ANALYSIS OF RADIATING END EFFECTS OF SYMMETRIC AND ASYMMETRIC COPLANAR WAVEGUIDE USING INTEGRAL EQUATIONS TECHNIQUE

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Abstract

An integral equation technique solved by the moment method associated with the single one-port model is used to analyse radiating end effects of symmetric and asymmetric coplanar waveguides (CPW). Theoretical results obtained on a short circuit end of CPW are compared with those obtained experimentally using series-gap-coupled straight CPW resonators.

1. Introduction

The extensive use of either open or short-end coplanar waveguide (CPW) terminations as tuning stubs in transitions (1) in the design of planar balanced mixers (2) and detectors (3) requires design data based on accurate models that account for radiation and discontinuity dispersion effects.

Many efforts were made to characterize microstrip discontinuities, but no similar efforts were devoted to determine their CPW counterparts in spite of the several advantages that CPW's offer over conventional microstrip lines for monolithic or hybrid MIC applications due to their easy adaptation to both parallel and series insertion of both active and passive components.

The present paper gives :

a) a rigourous analysis to characterize radiating end effects of symmetric and assymmetric CPW using integral equations technique.

b) an experimental method for the measurement of the reactance of a CPW short circuit end and consequently its radiation resistance can be determined.

2. Analysis

The theory is based on the resolution of two coupled magnetic field integral equations, expressing the boundary condition of the tangential magnetic field in each of the two coupled slots (Fig. 1). The scattered field is transformed into both vector and scalar potentials, which are in turn expressed by magnetic GREEN's functions (4). Then, they can be determined using stratified media theory, and are computed as Sommerfeld integrals in space domain (4). Finally, the equivalent magnetic current densities, and consequently the electric field in the two slots are calculated by the moment method which transforms the basic integral equations into a linear equation system solved by matrix inversion. The slots are assumed to be fed by a parallel current generator.

Considering the calculated fields in two slots in zones far enough from both generator and the discontinuity, they form standing waves of the fundamental propagating one (Fig. 2). Thus transmission-line theory can be applied to compute the reflection coefficient at a given reference plane and hence equivalent impedance of a CPW short circuit end can be determined.

3. Measurement of CPW Short-Circuit Reactance

The reactive part of the equivalent impedance of a pseudo CPW short circuit can be determined experimentally using the resonance method of three series-gap-coupled straight resonators of lenghts L, 2L and 3L (Fig. 3). In this way the short-end and gap effects are separated and determined as well as the CPW guided wavelength.

4. Theoretical and experimental results

Two examples of calculated results that give the electric field distribution in the two slots of the CPW along the whole length, are given in fig. 2 : The first one represents a symmetric CPW, while the second represents an asymmetric CPW.

The normalized reactance obtained by the present theory is compared with our measurements in fig. 4. The comparison shows a very good agreement.

The present analysis has the advantage of its capability to determine also the resistive part of this short-end of symmetric and asymmetric CPW due to free space and surface wave radiation. Fig. 5 gives an example of such results. It is seen that this resistance increases with the frequency and also with the asymmetry ratio of the CPW.

5. Conclusion

The integral equations technique solved by the moment method combined with the use of the simple transmission line theory is shown to be very efficient for characterizing radiating discontinuities of symmetric and asymmetric CPW's. An experimental set-upis proved to be capable of determining CPW short circuit end effect and of verifying the exactitude of our theoretical results.

References

(1) V. Fouad Hanna and L. Ramboz, "Broadband Planar Coplanar Waveguide-Slotline Transition," Proc. of the 12th European Microwave Conference, pp. 628-631, 1982

(2) L.T. Yuan and Asher, "A W-Band Monolithic Balanced Mixer P.G. , 1985 IEEE MTT-S Digest, pp 113-115, 1985

(3) M. Houdart, "Coupled lines : Applications to Broadband Microwave Integrated Circuits", Proc. of the 6th European Microwave Conference, pp. 49-53, 1976

(4) R.F. Harrington, "Time-Harmonic Electromagnetic Fields," MacGraw-Hill, 1961.

