

Plasma Diagnostic Systems - Data Acquisition and Processing

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Plasma diagnostics is an essential tool to understand and improve plasma stability in fusion devices. It provides useful information for analysis of physical phenomena, machine protection and plasma control. Plasma diagnostic systems measure various parameters of physical processes using passive and active methods. Passive methods mainly detect particles or radiation emitted spontaneously by the plasma, whereas active methods take advantage of generated supplementary radiation or particles to probe plasma parameters. In both cases, physical parameters need to be measured. Data Acquisition and Processing (DAP) systems are usually applied for physical parameters measurements. The measured and processed data provides useful information describing plasma conditions and its parameters. The active methods require also additional components to control the supplementary devices, such as lasers. Nowadays, digital data acquisition and processing systems are commonly utilized for accurate and reliable measurements. First, the physical parameters are measured by analogue sensors. The analogue signal, after suitable conditioning, is digitalized and further processed to extract the required information describing plasma parameters. A real-time control system with defined data processing time is required when the measured parameters are used to control thermonuclear fusion. Plasma diagnostic system could measure and analyze large number of signals (hundred and thousands of parameters) and therefore requires a suitable architecture of the DAP system.

Some of plasma diagnostic systems use also a digital camera as sensor to observe plasma and machine vault. In this case, the image acquisition and processing system is composed of image detector (digital camera), a frame grabber device that receives video stream and a device responsible for image acquisition and further processing. In case of vision systems, a significant processing power could be required to extract information from recorded video stream.

Acquiring and processing of such large amount of signals requires a flexible hardware platform that provides large enough capability, processing power and synchronization. Various architectures and hardware platforms can be used to design DAP systems for fusion diagnostics.

The lecture will provide basic knowledge how to design complex, scalable data acquisition and processing systems for plasma diagnostics applications. The whole chain of data acquisition, including signal conditioning, digitalization, data processing and timestamping will be discussed. Various hardware platforms and their crucial parameters will be compared and debated during the lecture. Data processing components including Central Processing Units (CPUs), Field Programmable Gate Arrays (FPGAs) and Graphics Processing Units (GPUs) will be compared during the presentation. Finally, two examples of typical data acquisition and processing systems will be presented. The Basic Divertor Neutron Flux Monitor, developed in PXIe and MicroTCA.4 hardware platforms, will be introduced as example of scalable DAP system. The image acquisition and processing system developed with MicroTCA.4 platform will be depicted as example of scalable and powerful vision system. The lecture will provide also basic information concerning firmware and software development for digital data acquisition and processing systems used in plasma diagnostic systems.