Analysis of Circularly Polarized Dual-Mode Waveguide Design to Reduce the Cross Polarization

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Abstract— This correspondence deal with the analysis of circularly polarized dual-mode waveguide by mode conversionTE_{11} → TM_{11} and mode matching technique. In mode conversion two types are considered, the simple step change in radius and a discontinuity covered by the dielectric ring. Modal matching to provide an accurate description of the internal fields in terms of the propagating waveguide mode. TE_{11} with different percentage of TM_{11} combined and propagate in dual-mode waveguide to improve the cross-polarization. This configuration is an excellent candidate for use in low noise microwave antenna system.

Key words: Circular Waveguide, Cross Polarization

I. INTRODUCTION

The circular waveguide preferred to as transducer and as feed for reflector antenna with horn[1]. The use of multimode waveguides as feeds[2][4],[5]. for low noise antennas, e.g in satellite communication systems, has stimulated interest in the properties of transducers which will launch higher order modes in correct relative amplitude and phase. Accuracy improved with the number of modes used. Multimode is used to obtain radiation pattern which either enhance the pattern of the dominant mode or provide extra information at Existing terminals. The higher mode added with appropriate amplitude and phase, to the dominant mode to enhance the radiation performance and improve the efficiency. One technique for achieving a dual-mode (TE_{11} and TM_{11}) excitation is by using a simple circularly symmetric discontinuity formed by Joining two circular waveguides of diameters 2a and 2b, as shown in Fig. 1.

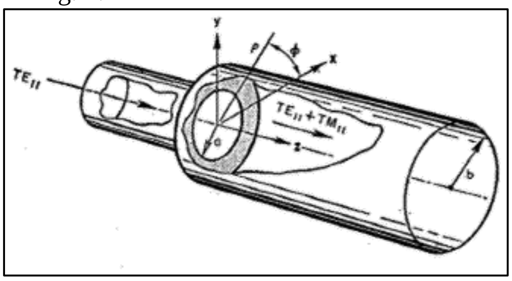


Fig. 1: TE_{11} → TM_{11} mode conversion at discontinuity in circular waveguide[3] .

The radii a and b[2] are selected such that the smaller waveguide supports only the TE_{11} mode, whereas the larger waveguide can support both the TE_{11} and TM_{11} modes. Although very simple, this configuration suffers from the fact that the relative phase of these two modes is a strong function of frequency.

II. PROPERTIES OF THE STEP DISCONTINUITY

The mode conversion properties of a simple step discontinuity where changing in radius have been considered by other investigator [6]. In it observed as in Fig.2 experimentally that i/p SWR is very low for frequencies more than 5% above TM mode cut-off frequency for oversized waveguide, this motivate perfect match for mode conversion by simple step discontinuity.

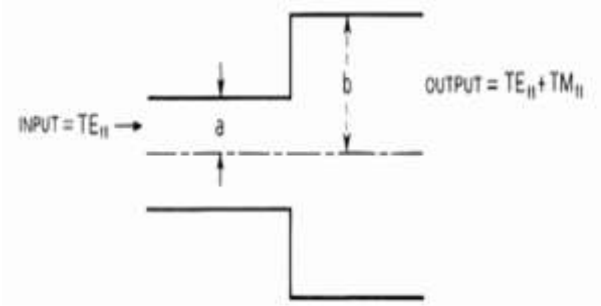


Fig. 2: Mode convers ion at step discontinuity by changing radius of waveguide [3].

The another type of step discontinuity using dielectric ring. The relative phase of the radial electric fields at the wall of the larger waveguide at any location z = d can be expressed as

$$\varphi = \varphi_0 + (\beta_{TM} - \beta_{TE})\, d \quad .... \;.... \;.... \;...(1)$$

Where φ equals the relative phase at the step z= 0 and β_{TM}, β_{TE} represents the propagation constants. The quantity φ_0 can be determined theoretically b by analyzing the waveguide dis- continuity in terms of normal modes [4]. Applying the necessary boundary conditions at the connecting aperture leads to an integral equation which can then be solved numerically for the modal amplitudes in each waveguide [4]. Fig. 2, for example, shows the conversion coefficient C, defined as

$$C = 20\ \log_{10} \left| \frac{E_\rho^{TM}}{E_\rho^{TE}} \right|_{p=b} \quad .... \;.... \;.... \;...(2)$$

plotted as a function of frequency. The measured results indicates in. Fig b for frequency band of 5.2 to 6.8 GH show good agreement.

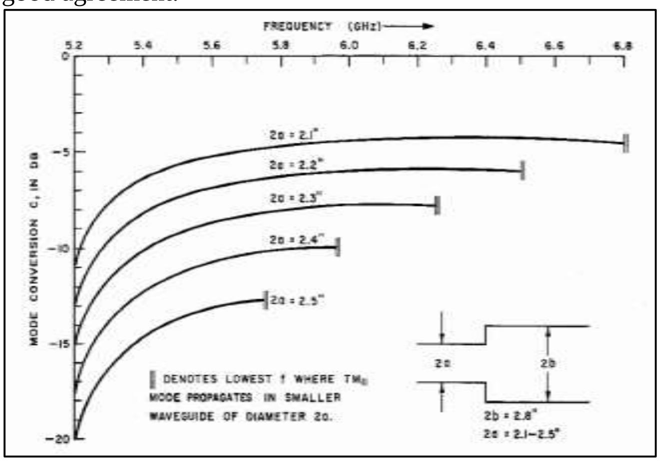


Fig. 3: TE_{11} → TM_{11} mode conversion coefficient at step discontinuity [3].

