An Improved Single Transmission-line Readout Method for Silicon Photomultiplier based positron Emission Tomography using Time Encoded Position Tag Pulses

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Objectives:

The primary objective of this study was to improve pulse-tagging multiplexing method (PTM) in which tag signals ahead of scintillation signals provide 2D interaction position information with single line readout.

Methods:

Anode signals from silicon photomultipliers (SiPMs) were shaped into tagging signals which provide timing and 2D interaction position information. Scintillation signals passed through high pass filter for robustness to baseline fluctuation and then were amplified through a high speed current feedback operational amplifier (AD8000; Analog Devices, USA). The amplified signals were converted into digital signals by dual threshold discriminator and false event rejection circuit. Subsequently, each digital signals were fed into two different width modulator circuits for horizontal and vertical position respectively and delayed 100ns to avoid interference with preceding scintillation signal. Finally, all width-modulated tag signals and pole-zero cancelled common cathode signal were merged by a summing amplifier, forming scintillation signal, which gives energy information, followed by L-shaped tagging signal. The simulation was done using Linear Technology Simulation Program with Integrated Circuit Emphasis (LT SPICE).

Results:

In the simulation, 2D position information for all pixels of 2*2 SiPM array were acquired well. The linearity between time over dual threshold voltages and scintillation pulse energy was secured presenting R squared value above 0.98. The linearity between capacity for tag width modulator and tag width was also secured presenting R squared value above 0.99.

Conclusion:

In this study, improvement is anticipated in coincidence resolving time (CRT) performance as multiplexing ratio and count ratio increase, due to no additional time consumption for tag signal. Also, better positioning performance is expected thanks to higher linearity of tag width modulator circuit comparing to tag height modulator circuit. It is expected that the actual timing and positioning performance with increasing multiplexing ratio will be further investigated.