MICROSTRIP FILTER CALCULATOR

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To my parents and brothers

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ABSTRACT

Low and high pass filters are used in many radio frequencies (RF) and microwave applications, such as communication to separate or combine different desired frequencies. Advancement in computer aid design (CAD) tools such as full-wave electromagnetic (EM) simulators has revolutionized filter design. The purpose of the project is to develop a low cost, calculator for microstrip filter design. But it will focus on parallel (edge)-coupled microstrip bandpass filter. In this project, a graphical user interface (GUI) will be design to determine the layout of the microstrip filter for given parameter. In the process, there is analysis and consideration of suitable methodology to use in designing of the microstrip low and high pass filter. It is important to understanding the step involved in constructing the microstrip filter as presently, there are many methods available to choose from. The main objective of the project is to conduct research and understand the existing literature on microstrip analysis and synthesis equations, to conduct research and understand the existing literature on microstrip filter and other variable, to propose a suitable design methodology and equations for developing of the calculator formulas and to develop a GUI use Matlab for the entry of the filter parameter and layout. Lastly, to design attractive and informative input and output display of parallel (edge)-coupled microstrip bandpass filter.

ABSTRAK

Penapis laluan rendah dan turas laluan tinggi digunakan dalam frekuensi radio (Rf) dan aplikasi gelombang mikro, seperti komunikasi mengasingkan atau menggabungkan frekuensi-frekuensi yang dikehendaki. Kemajuan komputer dalam reka bentuk bantuan (CAD) alat-alat seperti gelombang penuh elektromagnetik (EM) simulator telah merevolusikan reka bentuk turas. Tujuan projek ini adalah untuk membangunkan kalkulator satu kos rendah untuk mikrostrip reka bentuk turas. Tetapi untuk projek ini ia akan tertumpu atas selari (pinggir)-digandingkan mikrostrip penuras jalur laluan. Dalam projek ini, antara muka pengguna grafik (GUI) akan reka bentuk untuk menentukan susunatur mikrostrip menapis bagi parameter yang diperlukan. Proses analisis dan kaedah yang sesuai perlu diambil untuk menentukan sama ada ia mikrostrip turas tinggi atau rendah. Ia penting memahami mikrostrip turas dengan lebih mendalam. Objektif utama projek adalah untuk menjalankan penyelidikan dan fahaman kesusasteraan wujud di mikrostrip persamaan analisis dan sintesis, untuk menjalankan penyelidikan dan sifat mikrostrip turas dan pembolehubah lain, mencadangkan satu metodologi reka bentuk dan persamaan yang sesuai untuk membangun formula kalkulator dan untuk membangunkan satu GUI menggunakan Matlab untuk kemasukan turas parameter dan susunatur. Akhirnya, untuk merekabentuk input menarik dan informatif dan pameran pengeluaran selari (pinggir)-digandingkan mikrostrip penuras jalur laluan.

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ε_r	Dielectric Constant
ε_{eff}	Effective dielectric constant
λ	Wavelength
π	pi
Ω	Ohms
f	Frequency
h	Height
w	Width
Z_o	Impedance
l	Length

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION OF THE PROJECT

The use of microstrip in the design of microwave components and integrated circuits has gained tremendous popularity since the last three decades. Many researchers have presented numerous equations for the analysis and synthesis of microstrip. A variety of sophisticated computer aided designed (CAD) software packages have evolved from such work. Along with the sophistication come a high price tag, copy protection schemes, and training requirement s that create difficulties for exploratory usage in an academic environment. There is a need for a low cost, user friendly, open system software package that can be used as an effective training aid on microstrip design.

This project will focus on developing a low cost, user-friendly, calculator for microstrip low pass filter. This project will design graphical user interface to determine the layout parameter of the microstrip filter for the given physical and parameter and ε_r of substrate that require. The other variable are: type of filter, type of pass and stop band response frequency and BW. This project will use matlab for display and calculating support. The new software comprises two parts; a simple interactive graphical user interface (GUI) for entry of the filter design parameter, and a filter calculator to calculate based on the input parameters.

1.2 OBJECTIVE

The purpose of the project is to develop a low cost, calculator for microstrip filter design. In the process, there is analysis and consideration of suitable methodology to use in designing of the microstrip low and high pass filter. It is important to understanding the step involved in constructing the microstrip filter as presently, there are many methods available to choose from.

To achieve these aims, the objectives of the project are formulated as follows:

1. To conduct research and understand the existing literature on microstrip analysis and synthesis equations.
2. To conduct research and understand the existing literature on microstrip filter and other variable.
3. To propose a suitable design methodology and equations for developing of the calculator formulas.
4. To develop a GUI for the entry of the filter parameter and layout that will be link to matlab.
5. To design attractive and informative input and output display.

