TRB3 - multichannel TDC and DAQ platform

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Versatile measurement solution - high precision ADC, QDC, TDC

Trigger Readout Boards v3 as a new solution for any kind of charge or time measurement for modern physics experiments:

- **Hardware features:**
  - Power of 5x Lattice ECP3 150 FPGA gives a space for implementation of sophisticated measurement mechanisms, DSP algorithms and connectivity features
  - 4x 208-pin QMS connectors: high input/output channel density, act as expansion ports for different kind of mezzanine cards providing power and data channels
  - 106-pin Addon board connector on back for even more extendable solution

- **FPGA firmware features:**
  - High precision time measurement (~14ps RMS) based on FPGA logic, up to 64 channels per FPGA
  - Integration data acquisition
  - Gigabit Ethernet connectivity together with UDP stack and customizable basic protocols

FPGA based Time to Digital Converters

- 4x edge FPGA with TDC design
- Concept of using FPGA hardware structure to measure time
- Resolution of around 14 ps
- Average binning 30 ps
- Multi-hit TDC
- 40MHz hit rate per channel
- Configurable solution
- High channel density up to 64 per FPGA (256 per board)
- UVD inputs
- Temperature and power changes are compensated by online calibration mechanism

Field Programmable Gate Arrays

- **Main FPGA**
  - High speed LVDS connections to each of the slave FPGAs
  - Connectivity through 8x 2.3Gbps optical links
  - Controls the operation of the board

- Mounted FPGAs: Lattice ECP3 150
  - 149k LUTs
  - 16x 2.3Gbps SERDES channels
  - 6850 Ks SDRAM

QMS Connectors

- 208 pin high-speed connector from Samtec
- Used to transport:
  - timing signals
  - application specific data
- Slots to connect mezzanine card:
  - up to 4 cards per board
  - different applications
  - customizable solution

Network Features

- 8x general purpose 3.2 Gbps optical links
- Variety of network protocols
- Connection to larger complex systems

- Gigabit Ethernet 1000BASE-X enabled links
  - Transport of collected data
  - Slow control
  - Full Duplex
  - UDP stack implemented as FPGA logic
  - Plug-and-Play design (DHCP, ARP)
  - VLAN functionality
  - Easy custom protocol implementation
  - Jumbo frames

Applications

- **High energy physics experiments:**
  - Designed for any kind of detectors needing precise time measurement like Photon Momentum Tubes or Resistor Plate Chambers
  - Can be used for charge measurement - additional mezzanine Addon boards needed (development in progress)
  - Network HUB - 8x optical links installed on the main board can be extended by AddOn boards
  - Trigger system thanks to large number of input channels

- **Usage scenarios:**
  - The board together with a PC can be used as a stand-alone measurement station
  - Optical links provide connectivity in order to use the board in complex DAQ systems

- **Ongoing projects:**
  - Development of ADC mezzanine Addon board - 4 different approaches will be tested
  - Development of HUB mezzanine Addon board with 6 optical links
  - Integration with HADES Data Acquisition System (GSI, DE) experiment
  - Development of TRBv3 FrontEnd Boards for Barrel DIRC, Disk DIRC and Straw Tube Tracker for PANDA (GS, DE) experiment
  - Preparation for use in two Positron Emission Tomography projects at JU (Kraków, PL) and LIP (Coimbra, PT)
  - Evaluation of the board for RICH, TOF and MVD detectors readout for CBM experiment (GSI, DE)
  - Many more...

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