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Design and commissioning of the ATLAS Muon Spectrometer RPC Read Out Driver

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The RPC subsystem of the ATLAS muon spectrometer provides the Level-1 trigger in the barrel and it is read out by a specific DAQ system. On-detector electronics pack the RPC data in frames, tagged with an event number assigned by the trigger logic, and transmit them to the counting room on optical fibre. Data from each sector are then routed together to a Read-Out Driver (ROD) board. This is a custom processor that parses the frames, checks their coherence and builds a data structure for all the RPCs of one of the 32 sectors of the spectrometer. Each ROD sends the event fragments to a Read-Out subsystem for further event building and analysis.
The ROD is a VME64x board, designed around two Xilinx Virtex-II FPGAs and an ARM7 microcontroller. In this paper we describe the board architecture and the event binding algorithm. The boards have been installed in the ATLAS USA15 control room and have been successfully used in the ATLAS commissioning runs.

Summary

In the beams of the LHC collider, protons are grouped in "bunches"that interact (bunch crossing) every 25 ns. From the point of view of the trigger system, the ATLAS apparatus is a synchronous network working at the bunch crossing frequency (40 MHz) of the LHC.
For each of the 32 sectors of the barrel spectrometer, the front-end electronics pack RPCs'data in frames, tagged with an event number assigned by the trigger logic. Data in each event are associated to a unique progressive number (Event Identifier, or EVID) and to a number identifying the bunch crossing that generated the collision (Bunch Crossing Identifier, or BCID).
Data from each sector are transferred to the counting room via optical fibre and are then routed to a Read Out Driver (ROD) board.
The ROD hosts an event builder logic based on a Finite State Machine cluster that parses the frames, checks their syntax and builds an event fragment. Each ROD sends the event fragments, across the optical link S-Link, to a Read-Out subsystem for further event building and analysis.
The ROD also manages the timing signals of the trigger and data acquisition system. For this purpose, the ROD hosts a TTCrq receiver module from which it optically receives the ATLAS timing and control signals.
The ROD is a VME 64x board, equipped with two XILINX Virtex II FPGAs, labelled as VME FPGA and ROD FPGA, and an ARM7 microcontroller.
The VME FPGA interfaces the whole board with the VMEbus and allows the user to access the ROD FPGA memory locations and configuration registers and to read the microcontroller's data.
The core of the ROD board is the ROD FPGA. It performs the event building of the detector data by means of a cluster of Finite State Machines (FSMs). Also, this FPGA hosts the registers for the configuration and control of the entire event builder engine. It is interfaced with the TTCrq module - from which it receives the TTC timing signals and the 40 MHz LHC's clock - and to the S-Link transmitter.
The ROD FPGA communicates with the VME FPGA via a serial synchronous custom protocol, carried out by two point-to-point unidirectional lines with a data rate of 80 Mbit/s.
The main task of the ARM7 microcontroller is to program the TTCrq receiver, via I2C protocol. This makes it possible to access all the TTCrq registers, both for configuration and monitoring purposes. The microcontroller also allows reading, via the internal ADC, the three power supplies on the ROD board (5V, 3.3V, 1.5V).
The ROD Event Builder Engine has been designed with some error handling procedures, in order to recovery from EVID or BCID errors, format or syntax errors and timeout errors. Some specific fields are also included in the ROD frame, in order to perform analysis on the ROD event builder performances.
In this paper we describe the board architecture and the event binding algorithm. The boards have been installed in the ATLAS USA15 control room and have been successfully used in the ATLAS commissioning runs. During the commissioning of the ATLAS Muon Spectrometer, several millions of cosmic muons have been acquired through the Read-Out Driver without any failure of the event building logic.

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