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A bipolar shaping amplifier for low background alpha/beta counters with silicon detectors.

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Current existing alpha/beta counters use gas-flow detectors becasue of their low energy detection threshold compared to Passivated, Implanted, Planar Silicon (PIPS®) detectors. However, gas based systems suffer drawbacks with respect to safety and required infrastructure for the gas. The latest evolutions of the characteristics of PIPS® detectors allow to reach a lower energy threshold, that is comparable to gas-flow detectors. For these new alpha/beta counting systems, redesign of the front-end electronics is necessary. In this work we focus on the design of a bipolar shaping amplifier with adjustable gain and present the calculations, simulations and validation.

Summary

Gas-flow detectors are used for low background alpha/beta counters [1] because of the low energy detection threshold that can be reached with these detectors. However, they suffer drawbacks with respect to safety and required infrastructure for the gas flow. Moreover, frequent recalibrations are needed each time the gas is replaced, which is a time consuming process and could compromise the consistency of data. Alpha/beta counters with solid state silicon detectors address this issue but the current generation has an inferior low energy threshold compared to the gas-based systems.

The latest evolutions of the characteristics of Passivated, Implanted, Planar Silicon (PIPS®) detectors can help to overcome this limitation and allow to reach a lower energy threshold, that is comparable to gas-flow detectors [2]. For new alpha/beta counting systems, redesign of the front-end electronics is necessary because the electronics of existing silicon based alpha/beta counters do not allow to obtain the full potential of the improvement that can be reached with the new generation of PIPS® detectors. Most of the redesign effort is applied on the preamplifier and shaper. The goal is to re-use the back-end electronics such that the gas flow detector, and the front-end electronics can be easily substituted with a PIPS® detector and its front-end.

In this work we focus on the design of a bipolar shaping amplifier and present the calculations, simulations and validation. Making use of a bipolar shaper instead of a unipolar simplifies the complexity of the system by removing the baseline shift and thus eliminating the need for a baseline restorer. This combined with the property that the time of the zero-crossing of bipolar shapers is independent of the amount of deposited charge is why it is often used, for example in high energy physics experiments. The switching of the baseline restorer could introduce artifacts that would be seen as background, which is intolerable in a low background counting system where backgrounds lower than 0.6 cpm must be reached on a 2”detecting area. The pole-zero adjustment with a bipolar shaper is also less critical [3]. The shaping amplifier circuit is based on the existing amplifier for gas-flow based alpha/beta counting systems. The bipolar shaping amplifier is a 4 pole filter which consists of two stages with each an input CR-circuit for differentiation and an active bridged-T feedback amplifier [4]. The gain in a gas-flow detector chain in its proportional region can be adjusted by its biasing voltage. This is not the case for a fully depleted silicon detector where the gain remains unaffected by the bias voltage. This is addressed by implementing two gain stages, both fine and coarse gain, between the two stages of the shaping amplifier. By adding the gain in between the two shaping stages, any DC offset introduced by the gain amplifier is removed by the differentiation of the second stage of the shaping amplifier. An inverting stage is also added at the input of the amplifier to be able to accept both positively and negatively

biased silicon detectors.

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