Study of Dependence of Characteristic Impedance on Height of the Dielectric Substrate

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Abstract: For the study of the characteristic impedance of the microstripline coupler we develop the mathematical formula for even and odd-mode and then we will calculate the results. With the help of these results design synthesis technique is used to obtain the geometrical parameters of a coupler of given parameters. The microstrip transmission line consists of a narrow strip conductor separated from a conducting ground plane by an intervening supporting dielectric substrate.

Keywords: Phase Factor, Transmission line, Directional Couplers, Ch. Impedance, Guide wave length.

1. INTRODUCTION

Using computer aided programme developed by S. K. Kaul, CARE, DELHI. The results obtained have been placed in tabular forms. Exhaustive computations have been carried out by putting the different variables and fixed parameters such as: (I) Stripwidth of the metal, (ii) Spacing between two metal strips.

2. MATERIALS AND METHODS

2.1 Formulation of Phase Velocity for Coupled Microstripline

Phase velocity is an important parameter for the calculation of characteristic impedance of the microstripline coupler. The velocity with which wave propagates through the transmission structures is the functions of geometries of the structure, relative permittivity of the dielectric substrate and operating frequency so the phase velocity also determines the characteristic parameters of transmission structure. The phase velocity can be calculated by the formula

$V_p = c / \sqrt{\epsilon_{reff}}$ 1

In case of coupled microstripline structure there are two modes of propagation even and odd-modes. The equation (1) can be rewritten as

For even mode, $(V_p)_e = c / (\sqrt{\epsilon_{reff}})_e$ 2

and for odd mode, $(V_p)_o = c / (\sqrt{\epsilon_{reff}})_o$ 3

2.2 Formulation of the Guide Wave Length of the Wave Propagating Through Microstripline Coupler

The guide wavelength also determines the characteristic parameters of the transmission structure and is the functions of strip geometry permittivity and operating frequency for TM mode of propagation for low frequency guide wave length is written as

$\lambda_g = V_p / f = \lambda_o / \sqrt{\epsilon_{reff}}$ 4

For even mode propagation,

$(\lambda_g)_e = V_p / f = \lambda_o / (\sqrt{\epsilon_{reff}})_e$ 5

For odd-mode propagation

$(\lambda_g)_o = V_p / f = \lambda_o / (\sqrt{\epsilon_{reff}})_o$ 6

3. RESULTS AND DISCUSSION

3.1 *Study of Dependence of Characteristic Impedance on Height of the Dielectric Substrate*

For this study Alumina has been chosen for dielectric substrate. Exhaustive computations have been carried out for different values of substrate height keeping stripwidth, spacing and frequency fixed. Results obtained have been placed in table 1 keeping height on x-axis and even and odd-modes characteristic impedances on y-axis graphs have been plotted as shown in graph 1. Form the result it is clear that even and odd-modes characteristic impedances increases with increase with substrate height but rate of increase for even-mode is larger than that for odd-mode.

3.2 *Study of Dependence of Guide Wavelength on Stripwidth and Spacing*

For this purpose exhaustive computational works have been performed. Manual calculation of the guide wavelength has been also carried out. For different values of stripwidth even and odd-mode guide wavelength have been calculated keeping spacing, frequency and relative permittivity fixed. The results obtained have been placed in tables 2. Graphs have been plotted keeping stripwidth on x-axis and guide wavelength on y-axis as shown in graphs 2. The results show that as stripwidth increases guide wavelength for even-mode decreases but for odd-mode increases. For different values of spacing even and odd-mode guide wavelength have been calculated keeping stripwidth, frequency and relative permittivity fixed. The results obtained have been placed in tables 3. Graphs have been plotted keeping spacing on x-axis and guide wavelength on y-axis as shown in graphs 3. But effect of spacing on guide wavelengths is very little.

