DESIGN MICROSTRIP BANDPASS FILTER FOR WiMAX SYSTEM

NUR ZATUL 'IFFAH BINTI ZAKWA

This Report Is Submitted In Partial Fulfillment Of Requirements For

The Bachelor Degree of Electronic Engineering (Wireless Communication)

Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer

Universiti Teknikal Malaysia Melaka

JUNE 2012

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : **DESIGN MICROSTRIP BANDPASS FILTER FOR WiMAX SYSTEM**

Sesi Pengajian :

1	1	/	1	2

Saya **NUR ZATUL 'IFFAH BINTI ZAKWA**

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)

Tarikh: 15 JUN 2012

Tarikh: 15 JUN 2012

"I hereby declare that this report is the result of my own work expect for quotes as cited in the references"

Signature : …………………………….

Author : NUR ZATUL 'IFFAH BINTI ZAKWA

Date : 15 JUNE 2012

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 (Wireless Communication) With Honours"

Signature : …………………………….

Supervisor's Name : ENCIK AZAHARI BIN SALLEH

Date : 15 JUNE 2012

DEDICATION

This thesis is especially dedicated to my beloved parents and my family, thanks a lot to all your supports. For my friends and classmate, thank for helping and guide me to accomplish the objective of my project. I hope all of us will success in our life.

ACKNOWLEDGEMENT

First and foremost, I would like to praise the Almighty Allah for blessing me with strength and capability to provide and completing this final year report successfully. Besides that, I offer my sincerest gratitude to my university, Universiti Teknikal Malaysia Melaka (UTeM) for providing me the opportunity to involve to the INOTEK program as a partial fulfilment of the requirement for Final Year Project II which give me more new information about my project.

Furthermore, I would like to take this opportunity to express my deepest appreciation to my final year project's supervisor Encik Azahari Bin Salleh for his advice, precious guidance, support and all the countless help to accomplish the objective of my project. Besides that, I also would like to express my gratitude to my beloved parents and my family for all their supports.

At last but not least, I would like to say thanks to all my friends and classmates for helping and guide me to design, fabricate and accomplish the objective of my project. I appreciate their supports and helping. I hope all of them will success in their life.

ABSTRACT

This thesis provides the reader with a detailed and comprehensive study of theory, design, simulation, fabrication and result in designing microstrip bandpass filter for Worldwide Interoperability Microwave (WiMAX) Access system. The approaches used to achieve this project are through literature review, calculation, designation and simulation by using computer software. These approaches are used to analyze whether the characteristics of microstrip bandpass filter is fulfil the required specification before fabrication process is done to obtain the output result. Bandpass filter are used as frequency selective devices in many Radio Frequency (RF) and microwave applications. There are several types and techniques are used in designing the bandpass filter which is parallel-coupled microstrip bandpass filter, edges microstrip bandpass filter, and hairpin microstrip bandpass filter. The filter design for this project is concentrated on the parallel-coupled microstrip bandpass filter that operates at 2.5 GHz with 200 MHz bandwidth by using FR4 substates. This project were began on designing and simulating process by using Advanced Design System (ADS) software to analyze the characteristics of the microstrip bandpass filter and to determine and obtain the output result of Return Loss, S_{11} and Insertion Loss, S_{21}. The parallel-coupled microstrip bandpass filter is fabricate to measure the Return Loss, S_{11} and Insertion Loss, S_{21}. The better output result of Return Loss, S_{11} must greater than -20 dB and Insertion Loss, S_{21} is equal to 0 dB.

ABSTRAK

Tesis ini memberikan maklumat secara terperinci dan menyeluruh kepada pembaca mengenai teori, rekabentuk, simulasi, fabrikasi dan keputusan dalam merekabentuk penapis lulus jalur mikro untuk system WiMAX. Pendekatan yang telah dilaksanakan bagi menjayakan projek ini adalah menggunakan kaedah kajian secara ilmiah, pengiraan, rekabentuk, dan simulasi dengan menggunakan perisisan komputer. Pendekatan-pendekatan ini digunakan untuk menganalisa sama ada ciri-ciri penapis lulus jalur mikro memenuhi spesifikasi yang diperlukan sebelum proses fabrikasi dilakukan untuk mendapatkan hasil keluaran. Penapis lulus jalur digunakan sebagai alat frekuensi terpilih dikebanyakan aplikasi gelombang mikro. Terdapat beberapa jenis dan teknik-teknik yang digunakan dalam merekabentuk penapis lulus jalur antaranya ialah penapis lulus jalur gandingan selari, penapis lulus jalur sisi dan penapis lulus jalur penyepit rambut. Rekabentuk penapis untuk projek ini adalah tertumpu kepada penapis lulus jalur gandingan selari yang beroperasi pada frekuensi 2.5 GHz dan 200 MHz lebar jalur dengan menggunakan bahan dielektrik FR4. Projek ini dimulakan dengan proses merekabentuk dan simulasi menggunakan perisian komputer ADS untuk menganalisis ciri-ciri penapis lulus jalur mikro dan menentukan serta mendapatkan hasil keluaran S_{11} dan S_{21}. Litar penapis lulus jalur gandingan selari dicipta bagi mendapatkan hasil keluaran S_{11} dan S_{21}. Hasil keluaran yang tepat adalah keluaran S_{11} lebih besar daripada -20 dB dan S_{21} bersamaan 0 dB.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

