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Characterization of the noise properties of DC to DC converters for the sLHC

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The upgrade of the LHC experiments sets new challenges for the powering of the detectors. One of the powering schemes under study is based on buck converters mounted on the front-end modules. The switching noise emitted by these converters is susceptible to affect the performance of the powered systems. A model to identify and to control the noise sources of the converter was developed. A reference test setup with associated measurement methods is used to characterize the noise properties of the converter. Complementary tools and simulations were also used to evaluate the noise couplings at system level.

Summary

1. Introduction.

The experiments at the sLHC will be more demanding in terms of power and cabling than at the LHC, in particular for the trackers. The cabling constrains of the detectors, together with the thermal management and the overall power efficiency force the development of new radiation hard and magnetic field tolerant powering. One of the proposed powering schemes is based on an air core buck converter to be mounted on the front end modules of the trackers. The switching converter and its air core inductor will sit in the close vicinity of the front-end detectors and electronics. In order to achieve the appropriate noise performance of the front-end system, the noise properties of the converter need to be characterized and the way in which the noise interacts with the front-end electronics needs to be understood.

1. Modeling of the EMC properties.

The switched converter produces its noise in the form of common mode currents that are developed at the board level through stray capacitances at critical nodes. These nodes are identified and the magnitudes of the stray capacitances are estimated. The noise currents produced at these nodes depend strongly on the topology of the converter. Similarly, the air core inductor produces some leakage magnetic field in its vicinity, which can cause some near field inductive coupling to the front-end system. The magnitude of the coupling depends on the inductor topology and on the properties of the current that flows through it. With this, it is possible to determine the minimal distance between the inductor and the sensitive front-end areas.

1. Test setup.

The sample prototypes of the radiation hard converter need to be characterized in a standard manner that allows for objective comparisons of the noise properties. For this, a reference test setup is used. The test bench is built around line impedance stabilization networks (LISN) that normalize the common mode impedances over the entire noise frequency range. The noise currents are measured using calibrated current probes and a spectrum analyzer. The test setup is complemented with qualitative evaluation tools. Near field probes are used to identify hot spots of EMI sources on the samples. A near field scanning table is also used to produce a two dimensional image of the near field EMI emission of the sample boards.

1. Measurements.

Several samples of converters were modeled and measured on the reference test setup. The obtained results allowed identifying the topological aspects of the converters that could be implemented in the design of a custom, radiation hard and magnetic field tolerance buck converter for the trackers at the sLHC.

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