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#03-110 Development of a real-time signal processing unit for diamond detectors of ITER Vertical Neutron Camera

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Diamond detectors are going to be used in ITER neutron diagnostics, including the Vertical Neutron Camera (VNC). They are meant for neutron flux measurements and measurements of the energy spectrum of fast neutrons.
One of the main functions of VNC is measurement of the neutron source profile. In accordance with ITER requirements VNC has to calculate an updated neutron source profile each millisecond (at a frequency of 1kHz), as well as provide neutron spectrum updates each 100 ms. The required measurement accuracy is 10%. This necessitates development of a high-speed real-time signal processing unit.
Nuclear reactions between fast neutrons and carbon atom nuclei lead to ionization in the diamond detector' s volume. If voltage is applied to the crystal, a pulse of current is generated on each interaction between a neutron and a carbon atom nucleus. The amplitude of the resulting signal depends on the amount of energy E_p absorbed on each interaction. Typical width at base for pulses registered at the ADC input is around 30 ns. Due to this we have to use an ADC with a sample rate of at least 500 MHz.
This study describes the development process of a diamond detector signal processing unit, based on a heterogeneous computing device, consisting of an industrial computer and a fast ADC coupled to a high-speed I/O board with data processing capabilities provided by an on-board reconfigurable FPGA. In it we describe techniques used for signal filtration and pulse detection.
An algorithm has been developed to identify pulses in real-time and measure their parameters: amplitude, width at base. It is able to reject pulses based on their duration to avoid pile-ups, which has an unpredictable influence on the resulting statistics. This algorithm is able to mitigate a constant non-zero shift of the data baseline (from which amplitudes of pulses are measured), as well as baseline fluctuations.
This algorithm has been successfully applied in an experiment on the NG24M neutron generator. Diamond detector measurements have been performed in a neutron field with a flux of 14 MeV neutrons of up to 10^9 $\frac{n}{cm^2 \cdot s}$. In this experiment the pulse count-rate of the diamond detector exceeded 300 kHz. Results of this experiment show that this algorithm is suitable for use in the VNC diagnostics.
This work is being carried out in accordance with the state contract dated April 21, 2020 No. H.4a.241.19.20.1042 "Development, pilot production, testing and preparation for the supply of special equipment to ensure the fulfillment of Russia's obligations under the ITER project in 2020".

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