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Experience from design, prototyping and production of a DC-DC conversion powering scheme for the CMS Phase-1 Pixel Upgrade

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The CMS pixel detector will be exchanged during the technical stop 2016/2017. To allow the new pixel detector to be powered with the legacy cable plant and power supplies, a novel powering scheme based on DC-DC conversion is employed.
After the successful conclusion of an extensive development and prototyping phase, mass production of 1800 DC-DC converters and power-related PCBs has started and will be finalized in September 2015.
This contribution will summarize the lessons learned from the development of the power system for the Phase-1 pixel detector, and summarize the experience from the production phase.

Summary

The CMS pixel detector will be exchanged during the technical stop 2016/2017. The new device will be improved in many respects: better hit efficiency under the hit rates expected during LHC run 2 is achieved with a new readout chip; a new CO2 cooling system and an ultra-light mechanical design lead to a reduction of the material budget inside the active volume; and the movement of the innermost detection layer closer to the interaction point plus the installation of additional detection layers will improve the physics performance.

With the addition of one barrel layer and one disk per endcap, with the pixel size kept the same, the number of readout channels is roughly doubled. Consequently the power consumption is doubled as well. To allow the new pixel detector to be powered with the legacy cable plant and power supplies, a novel powering scheme based on DC-DC conversion is employed. These DC-DC buck converters receive 10V and generate the required low voltages for the readout chips (2.4V and 3.3V). They will be installed on the outside and inside of the pixel support structures, 1-2m away from the actual pixel modules, at a pseudo-rapidity of about 4, i.e. outside the tracking volume. In total 1200 DC-DC converters will be installed into the pixel detector.

The usage of DC-DC converters has required a complete redesign of the power system, including new DC-DC converter motherboards, low voltage and high voltage distribution boards, remote control of DC-DC converters and a modification of the power supplies.

A long and extensive period of development and prototyping has now concluded and the project has entered the production phase. The lessons learned, in particular regarding system aspects, will be summarized. The difficult control of voltage drops due to lack of remote sensing in a scheme where the DC-DC converters are located at a certain distance from the load is one example.

Mass production of 1800 DC-DC converters, as well as 40 DC-DC converter motherboards and similar numbers of voltage distribution boards, is ongoing, and will have to be concluded in September 2015. This contribution will report on the experience from the production of the various power components, but in particular the DC-DC converters themselves. Quality control includes optical and X-ray inspection, electrical testing, and thermal cycling under load. Test results based on a large sample of devices allow to judge the spread in important performance parameters. Production issues that are of general interest will be described and a fault analysis will be presented.

The sharing of the experience from the development and implementation of a DC-DC conversion powering system, and from the mass production of the components, can be useful for future projects, where a DC-DC

conversion powering scheme is under discussion and a production of DC-DC converters on a similar or even larger scale will be required.

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