DESIGN, FABRICATION AND MEASUREMENT OF INTERDIGITAL MICROWAVE FILTERS

ZURIATI BINTI MOHD KHAIRUDDIN

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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:
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Supervisor's name : Mr. Abd Shukur Bin Ja'afar

Date : 9 May 2008

Specially.....

To my beloved parents

To my kind brother and sisters

And to all my friends

For their

Love, Encouragements, and Best Wishes

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ABSTRACT

Filters are essential to the operation of this technology. There are various topologies to implement microstrip bandpass filters such as end-coupled, parallel coupled, hairpin, interdigital and combline filters. This thesis discusses design, simulation, analysis, fabrication and testing of a Interdigital band pass filter by using microstrip technology. There is several application of a bandpass filter, for example it is used at the output of the oscillator to take out the required frequency or at the input of the receiver and the amplifier to pass the required frequency. In this report, the choice of Interdigital filter topology is discussed and this filter is designed at center frequency of 2.4GHz. This frequency is presenting for wireless LAN application and operates in the ISM (Industrial, Scientific and Medical) band which is covering from 2.4 GHz to 2.4835GHz. There are several steps to design this filter that are including by determine filter specifications, order of filter, low pass filter prototype elements, low pass to band pass transformation, physical dimension (width, spacing, length) and wavelength guide. The EM simulation of the filter design was completed on Microwave Office software and fabricated on FR4 substrate by using etching process. The explanation details for design procedure, simulated results, methods and techniques are discussed in this report.

ABSTRAK

Penapis merupakan satu komponen penting dalam teknologi ini. Ada beberapa topologi untuk melaksanakan mikrojalur penapis lulus jalur seperti penapis *end-coupler, parallel coupled, hairpin, interdigital* dan *combline*. Tesis ini membincangkan rekabentuk, simulasi, analisis, fabrikasi dan pengukuran satu penapis lulus jalur *Interdigital* dengan menggunakan teknologi mikrojalur. Terdapat beberapa penggunaan satu penapis lulus jalur, sebagai contoh ia digunakan di keluaran pengayun untuk menapis frekuensi yang dikehendaki atau pada masukan penerima dan penguat untuk meluluskan frekuensi yang dikehendaki. Dalam laporan ini, pilihan topologi penapis *Interdigital* dibincangkan dan penapis ini juga direkabentuk pada frekuensi kendalian 2.4GHz. Frekuensi jalur penapis ini adalah untuk aplikasi LAN tanpa wayar dan beroperasi dalam jalur ISM di mana ia merangkumi frekuensi dari 2.4GHz ke 2.4835GHz. Kaedah pengiraan mempunyai beberapa langkah-langkah untuk mereka bentuk penapis ini, di antaranya adalah tentukan 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. EM (Elektromagnetik) simulasi pada rekabentuk adalah lengkap dengan menggunakan perisian *Microwave Office* dan di fabrikasi pada papan substratum FR4 dengan menggunakan proses goresan. Sebarang penerangan secara terperinci terhadap prosedur untuk proses rekabentuk, keputusan simulasi, kaedah dan teknik telah dibincangkan dalam bahagian laporan ini.

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A	-	Worsening
BW	-	Bandwidth
fo	-	Center Frequency
fL	-	Lower Cut-off Frequency
fH	-	Higher Cut-off Frequency
Zin	-	Input Impedance
Zo	-	Characteristics Impedance
Rin	-	Input Resistance
Ro	-	Characteristic Resistance
εr	-	Relative Dielectric Constants
εeff	-	Dielectric
εo	-	Wavelength
h	-	Substrate Height
t	-	Thickness
L	-	Length
w	-	Width
s	-	Space
Gaps	-	Internal Between
Lumped	-	Lumped of Earth

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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 Interdigital filter. It includes analysis, designing, simulation and fabrication. The filter is designed at centre frequency of 2.44 GHz for ISM (Industry, Scientific and Medical) band application. The project will be using microstrip technology and will design by using FR4 microstrip board. There are several steps to design this filter including by determine filter specification, order of filter, physical dimension (width, spacing and length) and wavelength guide. The approaches used to achieve this project are through literature review, dimensional calculation and computer software simulation.

