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Test system for the Service Hybrid of the 2S Module for the CMS Phase-2 Outer Tracker Upgrade

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In the context of the second phase of the CMS Outer Tracker upgrade two complementary systems for the testing of the service hybrids for two-sided silicon strip modules are presented. To enable prototype testing and long term active thermal cycling during series production a dedicated test board for stand-alone operation has been produced. In addition, a test card compatible with a production scale system has been developed. It is embedded in a common test system for all CMS-OT hybrids. The test systems will be introduced and first test results with both systems on prototype 2S service hybrids will be presented.

Summary (500 words)

During the LHC Long Shutdown 3 the CMS experiment's silicon tracker will be replaced to cope with the increase in instantaneous luminosity and radiation exposure. A key feature of the new tracker are modules with two closely spaced silicon sensors. By correlating hits in both sensor planes the transverse momentum of charged particles can be estimated at module level. Track information of tracks with transverse momentum above an adjustable threshold will be forwarded at the bunch crossing frequency of 40MHz to the Level 1 trigger. This enables the experiment's Level 1 trigger to utilize tracking information. The so-called 2S module type features two 10x10cm^2 sensors with two rows of 1016 strips at 90µm pitch on each sensor. Each 2S module is equipped with two front-end hybrids, which perform the readout. Their data output consists of six 320Mbit/s electrical links. The links are serialized on the service hybrid by the lpGBT to a 5.12Gbit/s stream and optically transferred to the back-end via the VTRx+. Trigger and configuration data are transferred in the opposite direction via an additional electrical link per side. The service hybrid also hosts two DC/DC converters to provide 1.25V and 2.5V for the module operation from the input voltage of about 10V. In addition, it filters the sensor bias voltage and supplies it to the sensors. With roughly 7600 2S modules needed for the new tracker, testing all objects before module assembly is a vital aspect of the upgrade effort. Two systems centered around different PCBs were developed to achieve this goal. The test board features two GBTx serializer ASICs and VTRx optical transceivers to provide electrical links to the service hybrid and emulate front-end hybrid data. All three optical links are connected to a FC7 data acquisition board, which provides and verifies the data streams. The test board's Cyclone 3 FPGA is capable to scrutinize the clock and reset signals distributed by the lpGBT. Functionalities that target the testing of DC/DC converter functionalities and the bias voltage distribution as well as the FPGA are controlled by a RaspberryPi single-board computer. Extension cables allow the use of the test board with a cooling setup. Hybrids can be temperature-cycled between -35℃ and room temperature during operation and testing. Direct cooling allows for fast cycling and a defined hybrid temperature. In addition to the test board, that targeted prototype and in-depth testing of small numbers, a test card for production scale testing was developed. It is compatible with a multiplexer backplane that is common for all hybrid types of the Outer Tracker upgrade. Instead of the RaspberryPi a USB-controlled micro-controller is used. The FC7 is electrically connected to the plug-in card so the need for the additional optical links is removed. Temperature cycling is realized by placing the setup inside a climatic chamber. Both, test board and test card, have been produced and tested alongside the cooling setup and service hybrid prototypes. Their concepts will be described and compared, and measurements on final prototype 2S service hybrids will be presented.

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