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Reliability of Power Conversion Card for CMS MTD-BTL

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The Minimum Ionizing Particle (MIP) Timing Detector (MTD) is introduced in the CMS experiment to measure the time of MIPs. The MTD consists of 432 Readout Units (RUs) in its barrel region (BTL), each powered by two Power Conversion Cards (PCC). PCCs host three radiation and magnetic field tolerant DC-DC converters. More than 1,000 PCCs will be produced to satisfy the assembly needs of BTL with sufficient margins. A reliability study has been conducted on a prototype batch of 80 cards to demonstrate the design and assembly robustness for up to 20 years of operation in BTL's conditions.

Summary (500 words)

The High Luminosity Large Hadron Collider (HL-LHC) will deliver up to 200 proton-proton interactions per bunch crossing. Interaction points are spread out over a period of ˜190 ps. With an initial timing resolution of 30-40 ps, the new Minimum Ionizing Particle (MIP) Timing Detector (MTD) will measure the time of MIPs, improving identification and event reconstruction capabilities of the CMS experiment in the increased pile-up conditions. The functional building block of MTD's Barrel Timing Layer (BTL), called Readout Unit (RU), is powered by two Power Conversion Cards (PCC). Design of BTL utilizes 864 PCCs and production plans reach 1,100 units.

The PCCs will operate in a static magnetic field of 3.8 T, while being cooled with liquid CO2 at -35°C. Estimated radiation levels reach a fluence of 1.90×1014 neq/cm2 and a total dose of ˜32kGy. Being a single layer sub-detector, BTL requires high reliability of its components. The reliability goal for PCCs allows for 0.5% failures in 20 years of operation. The forecasted mission profile of the detector assumes at maximum 10 thermal cycles per year of operation including warm runs at +10°C.

A set of 80 PCCs has been produced and tested with a yield of 92.5%. Among defected cards, three had minor and non-critical defects that were easily repairable, one card had a critical failure that was repairable, and two had critical defects with unidentified root causes. All cards underwent 20 passive thermal cycles between -35°C and +75°C and were re-tested yielding identical results. A reliability demonstration test has been performed on 96 DC-DC converters (32 cards) with a 95% confidence level. The test lasted for 1245 thermal cycles with specimen range of temperatures between -30°C and +83°C. The cards have been stressed and monitored under different load and powering conditions according to the Design of Experiment principles.

The design of PCC has matured to a production ready state, offering a compact and reliable DC-DC converter solution for high energy physics. 80 cards were produced and assembled according to the production stage design. In this contribution the reliability demonstration test results will be presented together with the plans for the environmental stress screening procedure envisaged for the full-scale production phase of the project.

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