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Design of hardware interfaces for the LHC Phase-2 CMS ECAL Barrel Safety System

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The CMS Electromagnetic Calorimeter (ECAL) uses lead tungstate scintillating crystals to measure the energy of electrons and photons produced at the Large Hadron Collider (LHC). The High Luminosity upgrade of the LHC (HL-LHC) at CERN during the LHC Long Shutdown 3 imposes significant challenges for its experiments. The higher luminosity changes the environmental conditions in which the ECAL detector will operate. In this contribution the upgrade plans and preliminary designs to accommodate the new operational requirements of the CMS ECAL Barrel Safety System are summarized, including the design and development of hardware components for RTD interfacing and the interlock control.

Summary (500 words)

The High Luminosity upgrade of the LHC at CERN will enhance collision capabilities imposing new challenges for its experiments. For ECAL those challenges are: 1) refurbishment of the electronics to cope with a higher luminosity, 2) lower detector thermal configuration to extend the lifetime of the crystals, below the cavern dewpoint, 3) decommissioning of the ECAL endcap regions. As part of the larger upgrade program, the ECAL Barrel Safety System (EBSS) will replace the existing one, necessitating updates such as industrial hardware, linear temperature sensors, and integration with a sniffer system for environmental monitoring.

The EBSS comprises environmental monitoring and an interlock system. The environmental monitoring will be composed of RTDs positioned in pairs across the 4 modules of each Supermodule (SM). With 36 SMs, the environmental monitoring will monitor a total of 288 RTDs. These sensors will be connected through cables exceeding 100 meters in length, to the rack hosting the core parts of the safety system. Protected from the radiation environment, the environmental monitoring and the interlock system will be in the Service Cavern (USC). The new requirements entail updated detector interfaces to transmit signals to the USC, including a 4-wire connection for RTD sensors, totaling 1152 wires. Proper identification and management of cables and sensors are essential. The new safety system will be implemented using the latest generation of Siemens S7-1500 PLC components due to their proven industrial reliability, extensive diagnostic features, and long-term market availability.

This presentation will outline the development and design process of distinct PCBs located at various locations within the cable path, essential for accessing environmental data from the detector. From the sensor's installation in the integration area to the production environment, ensuring the correct cable layout between the experimental cavern (UXC) and the USC is crucial.
The component's connections are prone to errors. To address this, a feature has been introduced to identify cable paths through hardware identification, aiming to streamline commissioning and validate connection correctness.

The interlock system must manage 3 distinct digital signals per SM, for the High Voltage (HV), Low Voltage (LV), and cooling interlocks. With additional lines connected to the CMS Detector Safety System (DSS), the EBSS will be capable of handling approximately 120 digital outputs.

Given the system's complexity, there is a need to eliminate custom hardware and transition from traditional methods to a new paradigm of DI/DOs rack organization, using SIMATIC TOP Connect modules [1]. This type of module simplifies cabling and offers flexibility in connecting and maintaining connections to the mentioned systems.

The described work shows the efforts aimed at facilitating the installation, commissioning, and maintenance of the upcoming ECAL safety infrastructure. Key focuses include upgrading the interlock system, minimizing interconnection issues via rigorous verification processes, and implementing robust sensor interfaces. Integration of redundancy measures across various components ensures uninterrupted functionality and reliability, mitigating potential component failures. These prioritized efforts pave the way for a robust and resilient system aligned with the safety requirements of the next physics period.

[1] SIMATIC Top Connect https://www.siemens.com/global/en/products/automation/systems/system-cabling-simatic-top-connect.html

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