ANALYSIS OF AN ARBITRARILY LOCATED AND ARBITRARILY POLARIZED THICK RECTANGULAR RADIATING WINDOW USING MULTIPLE CAVITY MODELING TECHNIQUE

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ABSTRACT

In this paper a moment method analysis of an arbitrarily located and arbitrarily polarized thick rectangular radiating window in an infinite ground plane excited by a rectangular waveguide has been done using Multiple Cavity Modeling Technique. The analysis has been validated by the excellent agreement between the data obtained using the present theory, measured data and CST Microwave Studio simulated data.

INTRODUCTION

Aperture antennas find many applications in feed for reflector antennas; flush mounted antenna for space craft, aeronautics, thermograph, hyperthermia, diathermy, measurement of material properties as well as large phased array systems etc. That is why theoretical studies of open-ended / window loaded waveguides have occupied the interests of numerous researchers for several decades [1]. The literature survey reveals the fact that no work has been done to analyze the window loaded waveguide radiator problem when the radiating window is inclined at a particular angle with respect to waveguide axis. With this in mind, a moment method formulation of an arbitrarily located and arbitrarily polarized thick rectangular radiating window in an infinite ground plane excited by a rectangular waveguide, as shown in Fig. 1. is presented.

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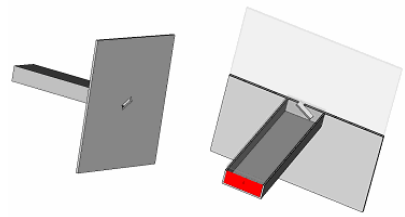

Fig. 1. Waveguide fed arbitrarily radiating rectangular window

The window of finite thickness is represented as a cavity and hence the technique is named as Cavity Modeling Technique.

PROBLEM FORMULATION

A developed view of the junction showing the feed waveguide and the finite thickness window is presented in Fig. 2. From the Fig. 2. it can be seen that the structures have three regions, namely, one waveguide region, one cavity region and one free space region.

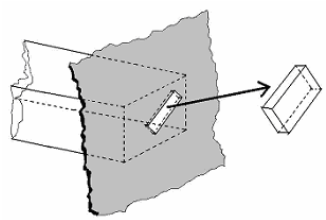

Fig. 2. A developed view of a thick inclined radiating window.

The interfacing apertures between different regions (waveguide-cavity, cavity-free space) are replaced by equivalent magnetic current densities.

$$M_{p\chi} = \sum_{p=1}^{M} A_{p\chi} m_{p\chi} \tag{1}$$

Where the basis function $m_{p\chi}$ (p=1, 2, 3…M) are defined by

$$M_{p\zeta} = \sum_{p=1}^{M} A_{\zeta} \sin\left\{\frac{p\pi}{2L}(\zeta + L)\right\} \qquad X_w - L \le \zeta \le X_w + L \tag{2}$$

$$M_{p\xi} = \sum_{p=1}^{M} A_{\xi} \sin\left\{\frac{p\pi}{2W}(\xi + W)\right\} \qquad Y_w - W \le \xi \le Y_w + W \tag{3}$$

The parameters used in the above equation have been described in Fig. 3. below.

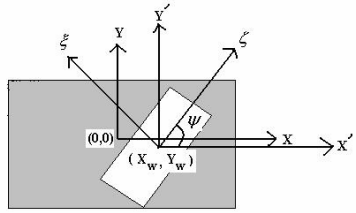

Fig. 3. Front view of the ground plane containing the window

The magnetic field scattered inside the cavity region due to the source is determined by using cavity Green's function of the electric vector potential solving the Helmholtz equation for the electric vector potential for the unit magnetic current source [2]. The scattered magnetic fields in the waveguide region due to the presence of the transverse magnetic current densities are solved by rigorous mode matching method [2]. The externally radiated field is determined using the spectral domain approach [3]. The incident field is assumed to be dominant mode of the waveguide. By applying the continuity condition of the tangential magnetic field at the interfacing apertures, and expanding the unknown magnetic current densities in terms of entire domain basis function (sinusoidal) by using Galerkin's specialization of method of moments [4], the problem is reduced to solving simultaneous equations. Finally the reflection coefficient can be calculated from

$$\Gamma = \frac{E^{ref}\left(TE_{10}\right)}{E^{inc}} \tag{4}$$

NUMERICAL RESULTS

Calculation has been done for a centered rectangular window of dimension 2.2 cm × 0.4 cm and thickness of 1.74 mm on a brass plate of 11 cm × 10cm with an inclination of 15 degree with waveguide axis. The variations of absolute value of reflection coefficient obtained using present method for the above window radiator is plotted in Fig. 4 and has been compared with measured data obtained by experiment in the laboratory, and CST Microwave Studio simulated data. Computations for Γ has also been carried out for different values of ψ. In Fig. 5. the magnitude of reflection coefficient for the window with 2L=1.016 cm, 2W=0.254 cm, x_w=0.0, y_w=0.0, 2t=1.6 mm are plotted for ψ =0,30,60 and 90 degrees.

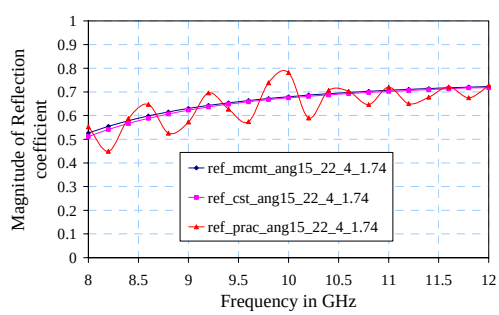

Fig. 4. Experimental, theoretical, literature obtained and CST Microwave Studio simulated data for absolute value of reflection coefficient for a WR-90 waveguide-fed resonant window with: 2L = 2.2 cm, 2W = 0.4 cm, X_w = 0.0, Y_w = 0.0, 2t = 0.174 cm, inclination = 15^0 over 8 to 12 GHz.

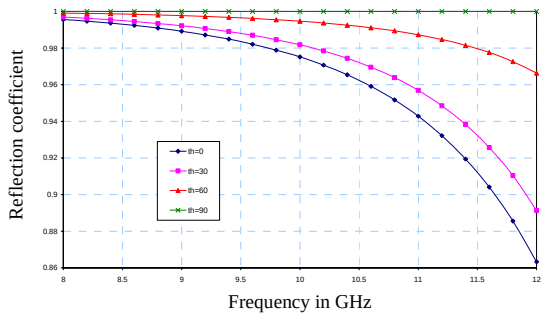

Fig. 5. Effect of angle of inclination on magnitude of reflection co-efficient for WR-90 waveguide-fed thick resonating windows with: 2L = 10.16 mm, 2W = 2.54 mm, t = 1.6 mm, X_w = 0.0, Y_w = 0.0, inclination = 0 / 30 / 60 / 90 degrees over 8.0 to 12.0 GHz.

CONCLUSION

The analysis is justified by the excellent agreement between the theoretical, experimental and literature available data. It is found from the result presented in Fig. 5 that for the same frequency $|\Gamma|$ increases with increase of window inclination with waveguide axis.

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