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Research Paper

Studies on Dielectric Loaded Slot Coupled Waveguide H-Plane Tee Junctions

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ABSTRACT:- Arrays of slot radiators are used to increase directivity. Orientation of slot in the narrow wall of the rectangular waveguide can be vertical, inclined or longitudinal as vertical slots could not radiate, marginally inclined slots from the broadside are used which produce horizontally polarized fields..But these small inclinations develop cross polarized components creating EMI problems.

Work on dielectric loaded slots is not considered for this analysis in the literature. It is therefore of interest to investigate such slots in order to control impedance loading, coupling and VSWR. The data presented in this paper is extremely useful for array designers to design small and large arrays. The analysis in this work involves the use of the concept of self- reaction, discontinuity in modal current, coupling and VSWR.

Keywords:- *Slot coupled waveguide junctions, Waveguide slots, Dielectric loading*

I. INTRODUCTION

It is evident from the open literature [1-5] that the overall admittance characteristics of waveguide junction radiators can be controlled by introducing dielectric loading. In this chapter, it is of interest to present detailed studies on the variation of equivalent network parameter, coupling and VSWR when different dielectric slabs are present.

The present data is useful for the design of array of such slots. In fact Dielectric loading would serve as an additional parameter for the design of junction coupled slot arrays. The slots considered in the present case are extremely useful for high power applications.

The slots which are entirely in the narrow wall having resonant length for a given inclination are only considered in order to make them suitable for planar arrays.

The computed data on the variation of normalized conductance and susceptance as a function of frequency for higher slot inclinations with different dielectric loading considering the feed and coupled guides are presented. The results are presented.

II. FORMULATION

The Tee junction of present interest is shown in Fig. 1. The geometry and co-ordinate system for the slot is also shown in the same figure. The electric field in the aperture plane of the slot is replaced by an equivalent magnetic current, $I_{dm.}$

