White Rabbit Module for NI CompactRIO

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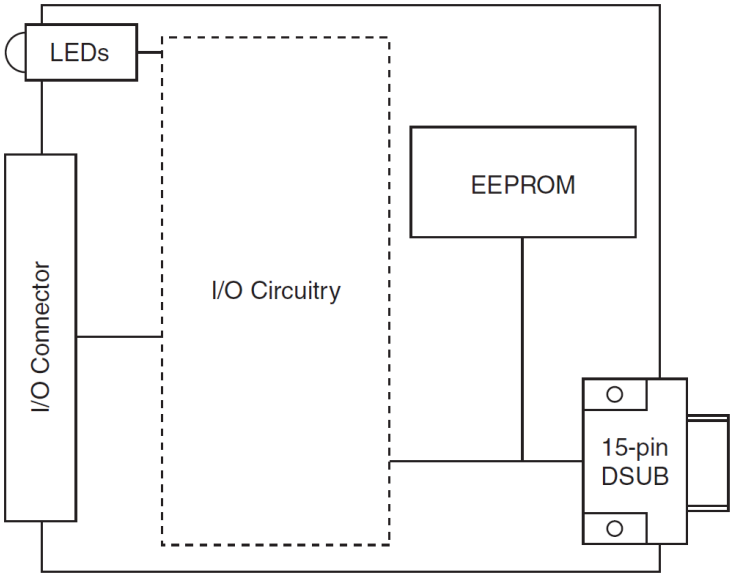
Overview

CompactRIO White Rabbit (CRIO-WR) is a standalone White Rabbit node implementation on a PCB with a form factor for National Instruments CompactRIO modules.

What Is CompactRIO?

- Reconfigurable embedded control and acquisition system made by National Instruments
- Includes a reconfigurable FPGA chassis, an embedded controller and I/O modules
- Programmed with NI LabVIEW

C Series Module Hardware Overview



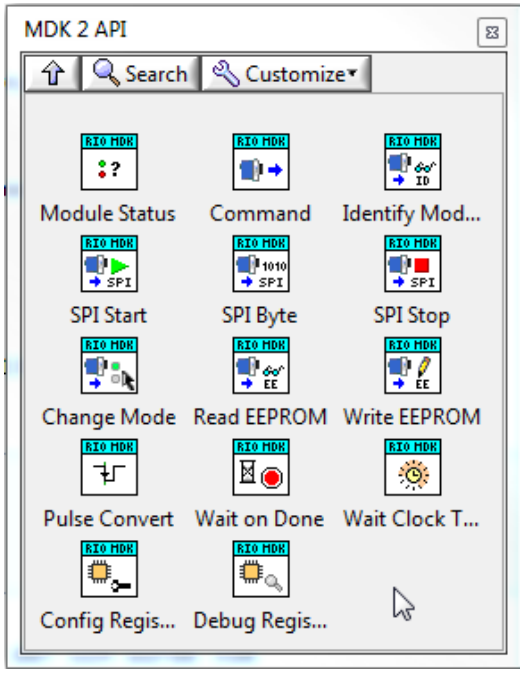
- The C Series module connects to the CompactRIO chassis through the 15-pin DSUB connector.
- The communication, power, and ground signals in this connection are collectively called the module interface.
- The EEPROM stores identification and calibration information.

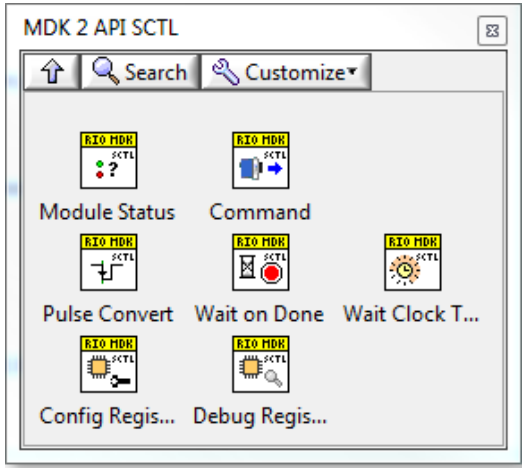
C Series Module Interface

- Modules and carriers interact with each other through the C Series interface.
- The C Series interface is implemented through a 15-pin DSUB connector, which includes all required signals in addition to power and ground connections.
- The functions of many of these signals vary depending upon the current operating mode of the module. Different operating modes are defined to enable module identification, module configuration, I/O access, and sleep states.

