Contribution ID: **112** Type: **Oral**

Software Tools for Hybrid Quality Control for the CMS Phase-2 Outer Tracker Upgrade

Friday, 23 September 2022 11:40 (20 minutes)

Fifty thousand hybrid circuits of five different types will be manufactured for the Phase-2 Upgrade of the CMS Outer Tracker. These circuits must undergo a strict quality control process, composed of functional testing and visual inspection, before they can be assembled into modules. The hybrids will be functionally tested first at the manufacturing sites. Afterwards, they will be visually inspected and functionally tested again at CERN or at collaborating institutes. Results from these processes will be stored in the CMS production database. This paper will present the software tools developed to carry out these tasks.

Summary (500 words)

The Compact Muon Solenoid (CMS) Outer Tracker Phase-2 Upgrade for the High Luminosity Large Hadron Collider (HL-LHC) is based on two main types of modules, the strip-strip (2S) module and the pixel-strip (PS) module. The 2S modules are made of two parallel strip sensors of 10 × 10 cm2 and two front-end hybrids interconnected with a service hybrid. The PS modules contain a strip sensor and a macro pixelated strip sensor of 5 × 10 cm2 and two front-end hybrids interconnected with a power and a data readout hybrid. In total, five different hybrid types are required for the assembly of 2S and PS modules , a power hybrid, a readout hybrid and a service (power and readout) hybrid.

The complexity and difficulty of repair of these hybrid circuits requires them to be tested and inspected during production. The quality control is composed of functional tests at the manufacturing site followed by visual inspection and an additional functional test upon the arrival of the hybrids at CERN.

A test system was developed to support the functional testing during production, based on a multiplexing crate in which up to twelve plug-in cards can be inserted. Six different plug-in cards were designed to test each of the five hybrid types. The crate is connected to both a computer via USB, and a data acquisition FPGA board (the FC7), which is connected through Ethernet to the computer.

As the functional testing of the hybrids will be performed by non-experts in the manufacturing sites, an easy-to-use system to test the circuits, handle the complexity of the test system and automatically process the results is needed.

The Phase-2 Acquisition and Control Framework (Ph2_ACF) developed by the Data Acquisition team was used to develop the test procedures for each of the hybrid types. It encapsulates the interfacing layers for the ASICs of all the CMS Inner & Outer Tracker objects. It also interfaces with the firmware of the FPGA, responsible for the configuration, control and read-out of the hybrids under test.

To enable the testing at contractor, a supervising test manager was designed. This software is able to control multiple crates, and handle all the testing in a pre-defined sequence, while presenting a simplified test result to the operator. The test manager monitors the test results and looks for test system failures that would require hardware maintenance. The test results are then uploaded to the CMS production database, to allow for close monitoring of the production from CERN.

The visual inspection of the hybrids will be carried out at CERN by experts. A fraction of the hybrids will also be subject to wire-bond testing. A dedicated web tool was developed to help increase the efficiency of this process and register the reports into the production database.

The CMS Production Database is designed to store the references, status and test results of all objects in the

CMS Tracker project, as well as the relationships among them.

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Session Classification: Production, Testing and Reliability

Track Classification: Production, Testing and Reliability