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#10-263 The FPGA-controlled biasing of the photomultiplier tube based on the Cockcroft-Walton voltage multiplier

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A common approach to photomultiplier tube biasing is to use a high-voltage power supply and a passive or active voltage divider to create the necessary electrical potentials to power the amplification process in the photomultiplier tube. The lowest current flows from the photocathode to the first dynode. The highest current flows from the last dynode to the anode. If a standard voltage divider is used, the current to the dynode must flow through the entire divider chain between that dynode and the photocathode potential. Due to this principle, the highest current flows from photocathode potential. This mechanism causes high power losses and can create a well-known strong dependence of the photomultiplier gain on the measured signal. The Cockcroft-Walton voltage multiplier can solve this problem when the voltage multiplier chain starts on the anode side. In this case, the direction of increasing currents is the same in the voltage multiplier as in the photomultiplier tube. This topology is especially suitable for a negative high-voltage topology with an anode potential close to the ground. We studied the existing topologies of the Cockcroft-Walton voltage multiplier and possible ways to excite this voltage multiplier. We used simulations of different circuit topologies. We focused on voltage stability, minimizing the number of discrete components, and minimizing the used printed circuit board area. We created an experimental setup based on FPGA signal processing to control and verify the proposed topology. Our experimental setup, based on FPGA signal processing, allowed us to maintain and verify the proposed topology. This setup included a photomultiplier socket with voltage multiplier, inverting switched power converter for excitation for voltage multiplier, A/D and D/A converters for control loops and state monitoring functions, the amplifier of the output anode signal, and auxiliary power supplies. This socket is connected to the FPGA development board. We tested and compared the proposed solution with classic passive and active voltage dividers. Our target applications for using photomultiplier tubes are gamma spectroscopy and mixed neutron/gamma measurement based on pulse-shaped discrimination. The stability of gain for the whole system at various count rates is essential. We use CeBr3 crystal in different strengths of Cs-137 gamma ray. A digital multichannel analyzer measured the output signal, and the position of the 661 keV peak was checked. The results show that the proposed solution can achieve similar or better stability than the active divider and a classic high-voltage source.

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