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The APx Board for the CMS Phase 2 L1 Calorimeter trigger: Testing and Performance

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The design, testing, system integration and performance of the ATCA processor (APx) boards firmware and software for the Phase 2 CMS trigger upgrade are presented. The 76 boards plus spares comprise the Calorimeter Trigger and half of the Global Track and Correlator Triggers. The production boards are based on the Xilinx VU13P and have 124 25G optical interfaces. A new optical link protocol provides robust performance. Large-scale optical link test results are shown. A full-slice environment for testing algorithms on multiple different boards together has been deployed. Measurements of thermal performance and latency are shown.

Summary (500 words)

The High-Luminosity LHC upgrade scheduled at CERN for 2027-2029 requires significant modification of the CMS detector. One of the most important part of this so called Phase 2 CMS upgrade, is a completely new Level 1 trigger system that should reduce the selected events rate from 40 MHz to 750 KHz with processing data volume of few hundreds TB/s. Such a challenging system requires new generation of hardware. The APx board developed at UW should be used in L1 Calorimeter trigger, some part of the Correlator and Global Tracker triggers. The main features of the board are the Xilinx UltraScale VU13P (in prototypes VU9P) FPGA and Intelegent Platform Manager Controller, based on Xilix ZYNQ device. The board supports 25 GB/s data exchange via 124 optical interfaces. A special protocol, CMS Standard Link Protocol, is developed to allow stable communication between boards in the trigger system. Results on stability of the links operation are presented. The maximum power consumption of the board with all I/O turned on and with maximum FPGA load is estimated. The L1 Calorimeter system will use 34 APx boards, collecting information from various calorimeter parts of the CMS detector with different time multiplexing intervals. The firmware and hardware requirements are discussed. Results of various tests are presented. The prototype of the L1 Calorimeter system demonstrates expected performance for all implemented algorithms that are running at 360 MHz. Commissioning of the trigger system that consists of many parts including boards of various flavour and connections between them is a very difficult task. To simplify the commissioning process a special software/firmware/hardware tool is being deployed. The tool makes it possible to test production bitfiles in a virtual representation of the full system environment, to support validation of the full geometry and assist in the planning of the optical fiber interconnections for the parts and the full trigger system. Results of tests with new tool are discussed. Based on results presented in this talk we conclude that the APx board demonstrates the expected performance and will be used in the Phase 2 upgrade of the CMS Level 1 trigger system.

Author: OJALVO, Isobel (Princeton University (US))

Presenter: OJALVO, Isobel (Princeton University (US))

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