§56. Real-Time Plasma Current Control Experiments

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The real-time plasma current control (RCC) system that consisted of a personal computer (DOS/V machine), Digital Signal Processor (DSP) and Reflective Memories was constructed and applied to the plasma current control experiments in the 4th campaign of LHD. 1,2) This system worked well in the control cycle of 100 msec. To improve the control cycle, the DSP was replaced with the VME controller. This system is linked to the LHD power-supply (PS) control computer. The measured plasma current I_p is inputted to the VME controller through an analog digital converter (A/DC). The Coil currents for the plasma current control are calculated using the standard proportional-integral control algorithm in the VME controller and sent to the RFM with 20msec cycle. During the 5th experimental campaign, this RCC system was used for the real-time feedback control of the plasma current.

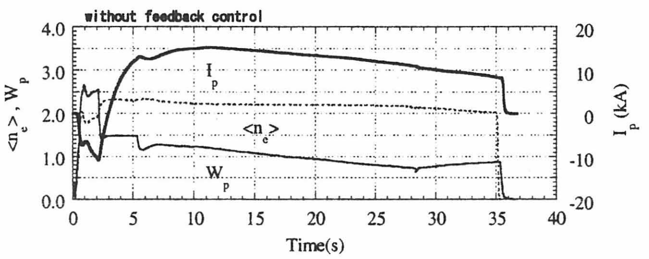

Fig. 1. Time evolutions of $<n_e>(10^{19}m^{-3})$, W_p (100kJ) and I_p without real-time plasma current control.

The real-time plasma current control experiments using the RCC system have been carried out at 1.5T during the 5th cycle experimental campaign. Figure 1 shows the time evolutions of a line averaged electron density $<n_e>$, a plasma stored energy W_p, and a plasma current I_p. Plasma current I_p shown here is calculated one after shot taking account off-set (zero shift) and thermal drift of signal. Plasma was produced by three Neutral Beam Injections (NBIs) and sustained by one NBI (co-injection). The electron density $<n_e>$ was kept about $2.2x10^{19}$ m^{-3} during discharge, and then the stored energy W_p was decreasing gradually. Since plasma current is sensitive to the electron temperature (roughly proportional to $T_e^{1.5}$), plasma current decreases faster than stored energy (W_p). Measured plasma current is mixture of beam driven current and Bootstrap current.

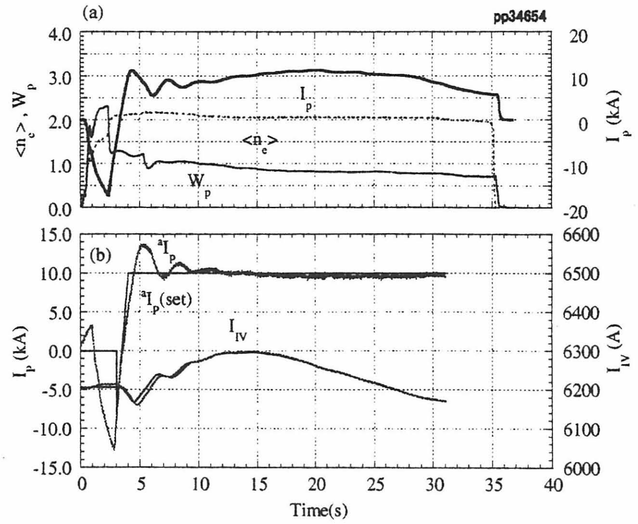

Fig. 2. Time evolutions of plasma parameters in real-time plasma current control shot.
(a) $<n_e>(10^{19}m^{-3})$, W_p (100kJ) and I_p,
(b) ^aI_p, target current ^aI_p (set) and IV coil current I_{IV}.

The control of the plasma current is carried out by ohmic current, which is induced by changing IV coil current. Figure 2 (a) shows the time evolutions of plasma parameters, as same as Fig. 1, and Fig. 2 (b) of inputted analog signal of plasma current ^aI_p, control target current ^aI_p (set) and IV coil current I_{IV}. The control was started at 3 sec and terminated at 30 sec. It takes about 8 seconds that the plasma current ^aI_p converges on the control target current ^aI_p (set) (10kA) as shown in Fig. 2 (b). After that, the plasma current is kept around the target current. Before 10 second, the plasma current tends to exceed 10 kA, as shown in Fig. 1, then the IV coil current increases. After 15 second, the plasma current tends to fall short of 10 kA, then the IV coil current decreases to make opposite directing flux.

The difference of the plasma current between I_p and ^aI_p is caused by the unstable operation of analog integrator. Problems of off-set (zero shift) and thermal drift of signal are not solved completely. Stable integrator is a next important subject.

References

1) Takami, S., Nishimura, K., Chikaraishi, H. et. al., J. Plasma Fusion Res. SERIES, Vol. 3 (2000) 513.
2) Nishimura, K., Takami, S., Chikaraishi, H. et. al., to be published in J. Plasma Fusion Res. SERIES, Vol. 5 (2002).