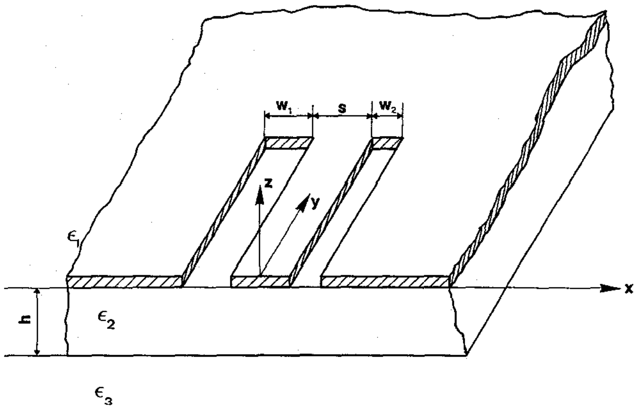
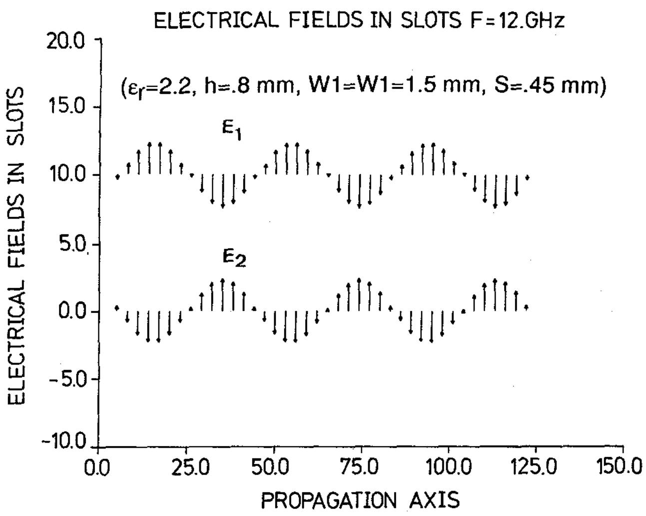
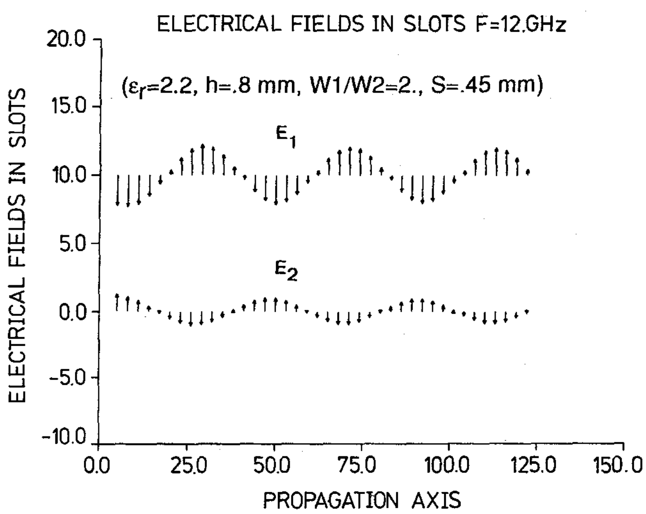


