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Study of Variation of Rise in Temperature with Stripwidth

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ABSTRACT

In this paper, I present about the study of variation of rise in temperature with stripwidth. Thus, microwave temperature becomes power tools for industrial and commercial applications and also for the study of some basic properties of materials. For the calculation of this rise of temperature and its dependence of geometry of the structure and stripwidth, we must study the characteristic impedance of the structure and the phase velocity of the wave traveling through the structure.
KEYWORDS: Stripwidth, VSWR, Microwave, Microstripline Couplers.

I. INTRODUCTION

There is much current interest in the study of wave propagation in planar transmission structure like stripline, microstriplines, coplanar wave guide and slot lines etc. in the giga hertz range of frequency. The presence of conduction strip and dielectric substrate causes heating effect or loss of energy in terms of heat. It is important to study such heat loss during the propagation of microwave in giga hertz range of frequency for designing the structures as this energy loss also limits the average power of the microstripline. Microwave heating becomes power tools for industrial and commercial applications and for the study of some basic properties of materials. For the growing need of microwaves in industrial applications and in commercial purposes microwave heating becomes important for study. Microwave propagation in gigahertz range of frequency covers the area of material science, high energy particle physics, bio-medical field, industry molecular, atomic and nuclear system. This results in the rise of temperature of the structure. For the calculation of this rise of temperature and its dependence of strip width of the structure, we must study the characteristic impedance of the structure and the phase velocity of the wave traveling through the structure.

II. FORMULATION OF CHARACTERISTIC IMPEDANCES FOR EVEN AND ODD-MODES OF A MICROSTRIPLINE COUPLER

When a microstripline is placed parallel to another microstripline, coupler is formed. The power flowing in one line is coupled to the other line either in same direction or in opposite direction. The power flowing in same direction is referred to as even-mode of propagation. Power flowing in opposite direction is referred to as a odd-mode of propagation.

For the present study of characteristic impedances in the case of even and odd-modes derivation of the equation for both modes begin with the consideration of a basic single microstripline conductor. The characteristic impedance can be calculated with the help of elementary transmission line equation expressed as

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

Where,

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

C_P = capacitance per unit length of the line.

The capacitance of the line is the result of the combination of different components.

These are:

C_{PP} = parallel plate capacitance between lower surface of the microstrip and the ground plane and is given by

$C_{PP} = [\epsilon_{reff} / c.\eta] . (w/h)$ ---------------- (2)

C_{PPU} = capacitance between the upper surface of the microstrip and the ground plane which is expressed as

$C_{PPU} = (2/3) [\epsilon_{reff} / c.\eta] . (w/h)$ ----------------- (3)

C_f = the fringing capacitance at the edges of the microstrip and is expressed

$C_f = [\epsilon_{reff} / c.\eta] . (2.7/Log4h/t)$ ---------------- (4)

Where,

w = Microstrip width

ϵ_{reff} = The effective dielectric constant of the medium

h = Height of the substrate

η = Free space impedance = 377 Ω

c = The velocity of light in free space

= 3.0×10^8 m/sec.

t = microstrip thickness.

Thus the total capacitance (C_P) of the isolated microstrip structure is expressed as

$C_P = C_{PP} + C_{PPU} + C_f$

or $C_P = (\epsilon_{reff} / c.\eta) (w/h) + (2/3) (\epsilon_{reff} / c.\eta) (w/h) (\epsilon_{reff} / c.\eta).(2.7/Log4h/t)$ ---- (5)

This is the expression of the capacitance of the microstrip structure in terms of its geometric parameters.

The phase velocity V_P can be calculated by the formula

$V_P = c / \sqrt{\epsilon_{reff}}$ --------------- (6)

For wide strip, $\epsilon_{reff} \approx \epsilon_r$, and

For narrow strip, $\epsilon_{reff} \approx (\epsilon_r + 1) / 2$

Where, ϵ_r = relative dielectric constant.

From equations (3.3.1), (3.3.5) and (3.3.6), we get

$Z_o = (\eta/\sqrt{\epsilon_{reff}}) . [1/[(w/h) + (2w/3h) + (2.7/Log4h/t)]]$ ---------------- (7)

The calculations made on the basis of this expression give the characteristics impedance, the propagation constant and other transmission parameters of a single microstrip structure.

