The new digital electronics for the JET Neutron Profile Monitor: Performances and first experimental results.

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The 2D neutron emissivity profile (n s^{-1} m^{-3}) is measured at JET by a set of NE213 liquid organic scintillators located in two fan-shaped arrays of collimators with 10 horizontal and 9 vertical lines (Neutron Profile Monitor). As the detectors are sensitive to neutron and gamma rays, pulse shape analysis is required for neutron/gamma discrimination. A digital architecture handling data acquisition and processing for the entire diagnostic has been developed by ENEA-Frascati and installed at JET during the 2009 campaign as a replacement of the existing analogue electronics. Such upgrade provides the Neutron Profile Monitor with two major improvements, namely the capability of yielding spatially resolved information on the neutron energy distribution and of operating at high-count rate (~1 MHz). The paper describes the performances of the digital architecture and the first experimental results in the JET C27b campaign.

The digital system consists of five boards, each one hosting four analogue input channels, external triggering, 1 MHz synchronization input clock and two Field Programmable Gate Array (FPGA) devices from Altera™. Two 14-bit resolution ADCs running at 100 MSamples/s in "interleaved" mode are used to obtain an effective 200 MSamples/s sampling rate for each input. The interleaving technique requires noise reduction methods which have been applied successfully (overall noise ≤ -80 dB). Each FPGA integrates acquisition of four 100 MSample/s ADC data, 200 MSample/s data flow, data reduction and output to a fast acquisition board (National Instruments PCIe-6537) for data storage on PC. A processing section performing a first approximation neutron/gamma discrimination and producing real-time separate neutron and gamma ray count rates is also included. The FPGA incorporates a soft-core processor to enable parameters' remote setting, monitoring and real-time data transfer via standard Ethernet. An embedded version of Linux has been integrated in the processor to increase the versatility of the system (telnet, ftp, etc.).

All 19 detectors of the Neutron Profile Monitor have been energy-calibrated using ^{22}Na gamma sources. Several deuterium NBI and RF-heated plasma discharges have been fully acquired during the C27b campaign and processed off-line through a dedicated LabVIEW™ software package. The results demonstrate the overall good performance and flexibility of the digital system: fine neutron/gamma discrimination has been achieved for all 19 detectors; the boards have been working up to typical total count rates of ~250 kHz, but transient rates in excess of 1 MHz have been handled correctly; line-integrated neutron pulse height spectra can be obtained in a wide proton energy range (approximately 1.7-14 MeV) and, within such range, line-integrated neutron profiles can be produced in any chosen energy window. For the first time in JET, the availability of multiple line-integrated neutron measurements with energy information offer the possibility of addressing studies of the spatial and energy distribution of neutrons produced in DD and DT reactions: examples of such application will be shown.