MICROSTRIP BANDPASS FILTER DESIGN (COMBLINE)

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” To my beloved Mother and Family”

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ABSTRACT

This project is about designing a wide bandpass microstrip filter that will operate at the industrial, scientific and medical (ISM) band. The ISM band was an unlicenced band which is originally reserved internationally for the use of RF electromagnetic field for industrial, scientific and medical purposes other than telecommunication. A bandpass microstrip filter working at the ISM band will reject other frequency outside the ISM band. The design process will be started by obtaining the order of the filter base on the specification given. Then, lumped element bandpass filter will be designed. Next is the realization to microstrip structure process. The dimension of microstrip such as the length, width and spacing of the microstrip filter will be determined by using filter realization method. Simulation was done by using Microwave Office software to observe the S_{11} and S_{21} of the filter. The next process is to fabricate the designed microstrip bandpass filter on the FR4 boar and measurement will be done on the fabricated filter by using network analyzer. The procedure, results and discussion were discussed in this report.

ABSTRAK

Projek ini adalah berkenaan dengan mereka bentuk sebuah penapis mikrojalur lulus jalur lebar yang beroperasi pada jalur frekuensi *Industrial, Scientific and Medical* (ISM). Jalur frekuensi ISM adalah jalur frekuensi yang tidak memerlukan lesen dan dikhaskan secara global untuk kegunaan medan electromagnet frekuensi radio untuk kegunaan industri, saintifik dan perubatan selain untuk kegunaan telekomunikasi. Penapis mikrojalur lulus jalur yang beroperasi pada frekuensi ISM akan bertindak menghalang frekuensi-frekuensi selain daripada frekuensi ISM. Proses mereka bentuk sebuah penapis lulus jalur bermula dengan menentukan bilangan peringkat penapis berdasarkan tentuan yang diberikan. Kemudian penapis lulus jalur elemen gumpalan akan direka. Seterusnya adalah proses untuk merealisasi kepada struktur mikrojalur di mana dimensi mikrojalur seperti panjang, lebar dan jarak untuk penapis lulus jalur mikrojalur akan ditentukan dengan menggunakan realisasi Simulasi dijalankan menggunakan perisian Microwave Office dimana nilai S_{11} dan S_{21} akan diperhatikan. Proses seterusnya adalah proses fabrikasi penapis mikrojalur lulus jalur diatas papan FR4 dan pengukuran akan dijalankan keatas penapis yang telah siap dibina dengan menggunakan alat penganalisis rangkaian.. Tatacara, dapatan dan diskusi akan dibincangkan di dalam laporan ini.

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LPP- Lowpass Prototypes

LPF- Lowpass Filter

HPF- Highpass Filter

BPF- Bandpass Filter

BSF- Bandstop Filter

S-parameter- Scattering Parameter

RF- Radio Frequency

FR-4 board- Frequency Redundant 4 board

ISM band- Industrial, Scientific and Medical Band

ADS- Advanced Design System

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CHAPTER 1

INTRODUCTION

Filters play important roles in many RF/microwave applications including cellular radio, satellite communication, and radar. They are used to separate or combine different frequencies. The electromagnetic spectrum is limited and has to be shared. Therefore, filters are used to select and confine the RF/microwave signals within assigned spectral limits.

The first chapter of this report is the introduction part of the report. In this chapter, the background studies, the problem statements, the objectives and the scope of work will be discussed

1.1 Background Studies

The development of applications such as wireless communication s continue to challenge RF/microwave filters with even more stringent requirement such as higher performance, smaller size, lighter weight and lower cost. Depending on the on the requirements and specifications and specifications, RF/microwave filters maybe designed as lumped elements or distributed elements circuits and can be realized in various transmission line structures, such as waveguide, coaxial line and microstrip.

Microstrip is a type of electrical transmission line which can be fabricated using printed circuit board [PCB] technology, and is used to convey microwave-frequency signals. It consists of a conducting strip separated from a ground plane by a dielectric layer known as the substrate. Microwave components such as antennas, couplers, filters, and power dividers can be formed from microstrip, the entire device existing as the pattern of metallization on the substrate. Microstrip is thus far cheaper than traditional waveguide technology, as well as being far lighter and more compact.

1.2 Problem statement

The industrial, scientific and medical (ISM) band was originally reserved internationally for the use of RF electromagnetic fields for industrial, scientific and medical purposes other than communications. Therefore, a device is needed to filter signals so that it will operate in this ISM band. Therefore, does microstrip filter fulfil this requirement? Theoretically, microstrip filter can operate at high frequency and microstrip filter is easy to fabricate. Therefore, the behaviour of microstrip filter will be studied.

1.3 Objectives

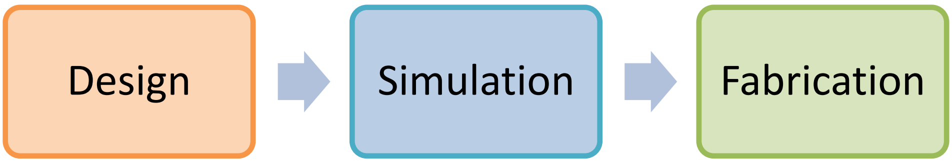
The objectives of the project are:

i) To design and simulate a microstrip filter that will operate at 2.4 GHz until 2.5GHz is suitable for the ISM band.

ii) To fabricate a microstrip combline bandpass filter on FR4 board by using etching technique.

iii) To make a comparison between the result obtained by simulation and the measured value.

1.4 Scope of Works



The scope of work of the project consists of three major parts which are the design part, the simulation part, and the fabrication part.