RF	-	Radio Frequency
WiMAX	-	Worldwide Interoperability Microwave Access
FR4	-	Flame Resistant 4
TDM	-	Time Division Multiplexing
FDM	-	Frequency Division Multiplexing
ADS	-	Advanced Design System
WiFi	-	Wireless Fidelity
TEM	-	Transverse Electromagnetic
PCB	-	Printed Circuit Board
BW	-	Bandwidth
FBW	-	Fractional Bandwidth
BPF	-	Bandpass Filter
Z_{oe}	-	Even Mode Characterictics Impedance
Z_{oo}	-	Odd Mode Characterictics Impedance
Q	-	Quality Factor
V_o	-	Output Voltage
V_{in}	-	Input Voltage
f_C	-	Centre Frequency
f_H	-	Higher Cut-off Frequency

f_L	-	Lower Cut-off Frequency
$Z_o J_n$	-	Admittance Inverters
W	-	Width
L	-	Length
S	-	Space
ε_r	-	Dielectric Constant
h	-	Height
tan δ	-	Tangent Loss
DSL	-	Digital Subscriber Line

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1 Project Background

This project provides the reader with the detail and comprehensive study of theory, design, simulation, fabrication, result, and problem encountered in the designing the microstrip bandpass filter. A filter is a device that passes electric signals at certain frequencies or frequency ranges while preventing the passage of others. Ideally, filter will not add new frequencies to the input signal but it will change the relative amplitudes of the various frequency components or their phase relationship. Bandpass filter is widely used in telecommunication system in receiving or transmitting devices to filter out unwanted frequency. It also is used as frequency selective devices in many Radio Frequency (RF) and microwave applications.

This paper presents the design of microstrip bandpass filter for WiMAX system with 200 MHz bandwidth at 2.5 GHz frequency. The microstrip transmission line is chosen because it is the most popular type of planar high frequency due to easy of fabrication. Other than that, microstrip filter also have become very attractive for microwave applications because of their small size, low cost and good performance. There are many possible techniques to implement microstrip bandpass filter such as parallel-coupled, end-coupled, hairpin, interdigital and comb line filters.

This filter design concentrated on the parallel-coupled technique to implement microstrip bandpass filter by using Flame Resistant 4 (FR4) as the substrate. The FR4 board was chosen for this project because it is cheap and efficient. The using of parallel-coupled technique is to design a bandpass filter with sharp-rejection characteristics. Major advantages of this type of filter include an easy synthesis procedure, good repetition and a wide range of filter fractional bandwidth.

The approaches used to achieve this project are through literature review, design, simulation, fabrication, and testing. The Advanced Design System (ADS) software is used in designing and simulation this filter to obtain the Return Loss (S_{11}) and Insertion Loss (S_{21}). This project will be fabricate after all the parameters and the simulation results shows their Return Loss (S_{11}) and Insertion Loss (S_{21}) is reach at the target value. The return loss must reach at 0 dB while the insertion loss at -10 dB or below than that. Finally, the parallel-coupled microstrip bandpass filter will be measure by using Network Analyzer to determine their return loss and insertion loss. This project is reaching their goal if the measured result shows the values that are equal to the simulation results.

1.2 Problem Statements

The large size of conventional filter is the one of the problem to design this project. Other than that, the cost of a bandpass filter is very expensive. To solve the problem, the microstrip bandpass filter is chosen to design this project because to reduce the size of conventional filter and the microstrip bandpass filter can enhance the overall system performance due to its planar structure, light weight, low cost and easy to fabricate by photolithography process. Other than that, the use of microstrip bandpass filter is to achieve more compact circuit size.

1.3 Objective

The objective of the project is to design and fabricate the microstrip bandpass filter for WiMAX system that operated at 2.5 GHz.

