The ITk Strips Powerboard (v2) for the ATLAS Barrel

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Introduction

The upgrade of the ATLAS silicon strip detector, the Inner Tracker (ITk) Strip detector (ITk), for the HL-LHC 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 slave electronics by an external 10-11V. The power of a single module will be managed using a custom electronics board called the Powerboard.

The Powerboard v2 has four main functionalities:

- las FEAST[2,3] to step down voltage from 15V to 1.8V for the on-module power in,
- moni 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.

This poster will contain the design of the second version (prototype) of the Powerboard aimed at barrel modules, initial results of the monitoring functionality and summarize the plans for scaling up the production of the full ~10,000 Powerboards required for the ITk 5th upgrade.

Shield Box

A tin-coated aluminium shield box is soldered with a continuous seam to the Powerboard to block the noise induced by the coil.

Shield box performance can be tested by measuring the noise on a coil placed below the Powerboard (above).

HVMux and Voltage Multiplier

The Powerboard contains a red-hard GaN FET that acts as a switch for the sensor high voltage bias (HVMux). It is rated at 500V, plus a safety margin. The gate voltage for changing the FET to ON state is higher than the AMAC output. Instead, the AMAC outputs a clock signal with a tunable 0-100 kHz frequency and a 3V amplitude. It is fed into quad voltage multiplier circuit.

Mass Testing Plans

The Powerboard V3 (production) will be tested in the industry. A prototype of the mass test system is being designed for the Powerboard v2.

The goal is to have a carrier card for ~30 Powerboards that can handle:

- Wirebonding
- Holes connecting to a vacuum system placed underneath bonding pads

Electrical Tests

- The (passive) carrier card will be connected to an active card
- MicroEd Zynq (FPGA+SoC) board used for control
- Active card contains ADCs for off-module voltages and a variable load for LV

Transport

- 3D printed bar presses down on the Powerboards for long term attachment
- Allows module building sites to test the PB after transport

An custom variable load is being designed to test the DCDC converter efficiency at currents in the range from ~10 mA to 4 A. It will be easily reconfigurable.

ITk Strips Module

The ITk Strips module[2] consists of a silicon sensor, two PCBs containing the readout electronics (aka ‘hybrid’) and a Powerboard in the middle.

DCDC Converter

The FEAST[2,3] is a red-hard switching DCDC regulator developed by CERN. It is responsible for converting the 15V low voltage input to 1.8V required by the on-module electronics. It uses a solid-state air coil designed at Yale.

The efficiency of the DCDC converter is around 70% at the expected 2A load current.

Autonomous Monitor and Control

The functionality is controlled using the Autonomous Monitor and Control (AMACv2) ASIC provided by University of Pennsylvania.

The Control Tasks

- Binary signal to enable LV output
- Clock signal to charge a voltage multiplier for HVMux enable signal

The Monitoring Tasks

- Input and output LV levels
- LV output current
- HV Leakage current
- sPOL12V AMAC and PB Temperatures
- sPOL12V status (POGOOD)
- AMAC input voltage and internal LDO
- Internal bandgap reference voltage

The AMAC contains interlock functionality to disable power output if any of the monitoring channels that exceed a programmable threshold.

Communication with the AMACv2 is accomplished using PC.

Towards Powerboard V3

The next version of the Powerboard is being designed. It will act as a basis for the production version. The main changes are:

- Support for updated version of the chips (AMACv2, sPOL12V)
- Red-hard LDO for the AMAC (sPOL12V)
- Shin functionality for adjacent modules
- Current measurement circuit moved into AMAC
- Improved input (Powers) and output current shorts
- Control and calibration signals to hybrid chip LDOs
- New coil design

https://gitlab.com/itmphysics/powerboard_v3

References: