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A Small-Footprint, Dual-Channel Optical Transmitter for the High-Luminosity LHC (HL-LHC) Experiments

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We present a small-footprint dual-channel optical transmitter module called MTx for the High-Luminosity LHC experiments. The MTx module consists of two separate commercial transmitter optical sub-assemblies (TOSAs) and a dual-channel laser driver ASIC. We have demonstrated that the module prototypes can operate at 10 Gbps using commercial 10 Gbps laser diode drivers. We are developing an 8 Gbps Vertical-Cavity Surface-Emitting Laser (VCSEL) driver ASIC to replace the commercial laser driver used in the current MTx prototypes and three prototype ASICs have been designed and tested. The design and testing results of the module and the ASIC are reported.

Summary

High-energy physics experiments have extensively used optical links, which provide many advantages including high bandwidth, long distance transmission, high density, low power consumption, and no ground loop. Small footprint is critical in designing front-end modules where the space is limited. In this paper, we present a small-footprint dual-channel optical transmitter module called MTx for the High-Luminosity LHC experiments.

The MTx module consists of two separate commercial transmitter optical sub-assemblies (TOSAs) and a dual-channel laser driver ASIC (or two separate commercial laser drivers in the prototype). We adopt the original idea of the small footprint versatile transceiver (VTRx) module developed by CERN. The electrical interface is a high-speed high-density surface-mount connector. The serializer ASIC is placed on the motherboard in the area underneath the laser drivers. The optical interface is a custom-designed plastic latch holding the two TOSAs and optical fibers. The latch used in the prototype is printed with a 3-D printer and the one used in the final design will be injection molded. Two 8-mm-high pluggable prototypes with LC connectors have been demonstrated. A 6-mm-high non-pluggable prototype without any connector is under development. With commercial laser diode drivers, we have demonstrated that the prototypes can operate at 10 Gbps. The commercial laser drivers will be replaced with a radiation-tolerant laser driver ASIC.

We are developing an 8 Gbps Vertical-Cavity Surface-Emitting Laser (VCSEL) driver ASIC to replace the commercial laser driver used in the current MTx prototypes. Three prototype ASICs have been designed and tested. The first prototype is a single-channel VCSEL driver. The modulation current and the biasing current are externally adjustable. The prototype provides the embedded inductive peaking with adjustable peaking strength. The prototype can operate error-free at 8 Gbps. The total power consumption is 215 mW (including the power consumption of the VCSEL). The prototype has been tested in X-rays (the maximum energy is 160 keV) up to the total ionizing dose required by the HL-LHC upgrade. The prototype has also been tested in a neutron beam with an energy spectrum close to the LHC background. No single event upset is observed with the fluence up to 1.8E11 n/cm2. The second prototype provides digital control interface I2C and is packaged in a QFN package. The third prototype has two channels with each channel operating at 8 Gbps. All prototypes are fabricated in a commercial 0.25-um Silicon-on-Sapphire (SoS) CMOS process. We present the design and testing results of the first two prototypes and the simulation results of the third prototype.

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