DEVELOPMENT ON UWB BANDPASS FILTER USING DEFECTED GROUND STRUCTURE

MUHAMAD AKMAL BIN TALIB

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Faculty of Electronic and Computer Engineering
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Tajuk Projek : **DEVELOPMENT ON UWB BANDPASS FILTER USING DEFECTED GROUND STRUCTURE**

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DR. MOHD AZLISHAH BIN OTHMAN
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 17/6/15

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SIGNATURE :

NAME : DR. MOHD AZLISHAH BIN OTHMAN

DATE : 17/6/15

DR. MOHD AZLISHAH BIN OTHMAN
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik & Kejuruteraan Kompute
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

DEDICATION

„In the Name of Allah, the most Beneficent, the most Merciful"

Special Dedication to parents:
Talib Bin Ahmad and Che Li Rohana Binti Madzhar

To my siblings
Nooryusma Laily Binti Talib and Noor Amira Binti Talib

To my beloved friend
Nur Ain Farhana Binti Abdul Latiff

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I dedicate this thesis to my dad, my mom, and my one who is everything to me.
Thank you all!

ABSTRACT

In this thesis, ultra-wideband (UWB) microwave filters and design challenges are studied and, a microstrip UWB filter prototype design is presented. The UWB bandpass filter operating in the 3GHz to 10GHz frequency band is targeted. The prototype filter is composed of quarter wavelength spaced shunt stub transmission lines. For the modification, a defected ground structure is added on the ground plane to obtain high performance of the filter. The circuit is first simulated and optimized by using ADS simulation software tool. The fabricated microstrip UWB bandpass filter is then measured using a vector network analyzer and results are presented. The prototype built can be used in UWB communications or localization systems.

ABSTRAK

Dalam tesis ini, ultra-jalur lebar (UWB) penapis gelombang mikro dan cabaran reka bentuk dikaji dan, yang mikrostrip UWB reka bentuk prototaip penapis dibentangkan. Penapis UWB laluanlulus beroperasi di 3GHz hingga 10GHz jalur frekuensi disasarkan. Penapis prototaip terdiri daripada panjang gelombang suku pirau jarak talian penghantaran puntung. Untuk pengubahsuaian itu, struktur tanah berpaling tadah ditambah pada satah tanah untuk mendapatkan prestasi yang tinggi penapis. Litar ini pertama simulasi dan dioptimumkan dengan menggunakan ADS alat perisian simulasi. Buatan microstrip penapis UWB laluanlulus kemudiannya diukur menggunakan rangkaian analyzer vektor dan keputusan dibentangkan. Prototaip dibina boleh digunakan dalam komunikasi UWB atau sistem tempatan.

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LIST OF ABBREVIATIONS

LPF	-	Lowpass Filter
HPF	-	Highpass Filter
BSF	-	Bandstop Filter
BPF	-	Bandpass Filter
ADS	-	Advanced Design System
UWB	-	Ultra-Wide Band
IL	-	Insertion Loss
RL	-	Return Loss
S-PARAMETER	-	Scattering Parameter
RF	-	Radio Frequency

CHAPTER 1

INTRODUCTION

1.1 Project Introduction

Since the authorization of the unlicensed use of ultra-wideband (UWB) frequency band from 3.1–10.6 GHz for commercial application by Federal Communications Commission (FCC) in 2002, the UWB technology has become one of the most promising technologies for short-range high-rate indoor wireless communications. In recent years, there are a lot of techniques or methods to design UWB bandpass filters (BPFs), one of the essential components of UWB systems. Multiple-mode resonators (MMR) were implemented in [2]–[5] in the design of UWB BPFs, resulting in a wide passband covering the whole band of 3.1–10.6 GHz. However, the out of band performance is not good enough due to higher order harmonics which arises just after the first pass band. In [6], the authors designed a UWB BPF by utilizing coplanar waveguide (CPW) structures and microstrip/CPW hybrid structures. Though this type of filter has a simple structure and could keep the skirt selectivity sharp, its frequency performance is marginal at high frequency. The UWB BPF in [7] was designed by cascading a low pass filter and a high pass filter to achieve a wide upper stopband bandwidth. However the transition band at the lower frequency is not sharp enough due to the low order of high pass characteristics. In order to avoid interferences from the undesired signals, UWB BPFs with single or multiple notched bands are required. UWB BPFs with notched bands using different structures have been reported in [7]–[12].A new compact UWB BPF with high selectivity filtering characteristics and relatively small size that uses defected ground structures (DGS) to suppress the spurious passband is proposed in this thesis.

