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ANALYTICAL STUDY OF VARIATION OF EVEN AND ODD MODE CHARACTERISTIC IMPEDANCES OF PLANAR TRANSMISSION LINE

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ABSTRACT: ***Stripline is a modified version of triplet structure, the first member of the planar transmission line family. It consists of a flat strip conductor placed symmetrically between two large ground planes with the intervening space homogenously filled with a dielectric substrate. The field lines concentrate around the strip conductor and decay rapidly with distance away from the strip in the lateral directions. The dominant mode of propagation is pure TEM. Microstripline is another member of planar transmission structure consisting of a metal strip attached with a dielectric substrate supported by metal plates which is the simplest and open structure used even in high frequency.***

Keywords: Impedance, and Permittivity.

1. INTRODUCTION

Because of the coupling of electromagnetic fields, a pair of coupled lines can support two different modes of propagation. These modes have different characteristic impedances. For coupled microstrip line the dielectric medium is not homogeneous. A part of the field extended into the air above the substrate. This fraction is different for the two modes of coupled lines. Consequently, the effective dielectric constants and the phase velocities are not equal for the two modes. This non synchronous feature deteriorates the performance of circuits using these types of coupled lines. When the two lines of a coupled line pair are identical then it is symmetrical configuration and is useful for simplifying the analysis and design. This method of analysis takes into account the coupling between quassi-TEM mode along the microstrip line and TM_{10} surface wave mode on the dielectric substrate with metallization on the bottom surface reported by Hartwig et. al and John et. al.

2. FORMULATION OF EVEN AND ODD MODE CHARACTERISTIC IMPEDANCE

The coupled microstripline and its field configurations are shown in figure 1 and figure 1 a & 1 b.

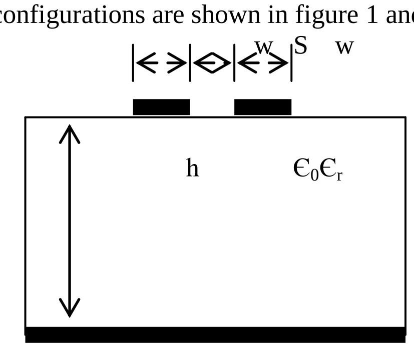

Figure 1: Coupled microstrip (cross-section)

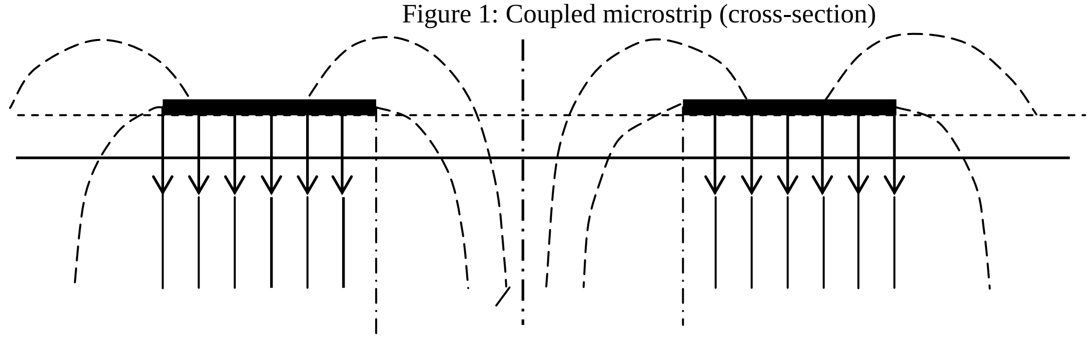

Figure 1 a: The Even-mode forward Coupling Study of Characteristic Impedance of Coupled Planar Transmission Structure

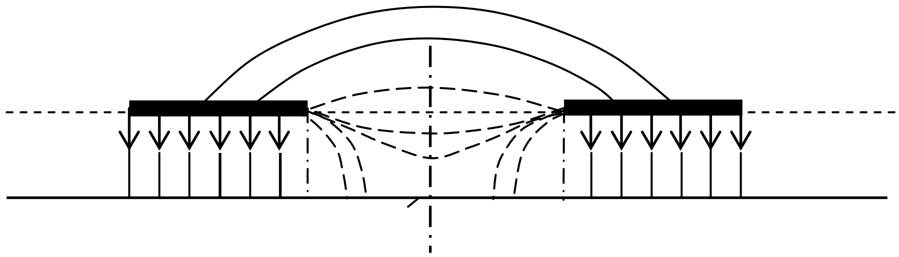

Figure 1 b: The odd mode reverse coupling

The derivation of the characteristic impedance of the single microstrip conductor will be carried using conformal transformal method developed by H. A. Wheeler. In this method microstripline is considered as a parallel plate capacitors whose characteristic impedance is given by

$Z_o = 1/V_P C_P$ --------------- 1

Where,

V_P= phase velocity of the wave traveling along the microstrip line.

$= c / \sqrt{\epsilon_{reff}}$, For narrow strip, $\epsilon_{reff} = (\epsilon_r + 1) / 2$ = Effective Permittivity and

C_P= capacitance per unit length of the line.

