DESIGN OF WIDE-BAND BANDPASS FILTER WITH TUNABLE NOTCH RESPONSE OF WIRELESS COMMUNICATION SYSTEM

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DESIGN OF WIDE-BAND BANDPASS FILTER WITH TUNABLE NOTCH RESPONSE OF WIRELESS COMMUNICATION SYSTEM

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DECLARATION

I declared that this thesis entitled "Design Of Wide Band Bandpass Filter With Tunable Notch Response Of Wireless Communication System" is the result of my own research except as cited in the reference.

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APPROVAL

I hereby declared that I have read this thesis and in my opinion, this thesis is sufficient in term of the scope and quality for the award of Bachelor Degree in Electronic Engineering (Telecommunication Electronics) With Honours.

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DEDICATION

Special dedication to my beloved parents,

Kuek Hock Seng & Leo Sai Eng

My supporting siblings:

Kuek Chooi Fah

Kuek Soo Kiang

Kuek Chin Pang

To my supervisor

PM. Dr. Zahriladha b. Zakaria

To my co-supervisor

PM. Dr. Abdul Rani Bin Othman

My friends and my fellow lecturers

Thank you for all your care, support and believe in me

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ABSTRACT

A compact ultra-wideband (UWB) band-pass filter suitable for a short distance and high-rate such as UWB radar systems for military, medical and civilian is presented. However, the applicability of UWB band is limited by existing narrowband radio signals. These radio signals such as Wi-MAX at 3.5GHz and WLAN at 5.2GHz, RFID at 6.8GHz, C-band satellite communication (4GHz) and X-band applications like satellite communications (8GHz) cause the interferences with UWB communication system. This project is to design a five order tunable band-pass filter by using optimum distributed high-pass integrated with Defected Micro-strip Structure (DMS). The purpose of using DMS is to produce a band reject response. Then, pin diode is added to act as a switch to tuning the notch response. This design is simulated by ADS software and using Roger Duroid 4350B with a dielectric constant of 3.48, substrate thickness 0.508mm and loss tangent 0.0019. The proposed UWB filters are verified by experiments and fabricated. Measurement for UWB filter implemented by using Vector Network Analyzer. When pin diode off, the passband obtained range from 2.639GHz to 10.472GHz. When the pin diode on, the pass-band obtained in the range from 2.485GHz to 9.800GHz. Both passband range obtained a return loss, S_{11} better than 10 dB and insertion loss, S_{21} less than 1 dB when pin diode on. DMS produces sharp band rejects response better than 20dB at a frequency of 6.8GHz and 8GHz when pin diode off. The sharp band rejects response is tuned to 4GHz with bandwidth 700MHz and 6.8GHz when pin diode on. The proposed filter has better performance for UWB application and it is able to eliminate and tuning the undesired frequency in UWB communication.

ABSTRAK

Sebuah ultra luas jalur penapis laluan jalur yang padat sesuai dengan aplikasi jarak pendek dan ketinggian kedar data seperti system radar UWB untuk ketentaraan, perubatan dan awam dipersembahkan. Namun begitu, isyarat radio yang tidak diingin seperti Wi-MAX di 3.5GHz dan WLAN pada 5.2GHz, RFID pada 6.8GHz, komunikasi C-band satelit (4GHz) dan X-band aplikasi seperti komunikasi satelit (8GHz) menyebabkan gangguan dengan UWB sistem komunikasi. Oleh itu, projek ini adalah untuk reka bentuk sebuah lima perintah merdu penapis laluan jalur dengan menggunakan optimum diedarkan jalur tinggi bersepadu bersama dengan struktur mikro-strip (DMS). Tujuan pengunaan DMS adalah untuk menghasilkan jalur menolak yang bercirikan serentak didalam respon ultra luas jalur. Reka bentuk ini disimulasikan oleh ADS perisian dan menggunakan Roger Duriod 4350B dengan pemalar dielektrik 3.48, ketebalan substrat 0.508mm dan kehilangan tanjen 0.0019. Penapis UWB yang dicadangkan adalah disahkan oleh eksperimen dan dibina. Pengukuran untuk penapis UWB dilaksanakan menggunakan Vector Network Analyzer. Apabila pin diode tutup, penapis mempamerkan ultra luas jalur respon dari 2.639GHz sehinnga 10.472GHz. Apabila pin diode buka, penapis mempamerkan ultra luas jalur respon dari 2.485GHz sehinnga 9.800GHz. Kedua-dua mempunyai kehilangan pulangan S_{11} baik daripada 10dB dan kehilangan masukkan S_{21} kurang daripada 1 dB. DMS mempamerkan respon jalur menolak baik daripada 20 dB pada kekerapan 6.8GHz dan 8GHz apabila diod pin off dan4GHz dengan 700MHz bandwidth dan 6.8GHz apabila diod pin buka. Penapis yang dicadangkan mempunyai prestasi yang lebih baik untuk aplikasi UWB dan mampu untuk menolak frekuensi yang tidak diingini dalam komunikasi UWB.