Ultra-wideband (UWB) microwave filters and design challenges are studied and, a microstrip UWB filter prototype design is presented. The UWB bandpass filter operating in the 3.6 GHz to 10.6 GHz frequency band is targeted to comply with the FCC spectral mask for UWB systems. The prototype filter is composed of quarter wavelength spaced shunt stub transmission lines. The circuit is first simulated and optimized by using ADS simulation software tool. The fabricated microstrip UWB bandpass filter is then measured using a vector network analyzer and results are presented. The prototype built can be used in UWB communications or localization systems.

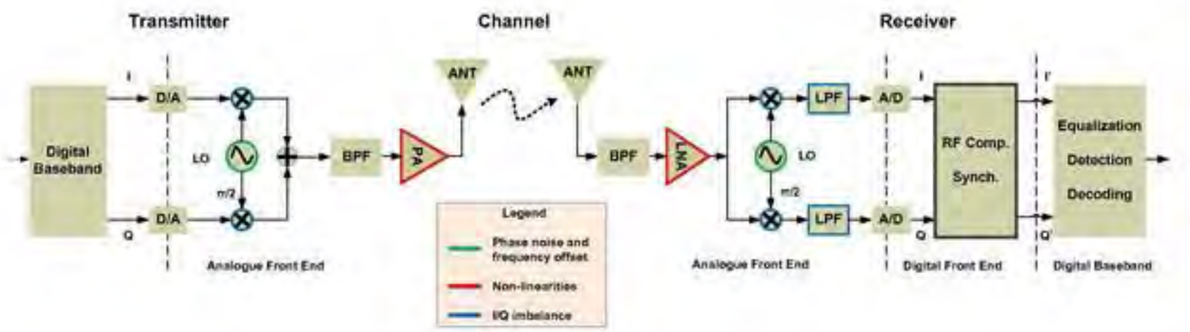

Figure 1.0: Basic wireless communication

1.2 Project Summary

This project is about development on compact ultra wide band bandpass filter using defected ground structures. Four symmetrical gap ring-shaped interdigital capacitors are formed to improve the BPF's performance. The filter will cover frequency from 3GHz to 10 GHz.

1.3 Problem Statement

Ultra wideband (UWB) signals operate from 3.1GHz to 10.6GHz has been released by the Federal Communications Commission (FCC). However, there are some existing wireless communication system partially overlap with UWB system. Multiple-mode resonators (MMR) were implemented in the design of UWB BPFs and resulting in a wide pass-band covering the whole band of 3.1-10.6GHz. However, the out of band performance is not good enough due to higher order harmonics which arises just after the first pass band. UWB BPF with single or multiple notched bands are required in order to avoid interferences from undesired signal.

1.4 Objectives

This project has three objectives. The first one is to design a UWB band pass filter with dual notched bands at 3-10GHz.Next is to analyze the performance of a band pass filter based on electromagnetic (EM) simulations. Last but not least is to analyze the S-parameter, insertion loss, and etc. using ADS (Advanced Design System).

1.5 Scope of Project

The main scope of this project is to design a bandpass filter. We need to design a filter in the range of 3-10 GHz.

This project is conducted by analysing the obtained values for the s-parameters, the return loss, and the insertion loss of designed filter. The analyzing procedure is conducted using computer software simulation. The software used in designing, simulating, and analyzing the performance of the filter is ADS (Advance Design System) Software only. The filter was design and simulated by using ADS (Advance Design System) software to analyse the S-parameter, return loss, insertion loss and group delay response measurements. Then optimization the results based from the calculation value.

CHAPTER 2

LITERATURE REVIEW

2.1 Filter

In signal processing, filter is device that functional to remove undesired signal and to accept only a signal that we want. There is different type of filter and bring own advantages and disadvantages. Some of the example is Butterworth, Chebyshev, Bessel and other. Electronic filter can be passive or active, analogue or digital, high pass, low pass, band stop or all pass. Passive filter can be the combination of resistor, inductor and capacitor. Filters may be specified by family and band form. A filter's family is specified by the approximating polynomial used and each leads to certain characteristics of the transfer function of the filter.

2.1.1 Butterworth Filter

Advantages:

- Maximally flat magnitude response in the pass-band.
- Good all-around performance.
- Pulse response better than Chebyshev.
- Rate of attenuation better than Bessel.

Disadvantages:

- Some overshoot and ringing in step response.

This filter has the flattest possible pass-band magnitude response. Attenuation is -3dB at the design cutoff frequency. Attenuation beyond the cutoff frequency is a moderately steep -20dB/decade/pole. The pulse response of the Butterworth filter has moderate overshoot and ringing.

2.1.2 Chebyshev Filter

Advantage:

-Better rate of attenuation beyond the pass-band than Butterworth.

Disadvantage:

- Ripple in pass-band.

-Considerably more ringing in step response than Butterworth.

This filter response has the steeper initial rate of attenuation beyond the cutoff frequency than Butterworth. This advantage comes at the penalty of amplitude variation (ripple) in the pass-band. Unlike Butterworth and Bessel response, which have 3dB attenuation at the cutoff frequency, Chebyshev cutoff frequency is defined as the frequency at which the response falls below the ripple band. For even-order filters, all ripples are above the dc-normalized passband gain response, so cut-off is at 0dB. For odd-order filters, all ripples is below the dc-normalized passband gain response, so cutoff is at - (ripple) dB. For a given number of poles, a steeper cutoff can be achieved by allowing more pass-band ripple. The Chebyshev has more ringing in its pulse response than the Butterworth - especially for high-ripple designs.

2.1.3 Bessel Filter

Advantage:

-Best step response-very little overshoot or ringing.

Disadvantage:

- Slower initial rate of attenuation beyond the pass-band than Butterworth.

Due to its linear phase response, this filter has excellent pulse response (minimal overshoot and ringing). For a given number of poles, its magnitude response is not as flat, nor is its initial rate of attenuation beyond the -3dB cutoff frequency as steep as the Butterworth. It takes a higher-order Bessel filter to give a magnitude response similar to a given Butterworth filter, but the pulse response fidelity of the Bessel filter may make the added complexity worthwhile.

2.2 Types of Filter

2.2.1 Lowpass Filter

The most basic filter is low pass filter. It rolls off all frequencies above its cut-off frequency with a particular slope. A low-pass filter is filters that go through signals with a frequency lower than a certain cutoff frequency and decrease signals with frequencies higher than the cutoff frequency. The filter design will affect the amount of attenuation for each frequency.

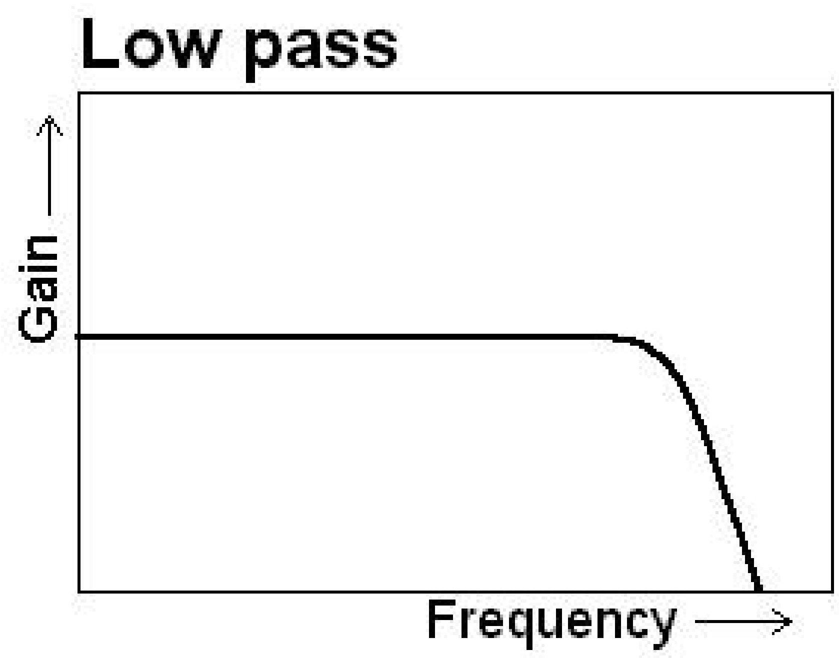

Figure 2.0: Lowpass graph

2.2.2 Highpass Filter

High-pass filter is an electronic filter that elapse signals with a frequency higher than a particular cut-off frequency and weakened signals with frequencies below the cutoff frequency. The amount of attenuation for each frequency depends on the filter design.

