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Thermal characterisation of the Versatile Link PLUS Transceiver

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The miniaturised optical transceiver module, developed in the framework of the Versatile Link PLUS project (VL+) will be installed in the upgraded detector front-ends at the HL-LHC. The modules will have to operate over a wide temperature range (-35 ℃ to +60 ℃). We describe the impact of the temperature on the performance of the transceiver and we present simulation and measurement results obtained during the thermal characterisation of different transceiver prototypes.

Summary

During the phase II upgrades of the ATLAS and CMS experiments at the Large Hadron Collider (LHC) several detectors will be replaced to improve their physics performance. In particular, these upgrades aim to replace the innermost detectors that are exposed to the harshest radiation environments. To cope with the increasing data volume and the higher trigger rate, high-speed optical links will be deployed in large quantities as part of the upgrade programme. The tight space constraints and the high channel count of the on-detector electronics will require to develop a low-profile (20mm x 10mm x 2.5mm target), multi-channel front-end component, the Versatile Link PLUS Transceiver (VTRx+). During its expected lifetime the VTRx+ will have to withstand the on-detector radiation levels (1MGy total dose, 1x10ˆ15 n/cm2 and 1x10ˆ15 hadrons/cm2 total fluence) and will have to operate over a wide temperature range (-35 ℃ to +60 ℃). The VTRx+ will be based on radiation-hard laser diode driver (LDD) and transimpedance amplifier (TIA) ASICs, and commercial Vertical Cavity Surface Emitting Laser (VCSEL) and PIN photodiode (PD) components.

Operating over a wide temperature range presents various challenges to an optical transceiver. In particular, since the static and dynamic characteristics of the VCSEL depend on the die temperature, the modulated optical signal characteristics will also be strongly influenced by the module temperature. Commercial VCSELs used in the VTRx+ are targeted to data centre applications, where the typical operating range is usually optimized for higher temperatures. At these elevated temperatures the major concern is the long-term reliability of the VCSEL, which can be improved by optimizing the heat dissipation of the transceiver module. In some LHC applications, however, the front-ends will operate cold to increase the radiation resistance of the detectors. The change of static and dynamic VCSEL parameters at lower temperatures will require the adjustment of the VCSEL bias and modulation currents generated by the laser diode driver. Due to the intrinsic limitations of the ASIC technology, however, the range of operating currents is limited resulting in sub-optimal performance at certain module temperatures.

Several prototypes were built either by commercial module manufacturers (based on their proprietary design), or by an industrial high-precision assembly house (based on a full-custom CERN design). Following a successful characterisation at room temperature, these modules were thoroughly tested in an environmental chamber. Based on the test data we evaluated the system-level performance achievable at the low- and high-ends of the specified temperature range. We will present the test procedure used for the temperature characterization, summarize the results obtained using different laser driver settings at different temperatures, and derive the system margins at the lower end of the temperature range.

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