$C_P = (\epsilon_{reff} / c.\eta)\,(w/h) + (2/3)\,(\epsilon_{reff} / c.\eta)\,(w/h)\,(\epsilon_{reff} / c.\eta).\,(2.7/\mathrm{Log}4h/t)$ ------------2

And $Z_o = (\eta/\sqrt{\epsilon_{reff}}).\,[1/[(w/h) + (2w/3h) + (2.7/\mathrm{Log}4h/t)]]$ ------------ 3

Now for coupled microstripline even-mode impedance for zero strip thickness is given as

$Z_{oe} = (\eta/\sqrt{\epsilon_{reff}}).\,[1/\ \{(w/h)\,[1+ (1/3/\sqrt{\epsilon_{reff}})] + (1/3\sqrt{\epsilon_{reff}})\,(1/(w/s)+1)\}$ --------- 4

And odd-mode impedance is given as

$Z_{oo} = (\eta/\sqrt{\epsilon_{reff}}).\,[1/\ \{(w/h)\,[1+ (1/3\ \sqrt{\epsilon_{reff}}) + (4/3\sqrt{\epsilon_{reff}})\,(1/(s/w) +1)\}]$ --------- 5

Where, η = Intrinsic impedance = 377 ohm.

Above expressions show that the even and odd mode impedances are the functions of width of metal strip, height of the dielectric substrate and spacing between two strip lines. The spacing and stripwidth play significant role in coupling of the power flowing through them. Our present study is related with the variation of these impedances with stripwidth and spacing.

3. STUDY OF VARIATION OF EVEN AND ODD MODE CHARACTERISTIC IMPEDANCES

After exhaustive computational work results for different metal strip width has been obtained which reveals that with increase of strip width characteristic impedance decreases both for even and odd-modes. But the rate of decrease is faster for even-mode than that for odd-mode. Also with increase of spacing, characteristic impedance for even-mode decreases and that for odd-mode increases. These results have been placed in table 1 assuming frequency (f) = 3 GHz, h = 100 mils and 1 mil = 2.54×10^{-3} cm.

	S = 10 mils		S = 20 mils		S = 50 mils	
Stripwidth (w) mils	Z_{0e} (Ω)	Z_{00} (Ω)	Z_{0e} (Ω)	Z_{00} (Ω)	Z_{0e} (Ω)	Z_{00} (Ω)
10	165.65	45.35	153.90	61.10	133.45	77.75
50	98.62	36.55	94.55	42.30	46.57	51.47
100	69.38	29.95	67.42	33.35	63.45	40.15
150	59.25	27.55	53.95	28.32	52.82	29.30
200	44.65	23.40	42.66	25.34	41.15	28.05

Table 1 Variation of even & odd mode impedances with stripwidth & spacing between two strips

4. DISCUSSION AND CONCLUSIONS

From the results it is evident that the even-mode characteristic impedance is ever greater than the of odd-mode. The rate of decrease of even-mode characteristic impedance with stripwidth is greater than that for odd-mode. It can be concluded that with the increase of stripwidth electric flux lines and flow of energy below the stripwidth increases. Further it is observe that the spacing between two strips affects the odd-mode coupled lines more than the even-mode coupled lines. Because increase of spacing increases the odd-mode characteristic impedance and decreases the even-mode characteristic impedance. This means electric flux lines and energy are larger in the coupled region. These results have been utilized in design of different capacity of directional coupler and also the losses of energy can be computed.

REFERENCES:

1. H.A. Wheeler, "Transmission line properties of parallel wide strip by conformal mapping approximation", IEEE, MTT vol.12, pp. 280-289, 1964
2. T. G. Bryat and J. A. Weiss, "Parameters of Microstrip lines of Coupled Pairs of microstriplines". IEEE Tr., MTT. Vol.16, no.12, pp. 1021 – 1027, 1968.
3. Pal, S and G. R. Babu, "Characteristics Impedance of microstrip line", JAEU, 5, pp. 21-27,1972.
4. K. C. Gupta, "Microwaves", Wiley Eastern Limited, New Delhi (1979).
5. B. Bhat and S. K. Koul, "Stripline like transmission lines for MIC's", Wiley Eastern Limited, (1990).
6. J. Choi, V. Govind, and M. Swaminathan, "A Novel Electromagnetic Bandgap (EBG) Structure for Mixed-Signal System Applications," *IEEE Radio and Wireless Conference*, pp. 243-246, 2004.
7. J. Qin,"Planar electromagnetic bandgap structure for wideband switching noise mitigation in high speed circuits," Master's thesis, University of Maryland, 2006
8. J. Qin and O. M. Ramahi, "Ultra-Wideband Mitigation of Simultaneous Switching Noise Using Novel Planar Electromagnetic Bandgap Structures," *IEEE Microwave and Wireless Components Letters,* vol. 16, pp. 487-489, 2006.
9. G. Yunchuan, G. Goussetis, A. P. Feresidis, and J. C. Vardaxoglou, "Efficient modeling of novel uniplanar left-handed metamaterials," *IEEE Transactions on Microwave Theory and Techniques,* vol. 53, pp. 1462-1468, 2005.
10. A. Suntives and R. Abhari, "Dual-Mode High-Speed Data Transmission Using Substrate Integrated Waveguide Interconnects," *IEEE 16th Topical Meeting on Electrical Performance of Electronic Packaging*, pp. 215-218, 2007.