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Radiated Electromagnetic Emissions of DC-DC Converters - Measurements and Simulations

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A new powering scheme is considered to be mandatory for the CMS tracker at SLHC. The baseline solution of CMS foresees the use of DC-DC converters, allowing to provide larger currents while reducing losses. An important component of most converters are inductors, which, however, tend to radiate the switching noise generated by the converter. The radiated emissions of several converters have been measured and simulated. In addition noise susceptibility measurements with radiated noise and present CMS hardware have been performed. A summary of the results will be presented.

Summary

The so-called 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 addressed. In particular, switching with frequencies in the MHz range might inject conducted noise into the detector system while air-core inductors, needed because of saturation of ferrite cores in the 3.8 T magnetic field of CMS, might radiate electromagnetic noise.

While conducted noise can be removed almost completely by passive low-pass filters, controlling radiated noise is more difficult, making it very important to have a solid understanding of the propagation paths of the radiated noise. To be able to minimize this noise by optimizing the inductor layout, the spacial distribution of the radiated emissions has been measured and simulated. The measurements have been recorded on a XYZ table that had been equipped with magnetic and electric field probes. The simulation of several different types of inductors has been performed with the finite element software COMSOL Multiphysics. With regard to toroidal inductors, one result from this work was the exposure of a multi-polar shaped magnetic field, which is most likely a superposition of the field of a perfect toroid with the field of
a single wire loop, formed by the first and last half-turn.

A XYZ table was also used in combination with present CMS tracker modules and electric/magnetic injection probes, allowing automated, high-resolution, position-depend susceptibility measurements.

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