1.3 SCOPE OF PROJECT

The scope of this project basically is the study of microstrip filter. This includes the study of the type of filters, type of response, ε_r of substrate that we want use. In this project, also will design the software to determine the layout of the microstrip filter for the given parameter.

The study of the type of filter will includes low pass filter, high pass filter, band pass filter and band stop filter. It is also includes all the filter characteristic, formula etc. For the type of responses are Butterworth filter, Chebychev filter response, Bessel filter and Cauer filter. Then, for ε_r of substrate that have to use such as alumina, FR4 Fiberglass, PTFE, Quartz and etc.

For any physical parameters it will includes Bandwidth, ripple, frequency, and number of section. The software will calculate the dimensions of structure of filter such as *l* (length), *w* (width), *s* (space) and also will display the layout figure.

1.4 PROBLEM STATEMENT

Nowadays, many software can be find in internet, but none of them is cover 100% user desire. Some of them have limited parameter to be measured, limited range measurement. Some calculator also includes in microwave software but they are expensive. This project will build friendly, cheap, wide range measurement software. Hopefully, with this microstrip filter calculator will help user in calculation.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, all the theory and formula that involve with microstrip filter will be discussed. Other than that, the application of microstrip filter also will be stated.

2.2 HISTORY OF MICROSTRIP

Microstrip is a planar transmission line, similar to stripline and coplanar waveguide. Microstrip was developed by ITT laboratories as a competitor to stripline (first published by Grieg and Engelmann in the December 1952 IRE proceedings). According to Pozar, early microstrip work used fat substrates, which allowed non-TEM waves to propagate which makes results unpredictable. In the 1960s the thin version of microst ip became popular.

2.3 MICROSTRIP TRANSMISSION LINE THEORY

Microstrip is a planar transmission line. It is a single conducting strip (microstrip line) with a width (W) and a thickness (t) is on the top of a sheet dielectric substrate that has a relative dielectric constant (ε_r) and a thickness (h), and the bottom of the substrate is a ground (conducting) plane.

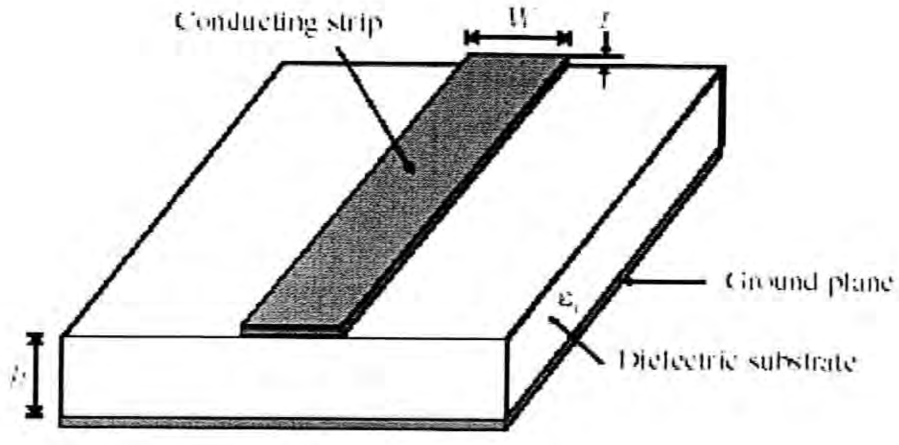


Figure 2.1: General microstrip structure

Microstrip, just the same as all transmission line which carries the RF signal from one point to another. In general, the transmission lines are represented as R, L, G and C (series resistance, series inductance, shunt admittance and shunt capacitance) in a circuit as illustrated below [1]. The lumped circuit element approximations of transmission line circuit theory are not valid in microwave frequencies (with short wavelength, λ). The microwave components usually are distributed not lumped [1].

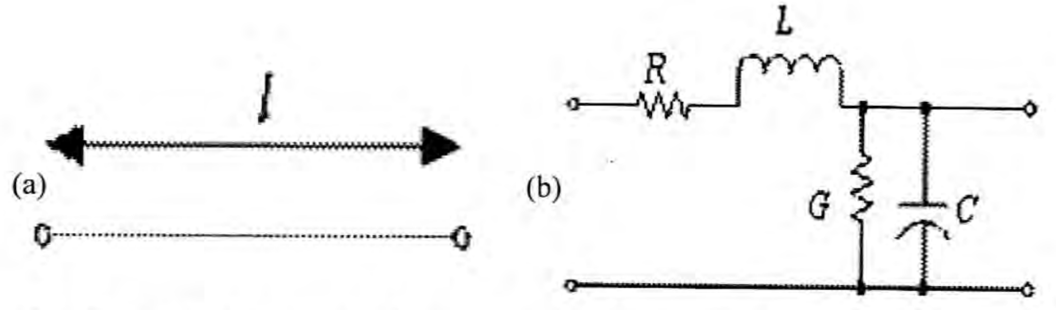


Figure 2.2: The equivalent circuit of a short length (l) of general transmission line.

