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Power hybrids for silicon modules with macro-pixel and strip sensors for the CMS Phase-2 tracker upgrade

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The upgraded CMS tracker at the HL-LHC will feature new silicon modules with a macro-pixel sensor and a strip sensor on top of each other. The modules require three supply voltages (1.0V, 1.2V, 2.5V), which are provided in a two-stage DC-DC conversion powering scheme. Two DC-DC buck converters are supplied in parallel from the first powering stage. A four-layer flexible power hybrid based on the FEAST2 and bPOL2V5 DC-DC converters by CERN has been developed, using custom air-core inductors and a custom shield. The power hybrid development will be presented and the results from the characterization will be discussed.

Summary

The CMS Collaboration will exchange its silicon strip detector during Long Shutdown 3 of the LHC with a completely new silicon tracker, which will be more radiation tolerant and be able to cope with the increase in instantaneous luminosity. The new tracker will feature modules with two closely spaced silicon sensor that are read out by common readout ASICs. This allows to correlate hits in the two sensor planes in order to estimate on-chip the transverse momentum of charged particles. Only information of tracks with a transverse momentum above a configurable threshold will be forwarded at the bunch crossing frequency to the Level 1 trigger, reducing the data volume to a manageable level. In this way tracking information can be used in the Level 1 trigger of the experiment. One type of these new modules, referred to as PS modules, features a strip sensor and a macro-pixel sensor, with 1.5mm long macro-pixels.

The PS modules require three operating voltages: 2.5V for the VTRx+ opto-electrical converter, 1.2V for the LpGBT ASIC, the VTRx+, the readout chip of the strip sensor, and the analog domain of the readout chip of the macro-pixel sensor, and 1.0V for the digital domain of the macro-pixel readout chip. This is realized in a two-step DC-DC conversion powering scheme, using DC-DC buck converters. DC-DC conversion allows us to reduce the current on the long supply cables and thus to reduce voltage drops and Ohmic losses on these cables. The first DC-DC conversion stage will be implemented with the CERN bPOL12V ASIC, receiving about 10V at the input and providing 2.5V for the VTRx+ and the second stage. The CERN bPOL2V5 ASIC will be used in the second stage, with two bPOL2V5 connected in parallel to the first stage. The three DC-DC converters are located on a flex PCB, the Power Hybrid, which sits on the edge of the PS module, very close to the sensors. The Power Hybrid connects via flexible pigtails to the two readout hybrids of the module.

Prototype Power Hybrids have been developed and produced. The FEAST2 ASIC is used in place of the bPOL12V in the first stage, since the bPOL12V was not yet available at the time of the development. For the second stage, though, close-to-final prototypes of the bPOL2V5 are used. The PCBs are flex boards with four copper layers. The bPOL2V5 is assembled in flip-chip technology, featuring a bump-bond pitch of 300µm. The boards have been tested and characterized. We will report on the development and the test results, including dynamic behavior as a function of load, efficiency, line and load regulation, voltage drops, the inductor and shield development, as well as conducted and radiated noise emissions.

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