rigorous welding requirements.





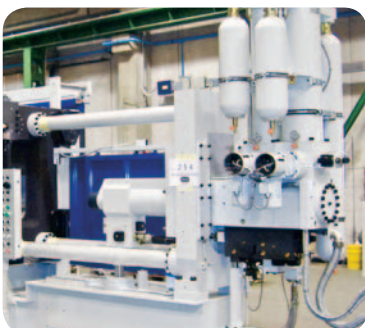
## Industrial Machinery and Control

When designing high-precision machines, teams are challenged with lowering development cost, increasing machine productivity, and shortening design times. Today, leading design teams are adopting RIO hardware and LabVIEW to integrate synchronized motion, vision, and I/O within one design platform that enables them to get ahead of the competition and design smarter machines.



### Predictive Maintenance of Conical Mills

A cone crusher is used in quarries to reduce the size of the elements being mined. O'Mos needed to create a mill monitoring system to detect misuse of material, measure the wear of the internal mechanical components, generate a database for modeling the aging machinery, and reduce machine downtime and maintenance costs. O'Mos turned to the rugged CompactRIO platform, because the company could easily integrate it into the harsh environment, and LabVIEW software to create a high-quality user interface.



### High-Speed Control of a Hydraulic Die-Casting Machine

EUROelectronics developed a closed-loop control system for a high-speed hydraulic cylinder die-casting press machine that needed to be both cost-effective and highly reliable. Project and development time was significantly reduced by using an integrated approach for homogeneous development. With CompactRIO and LabVIEW, EUROelectronics advanced from the prototyping phase to final machine setup in only three weeks.



## Transportation and Heavy Equipment

Many applications in transportation industries require some sort of embedded control or monitoring. You can use the NI graphical system design approach to develop complete solutions to address industry needs for applications like engine control unit (ECU) rapid control prototyping, machine condition monitoring of vehicle components, hardware-in-the-loop (HIL) simulation, and in-vehicle logging. Rugged and modular hardware provides the flexibility to meet specific project needs in a reliable and efficient manner.



Photo is courtesy of Vehicle Projects

### Controlling the World's Largest Fuel-Cell Hybrid Locomotive

A fuel-cell hybrid power train uses a fuel-cell prime mover plus an auxiliary power/energy-storage device to carry the vehicle over power peaks and recover kinetic or potential energy during braking. Vehicle Projects chose CompactRIO as the ideal platform to meet harsh operating conditions, manage and execute all power plant functions, and continuously monitor the performance and safety of the hydrogen storage and fuel-cell power systems.



### Monitoring Electromechanical Shovels for Open-Pit Mining

Electromechanical shovels for open-pit mining are huge, mobile machines used to load haul trucks, which transport ore to processing plants. CADETECH developed a specialized continuous monitoring system for electromechanical mining shovels to enable a predictive maintenance strategy for these critical machines. Using CompactRIO and LabVIEW, the company created a fully functional, tailor-made continuous vibration and stress monitoring system.





## Life Sciences

The diversity of the life sciences field is mirrored in the wide range of applications NI products address. From biotechnology to medical device testing and from analytical instrumentation to physiological monitoring, NI hardware and software are used to develop highly flexible, scalable, and cost-effective solutions. These tools help scientists complete their research on time and help engineers quickly prototype complex device designs and reduce time to market.



### The First Real-Time 3D OCT Medical Imaging System

Optical coherence tomography (OCT) is a noninvasive imaging technique that enables visualization of tissue or other objects with resolution similar to that of some microscopes. Kitasato University leveraged the flexibility and scalability of PXI and NI FlexRIO hardware and used LabVIEW to program, integrate, and control the different parts of the 3D OCT imaging system. This solution combined high-channel-count acquisition with FPGA and GPU processing for real-time computation, rendering, and display.



### Using Graphical System Design for Tumor Treatment

Sanarus created a user interface and control system for an FDA-approved, Class II medical device used to treat breast tumors in a less invasive and nearly painless procedure while maintaining the design process within strict regulatory guidelines. With LabVIEW, Sanarus designed and coded a CompactRIO controller in house and then prototyped and deployed machines much quicker than thought possible to achieve aggressive deployment timelines.

## Condition Monitoring

Condition monitoring can help your organization avoid unscheduled outages, optimize machine performance, and reduce repair time and maintenance costs. With online embedded condition-based monitoring systems from NI, you can gain insight into the operating condition and overall health of your assets. NI hardware and software are being used right now in condition monitoring systems deployed on a variety of turbines, compressors, generators, and other industrial machines.



