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Review Article

A New “T” Coupled Guiding Structure with Minimum Loses

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Abstract— A new ‘T’ coupled dielectric waveguide structure is been proposed in this paper which is suitable for millimetre wave integrated circuits. Stycast (ε_r=3.4) and Alumina (ε_r = 9.6) have been used as dielectric materials in fabricating the guide theoretically. A critical review on few of the dielectric waveguide which are reported in literature are discussed. Comparisons is been drawn between the ‘T’ coupled dielectric waveguide and other guiding structures on the basis of conductor and dielectric losses. As an application a ‘T’ coupled dielectric coupler can be realized at millimetre waves.

Index Terms— T Coupled Guide, Dielectric loss, Conductor loss, coupler.

1 Introduction

Much of the research has been directed towards the use of millimetre and submillimeter wave frequencies for the transformation of information. As conventional metal waveguides become quite lossy and more difficult to fabricate as the wavelength involved become shorter, alternative guiding structure made from dielectric material have been proposed by a number of authors[1],[2],[3],[4],[5]. In this paper a new T coupled dielectric wave guiding structure is presented [6], [7].

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2 Discussion

2.1 Strip dielectric guide

Inverted strip dielectric guide has been studied as a possible structure for reducing attenuation. Strip dielectric guide as shown in Fig. 1 utilizes a conducting ground plane these type of guiding structures are suited for millimetre wave integrated circuit. In dielectric waveguides most of the energy is confined to propagate in the region of highest dielectric constant. In strip dielectric guide confinement of energy occurs in the dielectric layer which is most easily and accurately fabricated, thus minimizing radiation losses due to mechanical irregularities on the side walls.

2.2 Inverted strip dielectric guide

Inverted strip dielectric guide as shown in Fig.2 is a natural extension of Strip dielectric guide ISG consists of guiding layer with dielectric constant ε_2 placed on a dielectric strip of dielectric constant ε_1 which in turn sits on a ground plane. Since ε_1 is less than ε_2 the energy is carried in the guiding layer of dielectric strip of constant ε_2. The difference between the two is of the ground plane therefore strip dielectric guide accounts for more losses as compared to inverted strip guide. Maxwell’s equation for strip dielectric guide would be exceedingly complex so the concept of effective dielectric constant will give simplification to study the dispersion characteristics as proposed by Toulious and Knox [8].

The conductor and dielectric loss depends on the physical quantities of the metal, orientation of em fields and design of the waveguide. Radiation losses are minimized through tight coupling. For the strip dielectric guide conductor losses may be reduced by inserting another dielectric layer and between the guiding layer and the ground plane and choosing its dielectric constant smaller than that of guiding layer.

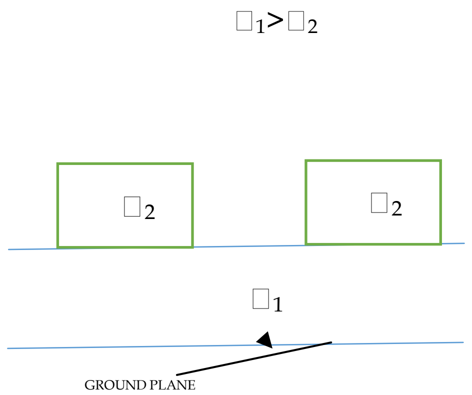

FIG1. Cross-section view of Strip dielectric guide

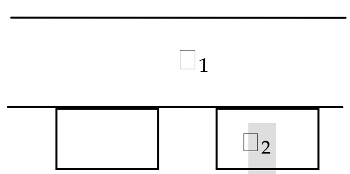

FIG 2. Cross-section view of inverted strip dielectric guide

2.3 Trapped coupled dielectric overlay guide

Trapped coupled dielectric overlay guide is formed by using the generalized structure. In a generalized dielectric guide structure as shown in Fig.3 if we assume $\varepsilon_{r1}=\varepsilon_{r2}=\varepsilon_{r3}=\varepsilon_{r6}=\varepsilon_{r7}=\varepsilon_{r9}=1$, $\varepsilon_{r4}=\varepsilon_{r}$ (stycast) and $\varepsilon_{r5}=\varepsilon_{r8}=\varepsilon_{r}'$ (alumina) then the structure reduces to dielectric broadside coupled guides having dielectric constant ε_{r} and over these guides an overlay dielectric of ε_{r}' where u and l are the top and the bottom metal plane distances. This geometry becomes a metallic trapped dielectric overlay coupler [9], [10] and [11].

2.4 Variation of conductor and dielectric losses with frequency for trapped coupled dielectric overlay guide

Fig.4 and Fig.5 shows the variation of conductor and dielectric losses as a function of frequency for trapped coupled dielectric overlay guide. The dielectric loss tangent taken in the order of 10^{-4}. It is observed that near the cut-off the conductor and dielectric loss are very high and reaching infinite this is due to the fact that at cut-off, no dominant mode can be propagated and all the energy will be dissipated as losses. It is observed that as the frequency is increased the losses decreases up to a particular frequency. It is further observed that the conductor loss is continuously decreasing after a particular frequency, but dielectric loss increases. This is due to the fact as the frequency is increased the em fields tends to confine in the dielectric slab and thus lesser and lesser fields will land on the metallic walls and thus the conductor loss is continuously confining in the dielectric slab as the frequency is increased.

