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DC-DC Conversion Powering Schemes for the CMS Tracker at Super-LHC

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With conventional powering the increasing power requirements of the CMS tracker at Super-LHC cannot be met using the existing power supplies and/or cable plant. Therefore a novel powering scheme based on parallel powering with DC-DC conversion is foreseen for the CMS pixel detector at SLHC phase-1, and for the CMS outer tracker at SLHC phase-2.
We will present electrical studies (efficiency, EMC) and system test measurements with strip modules, using DC-DC buck converters with either custom radiation-hard converter ASICs or with commercial ASICs. Low-mass air-core inductors have been developed, and various filters methods have been compared. The presentation will include studies of the noise coupling mechanism and the detector susceptibility. Finally the implementation of DC-DC converters into the future pixel detector and outer tracker will be discussed.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

The upgrade of the CMS silicon tracker for the Super-LHC presents many challenges. The distribution of power to the tracker is considered particularly difficult, as the tracker power consumption is expected to be similar to or higher than today, while the operating voltage will decrease and power cables cannot be exchanged or added. The CMS tracker has adopted parallel powering with DC-DC conversion as the baseline solution to the powering problem. In this talk, experimental studies of such a DC-DC conversion powering scheme are presented, including system test measurements with custom DC-DC converters and current strip tracker structures, studies of the detector susceptibility to conductive noise, and simulations of the effect of novel powering schemes on the strip tracker material budget.

The buck converter is the simplest inductor-based stepdown converter. With relatively few components and the ability to deliver currents of several Amperes at efficiencies of 70-80 %, even for high conversion ratios, this DC-DC converter type is currently the best candidate for use in the CMS tracker. However, several challenges exist on the system level and must be adressed: switching with frequencies in the MHz range might inject conductive noise into the detector system; air-core inductors, needed because of saturation of ferrite cores in the 3.8 T magnetic field of CMS, might radiate electro-magnetic noise; the converter's size and mass must be reduced as much as possible, without degrading its electrical performance. A low efficiency would cancel out the advantages of DC-DC conversion.

DC-DC buck converters based on a commercial, not radiation-hard chip, and small, light-weight air-core toroids have been developed. The noise performance has been studied extensively in system tests. In combination with pi-filters, which lead to an efficiency loss below 1% , the boards can be operated across the whole allowed input voltage range without adding extra noise to the test system. The material budget of the AC2 converters amounts to 10% of the material of a current strip module. Due to savings in cables and motherboards, about 8% of material could be saved by using such converters (for an efficiency of 80% and a conversion ratio of eight). Plans exist to use buck converters for the pixel detector already in phase-1 and in the outer tracker during phase-2. These studies will therefore be continued using custom radiation-hard converter ASICs.

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