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Design of a New Front-End Switching Power Supply

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We present the design of an upgraded switching power supply for the front-end electronics of the ATLAS Hadron Tile Calorimeter. The new design features significant improvement in noise, improved fault detection, and improved reliability, while retaining the compact size, water-cooling, output control, and monitoring features. We discuss the steps taken to improve the design. We present the results from extensive radiation testing to qualify the design, including SEU sensitivity. We also present our reliability analysis. Production of 2400 new bricks for the detector is in progress, and we present preliminary results from the production checkout.

Summary

We have designed a new switching power supply for use in the front-end electronics of the Atlas Tile Calorimeter at CERN. This is a drop-in replacement for the previous version. A supply consists of eight different bricks, which together provide power to the front-end electronics in a section of the Tile Calorimeter detector called a drawer. The different bricks all use the same topology and basic design, but each type is configured specially for the particular load that it services. There are 256 drawers in the detector, or a total of 2048 bricks on the detector.

The basic topology of the brick is a transformer-coupled buck converter. Each brick receives 200 VDC at low current, and converts it using switching techniques to low voltage at moderate currents.
There are several aspects of this project that are significant. Since the supplies reside on the detector, they must be capable of operation in a magnetic field. The use of switching supplies for analog front-end electronics that processes low-level signals poses a challenge to keep the conducted and radiated noise low. The bricks switch at 300 KHz, and produce harmonics through the entire spectral range of interest in the front-end electronics. Because the supplies reside on the detector itself, they will be exposed to radiation. Also, the compact size of the box and the fact that it is closed represents a challenge in cooling. Lastly, access to the detector is very difficult. There may be only one opportunity per year to perform maintenance and repair operations on the detector. This means that we require very high reliability for the overall design. The power system does not have redundancy, which makes reliability important, since the power supplies represent a single-point failure for a drawer in the readout system.

The power supplies currently on the detector were produced in 2007, and have been operating since then. The goals in the redesign project were to improve noise performance, reliability, and tolerance to single-event upset (SEU), while retaining the physical layout, interface to the detector control system (DCS), and other infrastructure. In particular, the current supplies exhibit spontaneous tripping as a function of luminosity, which has been addressed in the new design. We have built and tested a new design, and are currently in production. We have already installed 45 pre-production boxes on the detector. The remaining 211 supplies will be installed during the 2013 shutdown. We have performed extensive testing on our new supplies, including noise studies, extensive radiation tests, and long-term monitoring. The SEU results are particularly interesting, as we measured an energy threshold, and have implemented a fix to prevent if from happening. We have also performed a detailed reliability study to try to predict how our new design will perform. We will describe the design in detail, present the results of our measurements, and describe our plans for staging the production of 2400 new bricks.

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