§8. Development of Power/polarization Monitor for ECRH on LHD

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Measurements of the power/polarization states of EC waves are important for optimization of electron cyclotron resonance heating (ECRH). Polarization states of EC waves significantly affect the mode excitation purity and the power absorption in plasmas. EC waves are coupled to extraordinary waves or ordinary waves at the boundary between plasmas and vacuum. A monitor of power and polarization states of EC waves is under development to be installed on a miter-bend, which is a part of transmission lines of EC waves, on the Large Helical Device (LHD). The monitor can measure amplitudes and phase difference of the electric field of the two orthogonal polarizations which is needed for calculation of the power and polarization states of electromagnetic waves.

Figure 1 shows a diagram of the power/polarization monitor. The monitor is composed of bi-linear polarization directional coupler and heterodyne interferometer. The bi-linear polarization directional coupler is composed of square waveguide set in a miter bend mirror with a row of coupling holes to pick-up both orthogonal polarizations simultaneously injected to the miter bend. Only TE_{01} and TE_{10} mode waves can pass through the sub-waveguide. The EC waves are separated to two orthogonal polarizations by an orthogonal transducer. Both polarization components are down converted to a few hundreds MHz intermediate frequency (IF) by utilizing harmonic mixers and voltage controlled oscillator (VCO) as a local oscillator. The IF signals of the two orthogonal polarizations are acquired directly by a fast ADC using FPGA (Field Programmable Gate Array), with sampling rate of 800 MHz.

The power/polarization monitor was installed at a miter bend in 77 GHz ECRH transmission line. 759 kW 77 GHz EC waves were injected in the ECRH transmission line. Figure 2 shows temporal evolution of frequency responses of (a) amplitudes and (b) phase difference measured by the power/polarization monitor. Gyrotron frequency shifts 50 MHz during first 700 ms. Even with this frequency shift phase difference between bi-linear polarization is kept constant. Polarization scan experiments were also performed. 210kW 77 GHz EC waves were injected in the ECRH transmission line. Grating polarizers were rotated to sweep polarization states. Figure 3 shows polarization dependences of amplitudes and phase difference of the electric field of two orthogonal waves. The power and phase differences of two orthogonal polarizations were successfully detected simultaneously. The calibration of signal amplitudes, phase offset caused by optical path difference and the reference axis for calculation of the polarization angle α is needed to get the information of the polarization states.

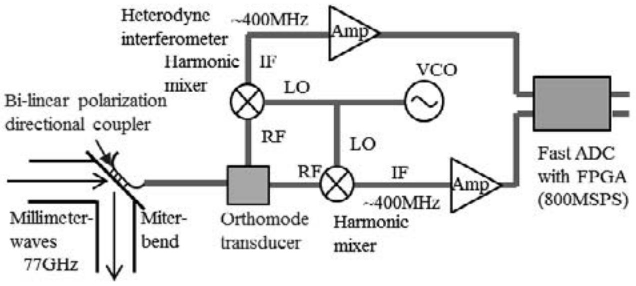

Fig. 1. Schematic of power/polarization monitor for EC waves.

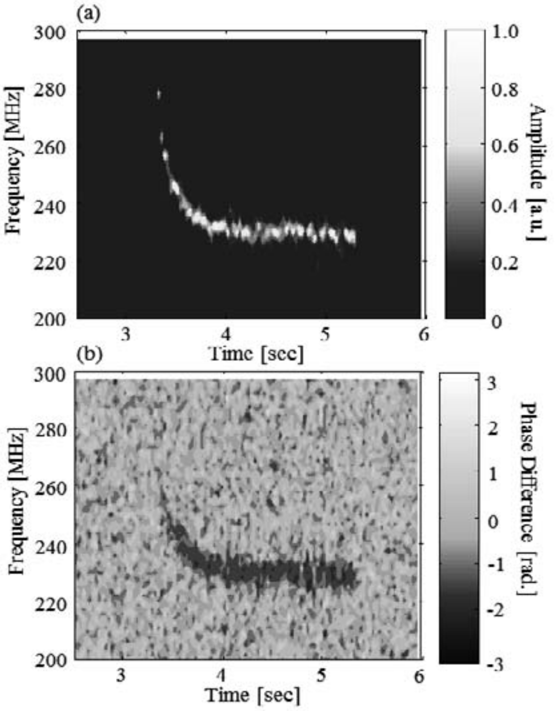

Fig. 2. Temporal evolution of frequency responses of (a) amplitude and (b) phase difference measured by the power/polarization monitor.

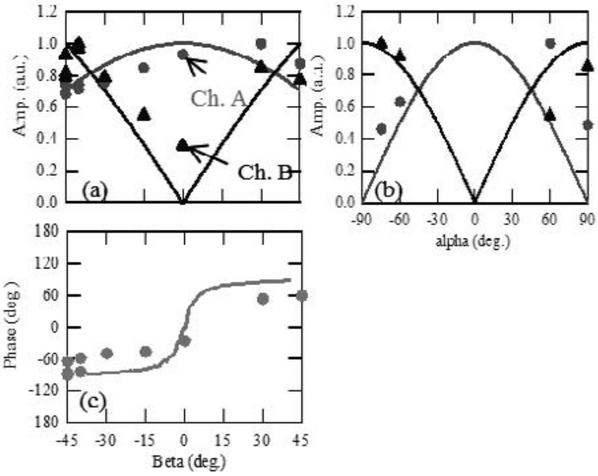

Fig. 3. β dependences of (a) amplitudes and (c) phase difference at $\alpha \sim 0$ degrees. α dependences of (b) amplitudes at $\beta \sim 0$ degrees. Markers and lines show experimental value and theoretical value, respectively.