III. MODAL MATCHING

Mode matching techniques used to provide an accurate description of the internal fields of a horn in terms of the propagating waveguide mode. It replaces the actual profile of a horn with a series of uniform waveguide sections slowly varying in cross sectional area. Formulation the Horn using Scattering Matrix:

$$\begin{bmatrix}[B]\\ [D]\end{bmatrix} = [S] \begin{bmatrix}[A]\\ [C]\end{bmatrix} \quad \text{.... ....(3)}$$

Where [A], [B], [C], [D] are column metrics.[A] Matrix Describe the modal coefficients of the field in the forward direction (S_{12})

$$[A] = \begin{bmatrix}1\\0\\0\\ \vdots\end{bmatrix} \quad \text{.... .... (4)}$$

Length of column matrix depends on how many modes used to represent the propagating field at the input. [B] - containing the modal coefficients of the reflected wave at the horn throat (S_{11}).[C] contain the modal coefficients of the transmitted waves at the aperture (S_{21}). [D] contain the modal coefficients of the reflected waves at the aperture (S_{22}). [S] - scattering matric Scattering parameters are an extremely useful description of the power transmitted or reflected by a system. For example a horn transmitting and/or receiving radiation is a two port network, this is illustrated in the Fig. 4 where the horn is represented by a box [S] – scattering matric described as

$$[S] = \begin{bmatrix}S_{11} & S_{12}\\ S_{21} & S_{22}\end{bmatrix} \quad \text{.... ....(5)}$$

Where, Reflection coefficients are S_{11} = b1/a1,S_{22} = b2/a2 and Transmission coefficients are S_{12} =b1/a2, S_{21} = b2/a1. At the aperture of the horn it is assumed that the1re is no reflection so [C] will be zero (this is not true for each waveguide section).[2]

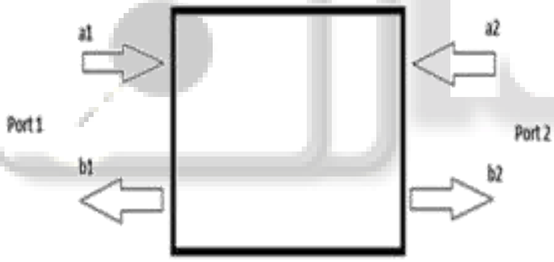
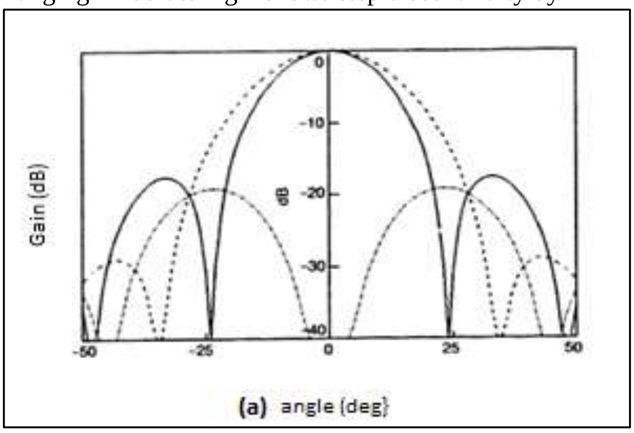


Fig. 4: N port network- Horn represents as box [2].

IV. Results

The objects of multimode horn to control the amount of cross-coupling which requires controlled discontinuity. In Fig 2 shows simple step discontinuity mode conversion by changing in radius. Fig 1 shows step discontinuity by



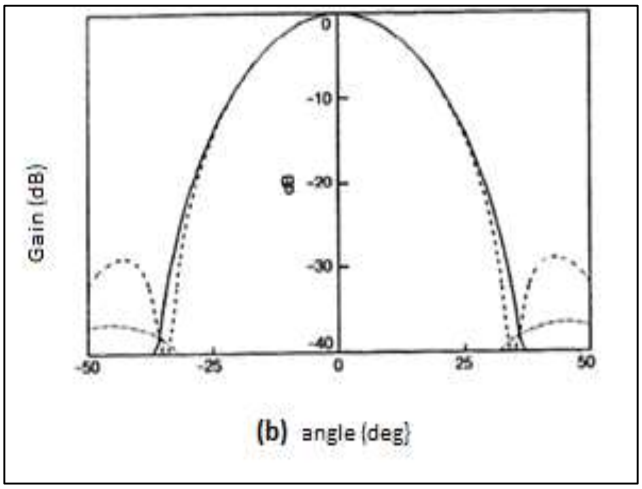


Fig. 5: Radiation pattern (Gain) of dual mode waveguide (a) TE_{11} mode alone, (b) TE_{11} + 5% TM_{11} mode [2]

———— E-plane
- - - - - H-plane
— ··· — ··· — crosspolarised

dielectric ring. The Fig.3 shows Mode conversion result in frequency band 5.2 to 6.8 GHz Which shows good agreement.

Using multi-mode cross polarization can be reduced. Mode matching techniques provide an accurate description of the internal fields of a horn in terms of the propagating waveguide mode. The radiation pattern of dominant mode TE_{11} mode and its combination with different % value of TM_{11} mode shown in Fig.5 Where in Fig.5(b) cross-polarization reduced than the Fig.5(a).

V. Conclusion

Any discontinuity in a circularly polarized waveguide which distorts the TE_{11} mode in such a way as to introduce a longitudinal component of electric field will couple the TE_{11} and TM_{11} modes of propagation. Prevention of coupling between these and other modes can be controlled by maintaining circular symmetry in the discontinuity and mode matching. Using multimode wave guide cross polarization reduced.

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