Contribution ID: **34** Type: **Poster**

Very fast front end ASIC associated with multi anode PMT for a scintillating-fiber beam hodoscope

Thursday, 20 September 2012 17:03 (1 minute)

For developing a scintillating-fiber beam monitor, we have designed a front-end 16-Channels readout chip to be associated with PMTs in a 0.35 μm BiCMOS process. Each channel consists of one input current conveyor driving separately a current comparator for signal event detection and a charge-sensitive amplifier for signal charge measurement. The ASIC version 2 has brought significant improvements: larger input dynamic range, lower power consumption, lower noise and a better phase margin. System testing has shown achievements of 4 MHz beam rate. The main limitation comes from the PMTs which saturates at such a rate

Summary

1. Introduction One recently-suggested method for quality control of ion therapy consists in detecting prompt radiation from nuclear fragmentation, which have a longitudinal profile correlated to the ion range [1,2]. This method can be implemented by a beam hodoscope made of detecting arrays of packed scintillating fibers coupled with PMTs. The system development requires a dedicated multi-channel readout ASIC. Each readout channel should have a low-impedance current signal input, with an adjustable current gain in order to compensate the optic fiber ageing and PMTs gain dispersion. Additional requirements include low noise for weak signal operations, low propagation time to reduce dead time at high counting rate and low power consumption. This paper presents front-end 16-channel Ma-PMTs associated readout ASIC dedicated to a beam hodoscope. It's an improved version to a Front-End readout chip [3]. Both circuits have been fabricated in a 0.35μm BiCMOS process, but the improved version provides better performances in input dynamic range, power consumption, noise, variable-gain stability and speed.
2. Circuit Design This ASIC integrates 16 readout channels, each consisting of 3 building blocks: a 4-bit current gain conveyor as an input stage, a current comparator and a Charge-Sensitive-Amplifier (CSA). The current conveyor is designed using large-transconductance bipolar components to reach low input impedance in a few ten ohms. Its bias currents are minimized to reduce power consumption without significant degradation of its bandwidth, which remains enough for the circuit operation. The gain stability is improved by implementing feedback and pole-splitting techniques for the super-common-base transistor structure. The improved version employs a new current comparator with local feedback [4] to lower its input impedance and thus to reduce the time constant of the input node. This allows significant improvement in response time.
3. Testing results The ASIC has brought significant improvements compared to its previous version: larger input dynamic range (53dB against 33dB), lower power consumption (11mW/channel instead of 22mW under a 3.3-V supply), lower noise (4fC versus 19fC in ENC) and a better phase margin for optimizing stability and speed. System testing has shown achievements of 4 MHz beam rate. The main limitation comes from the PMTs which saturates at such a rate.
4. Conclusion The presented ASIC has improved performances especially in power consumption and noise and transient speed. Testing of a scintillating-fiber beam hodoscope with the use of the ASIC has confirmed that the circuit performances meet the system requirements. References [1] E. Testa et al, Applied Physics Letters 93, 093506 (2008). [2] P. Henriquet et al, submitted in Phys. Med. Biol. PhD thesis, Lyon 1, 2011. [3] S. Deng, H. Mathez, D. Dauvergne, Y. Zoccaratto, G.N. Lu, to be published in Nuclear Instruments and Methods in Physics Research A, DOI: 10.1016/ j.nima.2011.11.042 [4] Borghetti,F.,et al., "A High Speed and Low Power CMOS Current Comparator for Photon Counting Systems". IEEE, 2004

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Session Classification: POSTERS