MICROWAVE HAIRPIN FILTER DESIGN

NADIAH BT MOHD NASIR

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

May 2008

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek : MICROWAVE HAIRPIN FILTER DESIGN

Sesi Pengajian : 2007/2008

Saya NADIAH BT MOHD NASIR

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

ABD SHUKUR B JA'AFAR
Pensyarah
Fakulti Kej Elektronik dan Kej Komputer (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM),
Karung Berkunci 1200
Ayer Keroh, 75450 Melaka

Alamat Tetap: PT 328 KAMPUNG CHERANG,
JALAN HOSPITAL,
15200 KOTA BHARU,
KELANTAN.

Tarikh: 9 MEI 2008

Tarikh: 9 MEI 2008

*CATATAN : Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

"I hereby declare that this report is result of my own effort except for quotes as cited in the references."

Signature : ....

Name : NADIAH BT MOHD NASIR

Date : 9 MEI 2008

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication) With Honors."

Signature : ....

Supervisor's Name : MR. ABD SHUKUR B. JA'AFAR

Date : 9 MEI 2008

To my beloved father and mother

ACKNOWLEDGEMENT

First and foremost, I would like to give Thanks to ALLAH SWT, for helping me through all the obstacles that I encountered during the work of this project.

I would like to express my appreciation to my supervisor, Mr Abd Shukur Bin Ja'afar for his support and guidance throughout this whole project. He guided me so that I will continue to be in the correct path during the development of this thesis.

I would like to thank my beloved family for their encouragement and never ending support. Their support and lovely companionship is another important source of strength for me. Without their devoted love and sacrifices, none of this would have been possible. My deepest appreciation goes to all my lovely friends especially for Thanaletchumi, Zuriati and other for the companionship, fruitful suggestion, proof reading and wishes.

Lastly, I would like to acknowledgement every individual who give me a helping hand in order to achieve this accomplishment.

ABSTRACT

The scope of this project presented analyze, simulation, fabricate and measurement for microwave hairpin filter design. Hairpin Filter is one of the most popular microwave frequency filters because of it is compact and does not require grounding. The filter is designed at center frequency of 2.44 GHz with a fractional bandwidth of 3.42%. This frequency is presenting for wireless LAN application and operates in the ISM band (Industrial, Scientific and Medical) application. There are several step to design this filter that including by determine filter specification, order of filter, low pass filter prototype elements, low pass to band pass transformation, physical dimension (width, spacing, length) and wavelength guide. All calculation to design hairpin filter were done using Mathcad software. The simulation of the filter will be done using Microwave office and fabricate on FR4 substrate by using etching process. Improvement technique will be introduced to get better response for scattering parameter.

ABSTRAK

Projek ini menampilkan merekabentuk, simulasi, analisis dan pengukuran untuk penapis jenis *Hairpin*. Penapis *Hairpin* adalah salah satu diantara penapis gelombang mikro frekuensi yang paling terkenal kerana bentuknya sangat padat dan tidak mempunyai penamatan bumi. Penapis ini adalah direkabentuk pada frekuensi 2.44GHz dengan jalur lebar 3.42%. Frekuensi jalur penapis ini adalah untuk aplikasi LAN tanpa wayar dan beroperasi dalam jalur ISM. Terdapat beberapa langkah untuk merekabentuk penapis ini di antaranya adalah menentukan spesifikasi penapis, bilangan peringkat, penukaran lulus bawah ke lulus jalur, elemen penapis lulus bawah prototaip, dimensi fizikal (lebar, jarak dan panjang) dan panjang gelombang berpandu. Semua pengiraan dilakukan menggunakan perisian *Mathcad.* Rekabentuk penapis dan simulasi menggunakan perisian Microwave Office dan di fabrikasi pada papan substratum FR4 dengan menggunakan proses punaran. Teknik penambahbaikan diperkenalkan untuk mendapatkan lebih baik respons untuk parameter serakan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF APPENDIX

