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The Phase 1 Upgrade of the CMS Pixel Front-End Driver

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The pixel detector of the CMS experiment at the LHC is read out by analog optical links, sending the data to 9U VME Front-End Driver (FED) boards located in the electronics cavern. There are plans for the phase 1 upgrade of the pixel detector (~2015) to add one more layer, while significantly cutting down the overall material budget. At the same time, the optical data transmission will be replaced by a serialized digital scheme. A plug-in board solution with a high-speed digital optical receiver has been developed for the Pixel FED readout boards and will be presented along with first tests of the future optical link.

Summary

The CMS pixel detector consists of 66 million channels, built up in three barrel layers and two endcap disks on either side. Each module contains up to 24 read-out chips (ROCs) and a central Token Bit Manager (TBM), which sends the collected ROC signals to analog optohybrids (AOHs), from where the data are transmitted through optical fibers over a distance of about 60 meters. 40 Pixel FEDs are installed in the electronics cavern, each of which has 36 optical inputs, receiving data from the front-end modules.

The Pixel FED consists of a 9U VME mother board with the communication infrastructure and three 12-way analog optical receivers. Nine quad-channel ADC daughter boards and five Altera FADC daughter boards are plugged onto the main board, all remaining within the single slot width of the VME specification. The modularity of the Pixel FED has proven advantageous for production, testing and spares management. Moreover, it allows to replace groups of three ADC boards by new plug-in boards containing a digital optical receiver and an FPGA for deserialization, without changing any other parts on the existing Pixel FED boards.

Arguments for going digital are the specific difficulties associated with analog optical signal transmission such as gain stability, linearity or noise. However, the main reason for this transition lies in the increased number of data links: The phase I upgrade of the CMS pixel detector will have a significantly reduced material budget, yet adding a fourth barrel layer and a third disk on each side for the benefit of physics analysis. But the optical fibers installed in CMS cannot be changed nor new optical cables added, so that the bandwidth of the existing fibers must be better utilized. This leads to a digital transmission speed of 320 Mbps, which corresponds to twice the information being sent in the present analog scheme. Only minor modifications are needed in the front-end ROCs and the TBM to achieve this goal.

Re-using the existing single-mode fibers for 1310nm wavelength imposes to find a high-speed receiver operating at this wavelength and, ideally, using the same optical MPO connector. Unfortunately, this is not compliant with the mainstream trend in optical communications, but thanks to the efforts of the CMS Tracker Optical Links group at CERN, we could test an engineering sample of an existing commercial device which was modified for the receiver optical sub-assembly (ROSA) part to fit the required wavelength. This device showed excellent results and is thus considered suitable for the Pixel FED upgrade. As the receiver is specified for 2.7 Gbps on each channel, it renders very clean eye diagrams at our comparatively moderate transmission speed.

Unfortunately, the digital output of the future pixel detector does not follow any of the standard protocols, such that it is not possible to choose an existing deserializer block from an FPGA library, but we have to develop our own phase alignment logic and decoding. We will present first measurements and ideas on how to proceed in this field.

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