§8. Performance of Remote Steering Antenna in Anti-Symmetric and Symmetric Directions

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A remote steering antenna concept has been proposed and developed for Electron Cyclotron Heating and Current Drive (ECH/ECCD) experiments at the International Thermonuclear Experimental Reactor (ITER). There are two operation modes in a remote steering antenna, anti-symmetric and symmetric modes. The anti-symmetric antenna has been considered as the ITER-antenna, and the symmetric antenna with an extended steering-angle capability was developed and used for the ECH/ECCD experiment in the TRIAM-1M tokamak[1]. The antenna length and the side of squared cross-section determine an operation range in anti-symmetric and symmetric directions. The output beams were calculated with a basis of the imaging property of a square corrugated waveguide[2]. Figure 1 shows the transmission efficiencies as a fundamental mode in the imaging property calculation for various antenna lengths L, when the electric field is perpendicular to the steering x z plane. The remote steering configuration with the co-ordinate system (x y z) is illustrated in Fig.2. A side of the square was fixed at 40mm, and the frequency was 170GHz. The input beam had a wait size w_0 of 14mm at the input aperture. The antenna with L=3.60 m was the normal ITER-type anti-symmetric direction antenna, while the antennae with L= 3.15 m and 3.30 m were two operation region with the high transmission efficiencies in the anti-symmetric and symmetric directions, respectively.

In order to test the antenna performance experimentally at various antenna lengths, low power test facilities to measure both the intensity and phase profiles have been built. Figure 3 shows photographs of the low power test facilities. The facilities had a large moving measurement-stage, and the wide area of 1.6 m × 0.6 m × 6.0 m was able to be scanned in the (x y z) coordinates. The spatial setting resolution was 0.01 mm in the area of 1.6 m × 0.6 m × 0.5 m, which was the order of 1/100 for the wavelength at the frequency. The He-Ne laser was set at the detector stage to align the test components. The intensity measurements have been begun at the low power test facilities. An HE_{11} mode generator, which was composed of a scalar horn antenna and a circular corrugated waveguide, was used to generate a Gaussian beam. The mirror array composed of four quasi-optical mirrors was prepared to modify the beam profiles, and to inject the beam into the antenna with proper input angles. The input angles were able to be set from 0 to 25 degrees. The obtained input beam respectively had the beam sizes of w_x =13.5 mm and w_y =14.2 mm in the x and y directions at the input aperture of the antenna, being similar sizes in the imaging property calculation. In order to test the antenna performance, the phase profile measurement was important as well as the intensity measurement[1]. The phase measurement system will be prepared, and the output beam from the antenna will be analyzed from the measured intensity and phase profiles.

This work was realized in the LHD-project collaboration (NIFS04KOAR005) organized by NIFS.

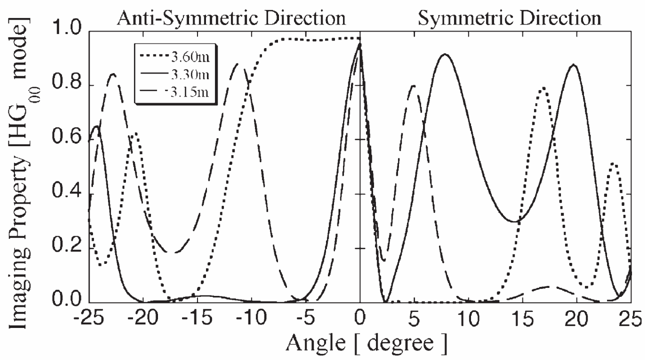

Fig. 1: Imaging property calculation of a fundamental mode as a function of the input angle.

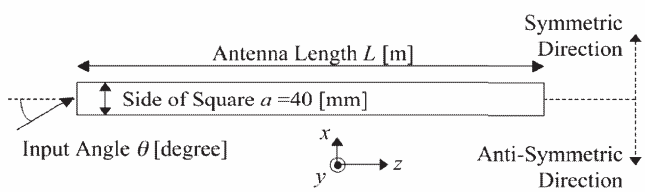

Fig. 2: Illustration of the remote steering configuration.

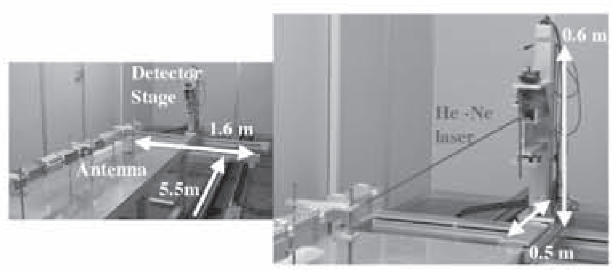

Fig. 3: Photographs of low power test facilities

References

[1] Idei, H., *et al* , Nuclear Fusion, **46**, 489 (2006).
[2] Ohkubo, K., *et al* , Fusion Eng. and Design, **65**, 657 (2003).