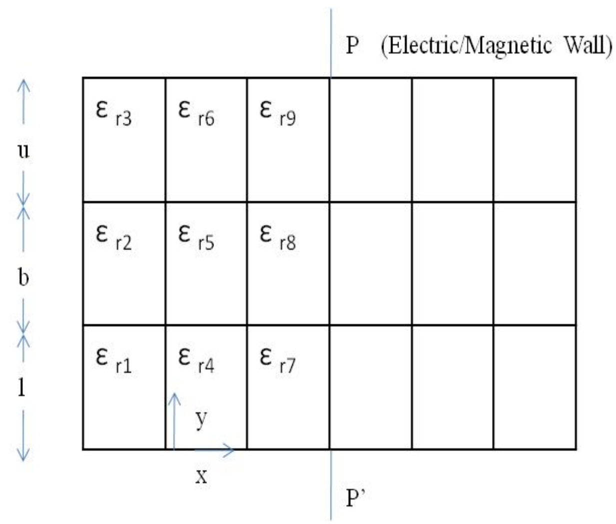

FIG 3. Cross-sectional view of Generalized Coupled dielectric guide structure

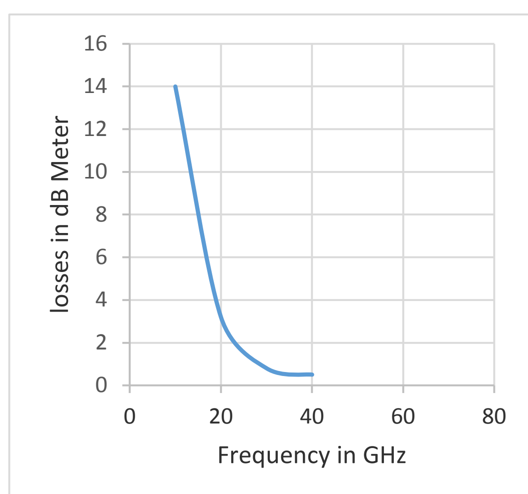

FIG.4 Variation of Conductor loss for trapped coupled dielectric overlay guide

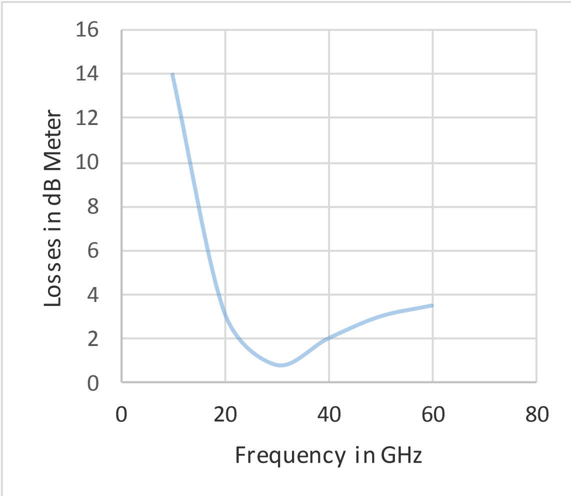

FIG 5. Variation of dielectric loss of trapped coupled dielectric guide

2.5 T coupled dielectric guide

T coupled dielectric guide can be obtained from the generalized coupled dielectric guide structures as in Fig.5 by making regions $^{\varepsilon}r3={}^{\varepsilon}r6={}^{\varepsilon}r9$ of lower dielectric material and region $^{\varepsilon}r5$ of higher dielectric material and remaining all region are air with an electric wall plane symmetry at pp, then the structure reduces to T coupled dielectric guide.

This structure is seen to be fixed between top metal planes. As only one region is touching the metal plane conductor losses will be very low. In any of the dielectric waveguides most of the energy is confined to propagate in the region having the highest dielectric constant. Most of the energy travel in the lower region of higher dielectric constant away from the metal plane. Electromagnetic waves can be guided by dielectric plates or rods without any metallic boundaries. Waves can be guided by the concepts of Total Internal Reflection of the wave from the boundaries between the two media of different permittivity at oblique angle of incidence of the wave on higher permittivity medium side. This total reflection is not in the actual sense but part of the wave propagated on the high permittivity medium or we can say that the wave propagates through immediate vicinity of the surface and rest of it is outside it.

3 Formulation of the Problem

Numerical Characterization and modelling of guided wave passive components have been an important necessity due to the increased research and development taking place in the field of millimetre wave integrated circuit and technique. Extremely accurate characterization methods are needed to model the structures. To evaluate the propagation parameters in the direction of propagation several methods are there- Finite element method [12], TLM method [13], Mode Matching Technique [14], Variation Method and Effective Dielectric Constant Method as proposed by Toulious and Knox is very effective to calculate the dispersion characteristics of T coupled dielectric guide same method has to be carried out to study and design of the coupler. The top and bottom metallic walls make the analysis simple, by varying the heights u and l of the top and bottom conductor planes, different configuration of dielectric overlay coupler are achieved. An electric wall for odd modes and a magnetic wall for even modes can be assumed at the symmetry of the plane PP'.

4 Conclusion

A review for strip dielectric guide, inverted strip dielectric guide and trapped coupled dielectric guide is done. A new 'T' coupled dielectric guide is theoretically fabricated by the use of stycast and alumina. The simplicity in fabrication, low material cost and low transmission losses give this guide an edge over all above guides. The concept of effective dielectric constant method works well for the proposed guide with any relative dielectric constant ratio. Although dispersion characteristics are not presented in this paper but is expected to prove better theory for couplers.

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