LIST OF TERM

A - Worsening

BW - Bandwidth

fo - Center Frequency

f_L - Lower Cut-off Frequency

f_H - Higher Cut-off Frequency

Z_{in} - Input Impedance

Z_o - Characteristics Impedance

R_{in} - Input Resistance

R_o - Characteristic Resistance

ε_r - Relative Dielectric Constants

ε_{eff} - Dielectric

ε_o - Wavelength

h - Substrate Height

t - Thickness

L - Length

w - Width

s - Space

Gaps - Internal Between

Lumped - Lumped of Earth

PCB - Printer Board Circuit

CHAPTER I

INTRODUCTION

1.1 Introduction

Bandpass filters are used as frequency selective devices in many RF and microwave applications. Filters are realized using lumped or distributed circuit elements. However with the advent of advanced materials and new fabrication techniques, microstrip filters have become very attractive for microwave applications because of their small size, low cost and good performance. There are various topologies to implement microstrip bandpass filters such as end-coupled, parallel coupled, hairpin, interdigital and combline filters. This project will present the design of a hairpin microstrip bandpass filter. The basic design specifications that will be use for this bandpass filter are center frequency and bandwidth while microwave office software will be use for simulation. The working frequency for this band pass filter is 2.4 GHz.

WLAN operates in the ISM frequency band covering 2.4 GHz to 2.4835 GHz. The filters are design to have passband from 2.4 GHz to 2.4835 GHz with minimum attenuation of -25dB at 2.5 GHz and passband ripple of 0.2 dB. The minimum attenuation of -25dB at 2.5 GHz is chosen to prevent interference from Broadband Radio Service (BRS). BRS operates in the frequency range 2.5 GHz to 2.69 GHz. The filters are designed using Microwave Office to design software and implemented on FR4 substrate with dielectric constant (εr) of 4.7, loss tangent (tan δ) of 0.019 and substrate height (h) of 1.6mm.

1.2 Objectives

The objectives of this project are:-

1. To design and simulation hairpin filter for 2.44 GHz operating frequency this is suitable for ISM (Industrial, Scientific and Medical) band application by using microwave office.
2. To fabricate and measurement the microstrip filter on the FR4 board by using etching technique.
3. To compare between simulation and measurement result.

1.3 Problem Statement

Nowadays filters in the market are more complex. The hairpin filter is better than other filters because it is compact and does not require grounding. This filter also produces high frequency a wide band filter

1.4 Scopes Of Work

A several scope of work has been determined are:-

1. To calculate hairpin filter using MathCAD software.
2. To design and simulation hairpin filter by using Microwave office or ADS software.
3. To fabricate the hairpin filter on the FR4 board.
4. To use the etching technique and measure filter.

1.5 Project Methodology

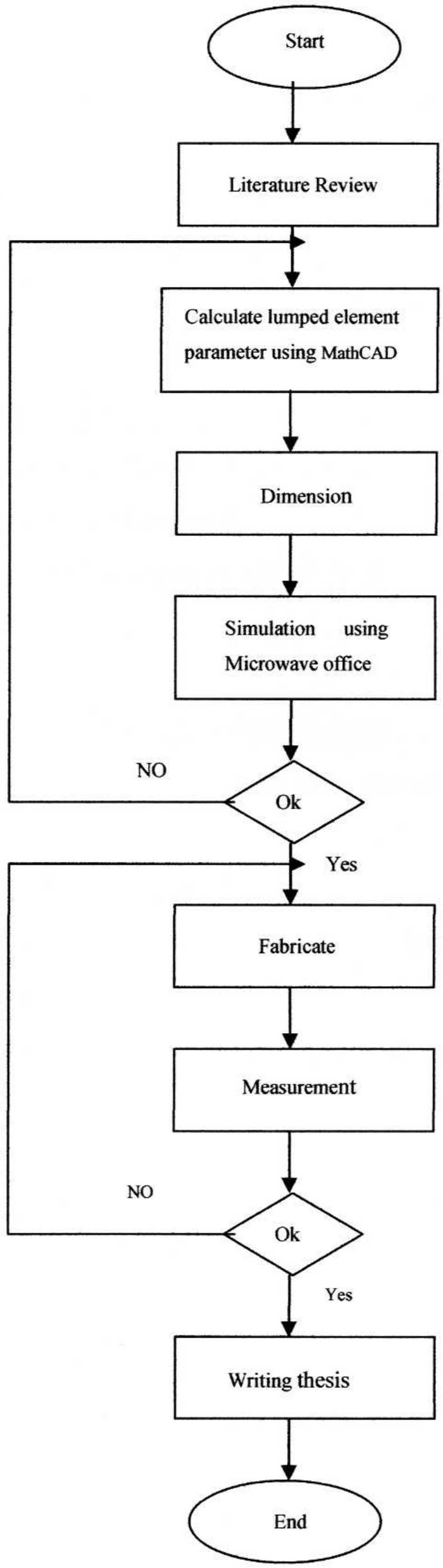

Figure 1.1: Project Methodology Flowchart

This project will involve 4 major phase:-

<u>1st phase: Literature Review</u>

- Gather the information about the project via Internet, journals, magazines, published work and reference books.
- Study of the software implementation (Microwave Office and MathCAD).
- Make research to know more detail about designing hairpin filter according all parameters

