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Study of Reflection and Transmission Coefficient of Microstripline

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ABSTRACT
In this paper, we present the study of reflection and transmission coefficient of microstripline. 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 back.
Keywords : MSL, VSWR, MICROWAVE

I. INTRODUCTION

Natural coupling exists when two transmission lines are placed in close proximity parallel to each other. Such coupling is possible in varieties of transmission structures like transmission lines, waveguides or striplines, microstriplines, slotlines or any other planar transmission structures are placed with their sides parallel to each other, mutual coupling exists between them. Power flowing in one line will be coupled to each other line & vice-versa. 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

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

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

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

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

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

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

From equation (2) & (3) we get

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

From equation (5.3.4) & (5.3.5) we get

$|S_{12}| = |S_{34}|$ ---------------- (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.

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

Also the characteristic of a loss less network is expressed as

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

Since S_{12} is real

$S_{23}^* + S_{14} = 0$ -------------- (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

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

Thus euation-1 can be written as

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

Here coefficient α and β are related by the equation

$\alpha^2 + \beta^2 = 1$ ---------------- (13)

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

III. STUDY OF REFLECTION AND TRANSMISSION COEFFICIENT OF MICROSTRIPLINE

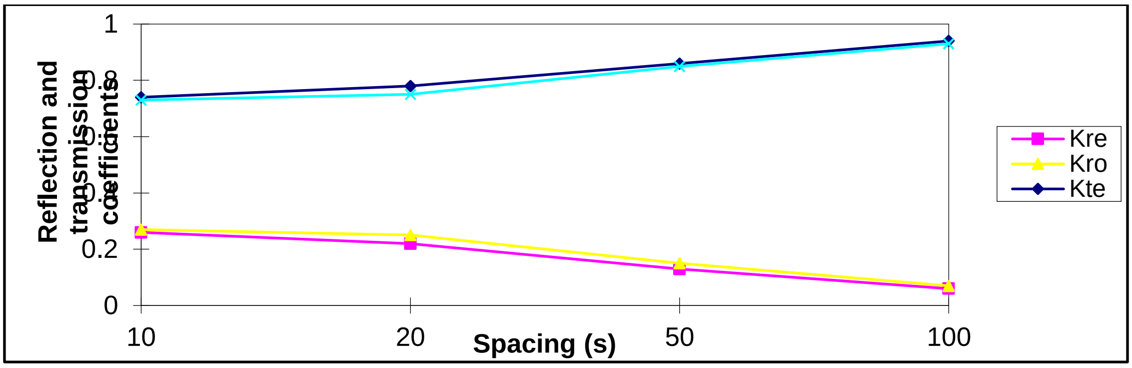
Reflection and transmission coefficient for even and odd-modes are related with characteristic impedance of the transmission structures which are the functions of the geometry of the structures such as metal stripwidth, height of the substrate and the spacing between two metal strips. In section 1 dependence of these coefficients on stripwidth was studied. Now dependence of these coefficients on spacing between two metal strips is to be dealt with. For these purpose exhaustive manual calculations have been carried out for different values of spacing. Results obtained have been placed in table 1. Keeping spacing on x-axis reflection and transmission coefficients for even and odd-modes both on y-axis graphs have been plotted as shown in graph 1. It is obvious that reflectivity decreases with increase of spacing between two metal strips in case of even-mode and odd-mode both. Whereas, transmission coefficient increases with increase of spacing between two metal strips for even and odd-mode both. It is also noted that reflectivity for odd-mode is greater than that in even-mode for a given stripwidth and spacing. Further it has been observed that for higher value of spacing reflection and transmission coefficient are almost identical for even and odd-mode both.

Table No. 1: Study of dependence of reflection and transmission coefficient on spacing between two metal strips

f = 2GHz, t = 0.05 mils, w = 10 mils, ϵ_r = 9.6

s (mils)	Even-mode		Odd-mode	
	K_{re}	K_{te}	K_{ro}	K_{to}
10	0.28	0.76	0.28	0.75
20	0.24	0.79	0.26	0.77
50	0.15	0.87	0.16	0.87
100	0.07	0.95	0.08	0.95

Graph No. 1:Study of dependence of reflection and transmission coefficient on spacing between two metal strips



IV. CONCLUSION

The discussion shows that reflection coefficients for narrow metal strips and narrower spacing is greater than that in wider stripwidth and spacing which shows that energy flux is greater in the reflected part than that of wider strip and spacing. The transmission coefficient both for even and odd-modes are greater in case of wider strip and spacing. Whereas, transmission coefficient increases with increase of spacing between two metal strips for even and odd-mode both.

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