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Study of Dependence of Characteristic Impedances on Dielectric Constant

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ABSTRACT

This paper presents about the study of dependance of characteristic impedances on dielectric constant. An ideal microstrip directional coupler makes use of the basic features that power flowing in one direction in the main microstripline induces a power flow in the second line in the forward direction or in the reverse direction. The coupling characteristics & reflected waves depend on the microstrip width, spacing between two microstrip and operating frequency. In the coupler some power flowing in the system gets reflected.

Keywords : MSL, VSWR, MICROWAVE

I. INTRODUCTION

When the coupled power flows in the direction of incident power in the same phase the coupling is forward and when the coupled power flows in the direction opposite to the incident power, the coupling is backward. The forward coupling is treated as propagation of power in the even mode of wave propagation and the backward coupling as the odd-mode of wave propagation. [1-4]. Such coupled transmission lines are used in various microwave circuits such as (i) Directional coupler (ii) Filters and (iii) Impedance transformers etc. The present chapter is devoted to the study of characteristics of microstripline coupler or directional coupler, reflection coefficient and hence the voltage standing wave ratio (VSWR) and their variations with strip geometries, spacing & operating frequency [5,6].

II. MATERIALS AND METHODS

The band width of the directional coupler can also be enhanced by using multi pairs of coupling holes. The characteristic of the directional coupler can be expressed through S-matrix.When all four ports of the directional coupler are matched the scattering matrix for the network is expressed as

$$S = \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{21} & 0 & S_{23} & 0 \\ 0 & S_{32} & 0 & S_{34} \\ S_{41} & 0 & S_{43} & 0 \end{bmatrix} \qquad \text{---------------} \ (1)$$

In writing equation-1 complete isolation between ports 1 & 3 and ports 2 & 4 has been considered. Also the reciprocal nature of the network has been taken into account. By considering the unity property of S-matrix for lossless network we have

$$S_{12} S_{12}^* + S_{14} S_{14}^* = 1 \qquad \text{---------------} (2)$$

$$S_{12} S_{12}^* + S_{23} S_{23}^* = 1 \qquad \text{---------------} (3)$$

$$S_{23} S_{23}^* + S_{34} S_{34}^* = 1 \qquad \text{---------------} (4)$$

$$S_{14} S_{14}^* + S_{34} S_{34}^* = 1 \qquad \text{---------------} (5)$$

From equation (2) & (3) we get

$$|S_{14}| = |S_{23}| \qquad \text{---------------} (6)$$

From equation (5.3.4) & (5.3.5) we get

$$|S_{12}| = |S_{34}| \qquad \text{----------------} (7)$$

At this stage we make use of an artifice which is commonly implied to change the phase angle of the coefficients of S-matrix. The phase angle of S_{mm}'s may be changed by adding a section of the wave guide at various ports. By choosing reference plane of port-1 with respect to reference plane of port-2 we can make S_{12} real. In the similar manner S_{34} can be made real by selecting suitably the reference plane of port-3 with respect to that of port-4.

$$S_{12} = S_{34} = \alpha \qquad \text{---------------} (8)$$

Also the characteristic of a loss less network is expressed as

$$S_{12} S_{23}^* + S_{14} S_{12}^* = 0 \qquad \text{---------------} (9)$$

Since S_{12} is real

$$S_{23}^* + S_{14} = 0 \qquad \text{--------------} (10)$$

Also we can further select plane of port-4 with respect to port-1 such that S_{14} is real. In this case we write

$$S_{23} = -S_{14} = \beta \qquad \text{--------------} (11)$$

Thus euation-1 can be written as

$$S = \begin{bmatrix} 0 & \alpha & 0 & -\beta \\ \alpha & 0 & \beta & 0 \\ 0 & \beta & 0 & \alpha \\ -\beta & 0 & \alpha & 0 \end{bmatrix} \qquad \text{----------------} (12)$$

Here coefficient α and β are related by the equation

$$\alpha^2 + \beta^2 = 1 \qquad \text{----------------} (13)$$

Further α is called transmission factor and β is called coupling factor of the directional coupler.

III. STUDY OF DEPENDENCE OF CHARACTERISTIC IMPEDANCES ON DIELECTRIC CONSTANT

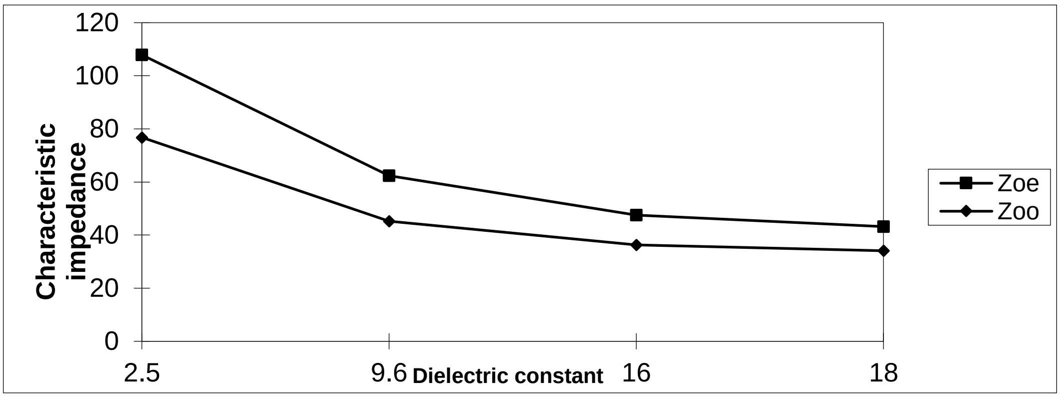
From the formulae it is evident that characteristic impedances for even and odd-modes also depend on dielectric constant of the substrate material used. Taking different substrate materials study has been performed for calculating these parameters for different dielectric constant keeping metal strip width and spacing between two metal strips fixed. The even and odd-mode characteristic impedances have been obtained and placed in the table 1 keeping dielectric constant on x-axis and characteristic impedances on y-axis graphs have been plotted as shown in graph 1. It is evident that both the impedances show decreasing trend with increase of dielectric constant for a given stripwidth and spacing. The rate of decrease in both the cases is almost the same.

Table No. 1:Dependence of characteristic impedances on dielectric constant

w = 100 mils, h = 100 mils, t = 0.05 mils, s = 100 mils, f = 2 GHz.

ϵ_r	Z_{oe}	Z_{oo}
2.5	107.90	76.80
9.6	62.40	45.20
16.0	47.50	36.30
18.0	43.20	34.10

Graph No. 1: Dependence of characteristic impedances on dielectric constant



IV. CONCLUSION

The above study reveals that characteristic impedances for even and odd-modes decreases with strip with where as in case of even-mode characteristic impedance shows decrease with increase of spacing between two metal strips and odd-mode characteristic impedance increases with increase of spacing between two metal strips. This concludes that more and more flux lines and power are concentrated in thicker metal strips when they are widely separated in case of even-mode of propagation. But in case of odd-mode of propagation lesser flux lines and power are concentrated when the strips are separated widely. Further it is also evident from the results that phase velocity and guide wavelength decrease with increase of width of metal strips in case of even-mode and both parameters increase with increase of spacing between two metal strips. Also, these parameters for even-mode are smaller than those of odd-mode. The results discussed above furnish useful guide lines for the design of different microstripline structures such as (i) coupler, (ii) directional coupler (iii) isolator and (iv) circulator etc.

V. REFERENCES

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