Contribution ID: **13**

Type: **Poster**

On-detector power distribution for CMS-HGCAL: a busbar-based approach

Tuesday 1 October 2024 17:40 (20 minutes)

A new on-detector power distribution scheme for the High Granularity Calorimeter (HGCAL) Phase-2 upgrade of CMS is under development. This scheme is based on a heavy-copper flexible printed circuit board (FPC), allowing for an efficient use of the tight integration space, with minimal insulation overhead, excellent electrical and thermal performance and simplified integration, when compared with a wired solution. This work introduces the technology, how it allows the HGCAL challenges to be overcome, and the characterization studies. Simulations and prototypes testing are presented to validate the concept and quantify the manufacturability, electrical performance, and safety of the proposed solution.

Summary (500 words)

The High Granularity Calorimeter (HGCAL) upgrade of the CMS experiment will replace the existing ECAL and HCAL calorimeter endcaps in the High Luminosity phase of the Large Hadron Collider (HL-LHC). HGCAL is a 47-layer sampling calorimeter, with 620 m2 of silicon sensors in the Electromagnetic section (CE-E) and high-radiation regions of the Hadronic section (CE-H), and 370 m2 of SiPM-on-Scintillating tiles in the low-radiation region of CE-H. The instrumentation of the silicon sensors is performed via ˜27k hexagonal modules, which are equipped with ASICs for data and trigger readout (HGCROC), clock distribution (RAFAEL), data and trigger transmission, and slow control (ECON, lpGBT and VTRX+). Each layer is radially divided in two regions, depending on the radiation level: Low Density (LD) in the outer radius with lower radiation, and High Density (HD) in the inner radius with higher radiation.

Given the demanding power requirements and low operating voltage of the ASICs, a point-of-load regulation at 1.2V is required to ensure that all the devices are correctly supplied, regardless of the sensor activity and throughout the lifetime of the detector. For this reason, custom low-dropout linear regulators have been added to the modules, which are supplied by 1.5V from DCDC mezzanines based on bPOL12V chips. The DCDC mezzanines are mounted directly on the silicon modules in the LD region but, due to the radiation levels, they cannot be placed directly on top of the modules in the HD region and thus need to be connected remotely. In turn, the DCDC mezzanines are supplied by 10V lines from off-detector power supplies.

The power distribution from the periphery of each layer to the input of the DCDC mezzanines, and from their output to the silicon modules in the HD region, need to be performed using service channels that run radially on each layer. The available vertical integration space in the service channel is only 5.1mm and needs to accommodate the power lines, components in the modules, optical fibres, and mezzanine boards. This tight integration space limits the choice of power connectors which, in turn, limits the maximum cross-section of the wires to 0.5mm2 (AWG20). This small cross-section generates differences in the ground level between modules, potentially creating communication issues in the single-ended communication or reliability issues. In addition, the efficient routing of the returns is very complicated, which increases the loop areas with the consequent increased risk of noise coupling and parasitic effects.

In order to reduce the impact of the aforementioned problematics, a new power distribution scheme based on a heavy-copper flexible printed circuit board is proposed. This scheme allows for a better use of the tight integration space, with a cross section equivalent to 4 times the one achievable with wires. Furthermore, the structure inherently tightly couples the supplies and returns, significantly reducing the effects of parasitic coupling on the silicon modules noise and can take the full short-circuit current without potential damage.

This work introduces the concept and details the characterization and validation studies through simulations and prototypes testing.

Primary authors: ANTOSZCZUK, Pablo Daniel (CERN); NOY, Matt (CERN); CAREGARI, Stefano (National Central University (TW)); FIGUEIREDO DE SA SOUSA DE ALMEIDA, Joao Pedro (CERN); SCHMIDT, Ianos (University of Iowa (US)); Mr SANTOS, Miguel (CERN)

Presenter: ANTOSZCZUK, Pablo Daniel (CERN)

Session Classification: Tuesday posters session

Track Classification: Power, Grounding and Shielding