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A FPGA-based Pulse Pile-up Rejection Technique for the Spectrum Measurement in PGNAA

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Prompt gamma neutron activation analysis (PGNAA) is a non-destructive nuclear analytical technique for the determination of elements. By detecting the prompt gamma which is emitted from thermal neutron capture or neutron in-elastic scattering reactions, the type of elements and their amount can be obtained through the prompt gamma spectrum.
As a on-line and in situ inspection method, the PGNAA technique need to acquire an accurate spectral information in a relatively short measurement time. This requires that the signal processing circuit should possess a high measurement counting rate. The pulse pile-up can cause the energy spectrum destruction in a high counting rate condition. To making the pulse duration of the various detectors as narrow as possible by using pulse-shaping techniques, the probability of the pulse pile-up can be decreased.
The traditional Gauss pulse-shaping technique can obtain a better signal-to-noise ratio (SNR). However, the quasi-Gaussian waveform have a long tailing edge. If the tailing edge of the shaped pulse can quickly return to the baseline after the peak collecting, then the pulse width will be reduced while the energy information is preserved. Therefore, a pulse pile-up rejection technique is developed.
The signal generated by the detector passes the CR-(RC)m shaping circuit and becomes a quasi-Gaussian pulse. The pulse is digitalized by the analog-to-digital converter (ADC). The digital signal is discriminated and recorded in field-programmable gate array (FPGA). Once the peak is found, the feedback signal is send back to the shaping circuit and control an analog switch to discharge. Then the tailing edge of the pulse is cut off quickly, and the baseline is recovered.
The test result shows that the signal processing time can less than 200ns when the RC constant of shaping circuit is 50ns, and the count loss is about 6.8% for a count rate of 100kHz. As a comparison, the pulse duration time and count loss are 1us and 16.6% without feedback control. The energy resolutions of 511keV gamma-rays of the DAQ, which covers the LaBr3 detector and the EJ 9813KB PMT, is 8.1%.

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