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First Implementation of a Two-Stage DC-DC Conversion Powering Scheme for the CMS Phase-2 Outer Tracker

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A novel, 2-step DC-DC conversion powering scheme will be used for the “2S” silicon strip modules of the HL-LHC CMS tracker. Each module is equipped with a service hybrid, which carries two DC-DC converters along with a LP-GBT and a VTRx+ module. The first DC-DC converter generates 2.5V, required for the optoelectronics, while the second stage converts 2.5V to 1.25V, required for all other ASICs. We will present a service hybrid prototype, describe its performance and demonstrate the feasibility of an on-module, 2-step powering scheme with system tests.

Summary

The challenging conditions at the HL-LHC necessitate a replacement of the CMS Tracker in 2026. The module concept is driven by the requirement that tracker information is to be used in the Level 1 trigger. The dependence of the track bending angle in the magnetic field on the transverse momentum (p_T) is exploited and high transverse momentum tracks are identified by comparing hit patterns in closely spaced sensor layers. So-called p_T modules carry two sensors with a distance of a few millimetres; two strip sensors are used for radii above 60cm (2S modules), while one strip and one macro-pixel sensor are used for smaller radii.

The modules require two supply voltages: about 1.25V for the readout chips (e.g. the CBC), a data concentrator ASIC (CIC) and the low power version of the GBT (LP-GBT), and 2.55V for the VTRx+ module that provides conversion between electrical and optical signals.

In order to reduce the material associated to cabling, and to limit power losses on the supply cables, CMS will adopt a DC-DC conversion powering scheme for its outer tracker. Since each module requires two voltages, a two-step scheme has been chosen. The first stage DC-DC converter receives 11V and converts this to 2.55V, while the second stage DC-DC converter converts 2.55V into 1.25V. Each module carries its two DC-DC converters, which are located on a PCB named “service hybrid”, together with the LP-GBT and the VTRx+. The service hybrid is mounted on one module side for 2S modules, and - split into a power and a readout part - on two module sides for the PS module. The distance to the sensors is only a few millimetres.

A first prototype of the service hybrid has been produced, which carries a FEAST2 DC-DC converter as first stage and a commercial DC-DC converter as second stage, along with a prototype VTRx+ module. A low mass shield made from a 150 μ m thick aluminium foil covers both DC-DC converters. We present first results on using a 2-step DC-DC powering scheme for the CMS tracker, including both standalone characterization in terms of e.g. efficiency and conducted and radiated noise, as well as system tests with 2S module prototypes, using prototypes of the final power supply and realistic cabling. This work demonstrates the feasibility of the chosen concept.

Primary author: KLEIN, Katja (Rheinisch-Westfaelische Tech. Hoch. (DE))

Co-authors: PAULS, Alexander Josef (Rheinisch-Westfaelische Tech. Hoch. (DE)); WANGELIK, Frederik (Rheinisch-Westfaelische Tech. Hoch. (DE)); Prof. FELD, Lutz (RWTH Aachen University); PREUTEN, Marius (Rheinisch-Westfaelische Tech. Hoch. (DE)); LIPINSKI, Martin (Rheinisch-Westfaelische Tech. Hoch. (DE)); RAUCH, Max Philip (Rheinisch-Westfaelische Tech. Hoch. (DE)); WLOCHAL, Michael; GADEK, Tomasz (CERN); KARPINSKI, Waclaw (Rheinisch-Westfaelische Tech. Hoch. (DE))

Presenter: KLEIN, Katja (Rheinisch-Westfaelische Tech. Hoch. (DE))

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