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Gain Compensation Technique by Bias Correction in Arrays of Silicon Photomultipliers Using Fully Differential Fast Shaper

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Proposed algorithm compensates the gain by changing the bias voltage of Silicon Photomultipliers (SiPM). The signal from SiPM is amplified in fully differential preamplifier then is formed in time by the fully differential fast shaper. The compensation method was tested with four channels common cathode multi-pixel photon counter from Hamamatsu. The measurement system requires only one high voltage power supply. The polarization voltage is adjusted individually in each channel indirectly by tuning the output common mode voltage (VOCM) of fully differential amplifier. The changes of VOCM affect the input voltage through the feedback network. Actual gain of the SiPM is calculated by measuring the mean amplitude of the signal resulting from detection of single photoelectron. The VOCM is adjusted by DAC so as to reach the desired value of gain by each channel individually. The advantage of the algorithm is the possibility to set the bias of each SiPM in the array independently so they all could operate in very similar conditions (have similar gain and dark count rate). The algorithm can compensate the variations of gain of SiPM by using thermally generated pulses. There is no need to use additional current to voltage conversion which could introduce additional noises.

Summary

The abstract presents a new method to compensate the gain of SiPMs. The algorithm brings the opportunity to add the gain compensation in the front-end circuit with little effort. The front end electronics uses the fast shaper. The FWHM parameter of the pulse corresponding to single photoelectron is equal to 6.4ns and its peaking time is equal to 4.3ns. Comparing with single ended amplifier, the fully differential amplifier has wide dynamic range. Hence, the changes of the output common mode voltage do not affect the range as much as it is in the single ended circuits.

There are many other gain compensation methods presented in scientific literature. One of them implements the compensation by adding a resistor with DAC to the anode of common cathode multi-pixel photon counter. In that case the current from SiPM is converted to voltage and the resistor introduces an additional noise. Another possible compensation method changes the amplification in read out electronics. But this method does not ensure similar dark count rate in each channel and could lead to difficulties when coincidence is used. Presented solution does not need the additional resistor since the SiPM is connected directly to the input of amplifier. The gain is adjusted by moderating the bias voltage and dark count rate should be comparable in each channel.

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