1.4.1 Design

During the designing process, the number of order for the filter will be determined based on the specification given. When the number of order has been determined, the lowpass prototype for the filter will be design. Since the objective of the project is designing a bandpass filter, transformation from lowpass filter to bandpass filter will be done for the lowpass prototype.

1.4.2 Simulation

When the design process had been done, the simulation will be done on the Advanced Design System (ADS) software and by using the Microwave Office software. From simulation, the Scattering Matrix and the cut of frequency for the bandpass filter can be observed.

1.4.3 Fabrication

When the results obtained from the simulation fulfil the requirement of the filter, fabrication of the filter will be done. For the fabrication, etching technique was used to fabricate the filter on the FR4 board. When the filter been fabricated, testing will be done. Testing was done by using the network analyzer. Then comparison will be made between the simulation and the measurement result obtained from the network analyzer.

1.5 Report Structure

Chapter	Content
I	Introduction
II	Literature Review
III	Methodology
IV	Result and Discussion
V	Conclusion and Suggestion

CHAPTER 2

LITERITURE REVIEW

This chapter will discuss about the literature review used for my project. For the project, some study had been done on the microstrip filters concept, the theory implemented, and the technique used for this project.

2.1 The Microstrip Filters concept.

2.1.1 Transfer Fuctions

A transfer function is a mathematical representation, in terms of spatial or temporal frequency, of the relation between the input and output of a system.

2.1.1.1 General definition

The transfer function of a two-port filter network is a mathematical description of network response characteristics, namely a mathematical expression of S_{21}. On many occasions, an amplitude-squared transfer function for a lossless passive filter network is define as [1].

$$\left|S_{21}(j\Omega)^2\right| = \frac{1}{1+\varepsilon^2 F_n{}^2(\Omega)} \tag{2.1}$$

Where ε is a ripple constant, $F_n(\Omega)$ represents a filtering or characteristic function and Ω is a frequency variable. For convenience purposes, let Ω represent a radian frequency variable of a lowpass prototype filter that has a cutoff frequency at $\Omega = \Omega_c$ for Ω=1 (rad/s). Frequency transformations to the usual radian frequency for practical lowpass, highpass, bandpass, and bandstop will be discussed later. [1]

2.1.1.2 Butterworth (Maximally Flat) response.

The amplitude-squared transfer function for Butterworth filters that have an insertion loss L_{AR}=3.01dB at the cutoff frequency $\Omega_c=1$ is given by

$$\left|S_{21}(j\Omega)\right|^2 = \frac{1}{1+\Omega^{2n}} \tag{2.2}$$

Where n is the degree or the order of the filter, which corresponds to the number of reactive elements, required in the lowpass prototype filter. This type of response is also referred to a maximally flat because its amplitude-squared transfer function has the maximum number of (2n-1) zero derivatives at Ω=0. Therefore a maximally flat approximation to the ideal lowpass filter in the passband is best at Ω = 0, but deteriorates as Ω approaches the cutoff frequency Ω_c. The Figure 2.1 shows the typical maximally flat response. [1]

2.1.1.3 Chebyshev Response

The Chebyshev response that exhibits the equal-ripple passband and maximally flat stopband is depicted in Figure 2.1. The amplitude-squared transfer function that describes these types of response is [1].

$$\left|S_{21}(j\Omega)^2\right| = \frac{1}{1+\varepsilon^2 T_n^{\ 2}(\Omega)} \quad (2.3)$$

Where the ripple constant ε is related to a given passband ripple L_{AR} in dB by $T_n(\Omega)$ is a chebyshev function of first kind of order n, which is defined as

$$T_n(\Omega) = Tn(\Omega) = \begin{cases} \cos(n\cos{-1}\Omega) & |\Omega| \le 1 \\ \cosh(n\cos{-1}\Omega) & |\Omega| \ge 1 \end{cases} \quad (2.4)$$

Hence, the filters realized from (2.3) are commonly known as Chebyshev filters. [1]

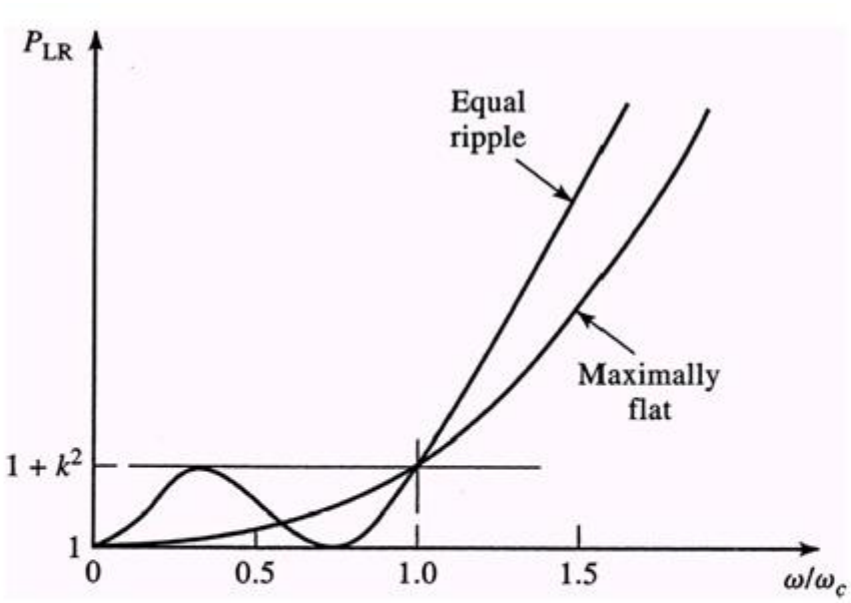


Figure 2.1 Butterworth (maximally flat) and Chebyshev lowpass response [4].