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DC-DC switching converter based power distribution vs Serial power distribution: EMC strategies for SLHC tracker up-grade

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This paper presents a detailed and comparative analysis from the electromagnetic compatibility point of view of the proposed power distributions for the SLHC tracker up-grade. The main idea is to identify and quantify the noise sources, noise distribution at the system level and the sensitive areas in the front-end electronics corresponding to both proposed topologies: The DC-DC converter based power distribution and the serial power distribution. These studies will be used to define critical points on both systems to be studied and prototyped to ensure the correct integration of the system taking critically into account the electromagnetic compatibility. This analysis at the system level is crucial to ensure the final performance of the detector using non conventional power distributions and to avoid interference problems and excessive losses that can lead to failures or expensive unpractical solutions.

Summary

The up-grade for the tracker sub-system in both CMS and Atlas detectors are based in a front-end electronic (FEE) circuitry that requires ultra-low voltages to power-up the integrated circuits. This constraint forces to define new schemes of DC power distribution to bias efficiently the tracker front-end electronics, reducing the volume of the power conductors. The proposed power distribution schemes can be grouped into: Serial Power Distribution System and DC-DC switching converter based Power Distribution System. Both schemes are not conventional and have advantages and disadvantages.
The high magnetic field in the central detector forces to use DC-DC power converters without magnetic material as kernel for the DC-DC switching converter based Power Distribution System. A large R&D effort is planned to develop unique DC-DC switching converters to operate under high magnetic field and particle radiation with minimum radiated and conducted noise emissions. The constraint imposed by the no-magnetic material design sets the conductive and radiated noise levels to a minimum that is higher than that achieved in conventional switching converters. Additionally, in this power distribution scheme, DC-DC converters will be located near the FEE, within the tracker volume, increasing the coupling for interference between the power converter and the detector and its front-end electronics.
Serial power distribution system has been already used in other small subsystems and experiments. This topology is mainly characterized by floating the Detector-FEE. This requirement forces special design to keep balanced the high frequency connections to ground. For that purpose special effort should be focused on the integral design of the FEE, detector and distribution systems to minimize the effect of parasitic elements that have critical impact in the system performance. Additionally, in order to increase the efficiency, the serial power distribution plans to use as a primary power supply DC-DC converters that may increase the total interference of the system due to the conducted output noise emitted.
Those scenarios force to conduct electromagnetic compatibility studies on the proposed systems to be able to improve the noise immunity of the front-end electronics to assess compatibility with the noise generated by the power supply system. CMS tracker power task force has recommended that the baseline powering system for an upgraded CMS Tracking system should be based on distributed DC-DC power conversion, with Serial Powering as a back-up solution, whereas ATLAS upgrade has no decision yet. In any case, electromagnetic compatibility between components in both the DC-DC switching converters based Power Distribution and the Serial Power Distribution topologies can be only achieved minimizing both the radiated and conducted noise emitted by the main noise sources and increasing the immunity to noise of the FEE by a robust design.
This paper analyses the main elements that defines the electromagnetic compatibility of both power distribution systems and defines the impact of the system design and integration strategies in the compatibility of FEE. The main aspects (noise sources and FEE immunity) that define the electromagnetic compatibility of both topologies are presented. The integration aspects have strong impact in the system compatibility. However, if an EMC strategy is implemented at an early stage of the design, the compatibility between both FEE and proposed DC power distributions may be achieved.

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