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Results of the Powerboard for ATLAS ITk Strip Barrel Modules

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The Inner Tracker silicon strip detector (ITk Strips) a part of the ATLAS upgrade for the HL-LHC. It employs a parallel powering scheme for the bias high voltage and the low voltage power. To reduce the amount of services, on-module DCDC conversion and high voltage switching is required. These features are implemented on the Powerboard using a step-down buck converter (bPOL12V) to drop the low voltage, a GaN FET for the HV switch and a custom ASIC (AMAC) for control and monitoring. This contribution will present the design, initial test results and plans for the production of O(10,000) Powerboards.

Summary

The ATLAS upgrade for the HL-LHC contains a new silicon tracker called the Inner Tracker (ITk). The ITk Strip detector is a subset of the ITk with striped silicon sensors. It will employ a powering scheme where a single power supply provides power to several modules in parallel. This includes both the high voltage to bias the sensor and the low voltage to power the on-module electronics. The low voltage is supplied to the supporting stave structure using an external 10-11V. The power of a single module will be managed using a custom electronics board called the Powerboard. The Powerboard has four main functionalities; employ a rad-hard switching DCDC regulator (bPOL12V) to step the low voltage from 11V down to 1.5V for local power, monitor the low and high voltage currents directly on a module, disable power in case of module failure and monitor the local temperature. The last three tasks are accomplished using a custom ASIC called the Autonomous Monitor And Control (AMAC) chip. The AMAC is powered using a rad-hard linear regulator (linPOL12V).

The pre-production version of the Powerboard aimed at barrel modules has been designed. Prototypes were used to demonstrate that the design meets the desired specifications.

All functionality was tested with the Powerboard being irradiated using x-rays past 66 Mrad, corresponding to the expected lifetime dose (plus safety margin). The bPOL12V ASIC provided a stable 1.5V output voltage at 2 Amps current load above the desired 70% efficiency. This meets the requirements from the expected maximum life-time load from the front-end chips. The high voltage switch remained closed throughout the irradiation with 500V applied. The monitoring functionality provided correct measurements, with the help of in-situ calibration procedures. The only unexplained result was the steady rise of the linPOL12V output voltage.

The Powerboard has also been operated as a part of complete ITk Strip modules. The only issue observed was an increase in noise hits on strips localized underneath bPOL12V circuit. Even in spite of a 100 μm thick metal shield box surrounding the air-core solenoid coil used as the main inductor. Its impact has been reduced through layout optimizations guided by multiple measurements.

To meet the construction schedule, the scaling up of the production to ˜10,000 Powerboards required for the barre of the ITk Strip upgrade has begun. To maintain high reliability, a stringent quality assurance (QA) and control (QC) plan has been developed. The QA involves a comprehensive stress testing of a random sampling from each batch. The QC will be done on every board at an industrial partner responsible for both the assembly and final testing. After standard manufacturing controls, a full electrical test and burn-in is performed. A custom system consisting of a passive carrier board containing multiple Powerboards that can be connected to an active board for testing. The active board contains the necessary circuits to test AMAC communication, monitor low and high voltage power outputs, measure the bPOL12V efficiency at varying loads and detect any EMI outside of the shield box.

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