When the second conductor is introduced close to the first one, the field distribution gets altered. In even-mode the electric field lines follow the pattern fairly similar to that of the isolated conductor. In case of odd-mode, the two conductors are linked by the electric field lines.

The form of equation (7) obtained for the isolated microstrip line are also useful in calculating the characteristic impedance of microstrip coupler in even- and odd- modes. In the even-mode C_P is replaced by C_{Pe} and in the odd-mode by C_{Po}. Since the electric field lines are distributed in air and below the conductor in the dielectric substrate, the dielectric medium now becomes inhomogeneous. Due to in homogeneity the phase velocity (V_P) for the isolated case is replaced by V_{Pe} for the even- mode and V_{Po} for the odd- mode. Further in place of ϵ_{reff} the effective dielectric constants $(\epsilon_{reff})_{eo}$ are to be used for even and odd-modes separately. Similarly, Z_{oe} and Z_{oo} represent the characteristic impedances for even-and odd- modes respectively.

III. STUDY OF VARIATION OF RISE IN TEMPERATURE WITH STRIPWIDTH

For the study of rise in temperature and its variation with stripwidth exhaustive computational and manual works have been performed both for even and odd-modes of propagation. In the results obtained have been placed in table 1 and graph between rise in temperature and stripwidth have been plotted as shown in graph 1. It has been observed that with increase of stripwidth characteristic impedance both for even and odd-modes decreases effective permittivity for even-mode and odd-mode increases slightly. This causes increase of thermal loss and subsequent increase in rise of temperature. Variation of rise in temperature in case of even-mode is slightly greater than that in case of odd-mode.

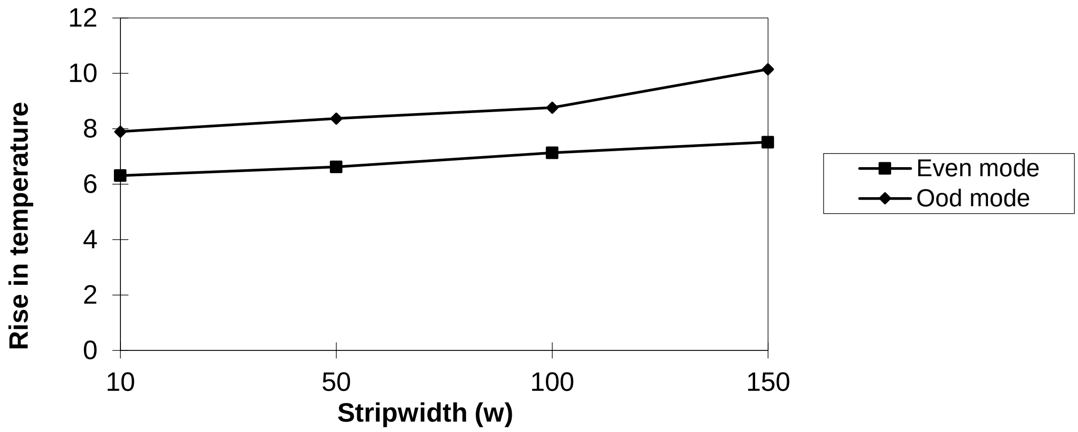
Table No. 1: Variation of rise in temperature with stripwidth for even and odd-modes

h = 100 mils, s = 25 mils, t = 0.01 mils, f = 2 GHz, ϵ_r = 9.6

Stripwidth (w)	Even-mode			Ood-mode		
	α_d dB/m	α_c dB/m	ΔT °C	α_d dB/m	α_c dB/m	ΔT °C
10	8.73	0.56	6.32	7.38	0.93	7.91
50	9.34	0.58	6.64	7.71	0.99	8.38
100	9.54	0.65	7.15	7.82	1.02	8.77
150	9.86	0.70	7.53	7.96	1.22	10.16

Graph No. 1: Variation of rise in temperature with stripwidth for even and odd-modes

h = 100 mils, s = 25 mils, t = 0.01 mils, f = 2 GHz, ϵ_r = 9.6



IV. CONCLUSION

In the results obtained have been placed in table 1 and graph between rise in temperature and stripwidth have been plotted as shown in graph 1. It has been observed that with increase of stripwidth characteristic impedance both for even and odd-modes decreases effective permittivity for even-mode and odd-mode increases slightly. This rise of temperature increases with stripwidth.

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