DESIGN OF ANTENNA WITH NOTCH FILTER TO SUPPORT MULTIFUNCTION OPERATION STANDARDS IN WIRELESS COMMUNICATION SYSTEMS

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

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2016

DECLARATION

I hereby declare that this report entitled “Design of Antenna with Notch Filter to Support Multifunction Operation Standards in Wireless Communication Systems” is the result of my own work and that, to the best of my knowledge and believe. It contains no material previously published or written by another person except for quotes as cited in the references and also no material which to a substantial has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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APPROVEL

“I hereby declare that I have read through this report entitled “Design of Antenna with Notch Filter to Support Multifunction Operation Standards in Wireless Communication Systems” and found that it is sufficient to a comply the partial fulfilment for awarding the degree of Bachelor of Electronics Engineering (Telecommunication Engineering) with Honours”

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Supervisor:Dr. Yosza Bin Dasril

Signature: ………………………

Co-supervisor: PM. Dr. Zahriladha bin Zakariar.

Date : 15 / 06 / 2016

DEDICATION

Special to my beloved mother and father who always standby my side in giving supports morally and physically

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ABSTRACT

In this project is a small size UWB patch antenna with single notch filter. U-shaped slot is loaded in the patch of the antenna for WiMAX frequency band rejection. The antenna is simulated using the CST Microwave Studio software. The slot dimensions are systematically calculated and optimized to achieve the desired band rejection response. The single notch filter can be implemented using U-shaped slot embedded on the patch for WiMAX frequency band rejection. In order to achieve the characteristics to the patch antenna. The achieved results have been demonstrated that the antenna can function over the entire UWB operating frequency range from 3.1 GHz to 10.6 GHz. On the other hand, it rejects one WiMAX (3.13 – 3.7 GHz) frequency band. The antenna is simulated using the simulation software CST Studio Suite. The comparison of the antenna performance is to take place, in terms of antenna parameters such as gain, return loss, bandwidth and radiation pattern. Whereas the obtained results have been validated experimentally and observed with good performance.

ABSTRAK

Dalam projek ini adalah saiz yang UWB patch antena kecil dengan penapis takuk tunggal. Slot U berbentuk dimuatkan dalam patch antena untuk WiMAX jalur frekuensi penolakan. antena simulasi menggunakan perisian CST Microwave Studio. Dimensi slot secara sistematik dikira dan dioptimumkan untuk mencapai balas band penolakan yang dikehendaki. Penapis takuk tunggal boleh dilaksanakan menggunakan slot U berbentuk tertanam pada patch untuk WiMAX jalur frekuensi penolakan. Dalam usaha untuk mencapai ciri-ciri untuk antena patch. Keputusan yang dicapai telah menunjukkan bahawa antena boleh berfungsi dalam julat keseluruhan kekerapan UWB kerja (3.1 GHz kepada 10.6 GHz). Sebaliknya, ia menolak Dia WiMAX (3,13-3,7 GHz) jalur frekuensi. antena simulasi menggunakan perisian simulasi Suite CST Studio. Perbandingan prestasi antena adalah untuk mengambil tempat, dari segi parameter antena seperti keuntungan, kehilangan pulangan, jalur lebar dan corak radiasi. Manakala keputusan yang diperolehi telah disahkan secara eksperimen dan diperhatikan dengan prestasi yang baik.

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CHAPTER I

INTRODUCTION

1.1 Introduction

The purpose of this project is to design a device that have small antenna with single notch band at 3.1–10.6GHz ultra-wideband (UWB) for wireless communication applications. It uses to support multifunction operation standards in wireless communication systems by using micro-strip patch and a perfectly conducting ground plane. Currently, various antennas have been designed for wireless communications applications. However, these antennas either they are expensive to build due to fabrication difficulty or having large size. Therefore, in this project an UWB is going to be designed at operating frequency of 3.1 to 10.6 GHz with introducing a wide slot to achieve a notch band filter at WiMAX (3.15-3.7) GHz. This is due to various advantages of UWB antennas such as cost effective, compact in size and having high gain. The range of this project is limited to certain application for wireless communications such as WLAN (5.15-5.85 GHz). The proposed UWB antenna will be designed and simulated by using the commercially available CST Microwave Studio Software. Then, the simulation results will be validated and verified through experimental results. It is believed that the proposed UWB antenna is going to be developed for WLAN, Smart Sensor Network, and other Wireless Communications applications.