### Online Monitoring of Nuclear Power Reactors

AMS Corporation developed an online monitoring (OLM) solution for equipment in environments that are too difficult or dangerous to access. The company used LabVIEW and CompactRIO to build a custom, flexible OLM system that has reduced equipment costs and provides access to additional data for maintenance during refueling outages as well as normal operation.

## Robotics and Unmanned Vehicles

Robotics is one of the fastest-growing and most complex engineering fields. When designing complex robotics applications, you can be more productive with the LabVIEW graphical development environment, which provides a high level of abstraction for sensor communication, kinematics and autonomy algorithms, motor control, and more.



Photo is courtesy of Solar Bright S.L.

### Designing an Autonomous Robot to Clean Solar Panels

Dirty solar panels result in solar radiation loss and reduced power output. The Instituto de Desarrollo Industrial and Solar Bright developed an autonomous robotic arm to clean solar panels that met several stringent technical requirements. Using LabVIEW and CompactRIO, they were able to design and control the contact pressure between the solar panel surfaces and the cleaning tool mounted on a moving vehicle to recover 100 percent of the panel efficiency.

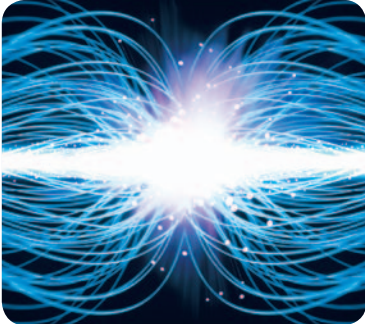
*“We successfully deployed a large-scale monitoring and management system from design to implementation within a short period of time. NI products gave us the flexible platform we needed to create a scalable, efficient, and deployable solution for our customers.”*

—Chua Seng Hiap, Singapore Technologies Kinetics Ltd



## Big Physics

Engineers, scientists, and physicists around the world are working to meet a variety of challenges in areas such as particle physics, fusion, and astronomy. From being able to program embedded real-time systems based on multicore processors and FPGAs to working with high-speed data acquisition systems requiring timing and synchronization, you can use NI commercial off-the-shelf (COTS) software and hardware to meet your control and instrumentation needs.

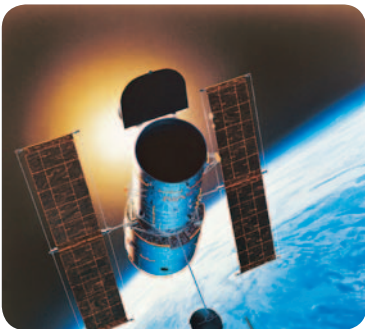


### FPGA-Based Feedback Control of a Single Atom

Max Planck Institute researchers developed a system that consists of a single neutral isolated atom interacting with a single photon—the fundamental excitations of the quantized electromagnetic field. Using NI FlexRIO and LabVIEW, they were able to build a powerful and versatile custom instrument to implement real-time execution of time-critical tasks in hardware. Max Planck could then develop a custom time digitizer to study fundamental quantum properties of light-matter interaction.

## Aerospace, Defense, and Government

National Instruments is a leading supplier of embedded measurement and control systems for aerospace, defense, and government entities. With solutions ranging from hardware-in-the-loop simulation to embedded signal intelligence, NI offers hardware and software tools you can combine to tackle your cutting-edge applications faster.



