EQUIVALENT CIRCUIT OF BROADSIDE-COUPLED MICROSTRIP OPEN ENDS

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ABSTRACT

In this paper a simple technique to determine the parameters of the equivalent circuit of the broadside-coupled microstrip open ends is described. This technique is based on the quasi -static spectral domain formulation in conjunction with the transverse transmission line method. Numerical data on the even-and odd-mode lumped capacitances of broadside-coupled square conductor patches in suspended microstrip configuration are presented. Further, data on the even-and odd-mode edge-capacitances and also the end effects are computed. This data should find extensive application in designing filters and directional couplers in broadside-coupled microstrip configurations.

INTRODUCTION

Broadside-coupled microstrip has received considerable attention in the recent years [1]-[5]. Propagation characteristics of this transmission line with isotropic as well as anisotropic dielectrics are reported in the literature [3]-[5]. Practical integrated circuits using this transmission media will require the design data on lumped capacitance of the conductor patches and also the end effects of abruptly ended strip conductors. Further, the equivalent circuit of the open ends will be quite useful in the computer aided design of Microwave Integrated Circuits using these transmission media. To the best of our knowledge, these parameters are not at present available in the open literature.

This paper presents the analysis and design data on the lumped capacitance of conductor patches and also the end effects of abruptly ended strip conductors in the broadside-coupled microstrip configuration. The problem is formulated using the quasi-static spectral domain technique in conjuction with the transverse transmission line method. In the final capacitance expression, the only parameter dependent on the transmission media is the admittance at the charge plane. The technique presented is very simple and can be easily extended to analyse the aforementioned parameters in the broadside-coupled microstrip configuration with anisotropic substrates. To do this only the admittance parameter needs to be modified.

ANALYSIS

Consider the broadside-coupled microstrip structure shown in Fig.1. Along the z-direction the strip conductors are abruptly ended at the plane TT'. The equivalent circuit at the plane TT' is given in the same figure. In order to determine the parameters of this equivalent circuit, we first analyze the structure shown in Fig. 2a. The two possible modes which this structure can support are called the even-and odd-modes. For the even-mode, a magnetic wall can be placed at the symmetry plane AA', whereas, for the odd-mode, plane AA' is replaced by an electric wall. The equivalent circuits for the odd-and even-mode cases are shown in Figs.2b and 2c, respectively. Using the quasi-static spectral domain technique in conjunction with the transverse transmission line method the even-and odd-mode lumped capacitance of the conductor patches shown in Fig. 2a can be obtained as:

$$C_{1i} = \frac{4\pi^2}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \left[\frac{f(\alpha,\beta)}{Q}\right]_i^2 \frac{1}{\sqrt{\alpha^2+\beta^2}\,Y_i}\,d\alpha\,d\beta} \qquad (1)$$

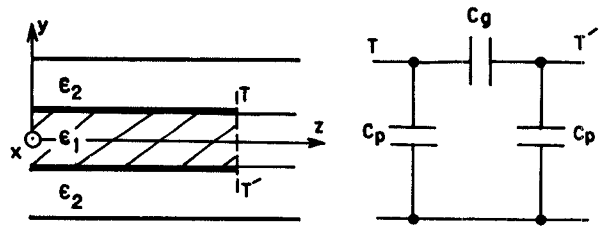

Fig.1 Abruptly ended conductors in broadside-coupled microstrip and the equivalent circuit.

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where, $f(\alpha,\beta)$ is the Fourier transform of the charge distribution on the stripconductor and Q is the total charge on the strip-conductor. The subscript i=e for the even mode case and i=o for the odd mode case. Y_e and Y_o are the even-and odd-mode admittance parameters at the charge plane $y=-d/2$ (or $y=d/2$) with a magnetic wall and an electric wall at the plane AA', respectively. For the structure shown in Fig.2a,

$$Y_{e,o}=\epsilon_0[\epsilon_{r1}[\coth(\sqrt{\alpha^2+\beta^2}\cdot\frac{d}{2}]^{-n}+\epsilon_{r2}\coth(\sqrt{\alpha^2+\beta^2}\,\frac{(b-d)}{2})] \qquad (2)$$

where n=-1 for the even mode and n=1 for the odd mode. For the present problem a charge distribution similar to the one used by the authors earlier [6] has been chosen. Once the lumped capacitance is obtained, the parameters of the equivalent circuit can be obtained as:

$$C_o=C_p+2C_g = \lim_{l\to\infty} 0.5\,[C_{lo}-l.C_{uo}] \qquad (3)$$

$$C_e = C_p = \lim_{l\to\infty} 0.5\,[C_{le}-l.C_{ue}] \qquad (4)$$

where C_{le} and C_{lo} are the even-and odd-mode lumped capacitances, respectively. C_{ue} and C_{uo} are the even-and odd-mode capacitances per unit length of a uniform line in the same configuration, respectively. The end effects for the even-and odd-modes, Δ_{le} and Δ_{lo} are then given by

$$\Delta_{le,o} = C_{e,o}/C_{ue,o} \qquad (5)$$

NUMERICAL RESULTS

Using the above set of formulae, numerical computations of the even-and odd-mode lumped capacitances, respectively have been carried out. Figure 3 shows the variation of the normalized lumped capacitance C_N versus d/b of broadside-coupled square conductor patches in suspended microstrip. Extensive data on the even-and odd-mode edge-capacitances C_e and C_o, respectively have also been generated. In addition, the aforementioned parameters for the broad-side-coupled homogeneous stripline($\epsilon_{r1}=\epsilon_{r2}$) and broadside coupled inverted micro-strip ($\epsilon_{r1}=1$) have been computed. These will be presented at the symposium.

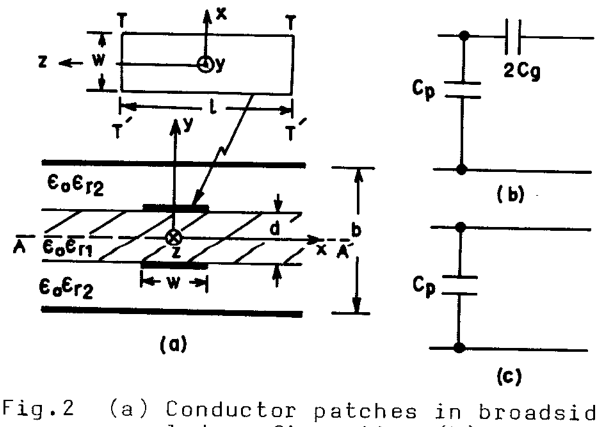

Fig.2 (a) Conductor patches in broadside-coupled configuration (b) Equivalent circuit for odd-mode (c) Equivalent circuit for even mode.

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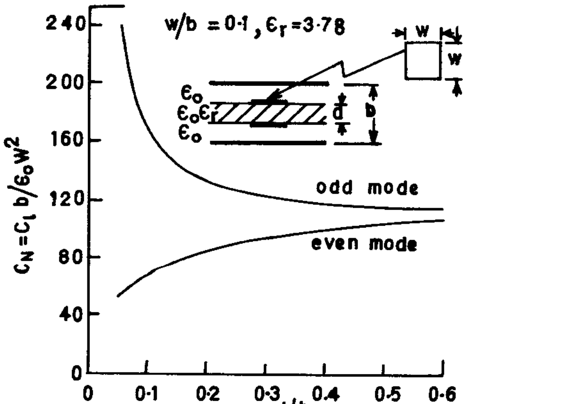

Fig.3 Normalised even-and odd-mode lumped capacitances of broadside-coupled conductor patches in suspended microstrip.