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Adaptive power supply for the gain stabilization of SiPM

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The gain of SiPMs depends both on bias voltage and on temperature. We can compensate the temperature variation by regulating the bias voltage. We have developed and built an adaptive bias voltage regulator and performed tests in a climate chamber at CERN. Over a temperature range 1 −40 degrees C we have tested the performance of the bias voltage regulator with five SiPMs / MPPCs from three different manufacturers. We demonstrate that we achieve a gain stability of less than 1% for temperatures between 20-30 degrees C as anticipated.

Summary

As part of the AIDA framework, the University of Bergen (UiB) and the Institute of Physics in Prague (FZU) are studying options for implementing an adaptive power supply. When the temperature changes, the power supply is supposed to adjust V bias to keep the gain constant. Taking into account uncertainties on the temperature measurement and power supply accuracy, the goal consists of keeping G constant within 1% over a temperature range of $\Delta T \pm 5$ ℃ at a nominal temperature of 25 ℃.
We have obtained several different SiPMs from three manufacturers: CPTA, Hamamatsu and KETEK. We utilize the default T3B calibration procedure to extract the single photo-electron spectra of SiPMs. DAQ includes preamplifier and 1.25Gsps digital oscilloscope (picoscope) [1], which was set to acquire 50,000 events per run. The algorithms identify the signal of a single photo-electron and they are subsequently capable of decomposing any SiPM signal into the cumulative signal of single photo-electrons [2]. All measurements were performed in a temperature range of 10 to 30℃. The results recalculated to individual dV/dT of each SiPM were used to design and build an adaptive bias voltage regulator test board. After completion, we measured a subset of four SiPMs/MPPCs again in an extended temperature range of 1 to 40℃ consisting of Hamamatsu #11759, CPTA #857 and #1677 and KETEK #W12. With these the performed tests of the gain stabilization with the bias voltage regulator test board.

The bias voltage regulator test board was designed in summer 2013 satisfying the following requirements.

- Provide stable regulated output DC voltage from 15 V to 90 V.
- Achieve a stability better than 5 mV and keep the temperature influence to less than 1mV/℃ (100 ppm/℃).
- Trim the signal with a slope of 10 to 100 mV/℃.
- Provide a soft start/stop.
- Have an ON/OFF ability.
- Provide analog settings with later possibility to implement digital settings with DAC.

The power portion of the HV regulator uses two HV MOSFETs in a totem pole configuration. In the control portion, the output voltage is divided by ten using precision resistors and attached to the feedback input of an error amplifier. The reference input of the amplifier is connected to a multi-turn potentiometer which is connected to a precision voltage reference LT1021-10. The voltage reference is trimmed to 10.000 V corresponds to 100 V at the output of the regulator. Multi-turn potentiometer sets output voltage in range 15V to 100 V. The error amplifier drives the gate of the lower MOSFET. Loop stability is achieved by means of a third order compensation network. Temperature sensor LM35D (Texas instruments) placed close to SiPM under the test provides a signal 10mV/℃ for the correction of the output voltage.

[1] Official PicoTech homepage: http://www.picotech.com/
[2] C. Soldner. The Time Development of Hadronic Showers and the T3B Experiment. Ph.D thesis, Ludwig Maximilian Universitat München, 2013.

Author: POLAK, Ivo (Acad. of Sciences of the Czech Rep. (CZ))

Presenter: POLAK, Ivo (Acad. of Sciences of the Czech Rep. (CZ))

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