Basics of Driver Development

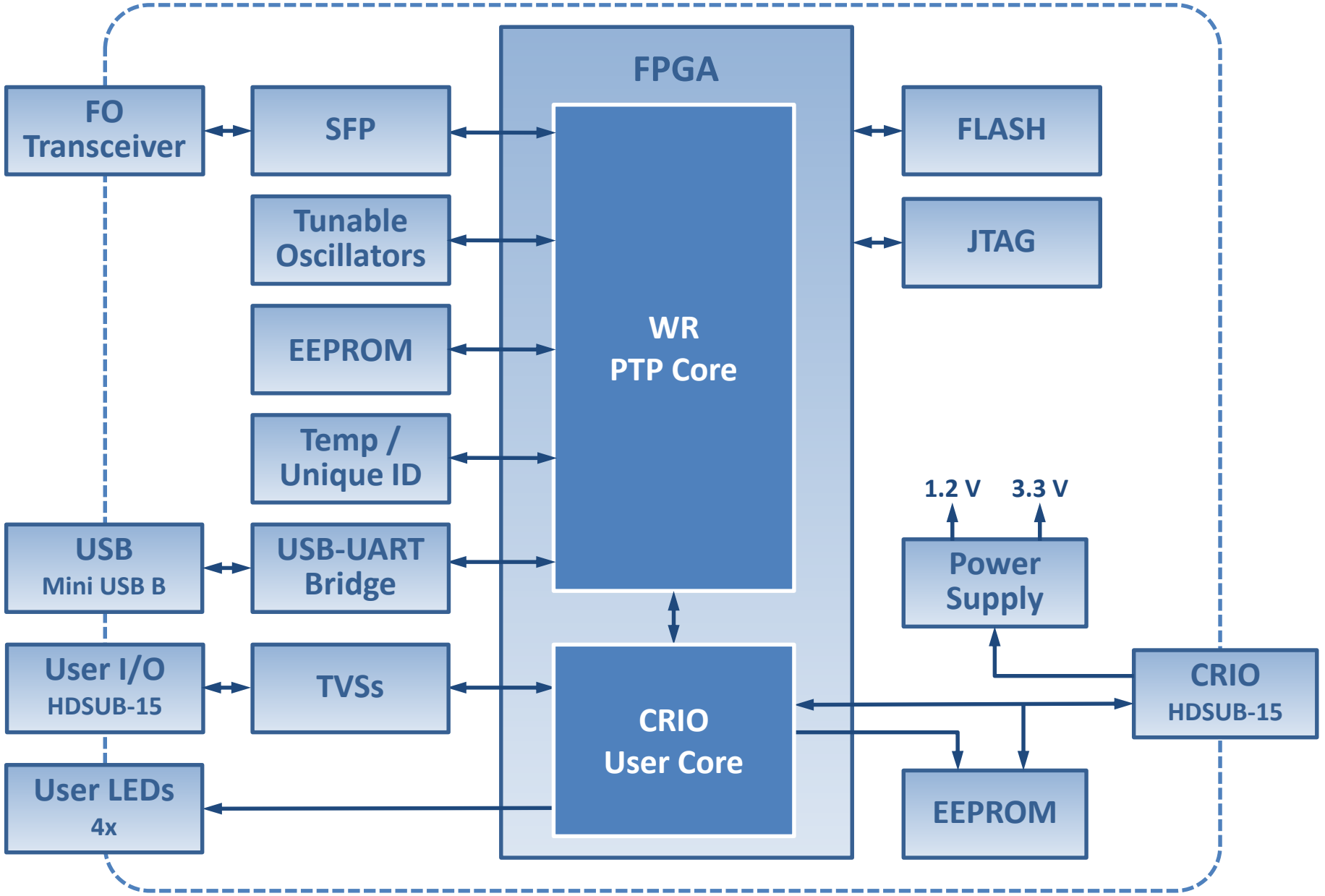
- **CompactRIO Module Development Kit 2.0**
  - **Configuration of EEPROM**
  - **Implementation of the communication over SPI**



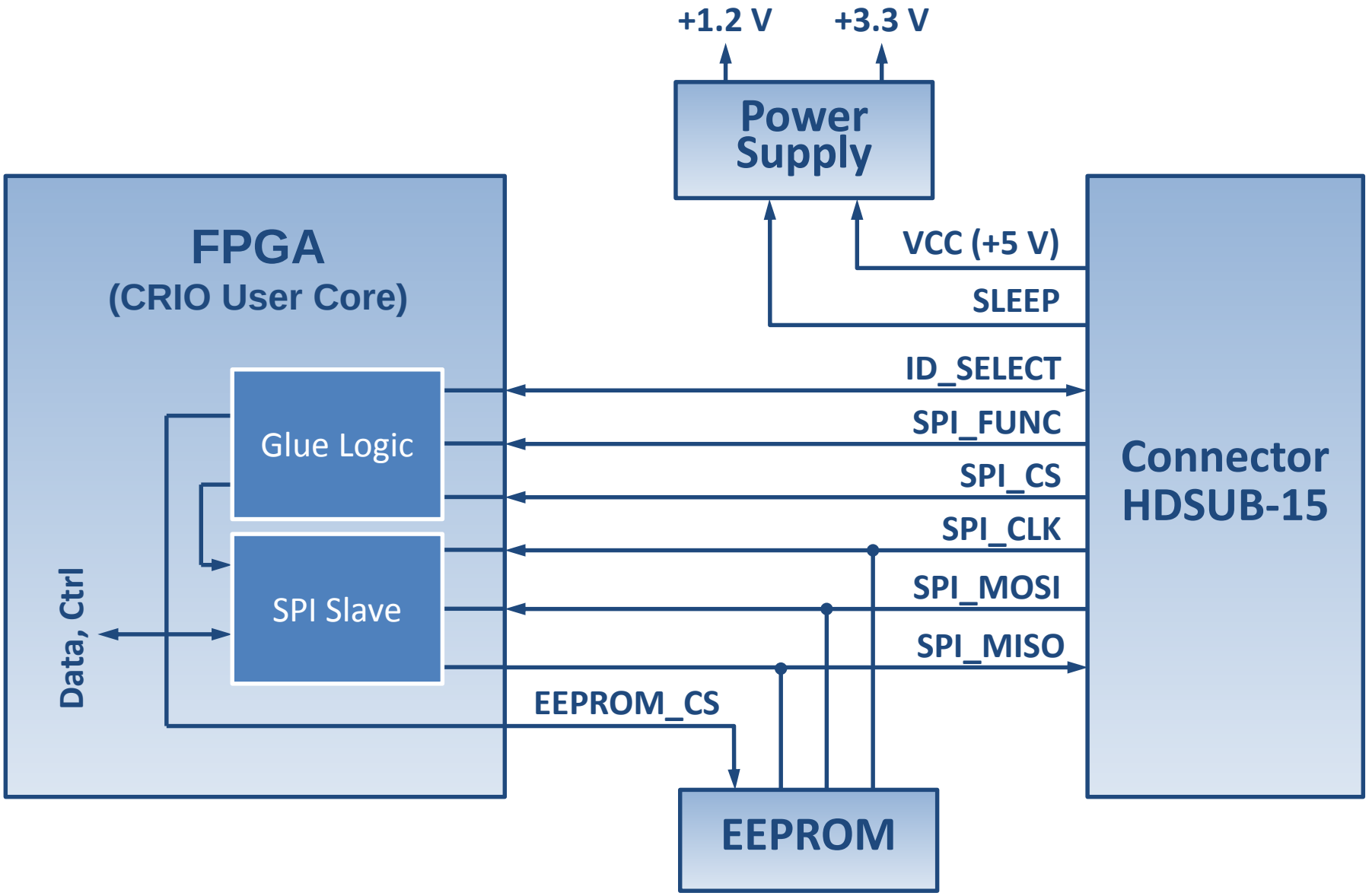


More information: http://sine.ni.com/nips/cds/view/p/lang/en/nid/14548

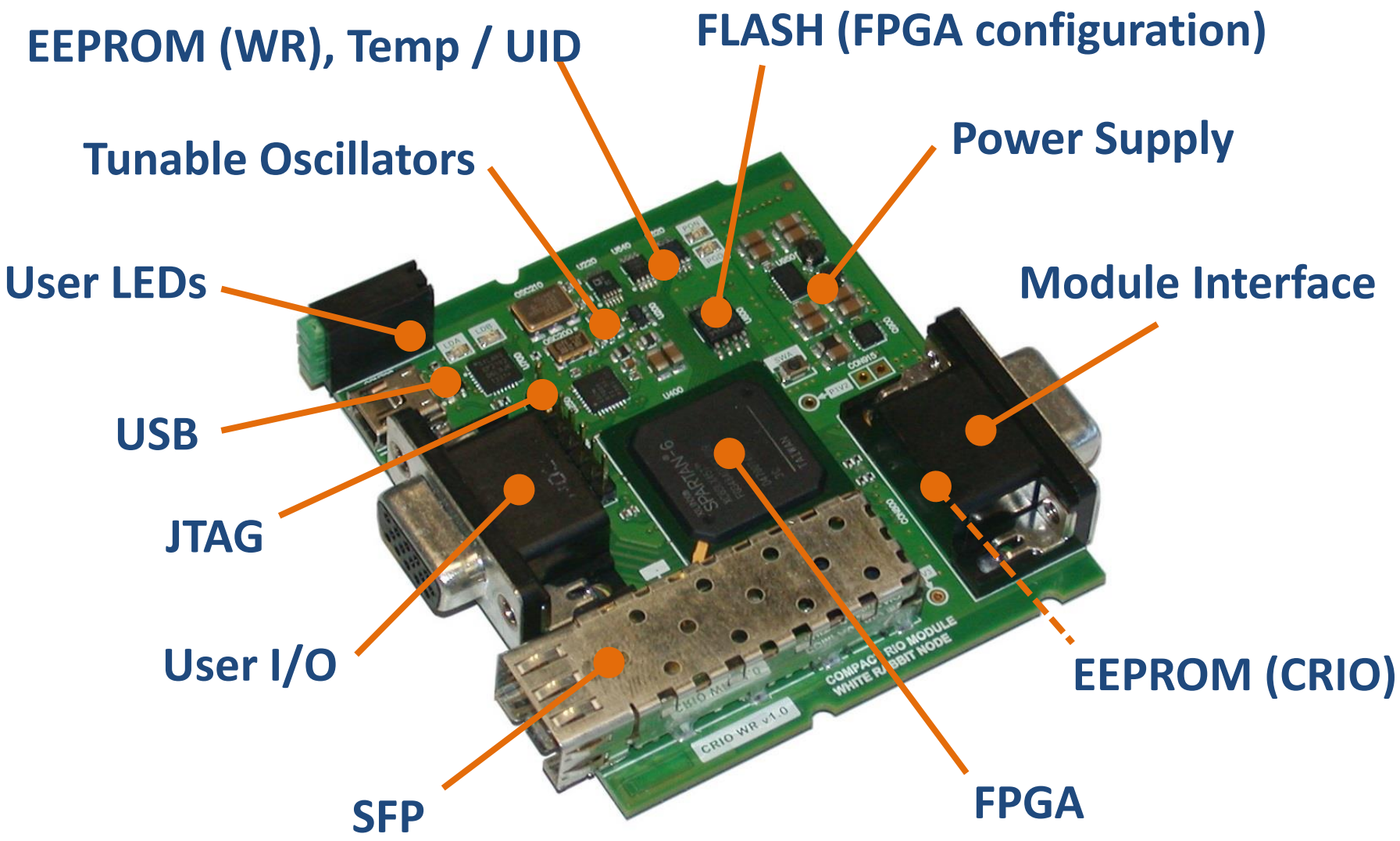
CRIO-WR Block Diagram



CRIO-WR Module Interface



CRIO-WR v1.0 Production Board



Main Features

- White Rabbit node in CompactRIO format
- Standalone WR operation (GrandMaster, Master or Slave mode)
- Xilinx Spartan-6 FPGA, SPI FLASH or JTAG configuration
- Programmable I/O (up to 10 x 3.3V / 5 x LVDS), e.g.
  - 10 MHz and PPS inputs (GrandMaster mode)
  - Reference clock and PPS outputs
  - Trigger inputs / pulse outputs
- USB-UART bridge (WRPC user shell)
- Originally derived from and keeps maximum firmware compatibly with SPEC and CUTE-WR

CompactRIO Spec Violations

CRIO-WR complies with most CompactRIO specifications. Violations (so far known):

Requirement	Specification	CRIO-WR
Current consumption	<= 200 mA	480 mA
Operating power, 85 °C rated components (100 °C rated components)	<= 0.625 W (<= 1.5 W)	2.4 W
Operating temperature range	-40 to 70 °C	TBD
Total inrush charge during module power-up time (integral of current drawn in excess of 200 mA)	<= 150uC	TBD

CompactRIO Spec Violations - Comments

- **Current consumption, operating power / temperature:**
  Hard to achieve specifications with present hardware!
