§35. Real-Time Plasma Control System for LHD

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Key issues of the LHD project are a demonstration of currentless steady-state plasma operation and achievement of reactor-relevant plasma parameters. To achieve steady-state operation, real-time plasma control (RTPC) is one of the most essential techniques.

Plasma parameters controlled by the RTPC system are plasma density, ion and electron temperature, plasma current, cross-sectional shape, position of plasma boundary and magnetic axis, and wall loading. Externally controllable parameters are a gas puffing rate, the number and the repetition time of injecting pellets, heating power of ECH, NBI and ICRF, and a combination of coil currents (one pair of helical coil currents and three pairs of poloidal coil currents). Each device forms an individual system called sub-system. They are controlled and operated by their own control computers. The role of the RTPC computer is analyzing data (plasma parameters) sent from the data acquisition computers and sending the control parameters, such as the fueling rate, coil currents, heating powers and so on, to the computers of the sub-systems through the local network. Conceptual diagram of the RTPC system is shown in Fig.1. To get good control performance, this RTPC system is required a good time response, flexibility and easiness of extension of the input and output parameters.

There are two main candidates for a control algorithm. One is a standard PID algorithm and the other is a fuzzy algorithm. PID algorithm has been used generally in feedback control systems. A fuzzy algorithm has been used in the disruption control system at high beta region in TFTR.

Plasma current, cross-sectional shape, position of plasma boundary and magnetic axis are controlled by a combination of coil currents. Figure 2 shows a concept of a coil currents feedback system. Input parameters are toroidal field B_0, plasma current I_p, plasma position Δ and an ellipticity κ of a plasma cross-section. Coil currents are controlled without changes in plasma position and its cross-sectional shape.

This plasma currents control program of the RTPC system are being prepared to apply the first stage of the LHD experiments.

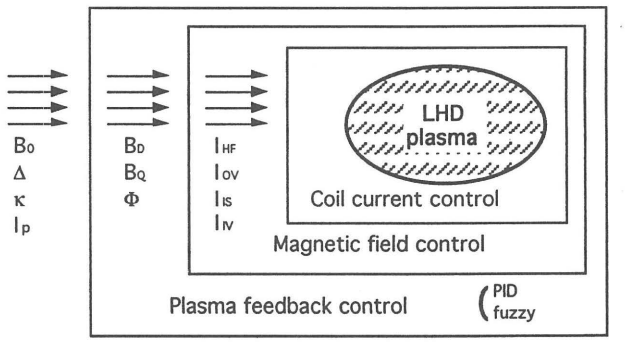

Fig. 2. Concept of a coil currents feedback system.

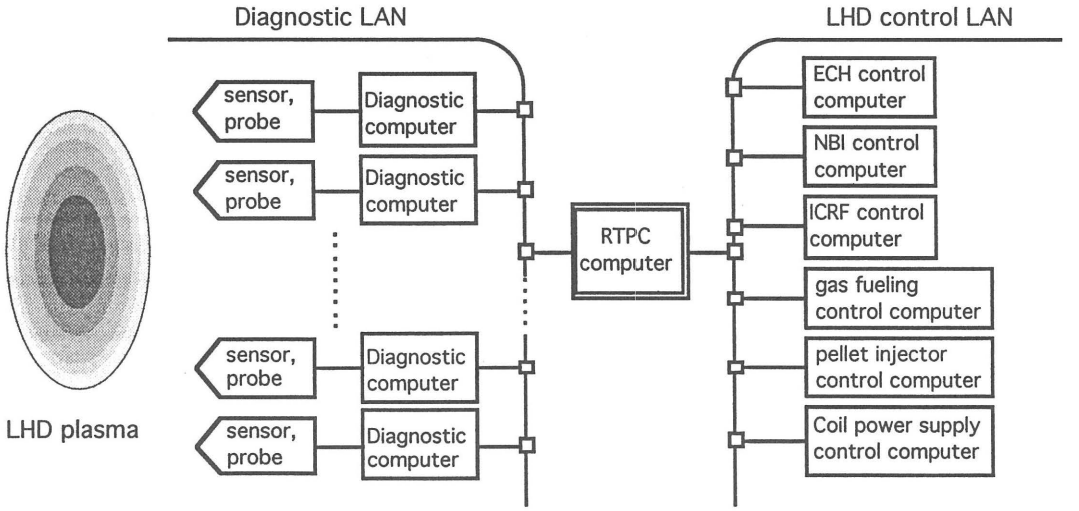

Fig.1. Conceptual diagrm of the Real-Time Plasma Control system.