1.4 Scope of Works

This project is focus on designing, simulation and fabrication the microstrip bandpass filter for WiMAX system that operate at frequency 2.5 GHz with 200 MHz bandwidth. The scopes of works of this project are:

i. Design and simulate the microstrip bandpass filter by using ADS software to obtain the output of return loss (S_{11}) and insertion loss (S_{21}).
ii. Fabricate the microstrip bandpass filter on the low cost FR4 substrate with dielectric constant, $\varepsilon_r = 4.5$, height = 1.6mm and tan δ = 0.02 by using Network Analyzer.
iii. Analysis the result and output of this project to obtain the Return Loss (S_{11}) and Insertion Loss (S_{21}). The comparison and analyzation the output value are based on ideal case where the designing process is reffering to L and C connection to get the value of Return Loss (S_{11}) and Insertion Loss (S_{21}) based on the simulation result. The comparison are also based on the calculation result of parallel-coupled anf the fabrication of the microstrip bandpass prototype at 2.5 GHz frequency for WiMAX system with the bandwidth of 200 MHz.
iv. The project of microstrip bandpass filter is operate at 2.5 GHz frequency to obtain the Return Loss (S_{11}) and Insertion Loss (S_{21}) for WiMAX system.

1.5 Thesis Outlines

Chapter 1 gives the explanation about the introduction of this project which consists of the project background, problem statements, objective and scope of works on designing the parallel-coupled microstrip bandpass filter.

Chapter 2 provides the information and literature review of the WiMAX System, microstrip transmission line, parallel-coupled microstrip filter, basic types of filter, frequency response of filter and scattering parameters.

Chapter 3 shows the detail process or method on designing the parallel-coupled microstrip bandpass filter. The flowcharts and sequence of the filter design will be presented. It is starting with the filter specification information that will give in the table. Then, the process will begin on the dimension calculation to determine the order of filter and the physical dimension of the coupled-line. The design will be simulate after getting the physical dimension of coupled-line by using ADS LineCalc.

Chapter 4 will shows the details results of the parallel-coupled microstrip bandpass filter that is consists of calculation, simulation and measurement results. For the calculation part, the process starting at determining the order of the filter by using normalized frequency equation. Then after getting the order, the ideal case of bandpass filter is design and determines the value of capacitor, C and the inductor, L. The physical dimension of coupled-line will be determine after getting the value of odd and even mode characteristics impedance. The parallel-coupled microstrip bandpass filter will be design based on the physical dimension value. The design will be fabricate and measure to obtain the output of Return Loss (S_{11}) and Insertion Loss (S_{21}).

Chapter 5 will concludes all the thesis contents and also includes the recommendations for future works.

CHAPTER II

LITERATURE REVIEW

2.1 WiMAX System

WiMAX is stands for Worlwide Interoperability for Microwave Access and it also goes by the name of IEEE 802.16. WiMAX system will probably become one of the most widespread methods for high-speed wireless data delivery. Thus, much research has been performed to develop the 2.3 – 2.7 GHz bandpass filter for WiMAX system [12]. WiMAX system provides high-speed data communication in the range up to 30 miles for fixed station and 5-10 miles for mobile station. With the full deployment of the WiMAX network, there will be the fundamental change the way of daily communication, owing to its large coverage area, high data rate and mobility [5].

WiMAX is able to support high-speed wireless broadband applications with rather long reach, mobility, and roaming. In standard of IEEE 802.16, there are three bands are proposed to use wich are 2.3 – 2.7 GHz, 3.3 – 3.9 GHz and 5.15 – 5.85 GHz [19]. There are the differences between WiMAX and Wireless Fidelity (WiFi), the problem with WiFi access is that hot spots are very small, so coverage is sparse. WiMAX technology can solve this problem that provide the high speed of broadband service, wireless rather than wired access, so it would be a lot less expensive than cable or Digital Subscriber Line (DSL) and much easier to extend to suburban and rural areas and also the broad coverage like the cell phone network instead of small WiFi hotspots [6].

WiMAX is expected to replace cable and DSL services, providing universal internet access just about anywhere you go. WiMAX will also be as painless as WiFi by turning the computer on will automatically connect to the closest available WiMAX antenna. The Table 2.1 shows the comparison between WiMAX and WiFi [6].

Spectrum allocation is a very important aspect for wide deployment of WiMAX for future broadband applications. The operating band may influence the coverage and achievable data rates. In order to ensure that resulting 802.16-based devices are in fact interoperable, an industry consortium called the WiMAX Forum was created. This WiMAX forum has identified some of the most likely frequency bands at 2.3 GHz, 2.5 GHz, 3.5 GHz and 5.7 GHz [21].

The licensed 2.3 GHz band is deployed in South Korea for WiBro (Wireless Broadband) services. This band is also available in Australia, New Zealand and United States. The bands between 2.5-2.7 GHz are the licensed bands allocated in the United States, Canada, Mexico, Brazil and some part of Southeast Asian countries. This is very promising band for wireless service in the United States. The Licensed 3.5 GHz band is the primary band allocated for fixed wireless broadband services in many countries across the globe. International allocation for this band is 3.4-3.6 GHz. This band does not allow for mobile broadband services because of heavier radio propagation losses at this band. The most interesting WiMAX application is the unlicensed 5.25-5.85 GHz band. This band may be the probable WiMAX deployment band for rural, low population density areas [21].