§6. Advanced Current Control Scheme Using H-infinity Design for LHD Superconducting Coils

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In these years, some basic control schemes for the LHD power supplies have been designed and operated. For some plasma operations, the experimental group requires more precise control and robust schemes, and some advanced control schemes were designed, installed and tested. In the controller design, the information of plasma current I_p was used directly but the signal of plasma current becomes too large when the plasma current shut down suddenly. This over scaled signal disturbs the control system. Therefore the non-linear LPF (Low Pass Filter) to clip the signal has been installed and tested.

Figure 1 and Figure 2 show the control diagram of $H\infty(1)$ and (2) controllers with the non-linear LPF, which keep coil current or magnetic flux constant while the plasma experiment, respectively.

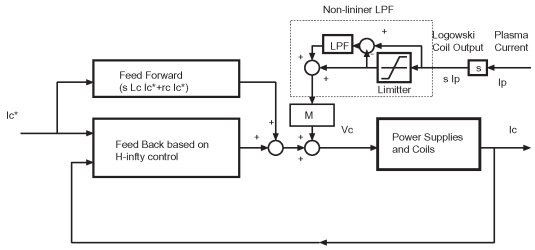

Figure 1: Block diagram of $H\infty$ (1) controller, which keeps coil current constant while plasma experiment.

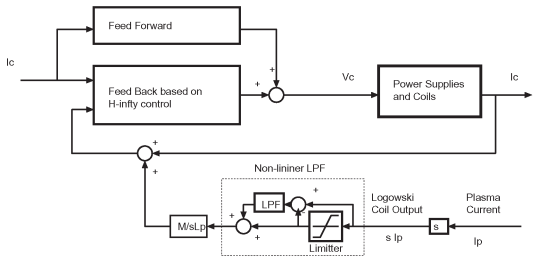

Figure 2: Block diagram of $H\infty$ (2) controller, which keeps interlinked magnetic flux constant while plasma experiment.

Figure 3 shows the reaction caused by a plasma current with the $H\infty(1)$ which uses non-liner LPF. The non-liner LPF clips the peak of sIp, which means $\frac{dI_p}{dt}$ signal and limits the signal in the operation range. Therefore the coil currents and terminal voltages are not disturbed so largely when plasma discharge is finished. In Figure 4, the HI coil current drifts while plasma discharges because the $H\infty(2)$ control scheme has an integrator to observe the plasma current. The offset voltage of the non-linear LPF causes a drift. Therefore, the long-term operation using this control scheme is difficult with above reason. However, as the control system has ability to swap the current control scheme and usual plasma experiments are shorter than 30 s, this scheme can be applied to plasma experiments.

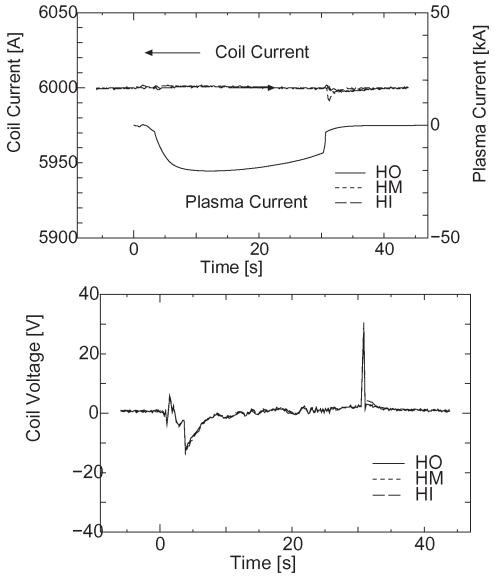

Figure 3: Reaction caused by plasma current, when $H\infty(1)$ control is applied.

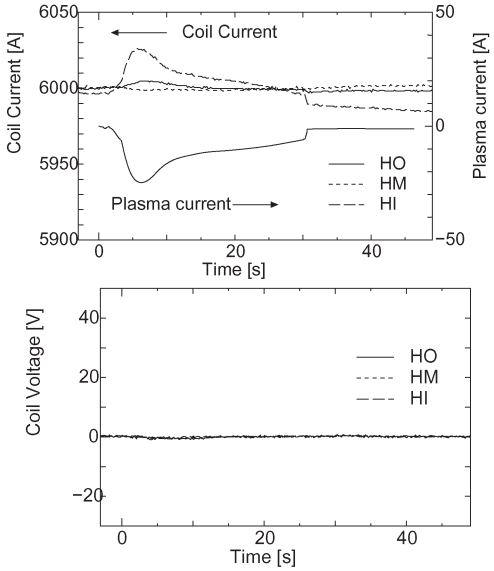

Figure 4: Reaction caused by plasma current, when $H\infty(2)$ control is applied.