Development of a microwave AM reflectometer for electron density profile measurement in Heliotron J

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Measurement of electron density profile is one of the important issues for the understanding of plasma confinement. The goal of this study is to develop a microwave reflectometer for Heliotron J and to investigate the particle transport by using the density profile.

The basic design is as follows: the time resolution of the system is less than 1 ms, which is shorter than the typical confinement time of Heliotron J plasma, and the spatial resolution is aimed at 2 mm in the edge region. We adopt an amplitude modulation (AM) system [1] to reduce density fluctuation effects. The X-mode is selected as the propagation mode since it can work even for hollow density profile, which is typically observed in ECH plasmas in helical systems. By using the carrier microwaves of 33-56 GHz (Q-band), it is possible to obtain a density profile over the full range of plasma diameter for low-density plasmas.

The schematic of the designed AM system is as follows. A pulse generator supplies a triangular-wave of 1 kHz to a voltage controlled oscillator (VCO) of 8-14 GHz. The frequency band of 33-56GHz is generated by the VCO and ×4 multiplier. The microwaves are modulated in amplitude by using a PIN modulator. The modulation frequency is 100 MHz. In the receiving system, a low-pass filter is assembled to remove the effect of 70 GHz ECH. A single ended mixer is applied to detect the reflected signal. A phase meter consists of a frequency down-converter (from 100 MHz to 5 MHz) and a phase-detector. The latter also measure the RF signal power to correct the power dependence of the phase comparator.

The characteristic tests of each component and the system have been carried out. The overall performance of the system has been tested by using an aluminum reflection plate instead of plasma. Here the length of the transmission line is changed by moving the plate position in the range of 30 cm at 1 cm intervals. The obtained phase shift after the compensation for the RF signal power dependence well agrees with that expected from the change of the plate position.

A program to reconstruct density profile from the measured phase shift data has been developed. It needs only relative phase shift data. The reconstruction program has been examined by using phase shift data which are calculated from density profile models such as parabolic, flat and hollow profiles. The result confirms that the program works well for all shapes of the density profile model with accuracy of fewer than 5 % at the plasma center region when the edge density is given by other diagnostics such as a Langmuir probe.

[1] J. Sanchez, B. Branas *et al*., Rev. Sci. Instrum. **63** 4654 (1992).