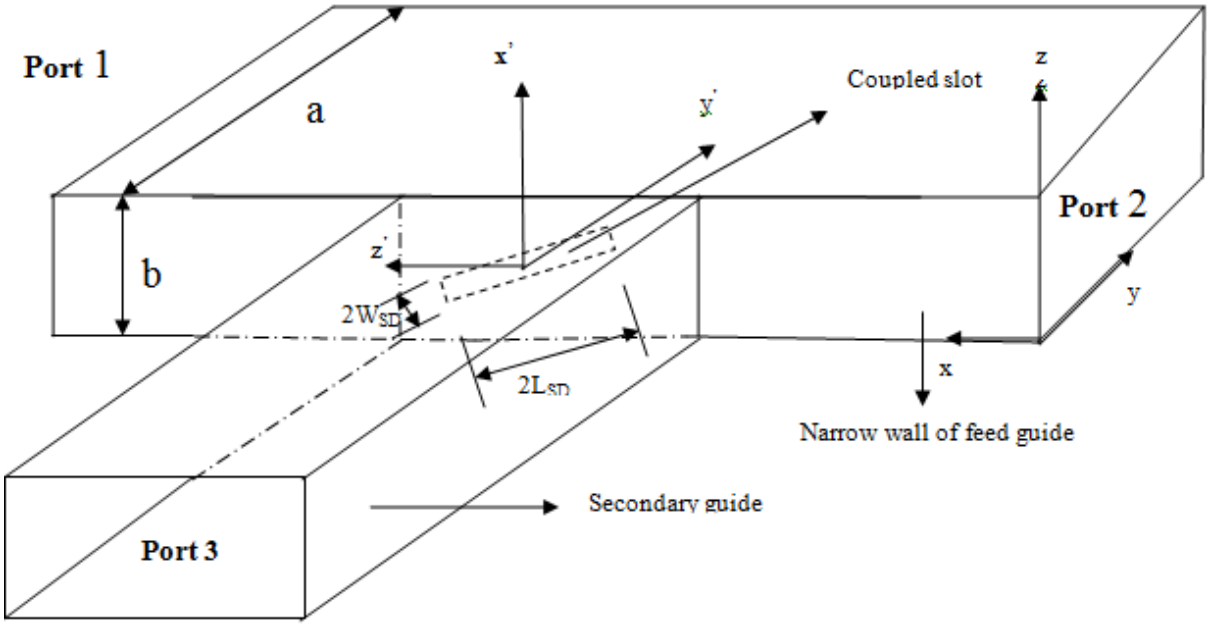

Fig 1. Inclined slot in the narrow wall of a rectangular waveguide Tee junction

The Expression for self-reaction is of the form

$$\langle s, s\rangle_{fc} = -\iiint H_{SD} \cdot M_{SD} dv \qquad (1)$$

The electric field distribution $\overline{E}_{SD}$ in the aperture plane of the slot is related to the equivalent magnetic current $\overline{M}_{SD}$ by the relation.

$$\overline{M}_{SD} = \overline{E}_{SD} \times \overline{U}_n \qquad (2)$$

Since the magnetic current is distributed over the surface, the volume integral appearing in the expression of self-reaction (2) is reduced to a surface integral.

Taking the effect of image in the wall y=b into account, the expression for the self-reaction takes the form,

$$\langle s,s\rangle_f = -\int_s \overline{H}_{SD} \cdot 2\overline{M}_{SD} ds \qquad (3)$$

The modified expression for self-reaction in guide 2 considering the effect of dielectric loading is obtained as

$$\langle s,s\rangle_c = \sum_m^\infty \sum_n^\infty 2\gamma_{mn} \sqrt{K} \left(L^2\right) \left[\frac{SinF_2}{F_2}\right]^2 M^2 Sin^2\left(\frac{m\pi}{2}\right) \left[Cos(abF)^2\right] (CosN)^2 (X)$$

$$K = \frac{ab}{(ma)^2 + (nb)^2}$$

$$L = \frac{E_m W_{SD}}{\pi}$$

$$F_2 = \frac{n\pi W_{SD}}{a}$$

$$M = \frac{2K_{r2}}{K_{r2} - \left(\frac{m\pi}{b}\right)^2}$$

$$F = \frac{n\pi}{ab}$$

$$N = K_{r2} L_{sd} - Cos\frac{m\pi}{b} L_{SD}$$

$$X = \left[\frac{\varepsilon_m \varepsilon_n}{j\omega\mu_0} \left(\frac{n\pi}{b} \right)^2 + \frac{4 j\omega\varepsilon_0}{\gamma_{mn}^2} \left(\frac{n\pi}{a} \right)^2 \right]$$

$K_{r2} = \frac{2\pi}{\lambda}\sqrt{\varepsilon_{r2}}$, ε_{r2} is the dielectric constant in the coupled or secondary guide.

2.1 EXPRESSION FOR DISCONTINUITY IN MODAL CURRENT

The expression for the discontinuity in modal current I_{dm} given by [1] is modified taking the dielectric loaded slot in the narrow wall into account and is expressed as

$$I_{dm} = E_{\max} K_{r1} \left[\frac{A'}{B'} \right] \left[CosC' - CosD' \right] \left[\frac{SinW_{SD} X'}{W_{SD} Y'} \right]$$

$$A' = \frac{1}{\mu_0 fc}\sqrt{\frac{2}{ab}}$$

$$B' = K_r^2 - (\beta_{01} Sin\theta)^2$$

$$C' = \beta_{01r} L_{SD} Sin\theta$$

$$D' = K_{r1} L_{SD}$$

$$X' = \beta_{01r} Sin\theta$$

$$Y' = \beta_{01r} Sin\theta$$

θ is the angle inclination of the slot and $\beta_{01r} = \left[K_{r1} - \left(\frac{\pi}{b} \right)^2 \right]^{\frac{1}{2}}$

III. RESULTS AND CONCLUSIONS

Using the above expressions, computations are made to obtain the resonant length of dielectric loaded inclined slot in the narrow wall of a rectangular waveguide for each relative permittivity value and using the corresponding resonant length and the same expressions, normalized admittance are numerically computed. In the present case computation has been done with variation in dielectric loading in the feed(waveguide 1) From the computed results, variations of normalised conductance and susceptance as a function of frequency for a resonant slot lengths , dielectric constants of 2.3 slot widths of 0.1 cm for slot inclinations of 70^0 are presented in fig.2 to fig.3.

