DESIGN OF SINGLE LAYER INTERDIGITAL BAND PASS FILTER WITH ELLIPTICAL RESPONSE

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Specially dedicated to my beloved parents, sisters and friends for their support and encouragement.

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ABSTRACT

The advancement in wireless technology has witnessed the development of many different types of wireless application. Among the more popular application in the recent years are Wireless Local Area Network (WLAN) application and Bluetooth technology. Both applications operate in the microwave region. Microwave filters have become one of the most important components in the whole system. The compactness of interdigital filter makes it a very popular filter where band pass is concern. This thesis focuses on the design of single layer interdigital band pass filter with elliptical response. The chosen frequency of operation is 2.45 GHz, suitable for wireless LAN and Bluetooth applications. MathCAD mathematical software was used to compute all the relevant formulations. In addition, the optimum order of filter was computed to be 4. Investigations on the designed filter were made using the electromagnetic simulation software, Sonnet Suite. The simulated results were satisfactory where the optimum designed filter exhibits the characteristics of an elliptical response band pass filter, albeit large ripples and poor reflections within the passband region. However, improvements can be made in order to achieve a well performed elliptic response bandpass filter.

ABSTRAK

Kemajuan teknologi tanpa wayar telah memperlihatkan perkembangan pelbagai aplikasi tanpa wayar. Antara aplikasi tanpa wayar yang sedang mendapat tempat di pasaran pada masa kini adalah teknologi Rangkaian Tempatan Tanpa Wayar (WLAN) dan *Bluetooth.* Kedua-dua aplikasi ini beroperasi pada julat gelombang mikro. Lantaran itu, penapis gelombang mikro telah manjadi satu daripada komponen paling utama dalam sesuatu sistem gelombang mikro masa kini. Saiznya yang padat telah menjadikan penapis *interdigital* antara penapis gelombang mikro lulus jalur yang paling digemari. Fokus utama tesis ini adalah untuk merekabentuk penapis gelombang mikro jenis lulus jalur yang mempamerkan ciri-ciri eliptik. Frekuensi kendalian yang dipilih ialah 2.45 GHz yang sesuai bagi kegunaan WLAN dan *Bluetooth*. Perisian matematik MathCAD digunakan untuk penghitungan semua rumus berkaitan. Tambahan pula, tertib optimum penapis bersamaan 4 telah diperolehi. Kajian terhadap penapis yang direkabentuk dibuat menggunakan perisian simulasi elektromagnet, Sonnet Suite. Hasil simulasi adalah memuaskan, dengan penapis optimum yang direkabentuk mempamerkan ciri lulus jalur sambutan eliptik, namun terdapat riak yang besar serta pantulan buruk dalam kawasan lulus jalur. Walau bagaimanapun, penambahbaikan boleh dibuat untuk memperolehi penapis lulus jalur sambutan eliptik dengan prestasi yang baik.

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LIST OF SYMBOLS

f_H	-	High cut off frequency
f_L	-	Low cut off frequency
f_0	-	center frequency
ε_r	-	dielectric constant
IL	-	Insertion loss
RL	-	Return loss
P_i	-	Incident power
P_r	-	Reflected power
ε	-	Permittivity
S	-	Spacing between resonator
W	-	Substrate width
h	-	Substrate thickness
t	-	Conducting strip thickness
λ_0	-	Free space wave length
θ	-	Electrical length
v_p	-	phase velocity
E	-	Electric fields
L	-	Resonator length
l	-	Input/output length
c	-	Speed of light
Z_c	-	Characteristic impedances
β	-	Propagation constant
η	-	Free space wave impedance
λ_g	-	Guided wavelength
Γ	-	Reflection Coefficient
α	-	Attenuation constant
RJ	-	Filter rejection

IL_m	-	Midband/minimum insertion loss
ϕ_T	-	Transmission phase (in radian)
τ_D	-	Group delay
L_m	-	Minimum attenuation
L	-	Inductance
C	-	Capacitance

LIST OF ABBREVIATIONS

SI	Single layer symmetrical interdigital filter
FBW	Fractional Bandwidth
IL	Insertion Loss
RL	Return Loss
RF	Radio Frequency
TEM	Transverse Electromagnetic Mode
VSWR	Voltage Standing Wave Ratio
WLAN	Wireless Local Area Network
DLP	Deviation from Linear Phase

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CHAPTER I

INTRODUCTION

This thesis presents the objective of the project, the problem statement, project background, the scopes of project, and the organization of the thesis.

