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Next generation of Radiation Tolerant Single-Mode Optical Links for Accelerator Instrumentation

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Long-reach data transmission is an enabling technology for Accelerator Instrumentation at CERN. We present the development of next generation radiation-hard single-mode optical links. This new design aims to support the increasing data volume produced by the beam sensing electronics deployed along the accelerators. We present design of the new optical data link and its characterization in terms of functional performance and radiation tolerance.

Summary

The proton beam in the Super Proton Synchrotron (SPS) and Large Hadron Collider (LHC) is monitored at regular distance intervals by dedicated measurement systems. The acquired data is used in the feedback loop controlling the beam. Radiation-hard optical links, with a reach of up to 3 km, are necessary to connect the beam sensing electronics with the radiation-free areas where the data are processed. During Long Shutdown LS3, part of the beam monitoring instrumentation will be upgraded.

In order to achieve higher measurement precision, digital electronics will replace the current instrumentation based on analog circuits. The high volume of digital data foreseen for the High Luminosity LHC, and the necessity to monitor the beam bunch by bunch requires deployment of a new generation of SM radiation tolerant high-bandwidth optical links.

The Versatile Link project developed a custom rad-hard transceiver (VTRx) targeting the upgrades of the LHC Experiments during Long Shutdown LS2. The VTRx is based on radiation tolerant ASICs (GBLD and GBTIA), and commercial laser diodes and photodiodes which were validated for radiation tolerance. It is a bidirectional transceiver operating at 4.8 Gbps and comes in both multimode and single-mode flavours for short and long reach data transmission respectively. In the field of Accelerator Instrumentation at CERN, the VTRx together with the GBTx ASIC has been adopted by the GBT-based Expandable Front-End (GEFE) project, which is the standard radiation-tolerant digital front-end for the Beams Instrumentation (BI) group.

This work develops next generation single-mode optical links for accelerator instrumentation based on the Versatile Link framework. It is desirable that the new optical datalink generation supports higher data rate than the first generation, in order to cope with the high data volume produced by the beam instrumentation. This optical transceiver will be installed in the harsh radiation environment next to the beam pipe. The radiation field varies depending on the installation site along the accelerator. It has been estimated that in the expected lifetime of the module (˜ 10 years) the radiation levels could reach a 10 kGy total dose and a 5x10ˆ14 n/cm2 particle fluence.

We present the static and dynamic characterization of a number of edge-emitting-laser (EEL) candidates to replace the part, which became obsolete, used in the first module generation. The devices were also tested for displacement damage and TID effects up to the maximum irradiation levels. A 3 km single-mode link based on the new VTRx prototype running at 10.24 Gbps in the uplink and 2.56 Gbps in the downlink was demonstrated and the results will be presented. The new VTRx is intended to be mounted onto the next generation radiation-tolerant digital front-end for the BI group together with the serialiser/deserialiser low-power GBT (lpGBT) ASIC. Potential solutions for high-density data transmission based on wavelength division (CWDM) multiplexing will be also shown.

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