Contribution ID: **87** Type: **Poster**

The 120Gbps optical transmitter development for the High-Luminosity LHC (HL-LHC) experiments

Tuesday 18 September 2012 17:24 (1 minute)

The 120Gbps optical transmitter is a 12-channel, 10Gbps per channel, parallel pluggable module to operate on the detector front-end for the readout and control of High-Luminosity LHC (HL-LHC) experiments. We present the design concepts based on multiple TOSAs, precision array coupling and drop-in opto engines. We describe the prototype development and the experimental set-up for parametric testing. Several commercial optical transceivers and sub-components are investigated for the total dose and single event error effects. Possible power penalties in parallel transmission links are also explored in simulation and survey testing.

Summary

The development of a high-speed, low power, radiation-tolerant optical data link is a critical task for the LHC upgrade. We conceive a 120Gbps transmitter module, i.e., a 12-channel, 10Gbps per channel, parallel pluggable module to operate on the detector front-end. The parallelization is realized via dense multiplication (120G_MTx) or array photonics (120G_ATx).

The 120G_MTx module incorporates individual 10Gbps single TOSA and driver components, densely placed in a compact package. Both single-mode (SM) and multi-mode (MM) flavors will be deployed. The single-mode transmission operates at 1310nm over SMF28e fiber and the multi-mode transmission operates at 850nm over OM4 MMF fiber. The electrical interface uses edge connector and the optical interface uses multiple LC compatible connectors. Customized optical couple mechanism provides reliable performance and material reduction.

The 120G_ATx module is based on array VCSEL and array driver components. This module provides even higher density and consumes less power. Only the multi-mode operation is investigated due to the availability of array photonic ICs. The electrical interface uses edge connector and the optical interface uses MT ribbon connector. Three array packaging design concepts are researched: 1) optical interface with photonic turn connector 2) standard MT coupling with flex circuitries 3) opto-engine sub-assembly integration. These designs are based upon emerging commercial parallel transceiver platforms and will be customized in collaboration with industrial partners.

The front-end transmitter is intended to work with commercial parallel receivers. System integration issues such as power budget are explored. Link model simulations are conducted with various jitter parameters to emulate the inter-channel crosstalk. Survey testing on commercial components is carried out to validate these parameter settings. There is no power margin on the multi-mode transmission links, therefore the transmitter output and receiver sensitivity are to be monitored closely with clearly specified test procedures. We describe the devices evaluated, the experimental set-up for multi-channel testing based on transceiver enabled FPGA evaluation kit, and our analysis of the performance test approaches.

For applications with an emphasis on HI-LHC tracker level radiation resistance, various custom ASICs are being designed. In the meanwhile, several commercial optical transceivers (QSFP, PPOD and miniPOD) and sub-components (single channel VCSEL driver and EEL driver) are investigated for their total dose and single event error effects. We report the ASIC survey and COTS test data to date and discuss their implications on system integration.

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Session Classification: POSTERS