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The design of an optical link for the ATLAS Liquid Argon Calorimeter upgrade

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We present the design of an optical link for the ATLAS liquid argon calorimeter upgrade. Challenging requirements are high data bandwidth (over 150 Gb/s raw data rate per board), radiation tolerance, low power consumption, high reliability, and low transmission latency. We discuss the link system design and component developments, especially those for the transmitting side that has to operate in the radiation environment. This presentation also serves as a summary of a few other presentations that detail in a particular function block of this link.

Summary

A few detector and readout upgrades are required in ATLAS to cope with the projected luminosity and the pile-up events associated with the high-luminosity LHC. We present here the design of an optical link for the ATLAS liquid argon calorimeter (LAr) upgrade. The challenging requirements of the link include the high data bandwidth (over
150 Gb/s raw data rate per board), low power consumption, high system reliability, low latency and radiation tolerance to the front-end electronics. These requirements call for a custom-made optical link transmitting side situating on the detector.

The current link design is based on the LOC ASICs, including these function blocks: an interface called LOCic, a serializer (LOCs2), and a laser driver (LOCld). The ASIC LOCic encodes and scrambles the data of the upstream ADCs with serial outputs for the downstream serializers. The counterpart, decoding and descrambling, of LOCic on the back-end is implemented in an FPGA. LOCic has been evaluated with an FPGA implementation. The functionalities, resources and performances of the implementation are presented. LOCs2 is a two-lane 16:1 serializer
sharing an LC-based phase-locked-loop (PLL). LOCld, the Vertical-Cavity Surface-Emitting Laser (VCSEL) driver, will be developed to be a single channel to drive a transmitter optical sub-assembly (TOSA) and an array that can be coupled to a VCSEL array. The challenges in the ASIC development of LOCs2 and LOCld are to reach the required speed of
8 Gb/s per channel. Prototypes of LOCs2 and LOCld are submitted in June 2012. The design and the preliminary test results of LOCs2 and LOCld are presented. Detailed reports on LOCic, LOCs2 and LOCld are submitted to this conference.

We are developing a TOSA based small form factor multi-channel optical transmitter called MTx and a VCSEL array based optical transmitter called ATx. Both MTx and ATx use radiation tolerant laser driver ASICs. While MTx has a larger footprint than the ATx, MTx offers the advantage of TOSA-based optical coupling, hermetic sealed VCSELs and less concern of heat dissipation from this sub-assembly. ATx offers an ultra-small footprint for high channel density applications, but reliable and uniform optical coupling, and VCSEL reliability operating in
open air and heat dissipation are all challenging issues in this development. There is a detailed report on the R&D submitted to this conference.

Several commercial optical transmitters (QSFP, PPOD and miniPOD) and sub-devices (single channel VCSEL driver and EEL driver) are investigated for their total dose and single event error effects. Irradiation tests indicate that no commercial optical transmitter and laser driver that we can find meets the radiation tolerance requirement.
We report the test data to date and discuss their implications on system integration.

We adapt the optical fibers and connectors, lasers diodes, and optical receivers from the Versatile Link project that has a report in this conference. System integration issues such as power budget are explored in simulation and survey testing.

Author: LIU, Tiankuan (Southern Methodist University)

Presenter: LIU, Tiankuan (Southern Methodist University)

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