Table 1:Dependence of characteristic impedance for even and odd-modes on height of the dielectric substrate,

t = 0.01 mils, f = 2 GHz, S = 100 mils,1 mils = 10^{-3} inch = 2.54 μm, w = 100 mils

Height h	Even-mode	Odd-mode
	Z_{oe} Ω	Z_{oo} Ω
50	36.21	32.06
100	58.95	44.01
150	75.72	49.35
200	89.93	52.53

Graph 1:Study of dependence of characteristic impedance on height of the dielectric substrate t = 0.01 mils, f = 2 GHz, S = 100 mils,1 mils = 10^{-3} inch = 2.54 μm, w = 100 mils

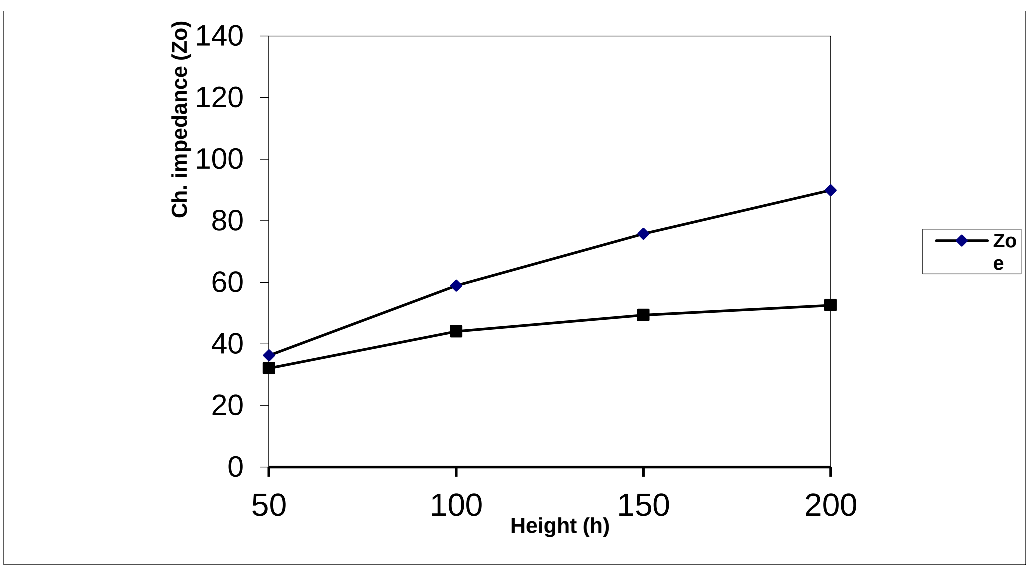

Table 2:Dependence of guide wavelength for even and odd-modes on stripwidth,
h = 100 mils, f = 2 GHz, t = 0.01 mils, S = 100 mils, $Є_r$ = 9.6

Stripwidth (w) mils	Even-mode				Odd-mode			
	$(Є_{reff})_e$	$\sqrt{(Є_{reff})_e}$	V_{pe} x 10^8 m/sec	λ_{ge} x10^{-2} m	$(Є_{reff})_o$	$\sqrt{(Є_{reff})_o}$	V_{po} x 10^8 m/sec	λ_{go} x10^{-2} m
10	6.50	2.55	1.177	5.88	5.37	2.31	1.299	6.50
20	6.60	2.51	1.168	5.84	5.38	2.32	1.295	6.47
40	6.75	2.60	1.154	5.77	5.40	2.33	1.288	6.44
60	6.87	2.62	1.145	5.72	5.47	2.34	1.281	6.40
80	7.21	2.68	1.110	5.55	5.62	2.37	1.266	6.33

Graph 2:Dependence of guide wavelength for even and odd-modes on stripwidth
h = 100 mils, f = 2 GHz, t = 0.01 mils, S = 100 mils, $Є_r$ = 9.6