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LIST OF ABBREVIATIONS

UWB	**-**	**Ultra wide-band**
BPF	**-**	**Band-pass filter**
DMS	**-**	**Defected Microstrip Structure**
DGS	**-**	**Defected Ground Structure**
WLAN	**-**	**Wireless Local Area Network**
WiMAX	**-**	**Worldwide Interoperability for Microwave Access**
RFID	**-**	**Radio Frequency Identification**
ADS	**-**	**Advance Design System**
RF	**-**	**Radio Frequency**
FCC	**-**	**Federal Communication Commission**

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CHAPTER I

INTRODUCTION

1.1 Introduction

Band-pass filters play a role important part. It is regarded as one of most usable structures in microwave engineering [1]. In 2002, the Federal Communication Commission (FCC) released the use of ultra wideband with frequency band from 3.1GHz to 10.6GHz for commercial communication purpose [2]. Ultra wideband band-pass filter consist a flat response from 3.1 GHz to 10.6GHz. Since the FCC authorized the commercial use of UWB, many researchers are more focused and paid more attention on designing UWB band-pass filter to fulfill the requirement of this wireless communication system [3]. Ultra-broad band (UWB) system has dozens of advantages for both academia and industry such as low power, high speed communication system and high precision ranging [3]. A number of the research wideband BPFs have been reported based on different methods and design methodologies from [1-14].

However, the applicability of UWB band is limited by existing narrowband radio signals. These radio signals such as WiMAX at 3.5GHz and WLAN at 5.2GHz, RFID at 6.8GHz, C-band satellite communication (4GHz), X-band applications like satellite communications (8.4 GHz) and radar systems (10 GHz) cause the interferences with the UWB communication system [1]. So, the researchers focus to avoid some interference signals when design the microwave filter [1]. A good performance with high selectivity and capabilities of band-pass response are required for wideband microwave filter [1].

Besides than that, the researcher concentrates to develop a high performance microwave filter by applying an electromagnetic band gap (EBG), the photonic band gap (PBG) structure, defected ground structure (DGS), and defected micro-strip structure (DMS) due to characteristic to produce a narrower notch frequency response [3]. DMS is produced by etching certain slot patterns in the micro-strip cable. The DMS is better in term of sharpness response and low loss [1]. The characteristic of equivalent circuit DMS provides a single band. DMS has the similarities with DGS. The only different is DGS manipulate of the ground plane. It is possible to design UWB band-pass filter by using defected micro-strip structure (DMS) resonator to produce notch response simultaneously.

1.2 Problem Statement

Ultra-Wideband (UWB) has the advantages of large bandwidth, good ratio of transmitting data, low power consumption, high speed data rate for many wireless applications such as UWB radar systems for medical, military and so on [8]. However, Wideband normally faces the interferences or interruption of other application signals such as WIMAX at 3.5GHz and WLAN at 5.2GHz, RFID at 6.8GHz, C-band satellite communication (4GHz) and X-band applications like satellite communications (8.4GHz) and radar systems (10 GHz) cause the interferences with the UWB communication system [7]. The accuracy of the data reception will decrease. As refer to this problem, the Defected Micro-strip Structure, DMS is implemented to create a notch response to remove the unwanted frequency and prevent interferences that occur from other signals. Sometimes, the application that removes is needed, so the pin diode is used for tuning the notch response without any effect to the response.

