

§22. Design and Development of Fast Response, Wide Dynamic Range Neutron Flux Monitor for the Large Helical Device

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The Large Helical Device (LHD), based at the National Institute for Fusion Science (NIFS), is the largest superconducting heliotron-type magnetic confinement system, providing an excellent opportunity to study three-dimensional currentless plasmas. So far, high β value, high ion and electron temperatures, and long pulse operation capabilities in hydrogen discharges have been demonstrated. To explore higher-performance plasmas, the LHD project will step into a new stage, i.e., deuterium experiments. Note that in LHD deuterium experiments, neutron and tritium budgets will be set for a reason of radiation safety. To execute this project as scheduled steadily and safely, a fast response, wide dynamic range neutron flux monitor (NFM) having fast time response is essentially required in terms of both radiation safety and plasma physics. In TFTR and JT-60U tokamaks, a wide dynamic range NFM had been employed [1-3]. The electronics used in the two tokamaks were based on traditional analog circuits and is no longer commercially available at this moment. Therefore, we have been developing the fast response, wide dynamic range NFM optimized for the LHD by using leading-edge digital signal processing (DSP) technologies.

LHD will be equipped with three NFMs to secure safe machine operation [5]. Fig. 1 shows the signal processing block diagram of DSP unit for LHD NFMs. The unit measures analog input signals, which are generated in a fission chamber and then amplified with a preamplifier. The unit calculates a neutron counting rate from those input signals using two different methods simultaneously. One is a pulse counting method applied for a low counting rate which is called a pulse mode; the other is a method to measure and process a mean square value (MSV) voltage for a high counting rate, which is called Campbelling mode [4]. Two different results calculated respectively with those two methods are combined to obtain a neutron emission rate and yield over the entire region typically up to 5×10^9 (cps). Fig. 2 shows respective shapes of the signals calculated with the pulse and Campbelling modes. These signals have a sufficient overlapping region, which is wide enough to make a smooth transition from one to another between two methods. The upper and lower boundary values of this region, 6×10^5 and 6×10^4 (cps), respectively, have been obtained through a trial evaluation at KUCA, and those boundaries are adjustable depending upon various fission chamber types. Leading-edge digital processing technologies using FPGA, such as high sampling rate, high-speed-analog-to-digital conversion, and digital

signal processing are incorporated in this unit. These technologies have realized the fast response of 2 ms. Moreover, these technologies made it possible to shorten the time constant of analog filter circuits and to realize better performance of a low-pass filter in the radio frequency region as compared to those obtained through conventional analog technologies. In addition, this unit has interfaces convenient for safety operation, data acquisition for plasma physics and maintenance, including analog signal outputs, digital signal output, Ethernet and serial data communication, as well as numerical and text displays.

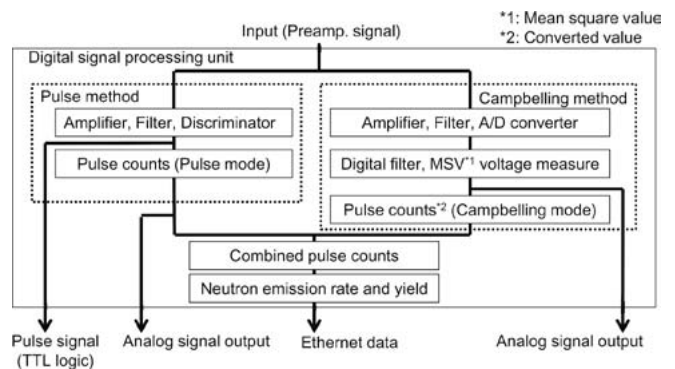


Fig. 1. Signal-processing block diagram of this unit. This unit measures and processes input signals by two different methods and calculates neutron emission rate and yield.

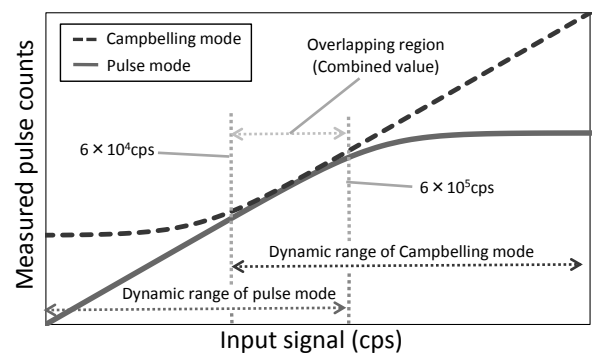


Fig. 2. Respective shapes of signals calculated by pulse and Campbelling modes.

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