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Low Noise DC to DC Converters for the sLHC Experiments

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The development of front-end systems for the ATLAS tracker at the sLHC is now in progress and the availability of radiation tolerant buck converter ASICs enables the implementation of DC to DC converter based powering schemes. The front-end systems powered in this manner will be exposed to the radiated and conducted noise emitted by the converters. The electromagnetic compatibility between DC to DC converters and ATLAS short strip tracker hybrid prototypes has been studied with specific susceptibility tests. Different DC to DC converter prototypes have been designed following a noise optimization methodology to match the noise requirements of these front-end systems. The DC to DC converter developed in this manner presents a negligible emission of noise that was confirmed by system tests on an ATLAS tracker front-end module prototype. As a result of this, power converters can now be integrated in close vicinity of front-end chips without compromising their overall noise performance.

Summary

The introduction of DC to DC converters on front-end systems provides an efficient solution to deliver the increasing demand of power. However the switching properties of the converters results in the emission of conducted and radiated noise that, in combination with the susceptibility of the front-end system, can result in an increase of the overall noise seen by the system.

The electromagnetic compatibility between DC to DC converters prototypes and front-end systems has been explored on the ATLAS short strip tracker hybrid prototypes. Tests performed in the past showed the compatibility between the hybrids and the DC to DC converters when those were placed at distances greater than 20mm; a closer integration requires however a better mitigation of the noise emitted by the converters and whenever possible the reduction of the system susceptibility. With this in mind, the noise susceptibility of the hybrid was explored in more detail by means of frequency scans using near field probes that provided important information about the susceptibility to electric fields, to magnetic fields and to conducted noise currents as a function of frequency. These properties allowed setting the noise constrains for the new generation of DC to DC converter prototypes.

The reduction of the magnetic field was achieved with the DC to DC board layout optimization, based on electromagnetic simulations and modeling. To reduce the emission of magnetic field, the connector and ASIC pin assignments were carefully chosen, resulting in an optimal layout. A shield enclosure that covers the identified noise spots is also introduced to confine the emission of electric field; this shield contributes to a further attenuation of the magnetic field. Input and output filters were carefully located across the shield boundary. This optimized board resulted in very compact plug-in module implementation that can be easily integrated onto systems. This implementation also provides a thermal interface that enables the cooling of the converter.

Two plug-in module DC to DC prototypes that used the AMIS2 radiation tolerant buck converter ASIC were laid out following the described methodology. The plug-in module delivers 2.5V up to 3.5A from an input bus voltage of 10V. The switching frequency was raised up to 3 MHz, reducing in this way the amplitude and the amount of harmonic peaks in the frequency band of the hybrids susceptibility that was previously identified. The conducted noise and the radiated fields were measured on the reference test stand to enable their comparison with previous designs. A noise reduction of more than 30 dB has been achieved with respect to the most performing former design, and common mode and differential mode noise currents of less than -10 dBμA have been measured. The magnitude of the radiated fields was also measured to evaluate the effectiveness of the shield. This outstanding performance was confirmed through system tests on the ATLAS hybrids, with a noise increase of less than 10% in the data when two converters are placed at distances of less than 10 mm of the front-end ASIC bondings.

The developed design methodology allows integrating very low noise DC to DC converters in the close vicinity of sensitive front-end circuits without compromising anymore the system performance.

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