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Progress with the CMS Tracker control system

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The recent progress on the CMS Tracker control system is reviewed in depth, with a report of activities and results related to ongoing parts production, acceptance testing, integration and system testing, as well as controls software development. The integration of final parts into Tracker systems and the subsequent testing is described taking the Tracker Outer Barrel as an example application.

Summary

The CMS Tracker control system is used to configure and then operate the CMS Tracker front-end electronics and readout system. The different component parts, firmware and software are in various states of production and integration, and QA/QC tests are taking place at all levels from that of the full control system down to component level. This paper will review the ongoing activities on the key parts and on the control system as a whole.
The off-detector front-end controller cards (optical mFEC) have been developed and tested at CERN. 900 optical mFECs (plus spares) are foreseen for the whole of CMS, since the same, or very similar, control system will also be used in the Pixel, ECAL, Preshower and RPC detector systems. The mFEC can be used either on the 9U FEC/CCS card or on a PCI carrier. A purely electrical version (i.e. without optical transceiver, TRX) of the mFEC has also been designed for test-system applications as well as a portable USB-interfaced FEC for rapid system debugging.
The FEC/CCS which hosts up to 8mFECs on a 9U board is approaching final production with version 3. The Tracker requires 44 FEC/CCS out of a total 130 for all of CMS. The card has been tested successfully in a VME 64x crate utilizing a bridge with a LINUX PC running the XDAQ software. It has been fully populated with 8 mFECs, and tests were carried out on the VME-local bus interface, fast timing path, as well as monitoring of the temperature of the TRXs. The power consumption is 30W. 10 earlier prototype FEC/CCS boards were made for use in system/beam tests and currently a pre-production of 10 boards is ongoing.
The production of optical control links components is almost complete. The yield is very high indeed. All parts have been tested either at the manufacturer or by CERN to ensure the reliability of the front-end digital optohybrid (DOH) and off-detector TRX parts, as well as the fibres and connectors. Only known-good parts are being used for assembly and integration into the final system. Component obsolescence in the very dynamic telecom/datacoms industries is also a serious concern and a suitably conservative approach to spares has been adopted. The DOHs are now being integrated into the Tracker sub-systems, where the different sub-systems have developed their own DOH modules (DOHM), that also include solutions for fibre-management.
The communication and control unit ASICs (CCUs), have been available in a final form for some time already, along with modules (CCUMs) to house them. A test-system was built at CERN, allowing for a full control ring with redundancy, to be tested exhaustively with up to 16 CCUMs in the ring. The test system is fully configurable such that the number of CCUMs can be adjusted, as well as the associated cable lengths, and the eventual failure of any given CCUM, or associated element can be simulated and studied.
On the software front, the controls software consists of several dedicated layers of code. The first layer is able to access the VME through the PCI to VME interface. The original software in this layer was intended as a Linux device driver able to drive either an electrical and optical PCI FEC. The second layer

manages the control ring and the way in which the the front-end ASICs are accessed and configured through the I2C bus. A third layer manages the eight rings on a single FEC/CCS board and the fourth layer is the high level software that will be integrated in the complete framework of the data acquisition system in the CMS experiment using XDAQ. The high level software is able to retrieve information from a database management system to configure the front-end ASICs with the appropriate settings. It also manages the handling of possible errors in the ring, switching between the primary and backup control path in the redundancy scheme. The speed at which the system commands are transmitted has been measured in detail and this will be reported.
The control system for the Tracker Outer Barrel (TOB) will be considered in more detail as an example application. The integration and assembly and testing of the various parts onto 'rods'(the basic detector unit of the TOB) has been defined and the activity is currently well under way. No rods have been rejected due to failures in the control elements so far. A thorough test of the TOB control system using final CCU and DOH carrier boards is also under way, employing the latest versions of the controls software. The performance of the control system with up to 10 TOB-variant CCUMs in the ring has been studied, with the front-end parts exposed to temperatures between ambient room temperature and -30C, which is below the intended operating temperature of the Tracker. The control system works well, with a low rate of transaction errors (at room temperature and at low temperature), in tests conducted continuously over several days with I2C commands sent to the various front-end components in a continuous stream. More tests at different temperatures are foreseen and these will be reported.

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