THE STUDY OF LOSSES AND LIMITATIONS OF MICROSTRIPLINE STRUCTURE

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ABSTRACT

The two parallel wire transmission lines are the simplest structure for microwave signal but these are very much lossy in giga hertz range of frequency. To minimize the losses & to reduce the size & cost new technology known as planar transmission line technology has been developed with the advent of microwave integrated circuits (MIC's). There are various transmission structures which have been developed & designed by different pioneer of this field suitable for giga hertz range of frequency such as stripline, microstripline, slot line, coplanar strips and coplanar wave guides.

KEYWORDS : TEM Mods

INTRODUCTION

Microwave Integrated Circuits (MICs) represent an extension of integrated circuit technology to extremely high frequencies, MICs is a subsystem function, which can vary greatly in complexity, and usually represents the major part of the microwave assembly of specific systems. Today's MICs are of monolithic and hybrid nature. The hybrid nature MIC is of main importance in which active devices and some passive devices in chip form are mounted on substrates on which remaining circuit elements have been fabricated using thin films. Monolithic MICs, although feasible presently for a few specific uses, represents a future generation of the MICs approach.

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/TM – modes. This is too lossy in giga hertz frequency range.

Stripline and microstripline devices are the convenient substitute for the above structure. The stripline structure is a three conductor TEM mode transmission line. The stripline structure is a three conductor TEM modetransmission line. It consists of a thin conductor strip sandwiched between two dielectric laminates metalized on the outer sides. The field configuration is shows that the field line concentrates 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 suffer from the conductor and dielectric losses. These losses are overcome by introducing microstriplines structure.

After World War II several types of microwave strip circuits and their variants have been developed and used as common microwave transmission devices. Microwave strips stand for stripline, microstripline, slotline, coplanar strips and coplanar waveguides etc. The special features of such strips are

(i) Reduction in size and weight,

(ii) Reduction in cost,

(iii) increase in reliability.

Development of striplines and micristriplines has proved to be very significant as regards the fabrication of various microwave components such as directional couplers, fitters, and isolators etc. with small size, lower cost and greater reliability, leading to the microwave integrated circuit (MIC).

PLANAR TRANSMISSION STRUCTURES

Planar transmission structures suitable for MICs have a geometry that allows the characteristic impedance of the structure to be controlled by defining the dimension in a single plane. This feature allows the complete transmission structure to be fabricated in one step by thin film technology and photolithography techniques. These processes are similar to that use for making printed circuit card for low frequency electronic circuitry. Several configurations for planar transmission structures are possible. Commonly used structures are strip line, microstripline, slot line coplanar strips, coplanar waveguide and their different types of variants such as suspended and inverted stripline and microstriplines etc. Many of these follow TEM – mode of wave propagation and others follow non – TEM – mode.

STRIPLINE CONFIGURATION

Stripline transmission structure is a three conductor following TEM-mode of wave propagation. It is a modified version of triplet structure and first member of the planar transmission line family. It consists of a flat strip conductor placed symmetrically between two large ground planes with the intervening space homogenously filled with a dielectric substrate. The field lines concentrate around the strip conductor and decay rapidly with distance away from the strip in the lateral directions. The stripwidth of the structure is much greater than its thickness. The upper and lower sides of the structure are completely metalized. These two metal laminates are clamped together to form a final stable configuration. The space between two metal substates is negligible due to small thickness of the stripline. The energy propagates mostly in the dielectric substrate just below the strip conductor, some part of it is associated with the fringe fields and some extends in the space above the dielectrics. The dominant mode of propagation is puer.

MICROSTRIPLINE CONFIGURATION

Due to following features Microstripline is more useful than stripline :

(i) There is an easy access to the top surface which makes it very convenient to mount active and passive devices and to make minor adjustment after the circuit has been fabricated.

(ii) Because of openees of the structure care has to taken to minimize the radiation loss or interference due to nearby conductors.

