

Fast TRD Pre-Amplifier Shaper for the CBM experiment

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One of the challenges in research and development for fast PASA suitable for MWPC-based detectors in future experiments (like TRD in CBM) is to achieve low noise with short shaping time and high pulse rate, low power consumption and small chip size. We present here a prototype using standard technology ($0.35\ \mu\text{m}$) to show that the requirements can be fulfilled.

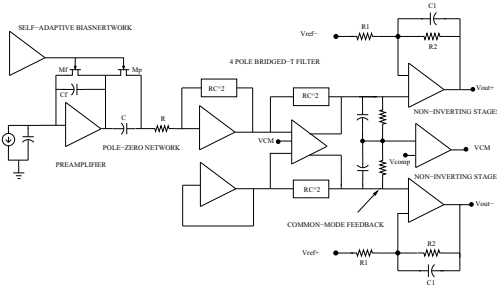


Figure 1: Schematics of the fast PASA done in $0.35\ \mu\text{m}$ technology

In order to achieve an overall noise of less than 1000 electrons per channel for a typical input capacitance of a total of 5-10 pF, the use of a low-noise circuit is required. A well proven topology to fulfil such a requirement is shown in fig. 1. Each channel consist of a low noise charge-sensitive amplifier, an active $\text{CR}-(\text{RC})^4$ pulse shaper. The main noise contributor is the input transistor of the preamplifier that is based on the folded cascode topology. The cascode consist of a common-source stage followed by a common-gate stage. It combines two transistors (a wide input transistor and a narrower cascode transistor) to obtain: i) high transconductance and low noise of a wide transistor, ii) high output resistance and low output capacitance of a narrow transistor, and iii) reduced capacitance between output and input. In addition a Pole-Zero network is included to avoid undershoot that will strongly limit the counting rate behaviour. In the design a MOS transistor (MF) is used with a feedback capacitance C_f that is continuously discharged with a decay time $td = C_f \cdot R_{ds}$ (MF). This continuously sensitive design is particularly suitable for a detector with high occupancy and high counting rate. A typical impulse response is shown in fig. 2. In this first prototype the peaking time is 70 ns ($t_0/100$), and the FWHM is about 70 ns. In terms of noise this circuit fulfil the requirement with an ENC of less than 400 electrons for an input capacitance of 10 pF. In terms of power consumption the circuit uses 16 mW/channel. The chip is fabricated in $0.35\ \mu\text{m}$ standard CMOS technology, and it has a pad pitch of $200\ \mu\text{m}$ and a total area of $12\ \text{mm}^2$.

A first prototype using this design was submitted in October 2005 and it has just been received from the foundry. The first tests in lab and in test beam show that the chip responds according to specifications, in particular with very

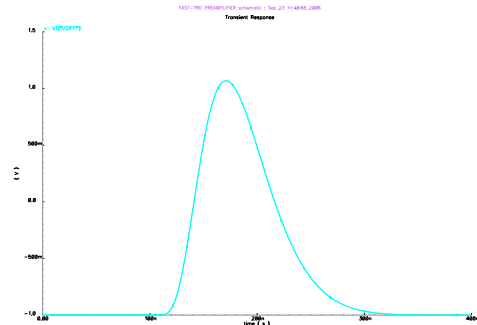


Figure 2: Typical impulse response of the fast PASA done in $0.35\ \mu\text{m}$ technology

good noise level, a good uniformity of the baseline and high yield. This circuits are now under preparation to be used in the Fast-TRD test beam in February 2006.

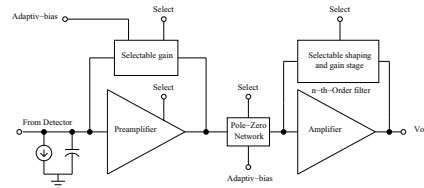


Figure 3: Schematics of the fast PASA under development in $0.13\ \mu\text{m}$ technology

The next step now is to migrate from $0.35\ \mu\text{m}$ technology to a smaller technology that will bring less power and less area, and that will be the standard in few years. A prototype development of a new circuit done in $0.13\ \mu\text{m}$ IBM technology is already under way. The proposed schematic layout is shown in fig. 3. This circuit consist of a low noise, selectable gain, preamplifier that can detect both polarities. The choice of gain range in the preamplifier is made by switching the relevant range capacitors. The reason of choosing a selectable gain preamplifier is to provide a versatile preamplifier potentially suitable for several of the proposed CBM detectors (RICH, ECAL and TRD). The core preamplifier is based on the same topology as used in ALICE-TPC/TRD [1]. The change in decay time (due to change in gain range) also influence the P-Z network, that has to change to preserve to same relation to avoid undershoot. The shaper/gain circuit is also made selectable. The purpose of the selectable shaper/gain circuit is to amplify the input signal to the full scale voltage of the ADC ensuring that the maximum signal resolution is achieved. Several programmable shaper/gain topologies are under investigation to find the best candidate for the proposed detectors.

References

- [1] H.K. Soltveit *et al.*, GSI Annual Report 2003, p 244