Bandwidth Characteristic of Arbitrarily Trapezoidal Groove Waveguide with Method of Moment

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Abstract **–Using method of moment, the single mode bandwidth properties of arbitrarily trapezoidal groove waveguide is obtained and discussed. There is a minimum of bandwidth along with inclination angle. It is of important values in theoretical studies and practical engineering applications of arbitrarily trapezoidal groove guide for millimeter waves.**

Keywords–**arbitrarily trapezoidal groove guide; bandwidth characteristics; method of moment**

I. Introduction

As one of millimeter wave transmission line, groove guide[1,2] has many advantages such as low loss, little dispersion, wide bandwidth, easy manufacture and so forth, so that it is widely applied to the millimetre wave fields. Trapezoidal groove guide[3,4] is a kind of typical groove guide. So, research of its transmission characteristics is of important meanings. In this paper, the single mode bandwidth properties of trapezoidal groove guide with arbitrary inclination angle are gotten and discussed by using the method of moment(MOM)[5]. It is of important values in engineering design and applications of trapezoidal groove guide.

II. Theory Analysis

The cross section of open trapezoidal groove guide with arbitrary inclination angle α and its geometrical dimensions are shown in Fig.1. Whole groove guide can be divided into central groove region I and parallel plane region II. The Cartesian coordinate system is used. When electromagnetic wave transmits along the longitudinal direction of groove guide, which is z direction, the transverse wave function $\psi(x,y)$ in groove guide satisfies two-dimensional Helmholtz's equation as follows

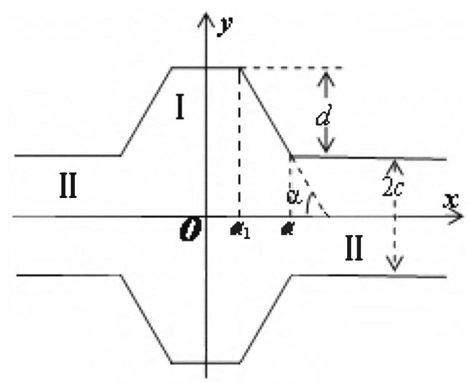

Figure 1: the cross-section of trapezoidal groove guide with arbitrary inclination angle

$$\nabla_T^2\psi(x,y)+k_c^2\psi(x,y)=0. \qquad (1)$$

where ∇_T^2 is transverse Laplacian factor. wave function $\psi(x,y)$ is E_z for TM modes or H_z for TE modes. $k_c^2=k^2-\beta^2$, here k_c is called longitudinal cut-off wavenumber of waveguide , k is wavenumber in the free space and β is phase-shift constant.

On the boundary of the cross-section of the groove guide , Equation (1) satisfies Dirichlet boundary condition for the TM modes or the Neumann boundary condition for the TE modes. ie

$$\begin{cases} \psi = 0 \\ \dfrac{\partial \psi}{\partial n} = 0 \end{cases} \tag{2}$$

On the interface $x=a$, the matching condition between groove region I and parallel plane region II can be described as

$$\begin{cases} \psi_1 = \psi_2 \quad \text{for } |y| \le c \\ \dfrac{\partial \psi_1}{\partial x} = \dfrac{\partial \psi_2}{\partial x} \quad \text{for } |y| \le c \end{cases} \tag{3}$$

Let $L = -\nabla_T^2 = -\dfrac{\partial^2}{\partial x^2} - \dfrac{\partial^2}{\partial y^2}$, $\xi = k_c^2$,

equation (1) can be written as

$$L\psi = \xi\psi \tag{4}$$

The equation (4) is exactly the eigenvalue problem of the MOM. Based on the Galerkin's Method of MOM, considering boundary condition (2) and matching condition (3), the following equation can be obtained

$$|\boldsymbol{A} - \xi\boldsymbol{B}| = 0 \tag{5}$$

Equation (5) is the characteristic equation of trapezoidal groove guide with arbitrary inclination angle and can be solved as general eigenvalue problem.