  Operating power of main functional blocks:
  - **FPGA: approx. 1 W**
  - **Clock generators: approx. 700 mW**
  - **FO Transceiver: approx. 500 mW**
- **Total inrush charge during module power-up time:**
  Specification possibly achievable by reducing the number of on-board bulk capacitors (22 uF) at +1.2V and +3.3V (tests planed)
- **Issues:**
  First tests at room temperature showed no issues. After 8 hours of constant operation (CRIO-WR master with CRIO-WR slave) the internal module ambient temperature is 45°C.

Considerations for a next hardware version

- Dedicated reference clock output at user I/O connector, i.e. not via FPGA output (jitter) but directly from disciplined reference clock generator
- Reducing operating power (clock generators …)
- Minor modifications on power supply / filtering / blocking
- … ?

Status, more information

- Status:
  - HW v1.0, FW WRPC v2.1, FW CRIO v0.1 (demo), LabVIEW VI v0.1 (demo)
  - WRPC mode GrandMaster, Master and Slave tested (CRIO-WR / CRIO-WR)
  - First tests in cRIO chassis with LabVIEW (SPI EEPROM read / write, SPI FPGA read / write)

- More information:
  - http://www.ohwr.org/projects/crio-wr/wiki

Thank you for your attention!

Questions?

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