§8. Optimized Injection of High Power ECH Beam by Feedback Control in LHD

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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 response time of plasma in a 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. The system was replaced to servo motors controlled by PLC and FPGA. Fig. 1 shows the FPGA board which was newly developed to carry out the signal processing for feedback control[1]. The new developed system improves the scan time of the mirror angle that is roughly 10 times faster than the previous system. The new system is equipped with an external trigger input to synchronize a timing of LHD events.

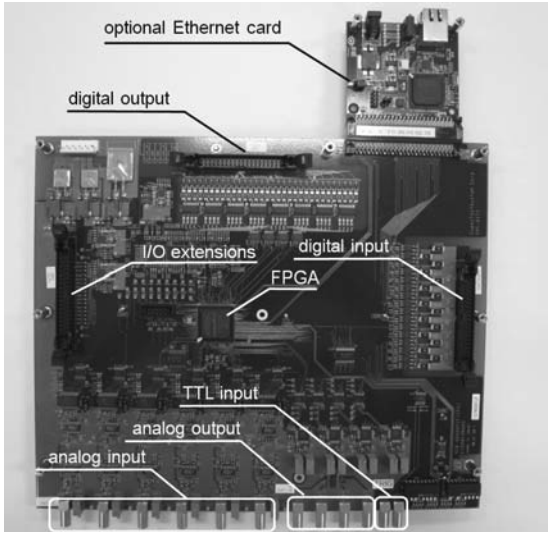

Fig. 1 FPGA board with various I/O channels and optional Ethernet card.

Before the 18th LHD experimental campaign, the new control system was tested in the mirror control for the collective Thomson scattering (CTS) diagnostic to have a reliability. Fig. 2 shows the encoder positions and the ECE radiations in LHD shots with and without feedback position control of ECH. The reference signal for the feedback control is taken from the ECE radiation measured by the CTS receiver at 1.5L-ECH antenna. The ECH beam is injected from the 2O-R antenna with 800 kW. The ECE radiation increases by the feedback control. However no clear difference in the Te profile of Thomson scattering diagnostic between two shots is not observed. We found that the electron density stability is significant for this experiment. Further precise position control will be studied for efficient ECH.

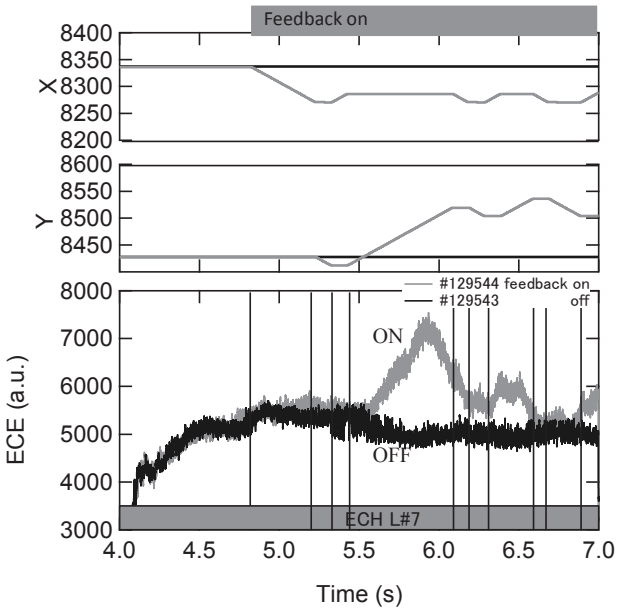

Fig. 2 ECH heating position feedback. (a)XY encoder values, (b)ECE signals with feedback ON and OFF.

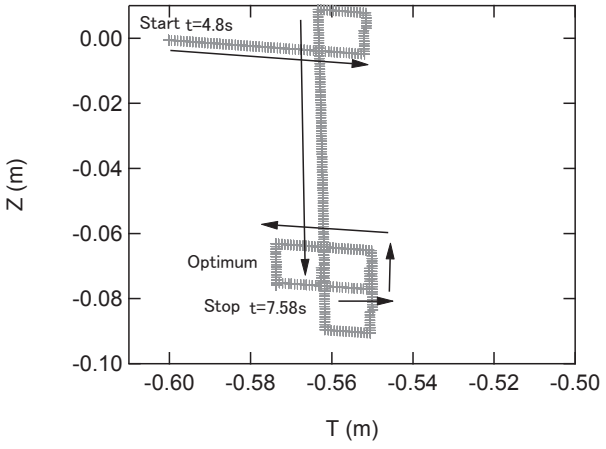

Fig. 3 The antenna position projected onto the TZ plane at R=3.9m for LHD#129544.

1) Okada, K., Nishiura, M., Kubo, S., Shimozuma, T., Yoshimura, Y., Igami, H., Takahashi, H., Tanaka, K., Kobayashi, S., Ito, S., Mizuno, Y., Ogasawara, S., Rev. Sci. Instrum. **85** (2014) 11E811.