§18. Antenna Feedback System for Electron Cyclotron Heating in LHD

Nishiura, M., Kubo, S., Okada, K., Mizuno, Y., Ogawa, H., Yokota, M., Ito, Y., Ogasawara, S., Shimozuma, T., Yoshimura, Y., Igami, H., Takahashi, H., Ito, S., Kobayashi, S., Mutoh, T.

Electron cyclotron heating (ECH), electron current drive (ECCD), and electron Bernstein wave (EBW) heating are essential not only to heat plasmas, but also to control plasma confinement and suppress plasma instabilities. In such plasma experiments, the existing ECH antenna system is not possible for controlling a heating position actively during discharge. It is desired for controlling it according to the order of plasma response time in a plasma discharge. The existing antenna driver system for the ECH final steering mirror consists mainly of ultrasonic motors and encoders for two axes, optical transmission lines for control signals and encoder values to the PLC, and control software on a personal computer.

Last year we have begun to improve the ECH mirror control system for 1.5L port of the LHD. One major change was the use of AC servo motors instead of ultrasonic motors. The servo motor was connected to the drive shaft where the original ultrasonic motor was attached. Two axes were controlled by the programmable logic controller (PLC), which was located outside the LHD torus hall (temporally B1 level as shown in Fig. 1, and has moved to the gyrotron room). The velocity control method was utilized for 15th cycle of LHD. For faster control, because the PLC scan time, even if within less than 1 ms, was the bottleneck, we changed it into the pulse control method. The absolute position encoders for two axes were used, and the signals were transmitted optically to the PLC based controller. The maximum sweep speed of the antenna using this system achieved about 18 [degrees/s], which was 10 times faster than the previous one as we expected. We also added the synchronization function with a trigger signal. The system has been operated during the collective Thomson scattering experiments for the 15th-16th cycle campaigns of the LHD.

As the next step, we include a feedback function to control plasmas actively. A heating location of an ECH is determined ideally, and is fixed before discharges. The operation is ideally correct. However the heating location has not been possibly optimized yet, because the heating beam might be distorted depending on the plasma parameters and other factors. Therefore we use diagnostic signals related to temperature and density for the judgment of the ECH antenna driving direction, while the motors for x and y axes are driven with monitoring the encoder values. The conceptual diagram is shown in Fig. 2. To realize these features, the design stage for a board of a field-programmable gate array (FPGA) has been completed.

After the production of the FPGA board, and testing this system by a mock up, we would install it into the LHD-ECH system.

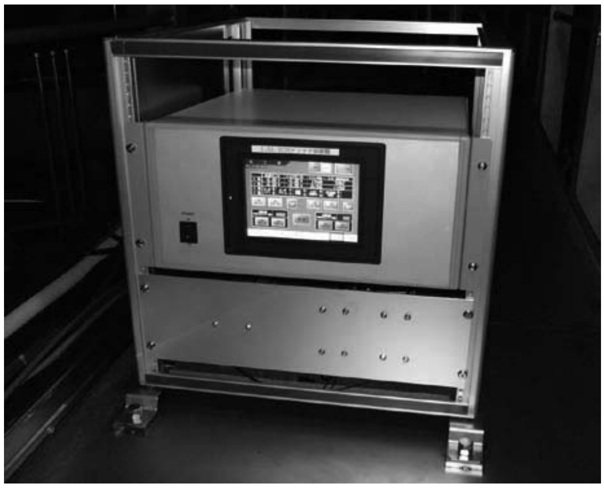

Fig. 1 PLC based control system for the 1.5L-ECH antenna.

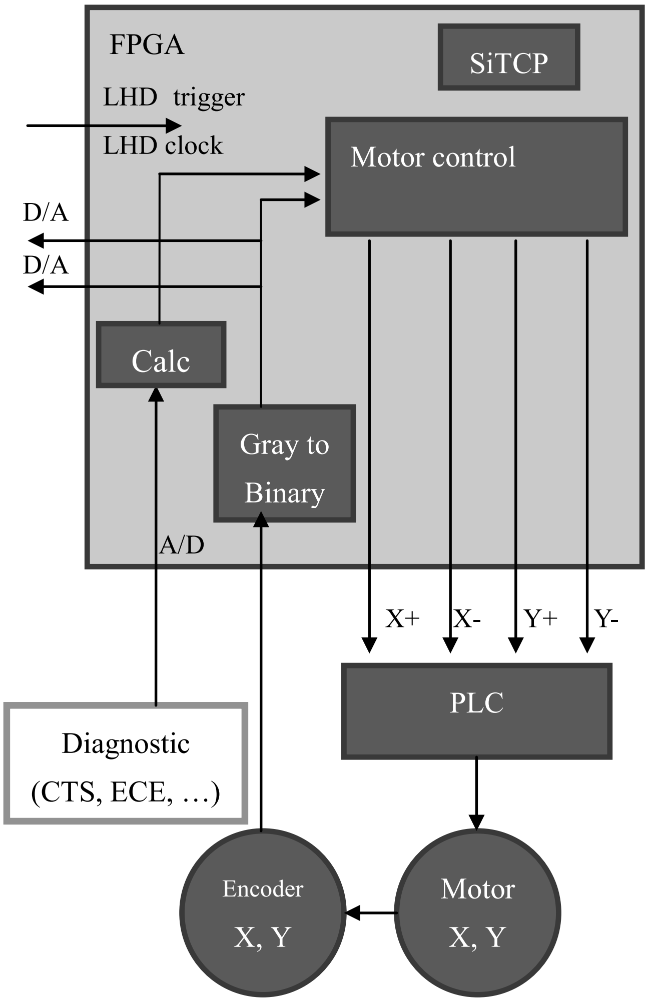

Fig. 2 Conceptual diagram of antenna feedback system for ECH/ECCD.