LOSS OF ENERGY OF MICROWAVE PROPAGATING THROUGHMICROSTRIPLINE STRUCTURE

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ABSTRACT

Microwave Integrated circuits (MIC'S) have changed since the days of large scale waveguides and co-axial component arrays to small light weight assemblies with introduction of microwave striplinesmicroslotlines, coplanar strip lines and coplanar waveguide etc. There are different transmission structures used for sending the message information, ideas and power (energy) from one place to another how far remote it is. The two parallel wire transmission line structure, coaxial line, & wave guide have become absolate now- a- days due to their bulky size, heavy cost and power losser in gigahertz range of frequency. The planar transmission line (2-dimensional) technology has been developed due to advent of microwave integrated circuits (MIC's) owing to certain special features and characteristics such as: Minaiaturized size, Reduced weight, Low cost, & Minimum power consumption. The present work aims at the study of characteristics impedance, phase velocity, Guide wavelength, consequent Rise of Temperature due to energy loss of microwave propagating through single microstrip structure. It is necessary to study these characteristics parameters to study different type of losses occurred during the propagation of electromaganetic waves through these structures. The TEM mode of propagation of wave is considered in the lower GHz range of frequency. This study also helps in the studyof variation losses due to stripwidth and permittivity of substrate used in the microstripline structure.

KEYWORDS: Substrate, Permittivity, Microstripline.

INTRODUCTION

The field of microwave is found very important in many new and excting applications in last four decades. Microwave is a primary vehicle for information exchange which makes greater importance in the international relation and global understanding. The great interest in microwave frequency aries from 109 to 1012 Hz. This microwave spectrum accommodates many more communication channels which becomes commo0n in society. With increasing need of microwave frequency it become necessary to develop different forms of planar transmission structure having properties: less lossy, reduced in weight and volume, reduced cost in mass production, and more reliable.

There are different systems for transmission of microwave signals. The simplest one is the two parallel wire transmission lines which is one dimensional structure and too much lossy in microwave frequency range. This leads to the idea of development of other transmission structure such as waveguide which is a three dimensional structure used for TE-mode/Tm-mode. This is too lossy in giga hertz frequency range.

Stripline and microstriplines devices are the convenient substitute for the bulky structure. The stripline structure is a three conductor TEM-mode transmission line. It consists of a thin conductor strip sandwiched between two dielectc laminates matalized on the outer sides (fig 1.a). the field configuration is shown in fig (1.b) which shows that the field line concentrate around the strip conductor and decrease outward with distance away from the metal strip. It is an excellent medium for realizing passive components but it suffers from the conductor and dielectric losser. These losser are studied by introducing microstriplines structure.

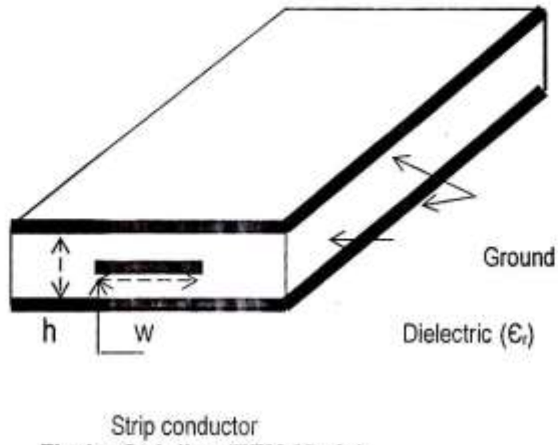

Fig 1a Stripline (TEM-Mode)

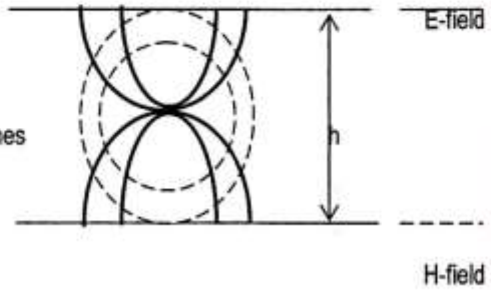

Fig 1b Stripline field configurations

CONCEPT OF MICROSTRIPLINE STRUCTURE

It is a simplest and modified dorm of stripline. The microstripes structure consists of a narrow conductor strip on one side of a dielectric substrate other side of which is metalized to serve as a ground plane shown in fig (2 a). The electric field lines and magnetic field configuration is shown in fig(2 b)