III. Numerical Results and Discussions

In central groove region I, power function is used as the base function. In parallel plane region II, exponential function, which attenuates along x direction, is used as the base function. According to the above theory analysis, single mode bandwidth characteristic curves of trapezoidal groove guide with

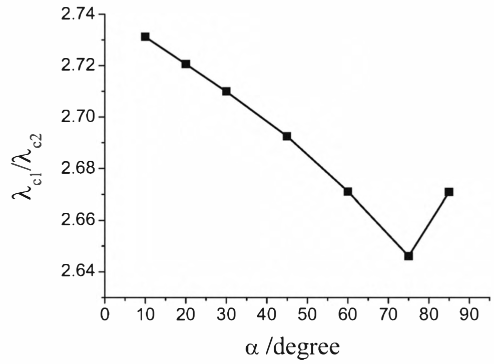

Figure 2: Bandwidth curve of arbitrary trapezoidal groove guide with α

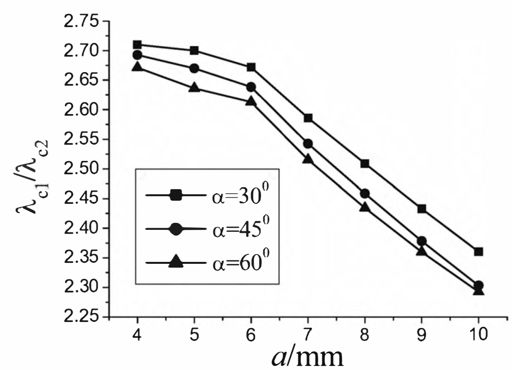

Figure 3: Bandwidth curves of arbitrary trapezoidal groove guide with a and α

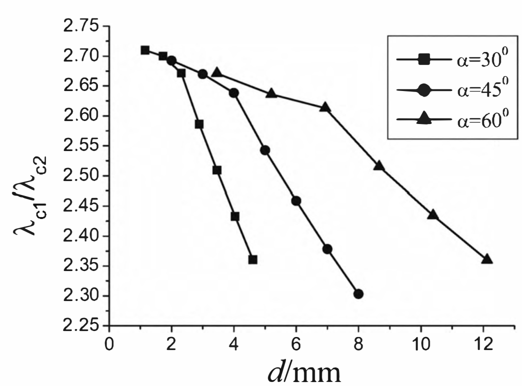

Figure 4: Bandwidth curves of arbitrary trapezoidal groove guide with d and α

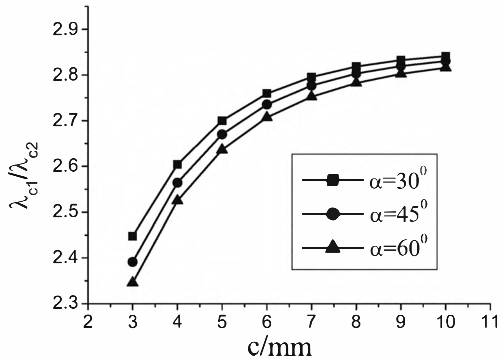

Figure 5: Bandwidth curves of arbitrary trapezoidal groove guide with c and α

arbitrary inclination angle α can be gotten and shown in Fig.2-Fig.5.

It can be seen from Fig.2 that there is a minimum of bandwidth along with α . As can be seen in Fig.3-5 that $\lambda_{c1}/\lambda_{c2}$ decreases when increasing the parameter a and d, while it increases as c increasing . Another feature is noted that the smaller α is, the more rapidly $\lambda_{c1}/\lambda_{c2}$ decreases when increasing d.

IV. Conclusions

Using the method of moment, the arbitrarily trapezoidal groove guide is studied. And the single mode bandwidth characteristics is gotten and discussed. The numerical results show that the single mode bandwidth of this kind of groove guide decreases when increasing the parameter a and d, while it increases as c increasing. And there is a minimum along with α .Another feature is noted that the smaller α is, the more rapidly $\lambda_{c1}/\lambda_{c2}$ decreases when increasing d. The obtained results are of important application values in analyzing and designing the groove guides performances in practical engineering problems.

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