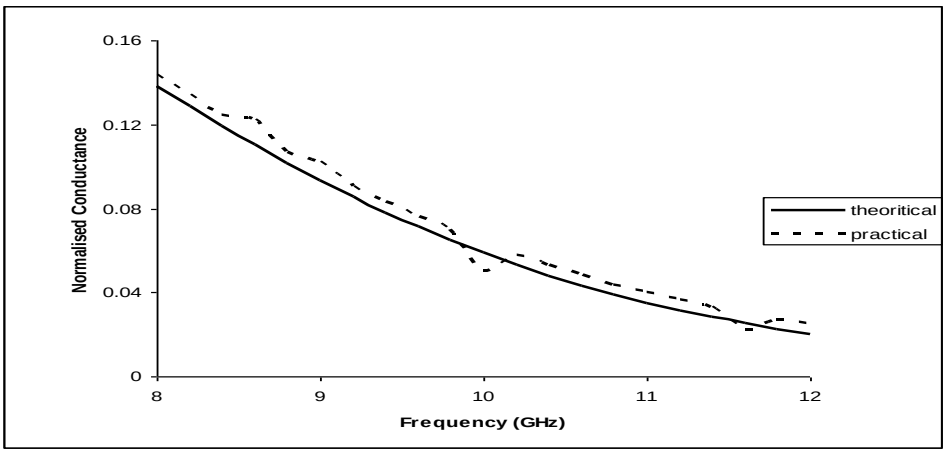

Fig 2. Conductance with frequency for slotwidth = 0.1 cm, slot inclination = 70^0

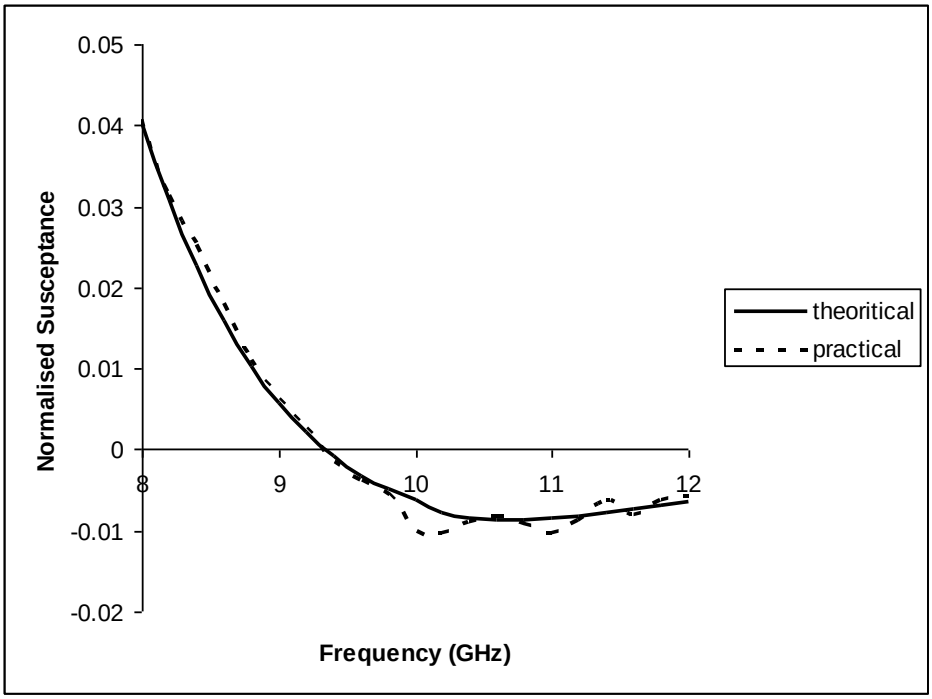

Fig 3 Susceptance with frequency for slotwidth = 0.1 cm, slot inclination = 70^0

From the investigation carried out in this work the experimental results are in agreement with the validity of the theoretical analysis. Teflon loaded guides exhibit higher admittance values whereas the waveguides loaded with higher dielectric constant, It is evident from the results that dielectric loading has considerable effect on the variation of admittance parameter and can be used as an additional parameter for the design of slot coupled H-plane Tee junction arrays.

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