1.2 Objectives

The objectives of this project are:

1. To designed, simulate and develop an Interdigital filter for 2.4GHz operating frequency.
2. To fabricate the microstrip filter on the FR4 board by using etching technique.
3. To compare between simulation result and measurement result

1.3 Problem Statement

This project develops the performance of the filter that will expect to overcome old types of filter in microwave with operating frequency at 2.44 GHz.

1.4 Scopes of Works

The scope of works in this project is:

1. Gather information for Interdigital filter design from internet, journal and book.
2. Calculate Interdigital filter using MathCAD/MATLAB software and design the filter by using Microwave office/ADS and simulate the designed filter.
3. Fabricate the Interdigital filter on the FR4 board.
4. Analyze the result by comparing simulation and measurement.
   Obtain filter specification, order of filter, physical dimension (width, spacing and length) and wavelength guide.

1.5 Project Methodology

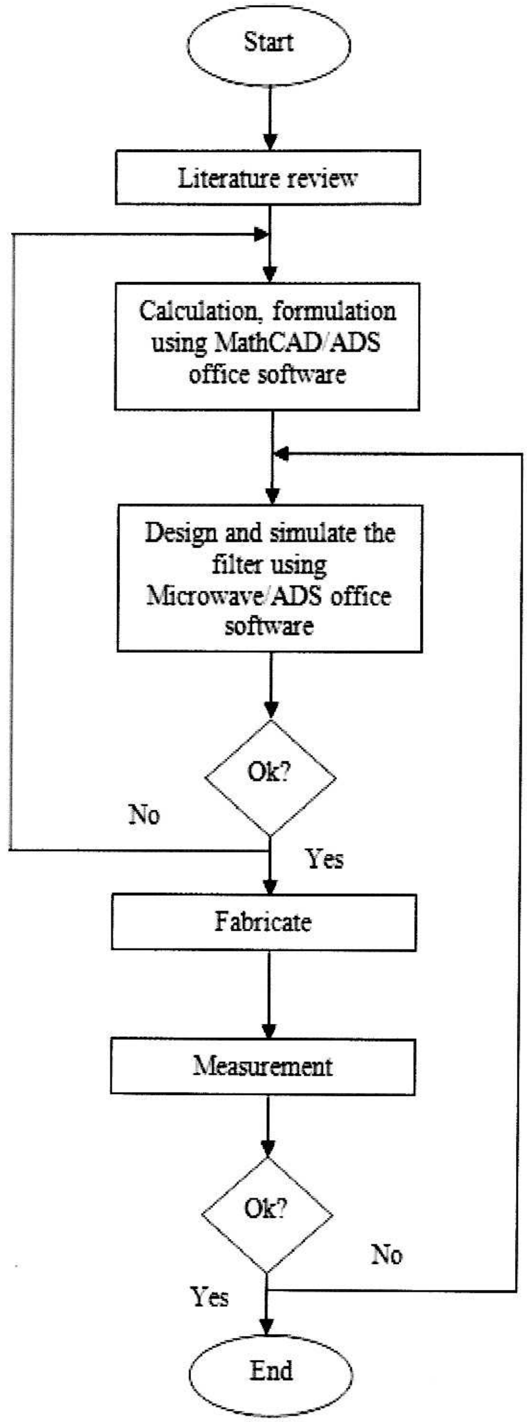

Figure 1.1: Methodology Project

1. **Literature Review**: Gather information for Interdigital filter design from internet, journal and book.
2. Study of the software implementation (Microwave Office and MathCAD)
3. **Calculation and analysis**: Analyzed and calculated all the parameters that related to design the Interdigital Filter.
4. **Running Simulation using software**: Used software (Microwave Office) to do simulation and designing filter.
5. **Hardware Fabrication**: Then proceed to design microstrip filter using etching technique and do some measurement. Lastly do comparison between simulation and measurement analysis

CHAPTER II

LITERATURE REVIEW

2.1 Filter

Filters are the most important passive components used in the microwave subsystems and instruments. Most microwave systems consist of many active and passive components that are difficult to design and manufacture with precise frequency characteristics. It contrast, microwave passive filter can be designed and manufactured with remarkably predictable performance. Consequently, microwave systems are usually designed so that all of the troublesome components are relatively wide in frequency response with filters being incorporated to obtain the precise system frequency response. Because filters are the narrowest bandwidth components in the system, it is usually the filters that limit such system parameters as gain and group delay flatness over frequency. The most popular filter configurations are parallel coupled line, interdigital, combline, and hairpin line. All these filters are of the bandpass and bandstop type [2].

