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Service hybrids for the silicon strip modules of the CMS Phase-2 Outer Tracker upgrade

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The silicon modules of the Phase-2 CMS Outer Tracker feature service hybrids, which are flex PCBs that will carry radiation-tolerant DC-DC converters, the Low Power GBT chip, and a VTRx+ module. The strip modules are powered via a two-step DC-DC conversion scheme, while the data from the front-end hybrids are collected and serialized by the LpGBT, and passed on to the VTRx, which performs opto-electrical conversion. A prototype of this board, featuring FEAST2, the GBTx, the VTRx (all by CERN), and a commercial DC-DC converter, was developed, and we will present the experience from characterization and testing of this board.

Summary

For the Outer Tracker of the Phase-2 upgrade of CMS a novel module concept was developed. The silicon modules feature two sensors on top of each other: either two strip sensors (2S modules) or one strip and one macro-pixel sensor (PS modules). These modules provide information to the Level-1 trigger by performing transverse momentum discrimination at the front-end, by correlating the hit information in the two sensor planes. Another interesting aspect is that all the service electronics required for readout and powering are located on the module itself, on a service hybrid (or two service hybrids in PS modules), so that each module is an independent unit.

The service hybrid hosts the DC-DC converters required to power the module via a two-step DC-DC conversion powering scheme. In addition the service hybrid receives the data from the front-end hybrids at 320 Mb/s (640 Mb/s for PS modules). The data are directed to the Low Power GBT ASIC. This chip serializes the data and passes them on at 5 Gb/s (10 Gb/s for PS modules) to the VTRx+ opto-electrical transceiver module, also located on the service hybrid. The service hybrid delivers the high voltage to the sensor backplanes via a fold over region, and provides slow control functionality (e.g. readout of a temperature sensor and of certain voltages).

We have developed a prototype of the 2S module's service hybrid, which features the full functionality. Since the final chips are not yet available, we used prototypes for them: the FEAST2 ASIC, a commercial DC-DC converter for the second stage, the GBTx chip, the GBT-SCA, and the VTRx module. The prototype board has been fully characterized, including measurements of the feasibility of the two-step DC-DC conversion scheme, measurements of data integrity and bit error rates, fast and slow control, readout of prototype front-end hybrids, and studies of noise performance of prototype silicon modules. In addition, a test system has been developed, which features an FPGA as well as two GBTx plus VTRx assemblies, used to emulate the data stream from the front-end hybrids. The test system can be used to perform standalone tests of the service hybrid, as will be required for quality control in the production phase, where in total about 20 000 service hybrids of various types will have to be tested.

We will describe the concept of the service hybrids and the test system and share our experience from the development of these prototypes. The various measurements done to characterize the performance will be presented, problems be discussed, and further steps be outlined.

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