Simplify System Complexity

With the new high-performance CompactRIO controller

Fanie Coetzer
Field Sales Engineer
Northern South Africa
CompactRIO
A Decade of Innovation

2004 10 2014
Using LabVIEW and CompactRIO to develop the internal controls of a Diamond Sorting Machine

by Anthon Voigt
De Beers Mining and Exploration Technology
June 2006
New control system

Plant PLC

Remote PC

view/control

Ethernet

CAN

RS-485

FieldPoint Internal I/O

Sensors & Actuators

CompactPCI

MMI/Sequencing/Logging

Acquisition Control

Supersonic Air ejectors

PMTs

X-ray Control

Signal Processing

X-ray generator

Remote PC

view/control
New control system

Plant PLC

Remote PC view/control

RS-232

Ethernet

X-ray generator

Ejection

Acquisition

Sensors & Actuators

Supersonic Air ejectors

PMTs

Ethernet
Conclusions

• Total development duration reduced to 25% of original time taken
• Design assurance much higher and risk lower
• Scope changes and added functionality much easier to incorporate
• Support, obsolescence and certification solved
• Developers still under pressure
• Future?
  – As product proves itself and more industrial interfaces are supported acceptance will be gained even where PLC’s are used.
  – LabVIEW is on the brink of revolutionising the embedded market
Mill Safety Start

- Protect your mill from a locked charge incident (drop charge).
- Record the performance of the liquid resistance starter.
- Get a comprehensive analysis of each start-up.
- Detect damaging torque transients and current spikes early.
- Pre-empt electrical and mechanical problems by taking corrective action expediently.

Big mills need extra care. Take proper care of your big geared mill, its gears and liquid resistance starter with a Mill Safety Start System.
We call this the LabVIEW RIO Architecture.

**Processor**
- Real-time OS
- Application software
- Networking and peripheral I/O drivers
- DMA, interrupt, and bus control drivers

**FPGA**
- Application IP
- Control IP
- DSP IP
- Specialized I/O drivers and interface
- DMA controller

**Analog I/O**
- Digital I/O
- Specialized I/O
- Custom I/O
- Bus Protocols

Highly Productive LabVIEW Graphical Programming Environment for Programming Host, FPGA, I/O, and Bus Interfaces
NI CompactRIO
The Worlds Only Software Designed Controller

- FPGA
- Processor
- Modular I/O

Extreme Ruggedness:
- -40 to 70 °C temperature range
- 50 g shock, 5 g vibration

High Performance:
- Up to 1.33 GHz, dual-core i7 processor

Highly Productive LabVIEW Graphical Programming Environment for
Programming Host, FPGA, I/O, and Bus Interfaces

Comprehensive I/O:
- Analog, digital, custom, specialty, bus communication

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NI CompactRIO
Value Range: 4-slot

- cRIO-906x
- 667MHz ARM-Cortex A9
- 256 – 512MB DDR3
- 512MB – 1GB storage
- Ext Temp available
New Performance CompactRIO

NI LabVIEW System Design
Program with LabVIEW Real-Time and LabVIEW FPGA modules
Quickly port existing LabVIEW applications

Simplify System Complexity
Embedded UI driven by NI Linux Real-Time
Integrate vision with FPGA co-processing
Removable SDHC data storage

High Throughput and Performance
Dual-Core Intel Atom 1.33 GHz processor
Xilinx Kintex-7 FPGAs with up to 325k logic cells
16 DMA FIFO channels for data streaming

Community and Code Reuse
NI Linux Real-Time Operating System
Integrate existing applications and libraries
Develop, debug, and deploy C/C++ code

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New Performance CompactRIO At-A-Glance

- **Dual-Core 1.33GHz Intel Atom Processor**
- **Modular C Series I/O**
- **Xilinx Kintex-7 FPGA**
- **Up To -40 to 70°C Operating Temperature**
- **2x USB2**
- **Display Support**
- **Power & Reset Buttons**
- **USB Device**
- **2x Gigabit Ethernet**
- **9-30VDC Dual Input**
- **RS232 & RS485**
- **User Defined Button**
- **Removable SD storage**
- **9-30VDC**
- **2x Gigabit Ethernet**
- **9-30VDC**
- **USB Device**
- **Display Support**
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Embedded Control and Monitoring Applications

Distributed Monitoring
Monitoring & Simple Control
Control Systems
FPGA Intensive Control

Heavy Equipment
Smart Machines
Electron Beam Welding Machine

Description
• Electron beam control
• Multiple axis of motion
• Vision guidance
• Local HMI

Challenges
• Increasingly complex control algorithms
• Complicated subsystem integration
• Additional design tools
• Time-to-market pressures
Electron Beam Welding Machine

