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High Counting-rate Data Acquisition System for the Applications of PGNAA

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Prompt Gamma-ray Neutron Activation Analysis (PGNAA) technique is a non-destructive nuclear analysis technique for the determination of elements. It can detect the composition and the content of the materials by analyzing the prompt gamma spectrum, which is emitted from thermal neutron capture or neutron in-elastic scattering reactions. This detection technique can obtain the internal element composition of the large thickness material, because of the neutron and gamma ray's penetration ability. Therefore, the PGNAA technique is becoming the best choice of element detection of industrial materials.

As an on-line and in situ inspection method, the PGNAA technique need to acquire an accurate spectral information in a relatively short measurement time. That demands a high counting rate and little counting loss of the data acquisition system.

To achieve an average counting rate of 500kc/s, with the counting loss less than 10%, the highest counting rate of the data acquisition system is as much as 5Mc/s. That demands the time width of processing one signal pulse must be less than 200ns to avoid a worse counting loss caused by the pile-up effect. That is not easy for the electrical system which has to insure the accurate of the spectrum analysis. To obtain a better SNR, the signal pulse has to be wider, however that will lead to an increasing of the counting loss caused by the pile-up effect.

This system uses a 14 bits high speed ADC circuit, which has a sample rates of up to 250 MSPS. Furthermore, the analog-to-digital converting, peek seeking and multi-channel analysis are operated as a pipeline, which can finish a data acquiring circle in the time of 4 system clocks. When passed through the CR-RC(m) shaping circuit, the tailing edge of the signal pulse reduces to about 140ns, and the whole time from the ADC output delay to finish the multi-channel analysis is up to 60-70ns.

The electrical tests shows that, the highest counting rate reaches 8Mc/s much higher than 5Mc/s which is required.The result of liner fitting of the curve of the input amplitude voltage in different channel shows that the standard deviation is 1.23mV, while the relative error is lower than ±1.5%, and is lower than ±0.5% in the middle and high channel range.

Primary author: Mr LIU, Yuzhe (Univ.of Sci.&Tech.of CHN (USTC))

Co-authors: Dr LI, Feng (Univ.of Sci.&Tech.of CHN (USTC)); Dr LIANG, Futian (University of Science and Technology of China); Prof. JIN, Ge (Univ.of Sci.&Tech.of CHN (USTC)); Dr CHEN, Lian (Univ.of Sci.&Tech.of CHN (USTC))

Presenter: Mr LIU, Yuzhe (Univ.of Sci.&Tech.of CHN (USTC))

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