1.3 Objectives

The primary aims of this task are to design and develop wideband band-pass filter with tunable notch response. DMS is implemented to eliminate undesirable frequency with notch response. This project also needs to fabricate and validate the design of band-pass filter with tunable notch response through experimental works in a laboratory.

1.4 Scopes

In order to design of Wideband Band-pass Filter with Tunable Notch Response of Wireless Communication System, the studies are based on UWB filter with notch band, DMS technology and tunable function. The simulation part is carried out using Advanced Design System 2011 (ADS) software. The simulation process includes design, layout, simulation to obtain the frequency response and tuning process. The band-pass filter is designed by applying the method of short circuited stub. The wideband frequency is used from 3.1GHz to 10.6GHz. The insertion loss and return loss of this project is set to better than 0.5dB and 15dB respectively. The DMS is implemented and design after the design of the band-pass filter to remove undesired frequency in wireless communication system. The pin diode is added to act as a switch to tuning the notch response. When the pin diode off, the notch response need to produce a sharp response at 6.8GHz (RFID) and 8GHz (X-band satellite communication). When the pin diode on, the notch response is tuned to 4GHz (C-band satellite communication) with a 400MHz bandwidth characteristic and a sharp response 6.8GHz (RFID). All the band reject response must be better than 20 dB. The fabrication process is followed by the ADS software design. After that, the tunable band-pass filter need to be measured by using Vector Network Analyzer. Finally compare the simulation and measurement results.

1.5 Chapter Review

Chapter 1 describes general overview of this project. This chapter demonstrates the introduction, problem statement, objectives, scope and review of all chapters of this dissertation. The finding of the project describes in this chapter 2. The overall studies are related to Ultra wideband design and its application. This chapter describes the introductions of filter and detected micro-strip structure is presented. This chapter will explain the basic concept of the filter response.

Chapter 3 presented the methodology of the design process of tunable band-pass filter. The methodology involves the procedure of designing UWB filter, DMS design with tunable function. Tuning and optimization process involved in this project.

Chapter 4 will present about simulation and measurement results. The results consist of the simulation result of transmission line, simulation result of micro-strip line, simulation result of layout structure, parametric study of various shapes of DMS, simulation result of tunable filter when implemented DMS where pin diode off and pin diode off. The current distribution of the design also will show in this chapter. Finally, the measurement result and comparison of simulation and measurement result are also shown in this chapter.

Chapter 5 will present the conclusion of this project after all the theoretical, simulated and measurement result is achieved. The future work also involved in this chapter.

CHAPTER II

LITERATURE REVIEW

The finding of the project describes in this chapter. Before starting the project, the literature review plays an important part. The overall studies are related to Ultra wideband design and its application. All the basic theory of design a band-pass filters cover in this chapter. There are a lot of method and technique to design a microwave filter. All the research and information that related to this project also explain in this chapter.

2.1 Ultra-Wideband (UWB)

In 2002, the Federal Communication Commission (FCC) released the use of ultra wideband with frequency band from 3.1GHz to 10.6GHz for commercial communication purpose [2]. Ultra-wideband (UWB) is a radio technology that applies a huge frequency spectrum with a low energy level, power and high data rate for short-range communications. UWB use base band pulses that without IF processing of ultra-short duration and spreads the signal energy across the bandwidth. UWB has very high data rates that transmission is about 1 to 2G-pulses per second. It consists of ultra high precision ringing that use the short pulse facilities. UWB is simplicity and low cost because it uses carrier-less radio impulses and without intermediate frequency. This will reduce the cost when compared with other communication systems [15].