(a) Transmission line of length (l). (b) Primary constants assigned to a lumped element model of a transmission line.

Microstrip line cannot support a pure transverse electromagnetic TEM[1] wave. The electric and magnetic field lines and ground plane are not entirely contained in the substrate. It is extended within two guided media – air above and dielectric below. Therefore, the fields are considered as quasi-TEM mode [2], [3]. The wave propagations will not depend only on the material properties, but also on the physical dimensions of the microstrip [3]. Such transmission line has effective dielectric constant (ε_{re}) and unique characteristic impedance (Z_0) is determined by selected W/h ratio and substrate material used [2].

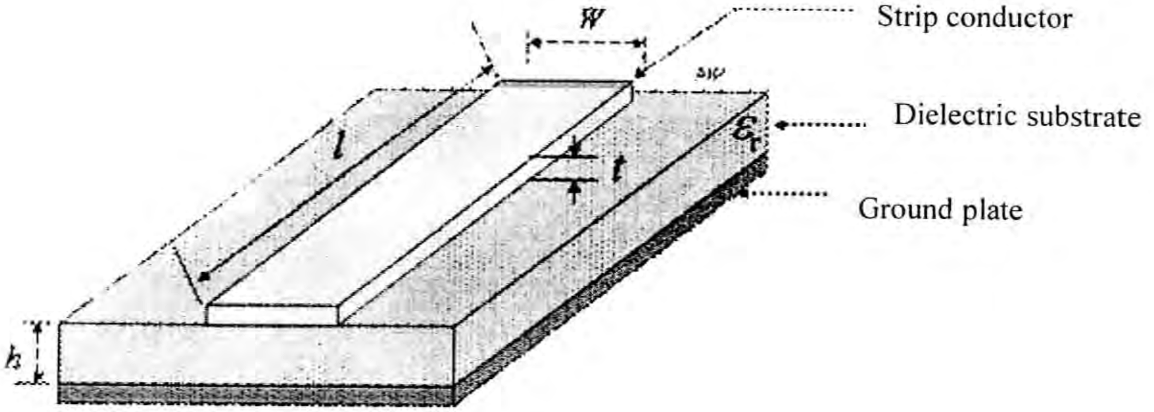
Circuit built with microstrip transmission line has several advantages [2], [4]:

- The circuit can be fabricated easily at a substantially lower cost.
- Accessible for probing and circuit measurement.
- Reasonable RF power handling and allow low impedance
- Smaller circuit size can be obtained.
- Able to handle wide operating bandwidth.

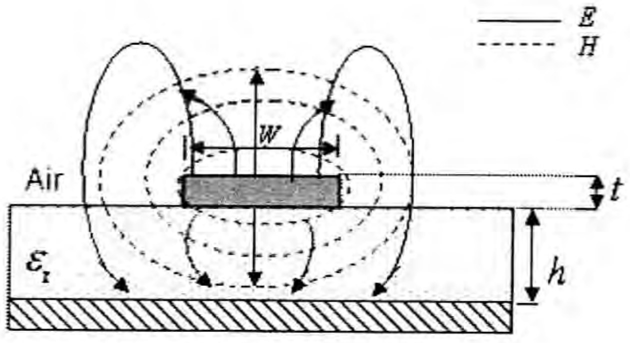
2.4 WAVE IN MICROSTRIP

The fields in the microstrip extend within two media—air above and dielectric below—so that the structure is inhomogeneous. Due to this inhomogeneous nature, the microstrip does not support a pure TEM wave. This is because that a pure TEM wave has only transverse components, and its propagation velocity depends only on the material properties, namely the permittivity ε and the permeability μ. However, with the presence of the two guided-wave media (the dielectric substrate and the air), the waves in a microstrip line will have no vanished longitudinal components of electric and magnetic fields, and their propagation velocities will depend not only on the material properties, but also on the physical dimensions of the microstrip.

The geometry and the cross sectional view of a microstrip line is illustrated below.



(a)



(b)

Figure 2.3: Microstrip Transmission Line. (a) Geometry. (b) Cross sectional view with electric and magnetic field lines.

2.4.1 Substrate Material

Important qualities of the dielectric substrate include

- The microwave dielectric constant
- The frequency dependence of this dielectric constant which gives rise to "material dispersion" in which the wave velocity is frequency-dependent
- The surface finish and flatness
- The dielectric loss tangent, or imaginary part of the dielectric constant, which sets the dielectric loss
- The cost
- The thermal expansion and conductivity
- The dimensional stability with time
- The surface adhesion properties for the conductor coatings
- The manufacturability (ease of cutting, shaping, and drilling)
- The porosity (for high vacuum applications we don't want a substrate which continually "outgases" when pumped)