Graphical System Design For Large Scale Deployments

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Technical Consultant

NI Technical Symposium 2012
Professional Development Conference for Engineers, Scientists and Educators
Modern System Builder’s Diverse Requirements

- Mechanical Design
- Discrete and Sequential Logic
- Motion Control Design
- Sensors and Signal Conditioning
- Logging, Database
- Embedded System Design
- Networking
- HMI
- Motors and Actuators
- Machine Condition Monitoring
- Machine Vision
So, how do engineers keep up with:

- Increase in complexity of systems
- Increase in complexity of hardware
- Shorter development cycles
- Build vs Buy
Graphical System Design

To do for embedded what the PC did for the desktop.”

Interactive Design
- Control design
- Dynamic system simulation
- Digital filter design
- Advanced mathematics

Tight I/O Integration
- I/O modules and drivers
- COTS FPGA hardware
- VHDL and C code integration
- Design validation tools

Deployable Targets
- Rugged deployment platforms
- Distributed networking
- Human-machine interfaces
- Custom designs
Diverse Applications

Photo Kiosk Design

OCT Imaging

Smart Grid Control and Monitoring

Automated Loader

RailBAM

Vibration Monitoring
Santec uses NI RIO Technologies to Prototype and Deploy Portable OCT Imaging System

The Challenge: Increasing the imaging speed and reducing the size of an optical coherence tomography (OCT) imaging system. While reducing the cost of the system.

Solution: Using NI FlexRIO and field-programmable gate array (FPGA) technology to create an OCT system that achieved a 4X speed increase and a dramatically smaller footprint compared to the previous solution.

Used LabVIEW and FlexRIO for fast prototyping
  - PXI infrastructure (bus interface, etc)
  - Custom adapter module to prove concept
  - Developed algorithms on host before moving to FPGA

The system was designed – prototype and deployed in 6 months

“Using the NI FlexRIO platform and moving to FPGA-based processing, we achieved an imaging speed-up of 4x and significantly reduced the size of our system.”

-Takuya Suzuki, Engineer, Santec
Optical Coherence Tomography

- Scanner Control
- Signal
- Optical Coherence Tomography
- PC
- User Interface
- Image Processing
- Analog Input
- Photo Detector
- Beam Splitter
- Scanning Laser
- Reference Mirror
- Analog Output
- Scanning Mirror
- Skin Sample
- Scanner Control
Optical Coherence Tomography
Flex RIO

NI FlexRIO Adapter Module
- Interchangeable I/O
- Customizable by users
- NI FlexRIO Adapter Module Development Kit (MDK)

NI FlexRIO FPGA Module
- Virtex-5 FPGA
- 132 digital I/O lines
- Up to 512 MB of DRAM

PXI Platform
- Synchronization
- Clocking/triggers
- Power/cooling
- Data streaming

PXI/PXIe
FlexRIO Adaptor Module Development Kit (MDK)

- CAD files (for PCB outline and gold finger cell)
- Detailed drawings
- Hardware documentation
  - Pin descriptions and power options
- Software documentation
  - CLIP development
  - Using adapter modules in LabVIEW FPGA
  - Identification protocol
  - Example TBC, VHDL, UCF, and XML files
- Metal adapter module enclosures
  - 1 windowed enclosure and 3 blank enclosures
  - Additional enclosures purchased separately
NI PXI Flex RIO Deployment Curve

System Flexibility and Price vs. Number of Systems Deployed

PXI RIO

PCIe

FlexRIO FPGA

User CLIP

Socketed CLIP

LabVIEW FPGA VI

PXI Bus

LabVIEW

Adapter Module

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Build (Custom Design) vs Buy(off-the-shelf)

**Build**
- Custom HW/SW solution
- Use a lot of in-house resources
- Long lead times for new product
- Ability to get exactly what you want

**Buy**
- Off-the-shelf HW/SW solution
- Use less resources because systems are pre-built
- Better responsiveness to your customers
- Often get more than you need
The Total Cost to Build

- Hardware & Software Costs
- Mechanical Components (non-electronic)
- EDA Development Tool Costs
- Design Specification and Component Selection
- Prototyping
- Hardware Design
- Hardware Test & Verification
- Software Development
- Software Test & Verification
- Mechanical Design
- Manufacturing Setup & Tooling
- Manufacturing Test

Compliance and Environmental Engineering
Documentation, training and customer support
Inventory Management, EOL Issues
Sustaining Engineering
Opportunity Cost
Other Costs of Building

- Adapting to new PC technologies and Operating Systems
  - PCI 3.3 V change: 3-5 months of design and validation
  - Porting to new OS: 1-3 months
  - Porting to new PC bus: 6-12 months