### Developing an Infrared Detector Control System

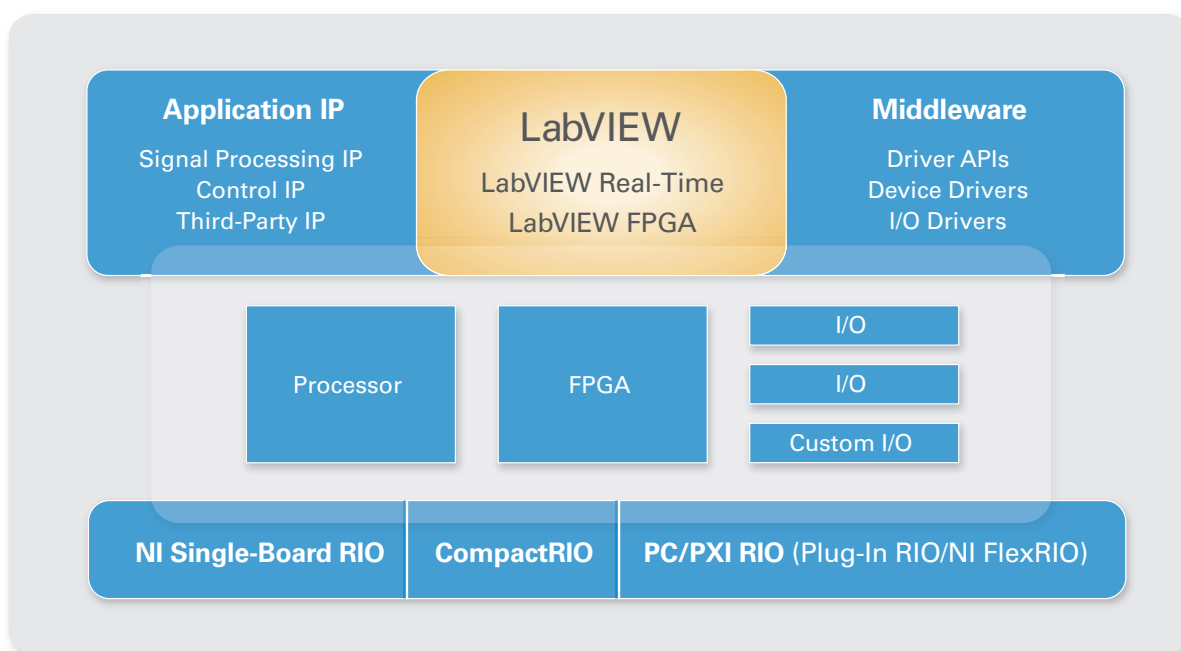
Mink Hollow Systems was tasked with replacing obsolete electronics and processors that control the readout of the detector in the infrared 256 by 256 InSb Spitzer Space telescope. With this telescope, astronomers can peer into dark nebulae and witness, literally, the birth of stars. CompactRIO and LabVIEW provided high-speed digital I/O.

*“Using NI FlexRIO, we created our own high-performance custom hardware. With LabVIEW FPGA, we were able to quickly develop our FPGA code because of its high level of abstraction, while also integrating VHDL IP when applicable.”*

—Christian Sames, Max Planck Institute of Quantum Optics

# NI RIO Hardware and LabVIEW Software

National Instruments embedded systems combine LabVIEW software with off-the-shelf hardware to simplify development and shorten time to market. All NI RIO hardware products are built on an architecture that features powerful floating-point processors, reconfigurable FPGAs, and modular I/O. And with LabVIEW, you can customize hardware and integrate custom timing, signal processing, and high-speed control without requiring expertise in low-level hardware description languages or board-level design.



“LabVIEW has made the software development side much quicker than our past experiences in C-based programming. What most C programmers take two years to do, we can accomplish in a couple of months. We can use that time savings to get to market quicker and capitalize on our competitors’ lag time.”

—Robert Stewart, LIME Instruments



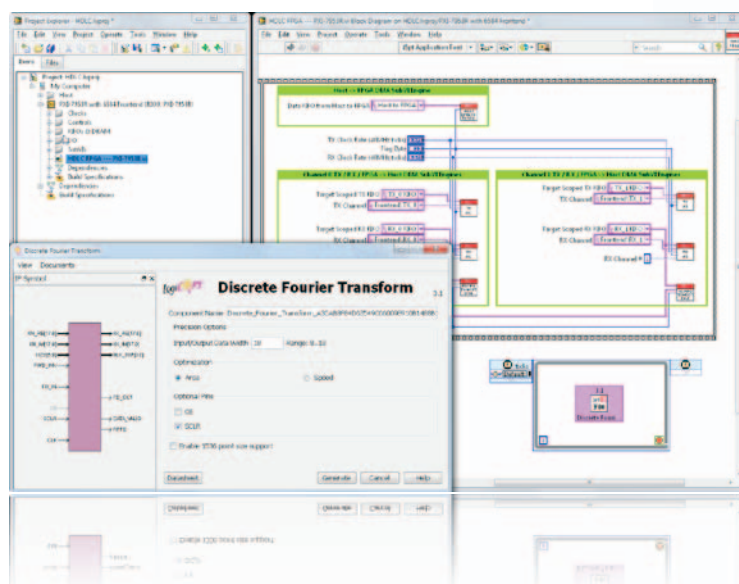
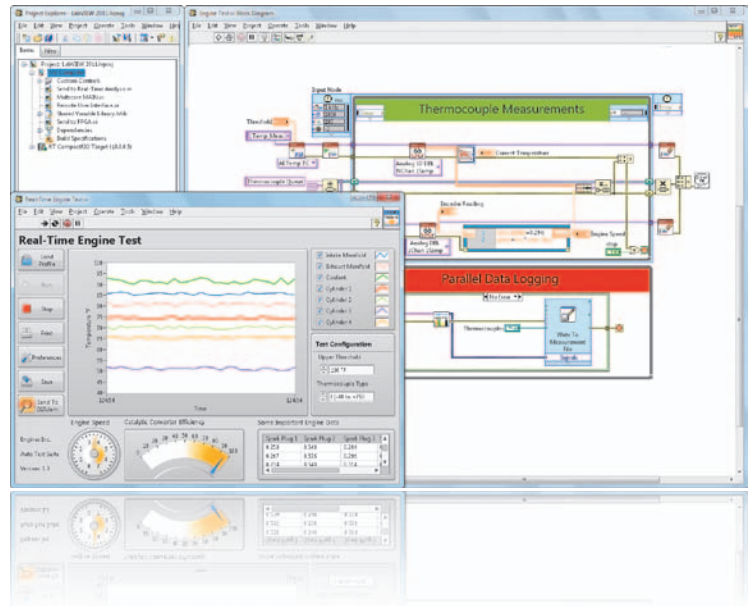
## The Ultimate System Design Software