It is an open structure and simple in realization. The field lines are confined in the vicinity of the strip conductor with a large concentration inside substrate and smaller in the air region it depends on the permittivity of the substrate used, Suitable substrate is preferred which can minimize the dielectric loss

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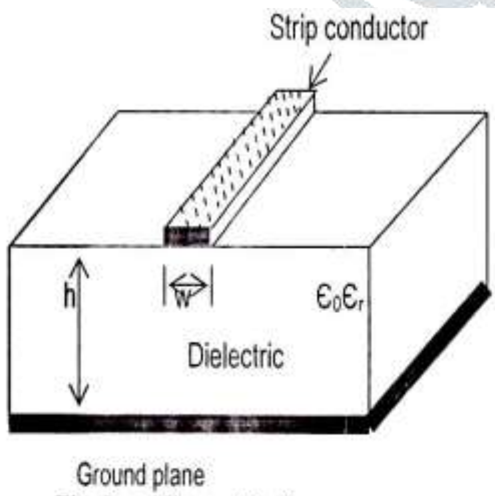

Fig 2. a Microstripline (Quasi -TEM Mode)

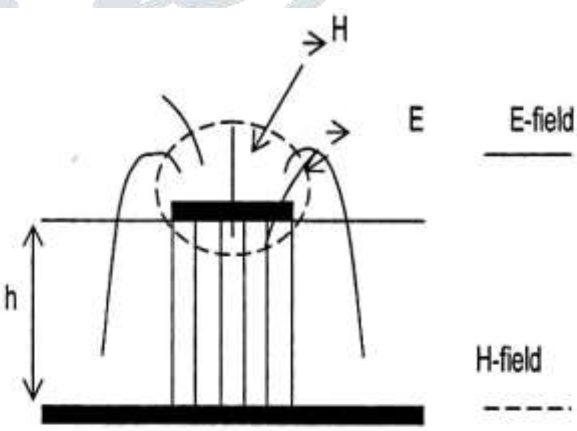

Fig 2.b Microstrip Field configuration

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and trip conductor on the surface effective permittivity $\epsilon_{reff.}$ is considered for the calculation of the characteristics and its losses. The knowledge of characteristic impedance and phase velocity enable us to obtain the energy losses of the wave travelling through the structure. The characteristics impedance in given by 2

$Z = \frac{1}{v_{p.C}}$ 1

$= Z_0/\sqrt{\epsilon_{reff.}}$ 2

Guide wavelength of the wave inside the structure is given by

$\lambda_g = \lambda_0/\sqrt{\epsilon_{reff.}}$ 3

Phase velocity of the wave travelling through the structure is given as

V_p= C//$\sqrt{\epsilon_{reff.}}$

Where , c= velocity of the wave in free space and $\sqrt{\epsilon_{reff.=}}$ effective permittivity of the inside the structure .

The value of $\epsilon_{reff.}$lies in the range 0.5(1+$\epsilon_{r)}$.≤$\epsilon_{reff.}$≤$\epsilon_{reff.}$(f) depending on the value of strip width (w) and substrate height (h). For small w/h << 1,the electric field lines are distributed nearly equally between the substrate and air region and $\epsilon_{reff.}$approaches the lower limits (ϵ_r+ 1)/2. For wide strip (w/h >>1), the electric field lines are concentrated mostly between the strip conductor and the ground plane. This configuration makes the microstrip line to be resembled with a parallel plate capacitor with $\epsilon_{reff.}$ Approaching $\epsilon_{r.}$

ENERGY LOSS OF MICROWAVE TRAVELLING THROUGH THE MICROSTRIPLINE STRUCTURE

The stripline and microstripline though are less lossy, they suffers most from Dielectric loss and Conductor loss (Skill loss). The dielectric loss in due to finite loss tangent of the dielectric substrate and conductor loss is due to the finite resistivity of the strip conductor. The loss tangent is expressed as

Tan $\delta = \sigma/w\epsilon_r$

Where, σ= specific conductivity of the substrate and ϵ_r= permittivity of the substrate.