- Environmental Regulations

- Inventory costs
  - Maintain warehousing system
  - Pay for inventory management at contract manufacturer

- OPPORTUNITY COST!
Example: Return on Investment

- Engineering = $300k
- Pre-release units = $25k
- Equipment = $25k
- Prototyping = $25k
- Tooling and Non-Recurring Expenses = $25k

Total Investment: $400k

\[
\text{Breakeven Point} = \frac{\text{Total Investment}}{\text{Savings per unit}}
\]

\[
\text{Breakeven Point} = \frac{\$400,000}{\$1000}\]

\[
\text{Breakeven Point} = 400 \text{ units}
\]
Build vs Buy

- **Build**
  - Volume per year:
    - 100
    - 1000
    - 10000
  - Cost:

- **Buy**
  - Volume per year:
    - 100
    - 1000
    - 10000
  - Cost:

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NI’s Hybrid Design Approach

*RIO Technology = Custom + Off-the-Shelf*
NI-RIO Deployment Curve

- PXI RIO
- PCIe
- CompactRIO Modular
- CompactRIO Integrated
- sbRIO

System Flexibility and Price vs. Number of Systems Deployed

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- RailBAM® acoustic monitoring system detects, identifies, reports bearing faults
- Wayside Monitoring System (WMS)
- Wheel Condition Monitor (WCM)
- RailSQAD® acoustic system monitors and reports excessive environmental noise
## NI Off-The-Shelf vs Custom Hardware

<table>
<thead>
<tr>
<th></th>
<th>Custom electronics/firmware</th>
<th>NI CompactRIO/LabVIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Development time</strong></td>
<td><strong>long</strong> - months</td>
<td><strong>short</strong> - weeks</td>
</tr>
<tr>
<td><strong>Development risk</strong></td>
<td>high - design refinement may require new PCB or firmware revisions, which need detailed design review and verification</td>
<td>low - design refinement may require different plug-in module or revised LabVIEW graphical model - simple functional verification</td>
</tr>
<tr>
<td><strong>Verification effort</strong></td>
<td>medium - PCBs must be tested for functionality - time consuming setup</td>
<td>low - NI chassis can be tested for functionality more easily with PC interface</td>
</tr>
<tr>
<td><strong>EMC certification risk</strong></td>
<td>high - we test, possibly re-layout PCB if it fails EMC</td>
<td>low - modules pre-certified by NI</td>
</tr>
<tr>
<td>&quot;Late game&quot; design change effort</td>
<td>high - changes require new PCB or firmware revisions</td>
<td>low - changes require new module or revised LabVIEW model</td>
</tr>
<tr>
<td><strong>Packaging effort</strong></td>
<td>medium - PCBs must be carefully supported, may need sub-enclosure</td>
<td>low - integrated NI chassis is inherently sturdy, simple to attach</td>
</tr>
</tbody>
</table>
What About Extremely High Volume?

- PXI RIO
- PCIe
- CompactRIO Modular
- CompactRIO Integrated
- sbRIO

System Flexibility and Price vs. Number of Systems Deployed

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NI Single-Board RIO Platform

“The power of CompactRIO on a single board.”
NEW! Single-Board RIO 2.0

Half the Size, Half the Cost

• Small footprint

• Direct access to processor and FPGA I/O through high-density, high-bandwidth RIO Mezzanine Card (RMC) connector

• More built-in peripherals (RS232, USB and CAN)

• Ideal for OEM and Volume Deployments

• Available in
  • Digital only
  • Multifunction IO
NI sbRIO-9605/6

• Small footprint at 4.05” x 3.8”

• Open architecture for customization and direct access to 96 FPGA DIO Lines through the RIO Mezzanine Connector

• Built-in RS232 with available USB and CAN

• Spartan-6 FPGA

• Well suited for OEM Applications

<table>
<thead>
<tr>
<th>Model</th>
<th>Processor</th>
<th>Operating Temp</th>
<th>Memory</th>
<th>Storage</th>
<th>FPGA</th>
<th>USB</th>
<th>CAN</th>
<th>Power Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>sbRIO-9605</td>
<td>400 MHz</td>
<td>-40 to 70</td>
<td>128M</td>
<td>256M</td>
<td>LX25</td>
<td>No</td>
<td>No</td>
<td>9-30V</td>
</tr>
<tr>
<td>sbRIO-9606</td>
<td>400 MHz</td>
<td>-40 to 70</td>
<td>256M</td>
<td>512M</td>
<td>LX45</td>
<td>Hi-Speed (x1)</td>
<td>Yes</td>
<td>9-30V</td>
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NEW! Multifunction I/O NI Single-Board RIO

