Adapter Modules for FlexRIO

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LabVIEW FPGA-Enabled Instrumentation
NI FlexRIO System Architecture

NI FlexRIO Adapter Module
- Interchangeable I/O
- Analog or digital
- 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
NI FlexRIO FPGA Modules for PXI

- Virtex-5 FPGA
  - LX30, LX50, LX85, LX110
- Direct access to FPGA I/O
  - 132 single-ended lines or 66 differential pairs
  - 400 Mbps single-ended
  - 1 Gbps differential
- 128 MB onboard DRAM
  - 2x 64 MB banks
  - 800 MB/s per bank
- Adapter module required for IO
NI FlexRIO FPGA Modules for PXI Express

• Onboard DRAM
  • 2x 256 MB banks
  • 1.6 GB/s per bank
• Enhanced Synchronization
  • Share PXI 10 MHz reference clock or DSTAR_A with adapter module
• Peer-to-peer streaming…
NI FlexRIO Adapter Module

- Analog
  - ADCs, DACs, clocks
- Digital
  - Buffers, transceivers, serializers, deserializers
- Card edge connector
- Defines I/O for LabVIEW FPGA
NI FlexRIO Adapter Module

- Xilinx Virtex-5 FPGA
- Socketed CLIP
- LabVIEW FPGA VI
- DRAM Memory
- PXI/PXIe Bus
- Socketed CLIP

ni.com
NI FlexRIO Adapter Module Options

NI Modules
- Complete integration with LabVIEW FPGA
- R Series-like experience

Third-Party Modules
- Expands NI I/O breadth
- Custom and application-specific modules

Custom Modules
- Requires PCB and HDL design work
- Supported through MDK
NI FlexRIO Adapter Modules

Digital

- 100 Mbps SE DIO
- 300 Mbps LVDS DIO
- 300 Mbps SE/LVDS DIO
- Camera Link
- RS-485/422

Analog

- 2 ch. 1.6 GS/s, 12-bit AI
- 2 ch. 3 GS/s, 8-bit AI
- 2 ch. 100 MS/s, 14-bit AI / 16-bit AO
- 4 ch. 250 MS/s, 14-bit AI
- 2 ch. 250 MS/s, 16-bit AI
- 32 ch. 50 MS/s, 12-bit Al
- 16 ch. 50 MS/s, 14-bit AI
- 2 ch. 40 MS/s, 12-bit AI
- 2 ch. 80 MS/s, 14-bit AI
- 2 ch. 120 MS/s, 16-bit AI
- 4 ch. 120 MS/s, 16-bit AI
New FlexRIO Modules

- 3GS/s, 8-bit Digitizer
- 1.6GS/s, 12-bit Digitizer
- 200 MHz – 4.4 GHz RF Transceiver
NI 5791 RF Transceiver Adapter Module for NI FlexRIO

- Tunable RF transceiver (TX & RX with shared LO)
- 200 MHz to 4.4 GHz frequency range
- 100 MHz instantaneous bandwidth 16 bits
- LO input and output for MIMO synchronization
- 12 bidirectional general-purpose digital I/O channels
- Large Xilinx DSP-focused FPGAs for real-time signal processing
- High-speed, low-latency PXI Express x4
- (~800 MB/s) connection to the host
NI FlexRIO Partner Modules

100 MHz PPMU
Camera Link and GigE
Multi-gigabit optical
Dual gigabit Ethernet
Video and Automotive
Adsys Controls Camera Link / GigE

- Camera Link interface
- Base, Medium, Full, and 80-bit configurations
- 4 DIO for custom use or IRIG-B signaling
- Future version with Gigabit Ethernet
Prevas Gigabit Ethernet Simulator

- Two PHY connections (RJ45)
- 10M/100M/1000Mbps rates
- Generate and analyze Ethernet traffic in real time
- Fault injection and channel simulation
Alfamation Video and Automotive Modules

- RS232
- K-line
- LIN
- CAN
- I2S
- SPI
- I2C
- Composite and component video
- LVDS frame grabber
- HDMI Analyzers
NI FlexRIO Adapter Module Development

- **Hardware**
  - PCB
  - Firmware
  - LabVIEW FPGA

- **Software**
  - API
  - Application
  - Examples

- **Mechanical**
  - PCB
  - Connectors
  - Thermal
NI FlexRIO Adapter Module

Schematic → Layout

VHDL → XML

LabVIEW
NI FlexRIO Adapter 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 FlexRIO Adapter Module

- 132 single-ended lines @ 400 Mbps (200 MHz DDR) – or – 66 differential lines at 1 Gbps (500 MHz DDR) – or – any combination thereof
- 6 W power – electrical and thermal limit
- 3.3 V (1 A) and 12 V (200 mA) rails
- 2 logic supply reference voltages connected to 2 FPGA I/O banks apiece
- I²C EEPROM for module identification and user-defined storage
- NI mechanical enclosures

