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# A real-time data acquisition and elaboration system for instabilities control in the FTU tokamak.

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Tokamak plasmas are prone to various kind of magnetohydrodynamic instabilities which may affect the energy and particle confinement time or lead in some cases to disruptive plasma termination. Such instabilities take the form of magnetic islands driven by the reduction of bootstrap current where the pressure profile is flattened (Neoclassical Tearing Modes) or by the radial gradient of the toroidal current (Tearing Modes) often in association with the so called sawteeth instability. Injection of powerful Electron Cyclotron waves into the magnetic islands has been proven highly effective in suppressing or at least controlling the size of tearing instabilities.
The detection of the islands and prompt reaction with accurate aiming of the EC power are crucial for the effectiveness of the control. For such reason a great effort is being addressed in many fusion laboratories to the development of complex equipments with real-time capabilities.
The system under development for FTU (major radius R=0.935m, minor radius r=0.31m, max toroidal field 8T, max plasma current 1.6MA, max flat top pulse duration 1.5s) encompasses existing diagnostics whose data are acquired with two different sampling rates. A first set of (fast) signals (20 kHz sampling rate, collected with 1x16 channels ADC board, 12 bit) is based on the 12 high pass filtered channels of the Electron Cyclotron Emission polycromator, on 28 signals of pickup coils and two gyrotron (ECH) driving signals. The slow signals set (2 kHz sampling rate, collected with 3x16 channels ADC boards, 12 bit) includes calibrated electron radiative temperature, calibrated density data, magnetic signals for the reconstruction of the position of the last closed magnetic surface of the plasma, toroidal magnetic field and plasma current. This last group of data is used for real-time computation of the magnetic equilibrium and of the ray trajectories of the EC waves beams in plasma.
Data acquisition and processing is performed using two VME based system. Each industrial PC runs Linux RTAI operating system and uses the MARTe framework to implement the control/processing cycle. One VME is devoted to fast signals preprocessing and runs a real-time thread at 20kHz feeding preprocessed data to the other VME on a RTNet Ethernet link. The other VME runs a real-time thread at 2kHz which handles the main part of the control algorithms generating controlling signals for actuators.
At present only a subset of ten fast signals (including two ECHs) can be actually acquired in the same plasma pulse. Processing of these signals is aimed to evaluate the cross-correlations of temperature and/or magnetic fluctuations in order to detect the existence and the radial position of the magnetic island (rmhd, being r the minor radius of the plasma). The cross correlation of ECE and ECH allows the detection of the injected power deposition layer (rdep). The real-time data acquisition and processing system constitutes a real-time rdep and rmhd diagnostics, so far validated by off-line analysis of dedicated plasma shots. The controller driving the ECH steering parameters and power switching-on can be based on the diagnostic data elaborated in this way, possibly integrated (or substituted) by the a-priori estimate of rdep and rmhd using the real-time equilibrium and ray tracing. Preliminary estimates how that islands producing temperature fluctuations of about 20 eV between contiguous ECE channels (Dr»3cm average separation) can be detected and trigger the actuator in less than 30ms. First system tests about island detection and actuator's control by using these methods are discussed in this paper.

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