§20. Fast Scanning Antenna System and Antenna Alignment for Electron Cyclotron Heating in LHD

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

Electron cyclotron heating is 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 and suitable for controlling a heating location actively according to the order of plasma response time during a plasma discharge. The existing antenna driver system for the ECH final steering mirror consists mainly of ultra-sonic motors and encoders for XY axes, optical transmission lines for control signals and encoder values to the PLC, and control software on a personal computer.

As the first step, we have begun to improve the scanning speed of the final mirror of the antenna, where it determines the injected direction of EC wave. The target is that the maximum sweep speed of the final mirror is 10 times faster than the existing one. Therefore we chose an AC servo motor instead of an ultrasonic motor. But for the protection of mechanical parts inside the vacuum vessel, the motor torque is well controlled not to exceed that of the ultrasonic motor. Fig. 1 shows the improved mechanical part of the antenna system at 1.5L port of LHD. It is controlled by the PLC based controller, which is located outside the LHD torus hall (temporally B1 level as shown in Fig. 2, and has moved to the gyrotron room).

After the installation of the control system, we have carried out the antenna alignment of 1.5L transmission line using the laser beam, which is inserted in between transmission waveguide. The laser spot on the final mirror is well aligned on the final mirror in the vacuum vessel in Fig. 3. There is no clear change before and after the installation. It is found that the discrepancy in location between the laser alignment and the numerical calculation was $\delta R < 20$ mm in radial direction and $\delta T < 20$ mm in toroidal direction at most.

The maximum sweep speed of the antenna using this system achieves about 8 [degree/s], which is 10 times faster than the previous one as we expected. We added the synchronization function with a trigger signal. The system can be operated during the collective Thomson scattering experiments throughout the 15th cycle campaign of LHD as a cold test. For the next step, we will include a feedback function to control dynamic plasmas by Field-Programmable Gate Array (FPGA).

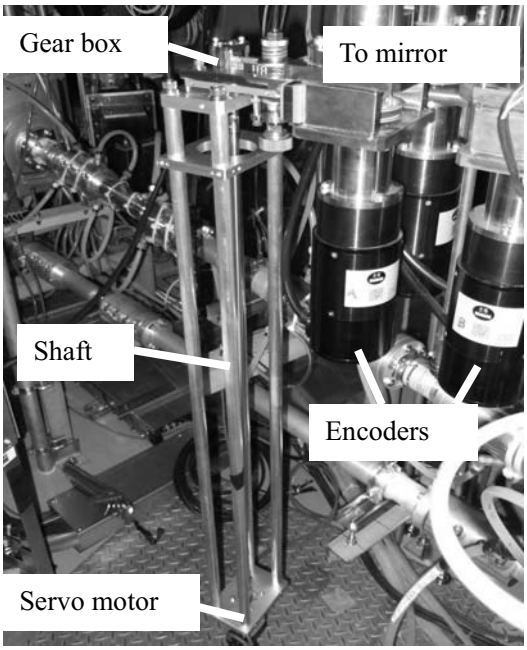

Fig. 1. Antenna driver system was installed at 1.5L port of LHD. Mechanical parts with AC servo motors (photo is one of them) for two axes were assembled and connected to the 1.5L-ECH antenna system instead of the existing ultrasonic motors.

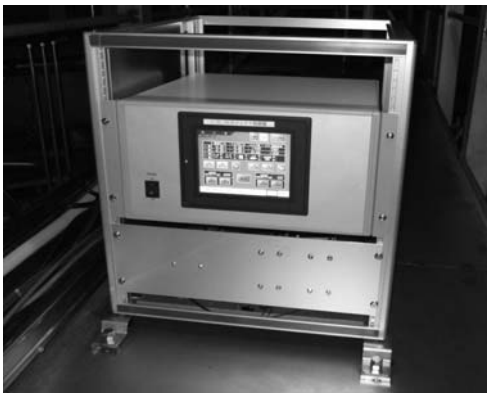

Fig. 2 PLC based control board for the 1.5L-ECH antenna.

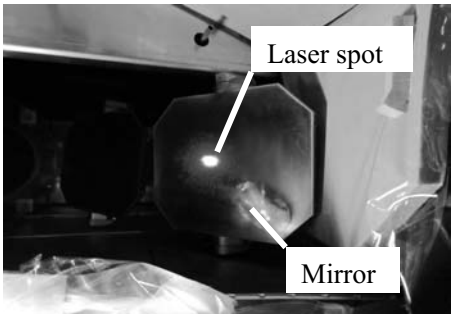

Fig. 3 Final mirror of the 1.5L-ECH antenna. The laser spot is seen in the final mirror center. The beam is directed to the target plate located at the major radius of 3.5 - 3.9 m.