<table>
<thead>
<tr>
<th>sbRIO-9623</th>
<th>sbRIO-9633</th>
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<tbody>
<tr>
<td><strong>CAN</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>USB</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>SDHC</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>FPGA</strong></td>
<td>LX25</td>
</tr>
<tr>
<td><strong>Digital I/O</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Analog I/O</strong></td>
<td>Good</td>
</tr>
<tr>
<td><strong>RMC</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Input Power</strong></td>
<td>9-30V</td>
</tr>
<tr>
<td><strong>Operating Temp</strong></td>
<td>-40 to 70°C</td>
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*models with RMC connector have 96 digital I/O lines
NEW! NI sbRIO-9633

- 16 Analog In
- 4 Analog Out
- 26 Digital I/O
- Spartan-6 LX25 FPGA
- 400 MHz Real-Time Processor
- 128MB RAM
- 256MB Flash
- RS485
- RS232
- SD
- CAN
- USB
- Ethernet
- RS232
NEW! NI sbRIO-9623

- RMC Connector with 96 Digital I/O (back)
- 400 MHz Real-Time Processor
- 128MB RAM
- 256MB Flash
- Ethernet
- RS232
- RS485
- 16 Analog In
- 4 Analog Out
- Spartan-6 LX25 FPGA

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RIO Mezzanine Card (RMC)

- Allows customization
- Gives access to FPGA, processor, and the ability to add peripherals and custom communication
- 240 pin Samtec SEARAY
Size Comparison of NI Single-Board RIO

- sbRIO 9605/63
Demo: Power analyzer Prototype and Deploy

1. Develop on Host

2. Download to Target

3. Deploy sbRIO
NexGEN uses CompactRIO and LabVIEW to Create a Wireless Monitoring and Control System for Electrical distribution System

The Challenge: Designing a wireless monitoring control system (WMCS) for an electrical distribution network using low-power frequency communication.

Solution: Used cRIO and cRIO MDK to developed a custom ZigBee module.

- Initial Prototype built with cRIO
- Once the algorithm verified and modules tested, deployed the system on sbRIO
Concept and Prototype
Deployment Solution

NI Sbrio-9601

Daughter Card
- RS 485 port
- Inbuilt Status input - 24 no
- Inbuilt Control Outputs - 24 no
- Analog Inputs - 8 No

C Series Card – GPRS Modem

NexGEN

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CompactRIO Module Development Kit

NI cRIO-9951

- Licensed right to design, manufacture and distribute custom CompactRIO I/O modules

Contents of Kit:

- CompactRIO module development software
- Development manual for custom I/O modules
- Starter set of CompactRIO module housings
- Technical support from National Instruments for your initial module development (up to 20 hours)
Now with new versions of sbRIO:
Gives the customer more flexible and cheaper Off-The-Shelf solution
NI’s Strategy for OEMs

- Leverage NI platforms
  - PXI, CompactRIO, Single-Board RIO
- Augment or add to NI platforms to customize for OEMs
  - Customization could be done internally or externally

Custom board with custom Analog, communication, display, etc…

NI RIO Platform Product

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NI Product Customization Services

- Special drivers, modified software features
- Custom installers, silent installers
- Board-only kits/packaging, OEM versions
- Board modifications and customization
  - Electrical Modification
  - Form factor
- Custom connectors and cables
- Extended warranties
## Product Life Cycle Management of sbRIO 1.0

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<td>Hi-Speed (x1)</td>
<td>Yes</td>
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<tr>
<td>sbRIO-9601</td>
<td>266 MHz</td>
<td>-20 to 55</td>
<td>64M</td>
<td>128M</td>
<td>1M Gate</td>
<td>No</td>
<td>No</td>
<td>19-30V</td>
</tr>
<tr>
<td>sbRIO-9602</td>
<td>400 MHz</td>
<td>-20 to 55</td>
<td>128M</td>
<td>256M</td>
<td>2M Gate</td>
<td>No</td>
<td>No</td>
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NI OEM Advantage

- OEM experience with many industries
- Extreme stability
  - 35 year track record of strong growth and profitability
  - No one industry/customer represents >15% of our revenue
- Global manufacturing facilities
- Focus on industry standard form-factors, technologies
- NI Product Life Cycle Management
  - Products designed with stable components and technologies
  - Manufacture most products for 10+ years
  - Automated product change notification (PCN) system
NI Services

Minimize Project Risk | Save Development Time | Reduce Deployment Costs

Software Services
- Software Subscriptions
- Volume Programs

Hardware Services
- Warranty and Repair
- Calibration
- System Services

Training and Certification
- Product Training
- Custom Training Plans
- Professional Certifications

Value-Added Services
- Technical Support Programs
- Professional Services
- Partner-Provided Services
Questions?