FIG. 1 : ASYMMETRIC COPLANAR WAVE GUIDE



Symmetric coplanar waveguide



Asymmetric coplanar waveguide

Fig . 2

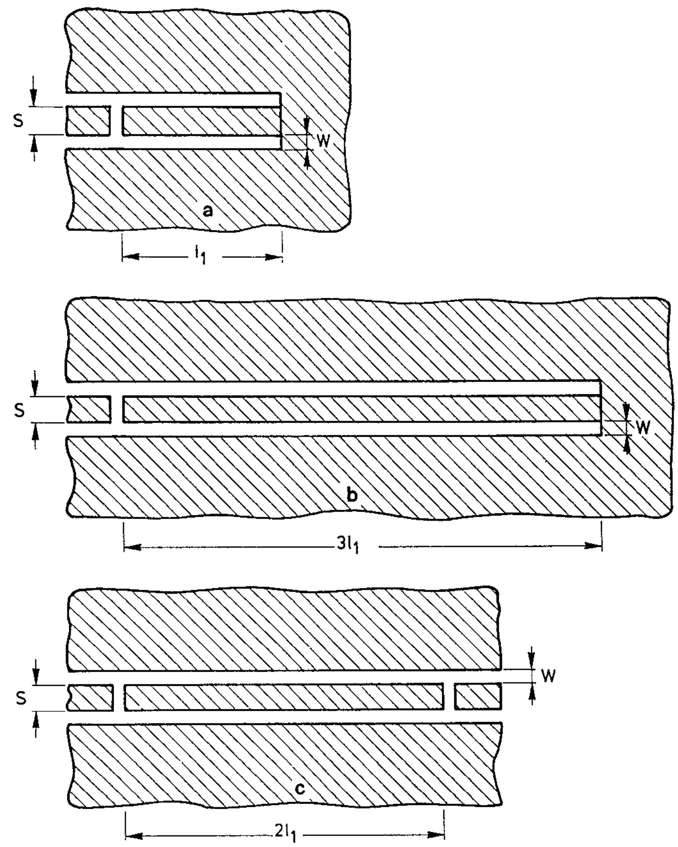


Fig 3 Three series_gap_coupled straight resonators

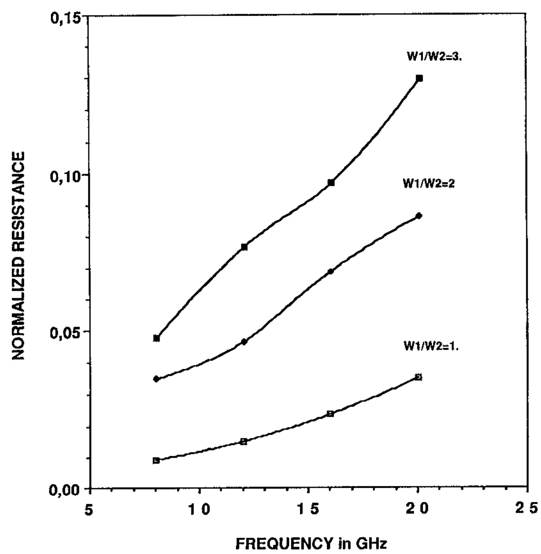


Fig. 5: Normalized end resistance of a shorted coplanar waveguide (ε_r=2.2, h= 8 mm, W1=1.5 mm, S=.789mm)

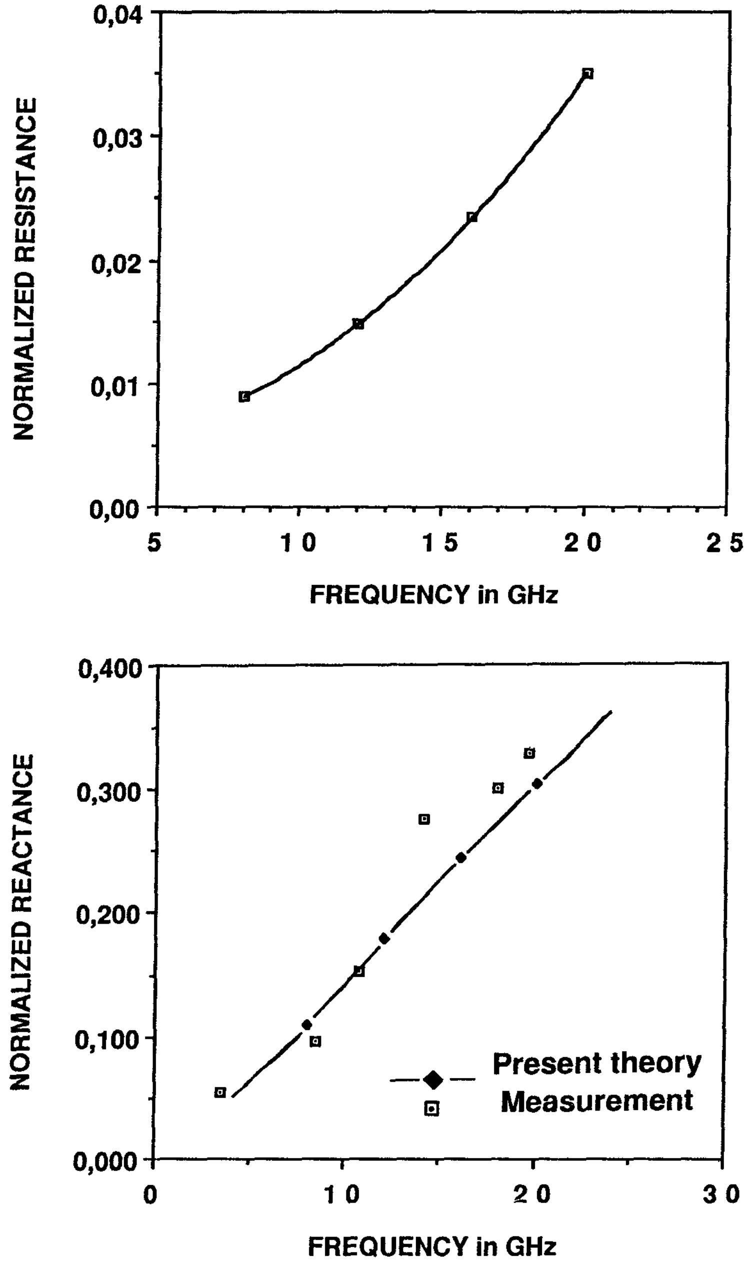


Fig.4: Normalized end impedance of a shorted coplanar waveguide (ε_r=2.2, h=.8 mm, W1=W1=1.5 mm, S=.789 mm)