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Radiation-Hard Power Electronics for the ATLAS New Small Wheel

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The New Small Wheel (NSW) is an upgrade for enhanced triggering and reconstruction of muons in the ATLAS forward region. The large LV power demands of the NSW necessitate a point-of-load architecture with on-detector power conversion. The radiation load and magnetic field of this environment, while significant, are nevertheless still in the range where commercial-off-the-shelf power devices may suffice.

We present studies on the radiation-hardness and magnetic-field tolerance of several candidate buck converters and linear regulators. Device survival and performance are characterized when exposed to gamma radiation, neutrons, protons and magnetic fields.

Summary

Studies conducted in collaboration by the University of Michigan and Istituto Nazionale di Fisica Nucleare aim to identify commercial power electronics which will tolerate the demanding environmental conditions of the ATLAS New Small Wheel (NSW). Over its design lifetime, the NSW will accumulate as much as 1700 Gy total ionizing dose and be subject to a non-ionizing fluence which can approach 3* 10ˆ14 1-MeV equivalent neutrons/cm2. It must operate in a magnetic field ranging from 3-5 kiloGauss.

A collection of candidate buck converters and linear regulators have been tested for their ability to survive these conditions. Devices were exposed to 4000 Gy using the 60Co source housed at Brookhaven National Laboratory. A similar source, available in the ENEA Casaccia research centre close to Rome, was used to expose devices at a very low dose rate, between 5 and 10 Gy/h. Separate samples were irradiated to a neutron fluence of 5*10ˆ14 1 MeV-equivalent neutrons/cm2 using the Fast Neutron Irradiation Facility at the University of Massachusettes Lowell. Other samples were irradiated at the fast neutron reactor TAPIRO, in the ENEA Casaccia centre. Finally, tests in 230MeV protons were conducted to a total fluence of* 410ˆ11 protons/cmˆ2 at the CDH Proton Center. All irradiations were conducted on active devices with automated monitoring.

We quantify the performance of candidate devices under varying load conditions using a suite of benchtop measurements. Buck converters are characterized by ripple, load regulation, radiated noise, and conducted noise. Linear regulators are tested for line and load regulation, dropout, and ripple rejection. We report the changes observed in these parameters for devices operating in magnetic fields as well as for the devices that survive the above irradiations.

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