To insure that fields are confined near the stip, use of high dielectric constant substrate is necessary. Since the electromagnetic fields extend in the space above the microstrip, microstrip configuration becomes a mixed dielectric transmission structure effective dielectric permittivity is considered. In this structure most of the energy is concentrated below the strip. It is a simplest and modified form of stripline structure. The microstriplines 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. It is an open structure and simple realization. The field lines are confined in the vicinity of the strip conductor with a larger 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. A quassi TEM mode is preferable but in in lower gigahertz frequency range TEM mode of wave propagation is considered. As microstriplines is an inhomogeneous structure consisting of a dielectric substrate and strip conductor on the surface, effective permittivity $\epsilon_{reff.}$ is considered for the calculation of the characteristics of the structure. The characteristics parameters of the structure. The knowledge of characteristics impedance and phase velocity enables one to obtain the capacitance of the structure when two microstriplines are placed together in close proximity with broadside parallel; the structure is called coupled microstripline. The characteristics parameter depends on the geometries of structure, substrate height and permittivity and spacing between the two striplines. This also offers the knowledge of coupling coefficient of the coupled microstripline.

DESIGN OF A MICROSTRIPLINE STRUCTURE

The analysis and synthesis are two methods for study transmission structure. The analysis method involves the study of characteristic parameters of the structures for given variables such as strip geometry, permittivity & frequency. The synthesis (design) involves choosing relative permittivity (ϵ_r) and height (h) for the substrate and calculating strip width (w) to achieve desired characteristics impedance (z) using equation. While selecting ϵ_r, h and w, it is important to insured that only dominant mode is propagating. For a 50Ω line on a lamina substrate (ϵ_r = 9.6) of thickness 0.633 mm, w/h = 1 or w = 0.535mm. assuming w = 0.4 mm, h = 0.254 mm, the cut off frequency range is 57 GHz for TM-mode and 40 GHz for TE-mode. The recommended frequency range for 50 Ω microstripline on alumina is 0 – 30 GHz. For increasing the upper limit, we need to reduce h or ϵ_r. reduction of h leads to more stringent dimensional tolerances during fabrication and reduction of ϵ_r increases the radiation loss.

In order to reduce to radiation and also to provide electromagnetic shielding, practical microstrip circuits are housed in a shielded enclosure. The lower limit of Z in a microstripline is 20 Ω and is set by the onset of TE-mode. The upper limit of Z is 120 Ω and is set by the smallest realizable value of W. one major advantage of the microstrip is that its surface is accessible for mounting passive as well as active discrete devices. It is also a versatile medium for realizing a variety of circuit forms and combining several circuit functions. By placing two similar strip lines parallel to each other at small spacing coupled microstrip structure is formed and for coupled stripline of given characteristic impedance and coupling we have to obtained the width of the strip and spacing between them which is the aim of the present work.

LOSSES IN MICROSTRIPLINE STRUCTURE

As microstripline structures are open and consist of metal strips embedded on the dielectric substrates, there are some losses especially in the case of high frequency range. The stripline and microstripline though are less lossy, they suffers from four types of losses : (1) Dielectric loss, (2) Conductor loss (skin loss), (3) Radiationloss & (4) Surface wave loss.

Out of these first two are important for the study. The dielectric loss is due to finite loss tangent of the dielectric substate 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, ϵ_r = permittivity of the substrate

w = 2TTf = the operating angular frequency.

These losses have been studied by several investigates . if α_c be denoted as the attenuation constant due to the conductor loss and α_d as the attenuation constant due to dielectric loss, both expressed in dB/ unit length, then the total attenuation is given as

$A = \alpha_c + \alpha_d$ dB/ unit length.

LIMITATION OF MICROSTRIPLINE STRUCTURE

Since microstripline is simple and open structure filled with mixed dielectrics air and dielectric substrate.

(i) As most of the field lines are concentrated at the dielectric substrate, a slight change in ϵ_r due to temperature change or due to batch to batch variation will change the impedance, guide wavelength and phase velocity considerably.

(ii) Circuit dimension at millimeter wave frequency are very small – results in fabrication problems.

(iii) Thinner substrate permits high frequency operation but at the cost lower Q-factor (≈100).

(iv) The conductor loss in the microstrip increases with an increase in frequency. The useful range of frequency for microstrip is upto about 50 GHz.

CONCLUSION

These results obtained in the synthesis process are also responsible agreement with those obtained in analysis process. So, this provides an important and necessary tool for the designer to fabricate directional coupler of desired coupling coefficient and directivity.

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