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Front End Electronics for SiPM Readout in the Mu2e CRV Detector

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The Mu2e experiment requires a very high efficiency (99.99%) Cosmic Ray Veto to reject events that mimic signals. The CRV covers an area of 323 sq. m and consists of 4 layers of extruded scintillator with WLS fiber readout and using SiPMs. To meet the strict requirements while maintaining a low cost, we designed new front end electronics that is simple, relatively inexpensive in small quantities and has very good performance. There are approximately 300 front end boards in the CRV system, each with 64 channels. This may be of interest to many groups using SiPMs.

Summary

The front-end readout board supplies the necessary SiPM bias voltages, reads out the SiPM signals, controls the LED flasher, reads the CMB temperature sensor and measures the dark SiPM current. One of the salient features of this design is the use of commercial off-the-shelf parts; no custom I.C.s are employed. The SiPM signals are fed to commercial ultrasound processing chips, each of which has eight sets of low-noise preamplifiers, programmable gain stages, programmable anti-alias filters and 80 MSPS, 12-bit ADCs. The digital portion of the card uses LPDDR SDRAM for buffering data and FPGAs for applying thresholds to the ADC data for zero suppression, buffering the data in the SDRAM and implementing the serial data links for communication to the readout controllers. A microcontroller is used for status and slow control. Power is supplied over the same category 5 cables used for the data link to the readout controllers, simplifying the cable plant. Commercial Power over Ethernet protocol is used. One front-end board can accommodate 64 SiPMs. A total of 320 boards are required for the entire cosmic ray veto, including spares. Each ultrasound chip consumes about one watt, and the remainder of the board consumes about six watts. The 48V power supply is designed for minimum noise at the expense of efficiency which is about 72%. The board consumes a total of 20W from the 48V supply. A trace of a SiPM illuminated by a flasher LED in a dark box is shown in Fig.2. The pulse represents about 75 photo electrons (p.e.). This is an accumulation of 100 triggers to show and after pulsing and dark current pulses. The current measuring portion of the board makes in situ determination of the I/V curves of the SiPMs. This consists of a single differential programmable gain amplifier (PGA) driving a slow 24 bit ADC. There is a 64 channel differential multiplexer connecting the SiPM biasing resistors to the input of the PGA. The R.M.S. of the current measurement is better than a 100 pA, sufficient for accurate determination of the SiPM breakdown voltage.

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