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CuOF : an electrical to optical interface for the upgrade of the CMS Muon Drift Tubes system

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The upgrade of the Drift Tube system of the CMS experiment foresees the relocation of the Sector Collector from the cavern to the counting room. It is thus required to convert the signals from electrical to optical, for a total number of 3500 channels running up to 480 Mb/s. A Copper to Optical Fiber (CuOF) board is currently under design. The board is divided into a mother board, which hosts the FPGA-based slow control system, and four mezzanine cards, each with 8 conversion channels. A prototype of the mezzanine board has been designed and tested under irradiation.

Summary

The upgrade of the Drift Tube system of the CMS experiment foresees the relocation of the Sector Collector electronics from the cavern to the counting room, in a more accessible and radiation-free position.
The fulfilment of this project envisages to turn electrical signals into optical ones for a total number of 3500 channels that run at up to 480 Mb/s data rate. The converters will be located in the CMS cavern and therefore demand electronic components qualified for a moderate radiation tolerance (of the order of 3.1x10ˆ11 neutrons (1MeVeq)/cm2 and 3.7x10ˆ8 charged particles/cmˆ2). Fault tolerance is a key issue since one of the main reason for the relocation is to remove single points of failure from the cavern. A second key issue is latency reduction, since this is critical for the correct operation of the CMS trigger.
For this purpose a Copper to Optical Fiber (CuOF) board is currently under design. The board is divided into a mother board, and four mezzanine cards. The motherboard hosts the slow control logic, which is based on two Actel FPGAs connected to two CAN buses. The slow control functions are managed by one FPGA and its corresponding bus, while the other is a backup and is activated only when the main FPGA does not respond properly. The slow control system manages both the laser driver settings and the temperature and voltage monitoring.
The mezzanine card is divided into 8 independent electrical to optical conversion channels. The electrical data stream is received on two RJ-45 connectors with 4 twisted pairs each. A line equalizer is used to compensate for distortion due to the copper line. The equalizer output is then sent to a laser driver which in turn drives the laser diode. VCSEL have been preferred over EEL for their low power consumption and radiation tolerance. The laser driver bias and modulation current can be adjusted via a two wire protocol by the slow control FPGA in order to adjust the optical power for ageing and degradation due to irradiation.
A first prototype of the mezzanine board with different combinations of laser drivers and equalizers has been designed and tested in order to find the best compromise between performances and power consumption. The boards have been tested on a test bench with the copper and optical cables of the final length. Both BER tests and jitter measurements on the received eye diagram have been performed.
The board has then been irradiated with a mixed field irradiation of high energy hadrons and neutrons at the H4IRRAD test area at CERN. During the 18 days of tests, with irradiation conditions similar to the ones foreseen at HL-LHC, the BER was continuously monitored. A value between 10ˆ-10 to 10ˆ-13 has been measured depending on the channel. No significant radiation dependence, nor SEU effects on the configuration registers has been observed.
A second prototype is currently under test. Irradiation tests are foreseen for May 2012.

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