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Evaluation of Multi-Gbps Optical Transceivers for Use in Future HEP Experiments

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Future experiments at CERN will increase the demand for high-bandwidth optical links. Custom developments for deployment within the detector volumes will be based upon commercially available transceivers.
We present our evaluation of commercial multi-Gbps optical transceivers and optoelectronic components. This serves as the basis to evaluate the performance of the future Versatile Transceiver that is being developed at CERN in the context of the Versatile Link project. We describe the experimental set-up for parametric testing, the devices evaluated and our treatment of the performance data.

Summary

High Energy Physics (HEP) experiments, such as the ones currently undergoing commissioning at the Large Hadron Collider (LHC), require tens of thousands of optical links each in order to extract raw data from the detector and to distribute clock and control data to the front-end electronics. An upgrade of the current LHC (super LHC or SLHC), planned for 2013-18, is expected to increase the luminosity by an order of magnitude to 1035/cm2/s, which will require higher-speed optical links with better radiation tolerance.
The Versatile Link project aims to propose both the architectures and the basic building blocks required for the implementation of future optical links across the various SLHC experiments. One of the main building blocks is a Versatile Transceiver (VTRx) for deployment on-detector that will be radiation hard and multi-Gbps capable.
A crucial stage of the VTRx sub-project will be the evaluation and validation of the versatile transceiver prototype modules. To accomplish this task we have set up a variety of test equipment, developed some software tools and specified the evaluation criteria and test procedures.
To develop the test set-up and evaluate the current state of the art, we have evaluated several commercial transceiver (TRx) modules from several families: SFP, XFP and SFP+. In the process, we have established performance benchmarks to which the VTRx modules can now be compared. Due to its low power consumption and high performance level we have chosen SFP+ devices as a basis for our custom VTRx development. We have also built and tested transmitters using commercial drivers attached to both off-the-shelf and custom lasers.
To evaluate TRx modules we have defined test points where it would be relevant to perform parametric testing. There are two basic types of measurements that we have used to characterize a TRx module: the eye diagram and the Bit Error Rate (BER) testing. To obtain the former we used a multi-Gbps data source and a multi-GHz sampling scope with electrical and optical input modules. To obtain the latter we used a multi-Gbps FPGA-based BER Tester (BERT).
The following signal information has been extracted from the eye diagrams: levels (average and difference), Q-factor, rise and fall times and jitter components (random and deterministic). We have also saved the raw data and performed off-line mask margin tests using custom masks. The BER test is a link level measurement but we have used it to qualify the receiver part of a TRx module. By measuring the BER for various attenuation levels of the input optical signal to the receiver, its sensitivity can be found.
Having gathered data from the parametric testing, these data must be compared so that a choice between devices can be made based on their respective test results. Since it is very difficult to accomplish this task by looking directly at all of the performance data together, we have introduced the concept of a Figure of Merit (FoM). We started by defining a set of minimum requirements and then constructed the FoM by calculating the relative distance between the measured parameters and the minimum requirements. The FoM concept has allowed us to clearly establish those commercial devices that are most suitable candidates for customization in order to turn them into Versatile Transceivers.

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