ANALYSIS OF OVERSIZED SLIDING WAVEGUIDE BY MODE MATCHING AND MULTI-MODE NETWORK THEORY


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Abstract

Transmission and reflection coefficients of hybrid modes in the sliding waveguide are discussed on the basis of mode matching method and multi-mode network theory. It is confirmed that the decrease in power of < 0.2% at 84 GHz is obtained for 2 cm in gap of the sliding waveguide which is composed of the corrugated waveguide with 88.9 mm$\phi$ and the smooth-wall waveguide with 110 mm$\phi$. At the sliding length near multi-half-wavelength in vacuum, transmission and reflection powers in the sliding waveguide change slightly, because the very small amount of standing wave in high higher-mode is produced resonantly in the gap.

Keywords: mode-matching method, multi-mode network theory, sliding waveguide, corrugated waveguide, coupling, transmission line, electron cyclotron heating

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1 Introduction

There has been considerable interest in plasma production, heating and current drive of fusion-oriented plasmas by high-power electron cyclotron waves in the range of millimeter wave [1-7]. In a real-world-scaled device such as ITER [8], the technical and physical development of electron cyclotron heating is being continued. The electron cyclotron heating system is mainly composed of gyrotrons, oversized transmission lines and antennas. It is well-known that alignment of an oversized waveguide transmission line is important from the viewpoint of transmission efficiency because deformation due to thermal expansion, its own weight or misalignment produces spurious modes. When the injection port of the device for electron cyclotron heating power is completely fixed, no change in transmission length and direction arises. In a super-conducting device, small movement of vacuum vessel during cooling-down phase of coils occurs. In addition, plasma disruption in Tokamaks produces vibration of vacuum vessel. To absorb movement and vibration, waveguide bellows or quasi-optical components are used. Combination of miter-bends with sliding waveguides is able to absorb perpendicular two-dimensional displacement on the waveguide-axis and change in the length. In the large helical device [1], sliding waveguides are installed from the first cooling phase onwards. In this paper, a theoretical analysis of a sliding waveguide is given on the base of the mode-matching method and multi-mode network techniques. Transmission and reflection characteristics including higher-order modes excited in the component and formation of standing wave are described.

2 Theoretical Analysis and Discussion

A sliding waveguide consists of movable and sleeve waveguides as shown in Fig. 1(a). Two corrugated waveguides with the inner diameter $2a = 88.9$ mm are inserted into the smooth-wall waveguide which has an inner diameter of $2b = 110$ mm. The sliding surface is coated