LabVIEW is the only development environment that delivers an entire toolchain for developing advanced test, measurement, and control applications. With tight hardware integration, the NI graphical system design approach increases innovation, enhances productivity, and reduces time to market.

### LabVIEW Real-Time Module

NI real-time technology offers reliable, deterministic performance for all your application needs. Use the LabVIEW Real-Time Module to develop and deploy complex, stand-alone applications to the embedded microprocessor in the RIO architecture.

- Execute programs with strict timing constraints
- Communicate with a host or other enterprise systems
- Conduct closed-loop control and signal analysis
- Host data through web services



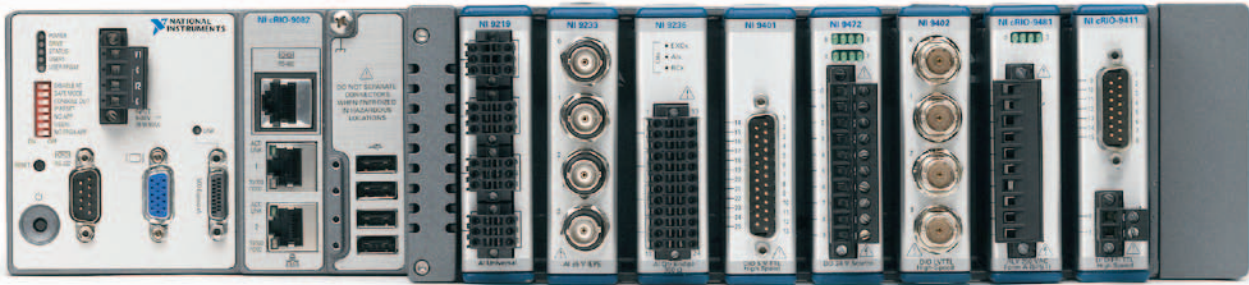
### LabVIEW FPGA Module

Take advantage of reconfigurable FPGA hardware to meet the most complex application challenges. The LabVIEW FPGA Module delivers a high level of abstraction to greatly simplify the generation of FPGA code and eliminate the need for expertise in hardware description languages.

- Implement custom digital protocols
- Perform inline signal processing
- Execute high-speed closed-loop control
- Perform custom timing and triggering
- Leverage resources and preconfigured IP

## NI RIO Hardware Platforms

National Instruments offers a variety of hardware platforms based on the RIO architecture, including NI CompactRIO, NI Single-Board RIO, NI R Series devices, and PXI-based NI FlexRIO modules. With varying degrees of performance, cost, I/O rates, form factor, and ruggedness, NI RIO devices can meet the unique needs of your embedded control or monitoring applications.



### CompactRIO

Options within the CompactRIO platform include smaller-footprint, lower-cost systems for OEM applications and ultrarugged, high-performance systems.