<u>2nd phase: Calculation and analysis</u>

- Analyzed and calculated all parameters that related to designing the Step impedance hairpin resonance.
- Using MathCAD software to calculate physical dimension and all parameters hairpin filter.

<u>3rd phase: Software Implementation development</u>

- Used software Microwave Office to do simulation and designing filter.

<u>4th phase: Hardware development</u>

- Then proceed to designing microstrip filter using etching technique and measure using spectrum analyzed.
- Lastly, compare between simulation and measurement results.

CHAPTER II

LITERATURE REVIEW

2.1 Background Study

The use of microstrip in the design of microwave components and integrated circuits has gained tremendous popularity since the last decades because microstrips can operate in a wide range of frequencies. Furthermore, microstrip is lightweight, ease of fabrication and integration and cost effective. Many researchers have presented numerous equations for the analysis and synthesis of microstrip. However, along with the sophistication comes with a high price tag, copy protection schemes and training requirements that create difficulties for exploratory usage in an academic environment. Therefore, a low cost, user-friendly, open source system software package is needed that can be used as an effective training aid on microstrip filters design.

The hairpin filter is one of the most popular low microwave frequency filters because of it is compact and does not require grounding. Its form is derived from the edge-coupled resonator filter by folding back the ends of the resonators into a "U" shape. This reduces the length and improves the aspect ratio of the microstrip significantly as compared to that of the edge-coupled configuration. There are many substrates with various dielectric constants that are used in wireless applications. Those with high dielectric constants are more suitable for lower frequency applications in order to help minimize the size. Its design on FR4 laminates is very difficult to do because of the relatively poor performance of the laminate at the microwave region. The laminate properties of the FR4 become nonlinear unlike more expensive microwave laminates. The motivation to use FR4 in the low microwave frequencies is its cost

2.2 Filter

Filters may be classified in a number of ways. An example of one such classification is reflective versus dissipative. In a reflective filter, signal rejection is achieved by reflection the incident power, while in a dissipative filters are used in most applications. The most conventional description of a filter is by its frequency characteristic such as lowpass, highpass, bandpass or bandstop. Typically frequency responses for these difference types are show in figure1. In additional, an ideal filter displays zero insertion loss, constant group delay over the desire passband and infinite rejection elsewhere. However, in practical filters deviate from these characteristics and the parameters in the introduction above are a good measured of performance.

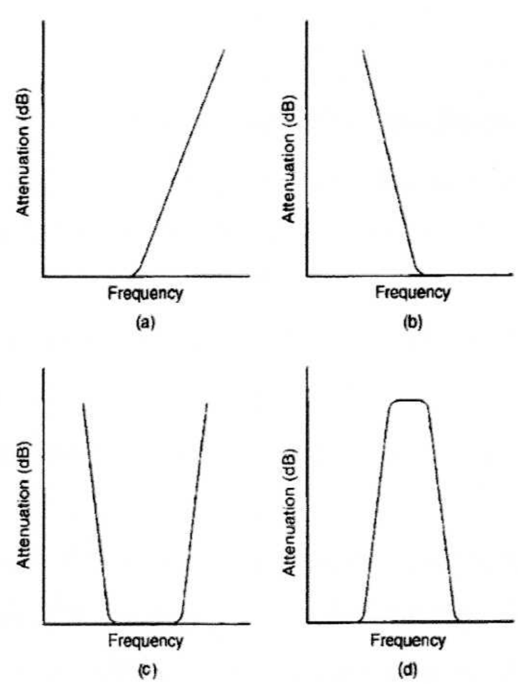

Figure 2.1: Basic Filter Response (a) Lowpass, (b) Highpass, (c) Bandpass, (d) Bandstop.