W= $2\pi f$= the operating angular frequency.

These energy losses have been studied bt several incestigator3. If a_c be denoted as the attenuation constant due to the conductor loss and a_d as the attenuation constant due to dielectric loss, both expressed in dB/ unit length , then total attenation is given as

$a = a_c + a_d$ dB/unit length

Where

$a_d = 27.3 \, (\frac{tan\sigma}{\lambda_0})\{\epsilon_r/\sqrt{\epsilon_{eff)}} \, (\epsilon_{eff-1})/ \, \epsilon_{r-1})\}$......................................5

Where ,λ_0 = free space wavelength, ϵ_r = the equivalent relative permittivity,

And

a_c= 8.68 Rs/ $Z_0 W$

Where Rs = Surface resistivity = $\sqrt{\mu\pi f}/\sigma_{c,}\sigma_{c,}$ = conductivity of the metal strip.

$\mu = Permeability\ of\ the\ medium\ and\ f = Operating\ frequency.$

Total Energy loss = Joule Energy Loss + Dielectric Energy Loss. This causes rise of temperature expressed by

$\sigma T = \left(\frac{0.23h}{K}\right)\left\{\frac{a_c}{w}\right) + \left(\frac{a_d}{2w}\right)\}^0$C/watt) 7

This is calculated for different metal strip width, different height of the substrate using different permittivity.

After exhaustive computation the energy loss in terms of rise temperature for different stripwidth and different relative permittivity have been studied and the results are placed in table- 1 assuming f = frequency = 3 GHz, t= 0.01 mils and h= 100 mils.

	$\epsilon_r = 3.25(Fused\ Qu$			$\epsilon_r = 6(Berila)$			$\epsilon_r = 10(Alumina)$		
Stripwidth (w) mils	ϵ_{reff}	$Z_0(\Omega)$	**ΔT (^{0}C)**	ϵ_{reff}	$Z_0(\Omega)$	**ΔT (^{0}C)**	ϵ_{reff}	$Z_0(\Omega)$	**ΔT (^{0}C)**
10	2.70	166.25	30.70	3.25	141.50	36.75	5.85	1.16.15	42.25
50	2.80	103.70	10.20	3.70	93.85	11.60	6.30	62.25	15.50
100	2.85	76.92	6.50	3.85	61.35	7.65	6.52	57.80	10.55
150	2.90	64.15	5.25	4.00	51.22	6.50	6.75	37.92	7.35
200	2.95	55.20	4.65	4.25	41.32	6.25	6.95	32.45	6.85

Table 1 variation of energy loss with stripwith& permittivity

DISCUSSION AND CONCLUSION

From the table it has been found that energy loss due to propagation of microwave through microstripline depends due to presence of metal strip and dielectric material of different nature. The increase of stripwidth decreases the energy loss and consequent rise in temperature. Further this energy loss is larger for dielectric materials of higher permittivity. Discussion of the result exhibits that change of strip geometry causes the distortion of field and flow of power through the stripline gets affected. In case of narrower strip, energy loss is large. Thus it can be concluded that to get smaller energy loss relatively wider metal strip and substrate material of lower relative permittivity should be taken for the design of any device based on planer strip like like patch antenna, isolator, resonator and couplers.

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REFERENCES

i. H. Howe, “ Stri[line circuit design of coupled Parallel lines”, Artech House pp.112-137, 1974

ii. B. Bhat and S.K. Koul, “ Stripline like transmission lines for mic’s”, Wiley Eastern limited, 1990

iii. M.V. Schneider, “ Dielectric loss in intergrated Microwave ciecuits”, Bell system, Technical Journal, vol.48, pp 2325-2332, 1969

iv. I.J. Bahl& P. Bharha, “ microwave engineering and application”, John Wiley & Sons, N.Y.1994

v. R.A. Pucel et al, “Losses in Microstrip”, IEEE MTT vol. 16, pp.342-350,1968