Low Pass filters can be designed from the classical lumped element low-pass prototype circuits and may either be fabricated in lumped element form or transformed into equivalent transmission line networks.

Band-pass filters require precise transmission characteristics that allow a desired band of signals to pass through the two-port network. Thus, between a transmitter and the transmitting antenna, a band filter may be used to attenuate unwanted signals and harmonic components that may cause interference to other users of the electromagnetic spectrum. Conversely, between an antenna and a receiver, a band pass filter will reject out-of-band signals that may cause interference within the receiver, especially if they are at a high signal level in comparison with the desired signals.

2.1.1 Types of Filters

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 reflecting the incident power, while in a dissipative filter, the rejected signal is dissipated internally in the filter. In practice, reflecting filter is used in most applications. The most conventional description of a filter is by its frequency characteristic such as lowpass, bandpass, bandstop, or highpass. Typical frequency responses for these different types are shown in Figure 2.1. In addition, an ideal filter displays zero insertion loss, constant group delay over the desired passband, and infinite rejection elsewhere. However, in practice, filters deviate from these characteristics and the parameters in the introduction above are a good measure of performance [2].

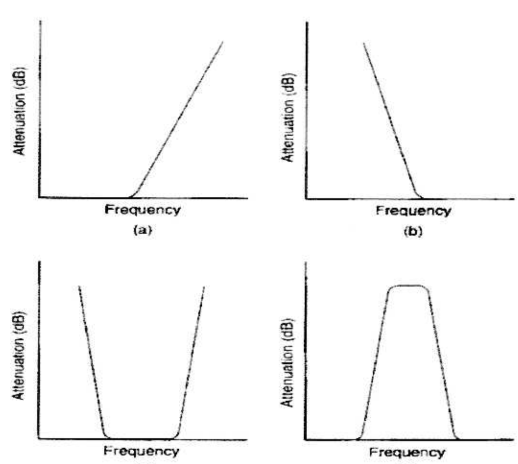

Figure 2.1: Basic filter response (a) Lowpass, (b) Highpass, (c) Bandpass, (d) Bandstop

2.2 Types of Filters Response

There are four useful types of filters response.

i) Butterworth
ii) Chebyschev
iii) Bessel
iv) Elliptic

2.2.1 Butterworth Filter

The butterworth filter has essentially flat amplitude versus frequency response up to the cutoff frequency. The sharpness of the cutoff can be seen in Figure 2.2, where it is compared with the chebyschev and the Bessel filter.

It is to be noted that all three filters reach a roll-off slope of -40db/decade at frequencies much greater than cut off. Although Butterworth filters achieve the sharpest attenuation, their phase shift as a function of frequency is non-linear.

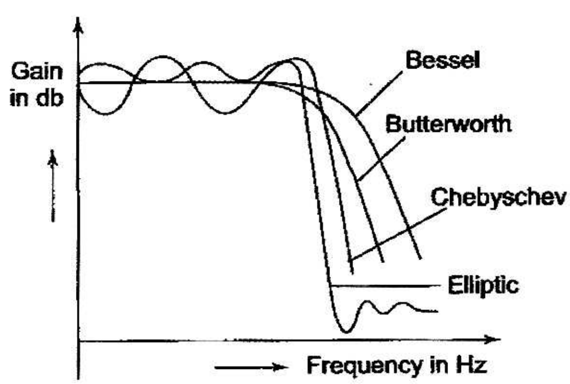

Figure 2.2: Frequency Response of Various Filters

Butterworth filters are also known as maximally flat type filters. This class of filters approximates the ideal filter well in the pass band. It is monotonic decrease in gain with frequency in the cutoff region and a maximally flat response below cut-off, as shown in figure 2.3.