Monitor

HMI

Controller

Vision Acquisition

Motion Drives

I/O

Camera
Intel Atom Dual-Core Processor

- Cutting edge Intel system-on-chip (SoC) with Silvermont microarchitecture
- High performance, low power, compact size and industrial temperature range
- Rich array of peripherals including GPU, PCIe, and USB (host and device)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Speed</td>
<td>1.33 GHz</td>
</tr>
<tr>
<td>Cores</td>
<td>2</td>
</tr>
<tr>
<td>L2 Cache</td>
<td>1 MB</td>
</tr>
<tr>
<td>Graphics Frequency</td>
<td>533 MHz</td>
</tr>
<tr>
<td>Memory</td>
<td>64-bit DDR3L-1066</td>
</tr>
<tr>
<td>Memory Density</td>
<td>1 GB or 2 GB</td>
</tr>
</tbody>
</table>
Support for NI Linux Real-Time OS

- Enjoy the **flexibility** of Linux, with the **determinism and reliability** of a real-time operating system.
- **Reuse** C/C++ code in or alongside LabVIEW Real-Time built applications on the latest CompactRIO controllers
Field-Programmable Gate Array (FPGA)

- **Configurable Logic Blocks (CLBs)**: Implement logic using flip-flops and LUTs.
- **Multipliers and DSPs**: Implement signal processing using multiplier and multiplier-accumulate circuitry.
- **Memory Blocks**: Store data sets or values in user defined RAM.
- **Programmable Interconnects**: Route signals through the FPGA matrix.
- **I/O Blocks**: Directly access digital and analog I/O.
Don’t Think You Need an FPGA? Think Again!

– 3 Reasons to Augment your Application with an FPGA –

Future-Proof Your Design

Adapt to changing requirements, evolution of projects

Maximize Reliability and Determinism

For time-critical, safety-critical, and deployed systems

Enhance Performance & Improve Functionality

Offload processing, Ultra-fast control, Custom timing…
Xilinx Kintex-7 Field Programmable Gate Array

- Almost 3X more CLBs and more then 13X more DSP slices then existing CompactRIO systems
  - Result: Process more channels, develop more complex algorithms, and perform more tasks in FPGA then ever before!

- 16 DMA FIFOs with 250MB/s aggregate streaming bandwidth in both directions
  - Result: You have the freedom to transfer data the way you want.
2-5x Reduction in Compilation Times with Vivado

- LabVIEW FPGA 2014 includes Xilinx Vivado compilation tools for Kintex-7 FPGAs, offering the following benefits:
  - Reliable timing closures
  - Improved resource utilization
  - 2-5x reduction in compilation times
Complex Control Application Benchmark

**Average CPU Usage**

- **cRIO-9025**
  - 46%

- **Performance CompactRIO**
  - 12%

- **cRIO-9082**
  - 4%

**4x Performance Improvement**

*Control loop rate of 500Hz*
Electron Beam Welding Machine

Monitor

HMI

CompactRIO

Vision Acquisition

Camera

Motion Drives

I/O

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LabVIEW 2014 Real-Time with Embedded UI
Simplify system complexity by implementing a local HMI on CompactRIO
Electron Beam Welding Machine

- Monitor
- Camera
- CompactRIO
- Vision Acquisition
- Motion Drives
- I/O
Implement Local Vision Acquisition

• Connect up to 4 cameras at once
  • GigE Vision provides higher bandwidth and longer cable lengths
  • USB3 Vision through USB 2.0 ports uses less processor resources

• Significant processing power with Intel Atom dual-core processor
  • Use Vision Development module to create advanced image processing algorithms
  • Make control decisions directly from image processing results
Vision Development Module includes Powerful IP

**Proven Image Technology**
Leverage over 50 FPGA image processing functions to design high performance vision systems and pass images between CPU and FPGA

**Improved Usability**
Prototype and generate code using Vision Assistant to design high performance vision systems

**Find Data Easier**
Automatically search an entire image for 1D Barcodes and perform decoding
Electron Beam Welding Machine

CompactRIO

Monitor

Camera

Motion Drives

I/O
Removable SD Card Storage

- Up to 32GB removable SD or SDHC cards supported
- 16GB and 32GB NI validated cards available at release
- USER1 button configurable to allow online SD card replacement
- NI SD card cover can be tethered to enclosure to prevent loss
Application: Semiconductor pick and place machine used to package silicon die

Goal: Consolidate subsystems to reduce cost and complexity and improve motion performance

Requirements
• Integrate 2 cameras for vision guidance
• Precisely control 8 axis of motion
• Implement a local HMI used for startup, calibration, and system status

Result: “By using the new CompactRIO controller in our semiconductor pick-and-place machine, we were able to integrate our local HMI and vision components into one device. This not only reduced our system costs, but it also reduced our development time.” – Kennes Wang, Master Machinery
New Performance CompactRIO

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