A Four-Channels Front End Electronics for ATLAS Muon-Drift-Tubes Detectors in 65nm CMOS Technology

ABSTRACT

Front-End-Electronics are utilized by ATLAS muon chamber (MDT) to detect charge and give information regarding charge arrival time and amount of charge being detected. Read-Out-Electronics along with being robust, should operate faster, be area and power efficient. This paper presents improved version of AFE, ASD designed in 130nm technology, that is actually used for MDT chambers of ATLAS Experiment. AFE is designed in 65nm CMOS Process, with single Mode of operation and minimal architecture by eliminating two stages without effecting performance. Along with scaling down technology this AFE consumes 16mW per channel, which is 46% efficient than the previous design.

SUMMARY

Background and aims

Front-End Electronics performs charge-to-voltage conversion by Preamplifier. This voltage pulse is further amplified and converted into Bipolar shape which carries information regarding Charge arrival time and amount of Charge been detected. To differentiate incoming small charges from noise Threshold level of 3-5 rms noise value is applied at discriminator Input. Each channel includes Analog part and Digital part. To control certain functional parameters, Shift Registers are used which can be programmed with Digital word at reset time through Serial Interface.

This paper presents a power and area efficient Front-End Electronics design for Muon Drift Tube which has minimum SNR of 14.5 dB and fast-peaking time of 11ns at Preamplifier output. It further, utilizes a new design of Shift Registers to re-read Data written through Serial I/O Data Interface.

Methods

Key parameter in designing Preamplifier is to minimize noise performance by setting very high Transconductance (gm_{M1}), 25mA/V, value of input Mosfets. This, however, increase current consumption, trade-off between noise and power, which is compensated by minimizing number of stages in overall design, hence saving overall power consumption. For fast peaking time, Op-Amp of Preamplifier is designed with High-Bandwidth of 2.4GHz along with good stability margin. For Bipolar Shaping of Signal, two stage shaper is utilized rather than three stages as used previously. Also, pre-discriminator stage is eliminated without effecting performance, thus further simplifying architecture and making it area, power efficient. With lower supply voltage, to keep maximum linear sensitivity at output of shaper, two stage differential amplifiers are utilized. Keeping circuit Architecture minimum and power-efficient, it operates in single mode of operation, Time-Over-Threshold, in which incoming signal is compared with threshold voltage set by programmable DAC's. Output of discriminator stage is sent to SLVS PADS cell, converted to external low-level signals for faster transfer rate.

To confirm that correct data is written into Registers, another block is implemented which reads registers Data using PISO interface. Programable Dead-Time circuit is added to suppress multiple threshold crossing in MDT Signal-Tail.

Results

This design has sensitivity of 1.1mV/fC at output of Preamplifier and 8mV/fC at output of Analog signal processing Chain. Input noise density of CSP is 1.1 nV/√Hz. Peaking time of Preamplifier is 11ns and 14.4ns at end of Analog Chain. Bipolar signal reaches baseline about 400ns. Minimum SNR at output of preamplifier is 14.5 dB which increases up to 44dB for maximum charge input-pulse. Performance is investigated with respect to Process/Voltage/Temperature (PVT) variations to check robustness of circuit. It consumes power of 16mW per channel

Conclusions

4-channels Front-End-Electronics for Muon-Drift-Tube has been presented. Design is carried-out in TSMC-65nm Technology. This work has targeted power and area efficient design along with achieving performance specifications of state-of-the-art AFE, ASD, already used in ATLAS detectors

Reference

S. Abovyan, V. Danielyan, M. Fras, O. Kortner, H. Kroha, R. Richter, Y. Zhao, A. Baschirotto, M. De Matteis, F. Resta, "**The new octal amplifier-shaper-discriminator chip for the ATLAS MDT chambers at HL-LHC**", Nuclear Instruments and Methods in Physics Research A936, August 2019 – pp. 374-375