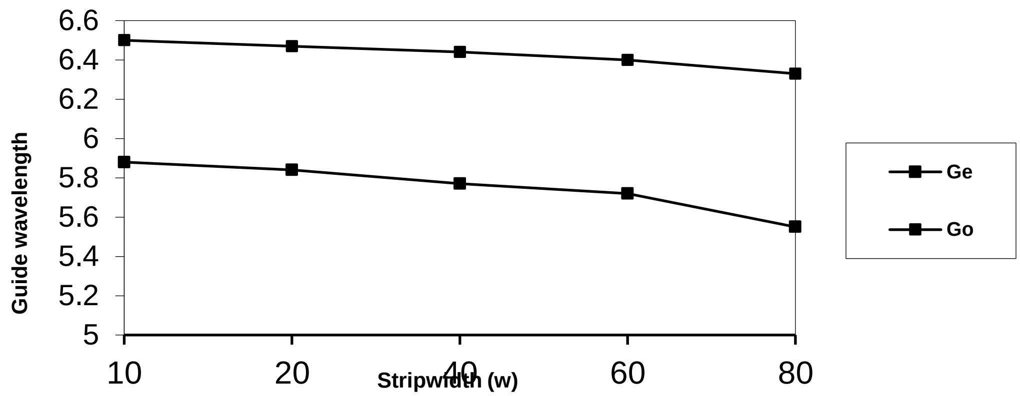

Table 3:Dependence of guide wavelength for even and odd-modes on spacing
f = 2 GHz, t = 0.01 mils $Є_r$ = 9.6

Spacing S mils	Even mode				Odd-mode			
	$(Є_{reff})_e$	$\sqrt{(Є_{reff})_e}$	V_{pe} x 10^8 m/sec	λ_{ge} x 10^{-2} m	$(Є_{reff})_o$	$\sqrt{(Є_{reff})_o}$	V_{po} x 10^8 m/sec	λ_{go} x 10^{-2} m
10	6.58	2.56	1.172	5.86	5.44	2.33	1.28	6.4
20	6.60	2.57	1.167	5.83	5.41	2.32	1.29	6.45
50	6.66	2.58	1.162	5.81	5.35	2.31	1.30	6.50
100	6.70	2.60	1.158	5.78	5.32	2.30	1.30	6.50

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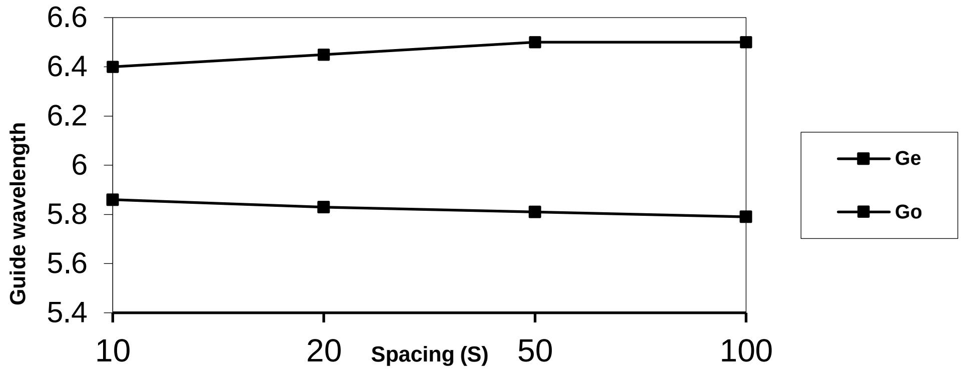
Graph 3:Dependence of guide wavelength for even and odd-modes on spacing
f = 2 GHz, t = 0.01 mils ϵ_r = 9.6



4. Conclusions

Study of dependence of phase velocity, guide ave length and characteristic impedance of the microstripline coupler with strip width, spacing between two striplines, we draw useful information for design of microstripline couplers of different coupling factors and feed line characteristic impedance. These results obtained in the synthesis process are also reasonable agreement with those obtained in analysis process.

References

[1] Sah, H. L. "A significant system for communication", Bulletin IAPT June, 1998
[2] Bhat & Bharti "CAD of microstrip circuits & antennas", 4th ISRAMT, New Delhi & Agra (India), 1995.
[3] Sah, H.L, K. B. Singh "A new horizon of Communication using fibre technology",
NSOE-03, April-2003,Meerut (India).
[4] S. Liayo "Microwave device and circuits" PHI, N.Delhi, 1995
[5] K. C. Gupta "Microwave"; Wiley Publication, (1976).