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The DC-DC Conversion Power System of the CMS Phase-1 Pixel Upgrade

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The CMS Phase-1 Pixel detector, to be installed in the year-end technical stop 2016/17, will feature a power system based on DC-DC conversion. The power system, including the final DC-DC converters based on the FEAST2 ASIC by CERN, DC-DC main boards, power distribution PCBs, power supplies and thermal management, will be described, and the performance of the components will be discussed. The results of a system test, in which the complete power chain with final components is used to power CMS upgrade pixel modules, will be presented.

Summary

The CMS collaboration foresees an exchange of its pixel detector in the extended winter shutdown 2016/2017. The new pixel detector will have one more detection layer, leading to almost twice the number of electronics channels. Powering this future detector is a challenge. The power that would be lost on the 50m long supply cables would exceed the power actually required by the detector, and the total power would surpass the capability of the power supplies. Also the heat load in the existing cable channels is a concern. The pixel detector will therefore be powered with the DC-DC conversion technique, in which the power is delivered at a higher voltage – and thus with lower current – to the detector, and locally converted into the voltage required by the electronics. In our case, DC-DC converters provide a conversion ratio of 3-4, reducing cable losses by a factor of about ten.

Our DC-DC converters are based on the FEAST2 ASIC by CERN. They will be installed on the service structures, at distances between 0.5m and 2m from the pixel modules, and outside the sensitive volume of the tracker. About 1200 DC-DC converters will be installed in total. One DC-DC converter powers between one and four pixel modules.

The converter concept has been optimized for the conditions in the CMS pixel detector. For example, very tight space constraints required a challenging shape of the converter envelope, and thermal management must take into account that the converters will be cooled through a CO2 cooling system. Voltage drops between the DC-DC converters and the pixel modules must be limited for all load conditions. The remote control of the DC-DC converters had to be integrated into the existing control architecture of the pixel detector.

The concept of the pixel power system is fully worked out and most components exist in their final version. The concept will be described and the performance of the components be presented, including the DC-DC converters, the bus board for the DC-DC converters, PCBs for further power distribution to the detector modules and for the remote control of DC-DC converters, and the power supplies. Mass production has started with a pre-series of 200 DC-DC converters, and will continue until early next year. Results of the quality control, including active thermal cycling, of a significant number of DC-DC converters will be available at the time of the conference, and will be summarized.

System tests will be presented in which the complete system is used to power the new, digital pixel modules. In these tests 26 DC-DC converters are powered from one bus board under full load, using the final power supply, cooling concept and cabling to the pixel module. This allows studying transient behaviour and failure modes with a realistic fraction of the system. This is also interesting in view of a potential use of DC-DC converters in the CMS Outer Tracker at Phase-2.

Primary author: Dr KLEIN, Katja (RWTH Aachen)

Presenter: Dr KLEIN, Katja (RWTH Aachen)

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