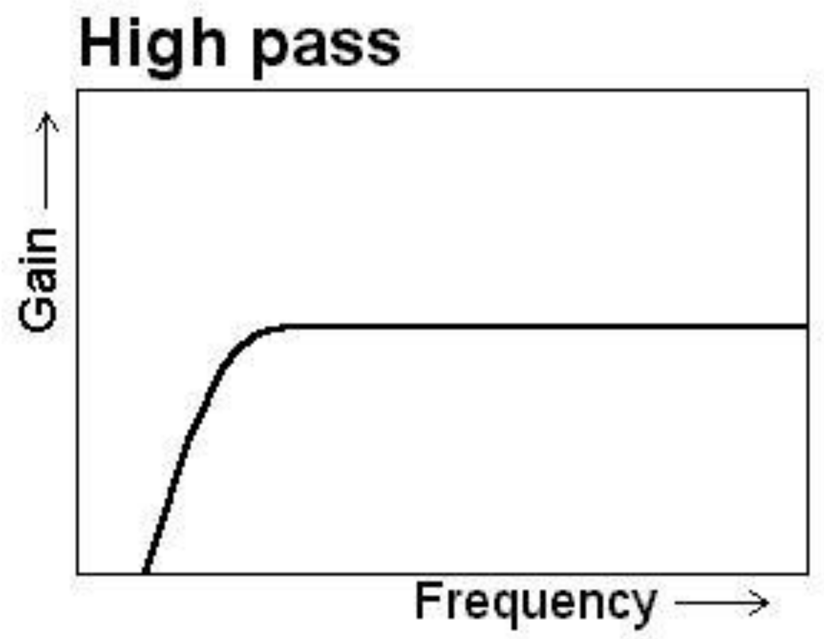

Figure 2.1: Highpass graph

2.2.3 Bandstop Filter

Band stop filter will cut a few ranges of frequencies. Relative notch filter actually filters resonance. Band-reject filter is the complement of the band-pass filter. Thoughts high signal losses between the WC2 WC1, hence the name of the band-stop and band-reject. In this case, the denied frequency band located between these two pass-bands.

Band-stop filter features two pass-band; passband lesser beginning from zero to f pass1, temporarily passband of the start of SS2 in fi f munity.

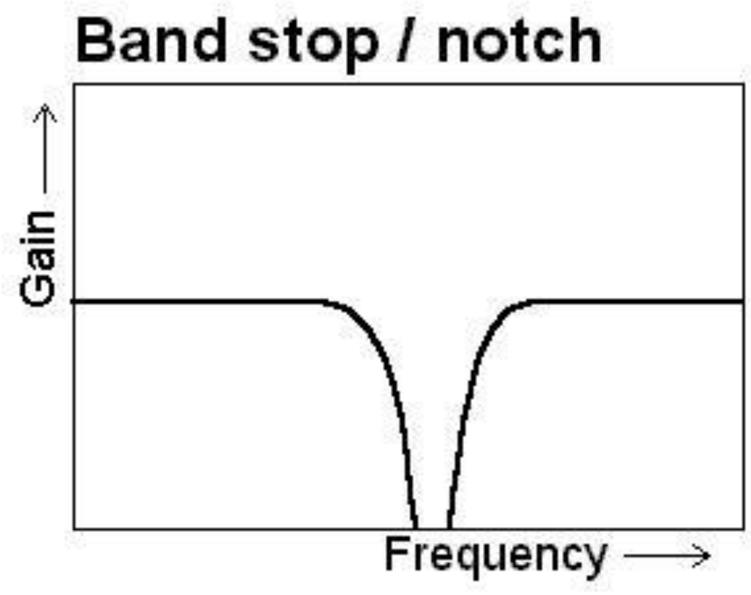

Figure 2.2: Bandstop graph