§14. Coil Excitation Test Using the Real-Time Plasma Control System

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The real-time plasma current control (RCC) system was designed and constructed as the first step of the real-time plasma control system. The main computer of this system is a standard DOS/V machine, which operating system is Windows-NT. This computer is linked to the LHD power-supply (PS) control computer through the reflective memory (RFM). The measured plasma current is inputted to the digital signal processor (DSP) through an analog digital converter (A/DC). The digital input and output (DI and DO) are used for the communication of the timing signal and the statements of the RCC system with the central control system computer. The Coil currents for the plasma current control are calculated using the standard proportional-integral (PI) control algorithm in the DSP and sent to the RFM with 100msec cycle (max. 20msec). The control priority is back to the PS system for the safety when any abnormal state is detected. During the third experimental campaign, this RCC system was tested using the LHD PS system.

Figure 1 shows the block diagram of the RCC system. During standard operations, the PS control system uses current references calculated by the PS computer. When the control priority of the power supply is switched to the RCC system, a switch (SW in Fig. 1) is turned to the RCCS side and control of the PS is carried out using current references calculated by the RCC computer. For the check of the controllability of the RCC system, simulation program is coded according to the block diagram in Fig. 1. For the electrical matrix calculation, the LHD system is assumed to consist of 10 electrical filament parts; six for coils, three for supporting structure and one for plasma. The dispersion model of 20msec period, which is same as the control cycle of the PS system, is used for this simulation. Standard proportional (P) control with 20msec cycle is used for the PS control system and proportional-integral PI control with 100msec cycle is used for the plasma current control system.

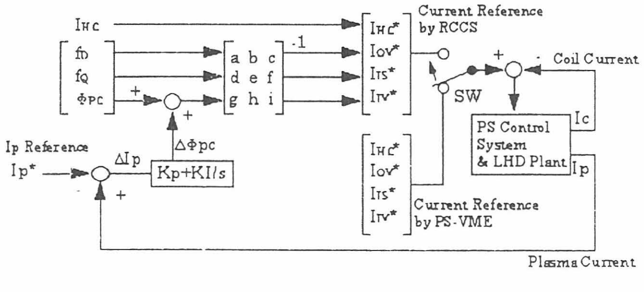

Fig. 1. Block diagram of the coil current control system.

The coil excitation test with the RCC system was carried out at 0.1T and 1.5T during the third cycle experimental campaign. Before these experiments, all interlock and security systems were checked using the quasi-interlock signals and the normal operations of them were confirmed. Switching operation of control priority between the PS system and the RCC system was also confirmed at the coil exciting condition.

In the first stage of these experiments, all coils were excited with the same current ratio to keep the same magnetic field structure. In the next stage, the IV coil current was increased and decreased with the changing rate of 10A/sec, 20A/sec and 40A/sec to change the inter-linkage flux for plasma. As the IV coil is located inside of torus, the influences of the IV coil current on the magnetic field configuration and the LHD cryogenic system are expected to be smaller than those of other coil currents. And single coil usage is useful to check the system reliability and makes the analysis easy. Therefore, only IV coil is used in the first experiment of plasma current. Figure 2 shows experimental result of IV coil current swing at 1.5T. The changing rates of the IV coil current are 10A/sec., 20A/sec. and 40A/sec. as shown in Fig.2. Although the reference current is set every 100msec, the IV current is controlled smoothly. The IV coil current has time delay of about 500msec to the reference current as shown in Fig.2. This time delay is caused by the thick stainless steel structure (vacuum vessel, coil supports and so on) without toroidal breaks and the limited abilities of the coil power supplies. These behaviors are reproduced by the simulation program. We are planning the plasma current control experiments with the RCC system in the next experimental campaign.

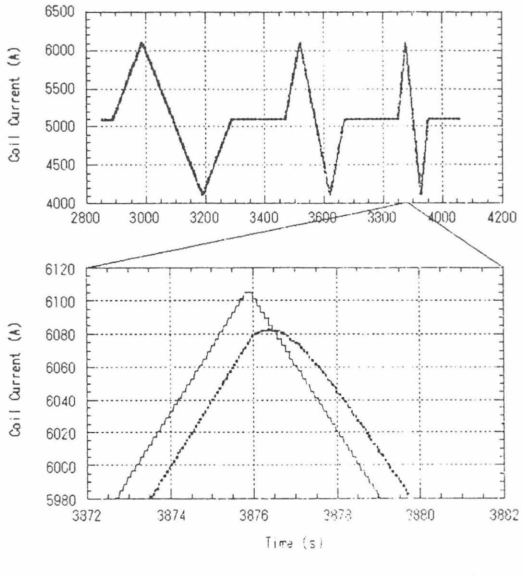

Fig. 2. Experimental result of IV coil current swing at 1.5T.