1.1 Objective of Project

The objective of this project is to design and simulate single layer symmetrical interdigital band pass filters with elliptical response operating at 2.45 GHz using MathCAD [1] and Sonnet v 9.52 [2] softwares.

1.2 Problem Statement

The recent years had witnessed the emergence and rapid development of wireless technology. Among the popular wireless application at present are the

Wireless Local Area Network (WLAN) and the Bluetooth technology. Filter is one of the most important components in an electronic circuit. Compact filter structure is essential in a space-limited modern circuit. Microwave filters are the solutions to the compact filter structure problem. Interdigital configuration has been chosen for this project due to its compact size.

1.3 Background of Project

This project is a continuation of that done by Mohd Fairus bin Mohd Yusoff [3]. The work presented the design of single and multilayer interdigital band pass filters with Chebychev response for both symmetrical and asymmetrical configurations. In this project, emphasize is given on the design of single layer symmetrical and asymmetrical interdigital band pass filters with elliptical response. It is aimed at investigating the characteristics of the response and its advantages compared to Chebychev response filters.

1.4 Scopes of Project

The scopes of the project are as follows:

(i) Literature review on basic microwave and filter theories as well as familiarization of MathCAD and Sonnet Suite softwares.

(ii) Design of symmetrical and asymmetrical interdigital and pass filters using MathCAD.

(iii) Simulating the designed filters with electromagnetic software, Sonnet Suite v9.52.

(iv) Analyze the characteristics and performance of the designed filter to determine the ideal filter structure.

(v) Analyze and compare the characteristics and performance of the optimum design structure with the results from the previous project.

(vi) Thesis writing.

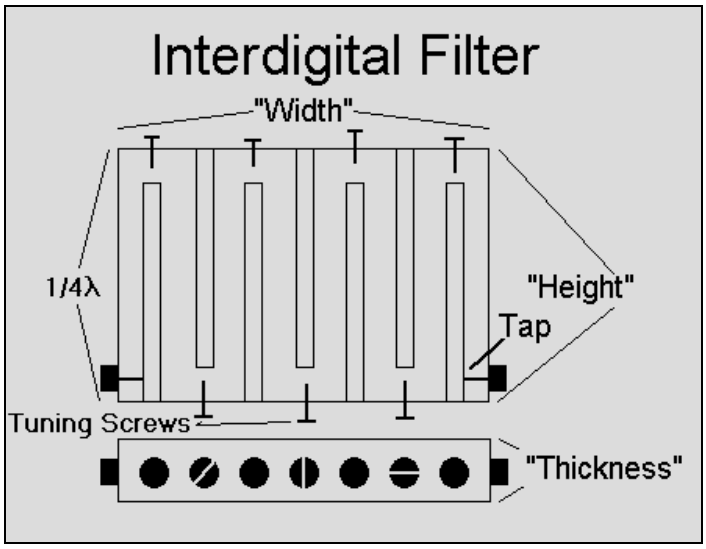
The specifications are as follows, which are similar to that of reference [3]:

(i) Center Frequency : 2.45 GHz
(ii) Filter Response : Elliptic
(iii) Bandwidth : 0.3 GHz
(iv) Pass band ripple : 0.2 dB
(v) Stop band attenuation : 30 dB

The microwave board parameters are as follows:

(i) Dielectric constant : 9.6
(ii) Substrates thickness : 1.27 mm
(iii) Metal thickness : 35μm

The configuration of a single layer symmetrical interdigital band pass filter is shown in Figure 1.1.



.Figure 1 : Configuration of an interdigital filter [4].

1.5 Organization of Thesis

This thesis consists of six chapters. Chapter I presents the objective of the project, the problem statement, project background, the scopes of project, and lastly the organization of the thesis.

Chapter II discusses the microwave fundamentals. This includes Scattering parameters, frequency response and microwave transmission lines theory.

Chapter III discusses the filter theory. Discussion includes the various types of filters, ideal and non-ideal filters, microwave filters and filter synthesis.

Chapter IV discusses on the softwares used in the design, mainly MathCAD and Sonnet v9.52

Chapter V presents the results and discussions were made.

Chapter VI concludes the thesis and suggestions for future work were made.

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