- 400 MHz to 1.33 GHz dual-core processors
- Hot-swappable I/O modules
- Xilinx FPGAs for processing and control
- Up to -40 to 70 °C temperature range

### NI Single-Board RIO

- Processor, FPGA, and I/O all on a single board
- Smallest form factor for high-volume, embedded applications
- Built-in analog, digital, and peripheral I/O



### PXI- and PC-Based RIO Systems

- NI PXI/CompactPCI systems provide the highest performance RIO systems
- R Series PCI/PXI devices feature multifunction I/O and the power of an FPGA
- NI FlexRIO delivers the highest performance FPGAs with custom external signal conditioning

## Multifunction I/O

Multifunction I/O is an integral part of the NI RIO hardware architecture that you can use to interface directly with sensors, actuators, motors, discrete inputs, and other devices in your system. The I/O feeds directly into the user-configurable FPGA, where you can perform inline signal processing, I/O synchronization, and closed-loop control.



## C Series I/O

In addition to integrated I/O, both CompactRIO and NI Single-Board RIO feature interfaces to C Series I/O modules. NI offers over 60 different kinds of C Series I/O modules with built-in signal conditioning, direct sensor connectivity, and industrial ratings to meet unique I/O needs.

- Voltage
- Temperature
- Digital input and output
- Relays
- Strain/bridge completion
- Counter/timer/pulse generation
- Acceleration
- Microphones
- Current
- Resistance
- Drives and motors
- Analog output
- Serial
- CAN communication
- PROFIBUS communication



## Custom I/O

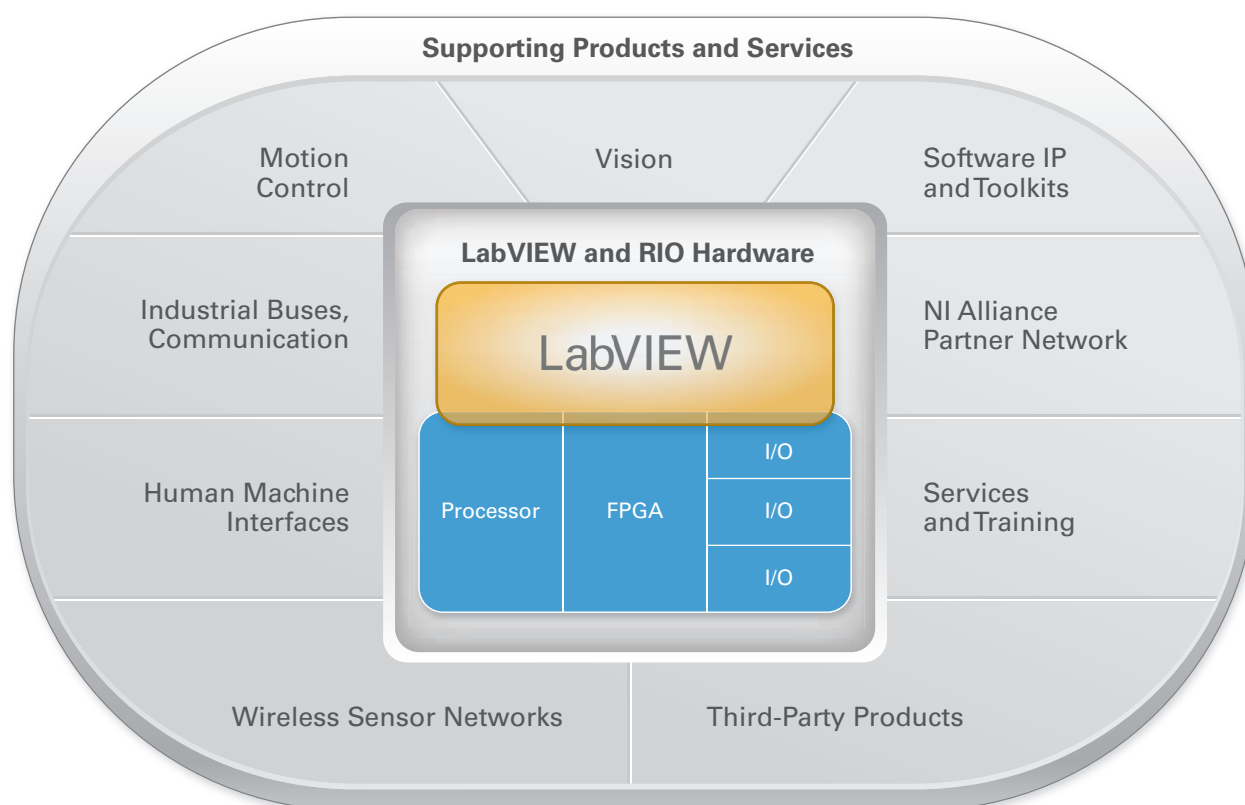
NI provides module development kits (MDKs) for creating your own custom I/O interfaces and software drivers.

