§47. LHD Central Control System

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Among large physics experimental systems, a usion machine is characterized by the complicated and intensive energy density system, and its safe operation is important. In addition, the present fusion machines requires flexible operations as a physics research machine. Therefore, we adopted the following principles for LHD central control system design:

(1) Safe and reliable distributed processing for machine operations,
(2) Flexible and centralized operation for experiments, and
(3) Standardization and flexible design using open system.

The LHD machine operation (Fig.1) is divided into three modes; shut-down mode, facility operation mode and experiment mode. The experiment mode consists of the SC (superconducting) magnet operation mode and the plasma experiment mode. These modes are defined for clarifying the personnel entrance permission, magnetic field hazard and possible radiation exposure. Besides the slow software interlock, the hardwired interlock logic should be determined independent of these modes. The SC magnet will be operated for about 10 hours per day, and the number of short-pulsed plasma operations with 10 second duration will be typically 50 - 100 shots per day. Different from the present conventional pulsed fusion machines, the LHD is going to be operated in steady state (more than 1 hour pulse length) and requires interactive control of the machine and the plasma. The electromagnetic sensors for the long-pulsed control are required, which is different from the control concept of present conventional fusion devices.

On the basis of the above-stated operation scenarios, the designed control system is composed of the central experimental control system to arrange plasma experiment mode, and several sub-supervisory control systems to arrange operation modes of facilities such as torus machine control, heating machine control, diagnostic control and electric / cooling utility control systems. All sub-supervisory systems are connected by the Ethernet-LAN(local area network). The data acquisition system with conventional CAMAC modules with our specially developed softwares and the large super-computer system for theoretical analyses using experimental data are connected to the experimental control computer by the inter-laboratory backbone FDDI-LAN.

The feedback control for plasma current, position and cross-sectional shape will be carried out using intelligent control systems, such as applications of fuzzy logic and neural networks in addition to standard PID algorithm.

As a R&D program for this LHD control system, a new simulation system is made consisting of UNIX-EWS (Sun Sparc Station), Ethernet-LAN, VME multiprocessors (CPU 68030) with VxWorks real-time OS (tentatively PDOS is used), simulation power supplies and plasma-coil system (Fig.2). For quick and accurate control response, a DSP(digital signal processor) board was installed and the fuzzy logic plasma control algorithm [3] in addition to a PID controller is tried for the demonstration of the plasma control and display. This R&D program will help the design and construction of LHD central control facilities.

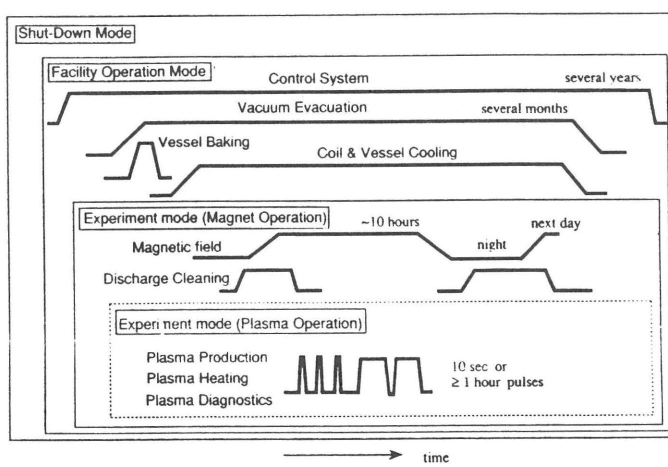

Fig. 1 LHD Operation Scenario

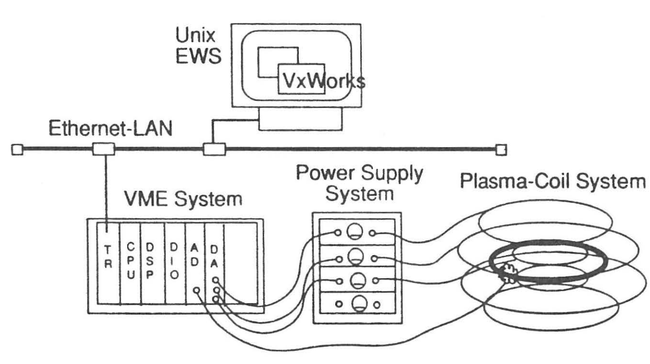

Fig. 2 R&D system for LHD Plasma Control

Reference

[1] K.Yamazaki et al., Proc. Int. Conf. on Accelerator and Large Experimental Physics Control Systems (October 12-18,1993,Berlin, Germany)