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FlexRIO - Socketed CLIP

PXI-795x FPGA

LabVIEW FPGA VI

User CLIP

User CLIP

User CLIP

Socketed CLIP

Socketed CLIP

Socketed CLIP

DRAM

DRAM

Terminal Block
Adding a CLIP to the LabVIEW Project

- CLIP Node Files
  - IP source code (HDL, netlists, coregen)
  - Constraints file (optional)
  - XML file
    - Describes the interface between the CLIP and LabVIEW
    - Identifies path to source code
Adding a CLIP to the LabVIEW Project

AnalogFrontEnd.vhd

entity AnalogFrontEnd is
  port (
    adcCh0_LV : out std_logic_vector(15 downto 0);
    adcCh0_TB : in  std_logic_vector(15 downto 0) := x"0000"
  );
end AnalogFrontEnd;

architecture rtl of AnalogFrontEnd is
begin
  adcCh0_LV <= adcCh0_TB;
  ...
end rtl;

AnalogFrontEnd.xml

```xml
<?xml version="1.0" encoding="utf-8"?>
<CLIPDeclaration Name="AnalogFrontEnd">
  <HDLName>AnalogFrontEnd</HDLName>
  <InterfaceList>
    <Interface Name="AnalogIO">
      <InterfaceType>LabVIEW</InterfaceType>
      <Signal Name="ADC Ch0_LV">
        <HDLName>adcCh0_LV</HDLName>
        <DataType>I16</DataType>
        <Direction>FromCLIP</Direction>
        <SignalType>data</SignalType>
      </Signal>
    </Interface>
  </InterfaceList>
</CLIPDeclaration>
```
Adding a CLIP to the LabVIEW Project
Adaptor Module Features:
• Card Edge Connector
• Direct Mapping to FPGA I/O pins
• 6W of Power

FPGA Features:
• Virtex 5 (LX85 & others)
• LabVIEW FPGA
• LabVIEW Host Interface
Custom Adaptor Modules

Circuit Design & PCB Layout

Mechanical Components and Enclosure

VHDL to Socket CLIP
PCB Layout

- BNC
- SMB
- Banana

- User Defined Connectivity
- Custom Circuit
- Card Edge Connector

- High Speed Analog to Digital
- Clocking/Triggering
- Power/Support
Adapter Module Implementation

- Chip Validation
- Customer Evaluation
NI FlexRIO Adapter Module Development Kit (MDK)

- CAD files (for PCB outline and gold finger cell)
- Detailed drawings
- Hardware documentation
- Software documentation
- Metal adapter module enclosures
NI FlexRIO Target Applications
Chip Validation

- Chips on adapter modules can be characterized with PXI
  - Variety of Power, Digital & Mixed-Signal Instrumentation
  - Automate tests with LabVIEW
- Flexibility
  - Reuse test system and test code for multiple chips
  - Create custom adapter modules for unique test requirements
Semiconductor Validation – Protocol-Aware ATE

- Use NI FlexRIO to provide fast, deterministic response to an IC (DUT), rather than static pattern generation
- Hardware-in-the-loop (HIL) for semiconductor
- Relevant adapter modules:
  - NI 6581 100 MHz DIO module
  - NI 6585 200 MHz LVDS DIO module
  - Protocol-specific modules (422, 485, I²C, I²S, SPI)
  - Customer-developed board or IC interfaces
High-Speed Digital

- Use NI FlexRIO’s 66 Gpbs (8.25 GB/s) of I/O bandwidth to interface with high-speed digital ICs
- Relevant adapter modules:
  - (NI 6587, 20-ch. 1 Gbps)
  - Customer-developed, application-specific modules
HIL and Custom Protocols

• Use an NI FlexRIO adapter module to implement the physical layers of common communication protocols
• Use the FPGA to define MAC layer and above for custom protocols and real-time, low-latency communication
High-Performance Silicon with Fast Time-to-Market

• Build an NI FlexRIO adapter module with the latest DACs, ADCs, SERDES, and other ICs to get the latest / highest-performance measurement capabilities
• Strategy employed by NI, partners, and customers
Custom Measurements and Triggering

• Use the FPGA on NI FlexRIO to perform custom triggering, measurements, data reduction, and processing
• Common applications include Nondestructive Test (NDT), complex analog triggering, custom digital triggering
• Most general-purpose use case
Software-Defined Radio (SDR)

- Use common hardware to implement radio components in software
- Relevant adapter modules:
  - NI 5781 Baseband Transceiver – 100 MS/s 14-bit 2-ch. ADC, 100 MS/s 16-bit 2-ch. DAC
Spectral Monitoring and Signal Intelligence

• Use both high dynamic range and high bandwidth ADCs to monitor a large frequency range with the ability to “zoom in” on specific signals with higher dynamic range

• Relevant adapter modules:
  • NI 5171 8-bit 3 GS/s ADC
  • NI 5172 14-bit 250 MS/s 4-ch. ADC
  • NI 5173 16-bit 250 MS/s ADC
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