

## **2,000 Robotic Applications Using the National Instruments CompactRIO Embedded Control System**

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The FIRST Robotics Competition is an international contest that challenges nearly 2,000 teams with a unique task. Over the course of six weeks, the 100,000 participants in FIRST design, manufacture and test robotic platforms capable of competing in a mechanical sport. The teams then gather at regional and championship competitions to compete with their 120 pound robots, and in the process inspire young people to pursue a future in science and technology. In 2009, the FIRST Robotics Competition migrated to a new control system that to allow autonomous and tele-operated control of the robots that allowed for six robots to be independently operated at one time. This paper details the components of this new control system and documents how the system was used for robot control.

The National Instruments (NI) CompactRIO embedded controller served as the center of the control system, and this controller was augmented with additional hardware to interface with the robot and its controllers. The specific components of the 2009 FRC control system consisted of a Driver Control System, a Wireless Communications System and on-board Robot Controller. The controller was programmable in LabVIEW and C/C++ using the WPI Robotics Library that was written to support the new controller.

The NI CompactRIO consisted of a field-programmable gate array, a Freescale Power PC process and a variety of input/output modules. Two eight channel analog input connected to the CompactRIO to gather data from the robot's sensors. Two thirty-two channel Digital Input/Output modules also connected to the CompactRIO to collect sensor data and to communicate with the voltage controllers and relays that provided power to the robot's motors. An eight channel relay module provided up to 12V power to directly control pneumatic solenoids. Interface adapters were designed for this application to serve as an interface between the standard robot systems and the commercial data acquisition components. The CompactRIO could be configured for programming in either the NI LabView language or the Windchill C++ IDE. The hardware-specific code, which was downloaded to the FPGA, was developed in a partnership between the Worcester Polytechnic Institute and National Instruments.

The Wireless Communications System consisted of a Driver Station with USB connections that interfaced with any standard or user-designed game controllers and a Linksys wireless router. Signals were received on the robot with a Linksys game adapter which was connected to the CompactRIO. The system communicated using the 802.11n protocol. The system was configured to provide for remote control of the robot and wireless programming from a computer connected to an Ethernet port on the Driver Station.

This paper will describe all components of the FIRST Robotics Control System, and explain how this system enabled the use of vision systems, feedback control, autonomous control, and system monitoring. The experiences of an award winning team that participated in the 2009 FIRST Robotics Competition will be included in the paper to provide examples of the utility of this new robot control system.