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Link Model Simulation and Power Penalty Specification of Versatile Link Systems

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This paper presents simulation and experimental studies of optical power penalties on the Versatile Link, the common R&D project on high-speed optical link for SLHC. It also presents how the 10 GbE fiber link model is incorporated into the Versatile Link system level specification.
Receiver sensitivity tests on multi-mode and single-mode fibers over different fiber lengths are demonstrated. The 10 GbE link models are examined and parameter sensitivity analyses are conducted. Transmitter characteristics affect link power penalty most. Optical power budget for a maximum reliable link is then predicted from the simulations for characteristic parameters of the Versatile Link.

Summary

The Versatile Link project aims to provide a radiation and magnetic field tolerant, high-speed (4.8 Gbps tentative) optical link for the readout and control of SLHC experiments. A system specification ensures the functionality, environmental resistance and operational reliability of the Versatile Link in its proposed applications. This paper examines the physical model of the link, conducts sensitivity analysis tests on components and fiber parameters, and compares the results with receiver sensitivity tests over a range of configurations and devices. A conservative yet realistic power budget specification is proposed.

Defining a link power budget involves decisions regarding three main blocks, transmit power, receiver sensitivity, and link penalties. Relevant industrial standards are 10GBASE-SR and 10GBASE-LR as well as fiber channel 400-SM-LC and 400-M5E-SN. The fiber channel technical committee also developed a 10GbE link model as a tool to facilitate specifying the optical power levels. Due to the philosophy of "worst case" conditions for all components and the "interoperability" at each interface, link power budget recommendations specified by these standards are quite conservative. There are not enough margins to accommodate degradations caused by irradiation effects (on lasers, PIN diodes and fibers). The first place to recoup power is to re-evaluate link penalties since the Versatile Links are operating at a lower data rate and shorter target length than those in a 10 GbE link. The goal is to produce a link power penalty specification as conservative as possible, but realistically close to the Versatile Links to be applied in practice.

The most important finding of the link model sensitivity test is that transmitter characteristics especially rise/fall time affect link power penalty most, as compared to receiver characteristics and fiber characteristics. We also construct a "conservative case" configuration to support the link power penalty specification, which are 1 dB for multi-mode Versatile Links and 1.5 dB for single-mode Versatile Links.

Receiver sensitivity tests on multiple links of 50, 100 and 150 meters of single-mode and multi-mode links over a range of 10 Gigabit/second applications compliant transmitters and receivers are conducted. The results populate the link power penalty variation space, and are all within the "worse case" power penalty predicted by the link model. Further work is presented on extended link lengths and data rates that are beyond current Versatile Link specifications, but within model validation range. Again the test results agree with model predictions.

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