- Create custom C Series modules with the NI C Series MDK
- Create custom daughter cards with the RIO Mezzanine Card (RMC) connector for NI Single-Board RIO
- Build custom NI FlexRIO adapter modules with the NI FlexRIO Adapter MDK



# The Supporting Ecosystem

The NI RIO hardware and LabVIEW ecosystem extends beyond I/O and processing to offer training, services, preconfigured software, and proven NI partners that can help you create turnkey solutions. NI also provides specialty I/O and visualization products that integrate seamlessly with core RIO products for vision, motion, wireless I/O, and human machine interfaces.



“We found that the combination of LabVIEW and NI hardware was infinitely configurable to meet our needs, leading to rapid development, continuous improvements throughout the life cycle of the product, and, most importantly, a compact and simple controller architecture.”

—Daniel Giroux, PBS Biotech Inc.

## Additional Products and Offerings



### NI Vision Systems

From image acquisition and precision inspection to customized sorting and autonomous guidance, NI vision systems deliver an integrated hardware and software solution that helps you develop applications faster and at a lower cost. Learn more at [ni.com/vision](https://ni.com/vision).



### NI Motion

Engineers are using LabVIEW system design software, versatile real-time controllers, and a complete drive and motor portfolio to build advanced motion applications faster and at a lower cost. NI offers PCI and PXI plug-in motion controllers as well as C Series drive and drive interface modules for CompactRIO. Learn more at [ni.com/motion](https://ni.com/motion).



### Industrial and Embedded Networks

For communication protocols like CAN, CANopen, PROFIBUS, DeviceNet, Modbus, and EtherCAT, NI offers a variety of tools to help you communicate with other devices in your system. Learn more at [ni.com/comm](https://ni.com/comm).



### NI Wireless Sensor Networks

Extend the reach of your system by wirelessly monitoring your assets or environment with reliable, battery-powered measurement nodes that feature industrial ratings and local analysis and control capabilities. Each wireless sensor network can scale from tens to hundreds of nodes and seamlessly integrate with your existing wired systems. Learn more at [ni.com/wsn](https://ni.com/wsn).



### NI Human Machine Interfaces (HMIs)

Create robust, reliable operator interfaces and visualization systems with NI HMIs and touch panel computers. With a variety of sizes, operating systems, and communication interfaces, you can find the right product to remotely visualize data or create embedded interfaces for OEM applications. Learn more at [ni.com/hmi](https://ni.com/hmi).

## Software IP and Toolkits

Get a head start on software development with preconfigured software blocks, example code, and turnkey toolkits for some of the most common algorithms, design architectures, and applications.

## NI Alliance Partner Network

This worldwide network of more than 600 consultants, system integrators, developers, and industry experts works with NI to provide complete, high-quality virtual instrumentation solutions.

# NI Global Services and Support

## Professional Services

The NI professional services team, comprising NI engineers and worldwide National Instruments Alliance Partners, can help you with prototyping, feasibility analysis, consulting, and systems integration. Visit [ni.com/services](http://ni.com/services) for more information.

## Software Maintenance and Support

Visit [ni.com/ssp](http://ni.com/ssp) to learn how, as a National Instruments Standard Service Program (SSP) member, you can receive free software upgrades and maintenance releases, direct mail and phone support from NI applications engineers, and access to exclusive software training modules.

## Hardware Services

Make the most of your hardware investment by using NI hardware services including flexible and renewable extended warranties, time-critical repair services, and hardware recalibration options. Visit [ni.com/services](http://ni.com/services) for more information.

## Training and Certification

The NI training and certification program is the most effective way to increase application development proficiency and productivity using NI software and hardware. Visit [ni.com/training](http://ni.com/training) for more information.

## Volume Licensing

Designed for organizations with five or more licenses of the same software program, the NI Volume License Program features services such as centralized license management, flexible budget purchasing, customized on-site training, and more. Visit [ni.com/vlp](http://ni.com/vlp) for more information.

## Technical Support

NI provides superior worldwide technical resources. Visit [ni.com/support](http://ni.com/support) and [ni.com/zone](http://ni.com/zone) to access volumes of self-help technical information including

- Application tips and case studies
- Example programs and frequently asked questions
- Troubleshooting wizards, user forums, and developer communities

For those who have software maintenance memberships or volume license agreements, qualified NI applications engineers are available for technical support directly via email or phone.

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