1.2 Problem Statement

Recently, antennas are widely used in satellite communication, military purposes, GPS, mobile, missile systems. This is due to its compact shape and light weight, less complexity and easy to implement. However, these antennas are facing some difficulties such as low impedance bandwidth, low gain, extra radiation occurs from its feeds and junctions, and large in size. Therefore, an ultra-wideband (UWB) micro-strip antenna with single notch filter is proposed in order to have a high gain with large bandwidth which can be used for many applications in the same time. [19] This is due to its advantages such as ease of fabricating, cost effective, has efficient radiators and it can support both linear and circular polarization.

1.3 Objectives

a. To design Ultra-wideband (UWB) antenna with single notch filter to support multifunction operating standards frequencies for wireless communication system applications.
b. To simulate and fabricate a micro-strip patch antenna using CST software.
c. To validate and verify the simulation results with measurement results.

1.4 Scope of Work

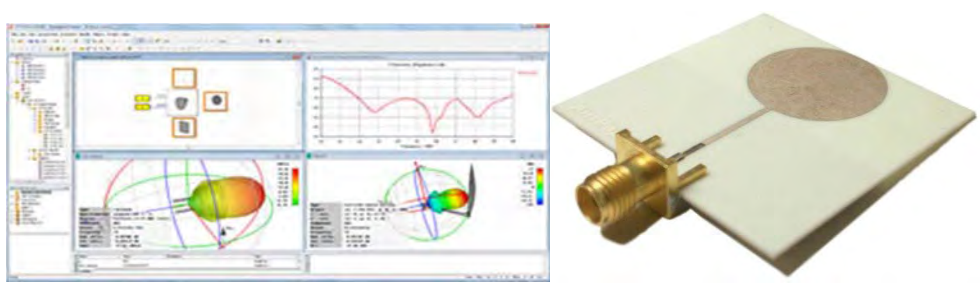
This project will mainly focus on the design and analysis, testing and measurement of Micro-strip patch antenna captures by the communication system in the frequency range of UWB (3.1-10.6 GHz) except for WiMAX at (3.15-3.7GHz). Furthermore, a single notch will only be used as filter for undesired frequencies or rejected frequencies. This project limits to certain applications on wireless communications systems such WLAN. CST (computer simulation technology) software will be utilized to design the antenna. After completing the design process, the next procedure is to fabricate circuits and do testing and measurement. This includes a comparison between the simulation result and the measurement results. The purpose of this project is to validate and verify the simulation results of a micro-strip patch antenna for UWB usage.

1.5 Methodology

This project begins by the literature review process to study and learn about the UWB antenna fundamentals, Micro-strip Ultra-Wideband Antenna with single Notch Filters. After all the parameter involves in this UWB antenna design is calculated, the physical layout of the design antenna will be constructed. Then the simulation will be carried out by using the CST software. The design of the Ultra-wideband antenna will be optimized by considering all antenna basic characteristics such as a resonance frequency, return loss, bandwidth, gain, and directivity. After completing the design process in CST software, the antenna will be fabricated. The fabricated antenna then will be measured to observe the result of return loss, bandwidth, gain and directivity of the antenna design. When all the specifications meet the requirement, the fabrication process of the antenna will be carried out. Next to the testing and measurement of the fabricated antenna will be carried out hence again will compare it with all the calculated and simulated results. All experimental results will be included in the final report. Figure 1.3 shows the flowchart of the project development

Software and hardware:

The software program that will be used for designing the proposed UWB antenna is CST. Computer Simulation Technology (CST) Microwave Studio offers accurate, efficient computational solutions for electromagnetic design and analysis. 3D EM simulation software is user-friendly and enables you to choose the most appropriate method for the design and optimization of devices operating in a wide range of frequencies. CST STUDIO is a specialist tool for signal integrity (SI), power integrity (PI), and electromagnetic compatibility (EMC) analysis on printed circuit boards (PCB). It integrates easily into the EDA design flow by providing powerful import filters for popular layout tools.



(a) (b)

Figure 1.2 a-CST Software b-PCB Hardware

The hardware is by using printed circuit board (PCB) the board base for physically supporting and wiring the surface-mounted and socketed components in most electronics which the fabrication process will be settled on PSM 1 Lab.

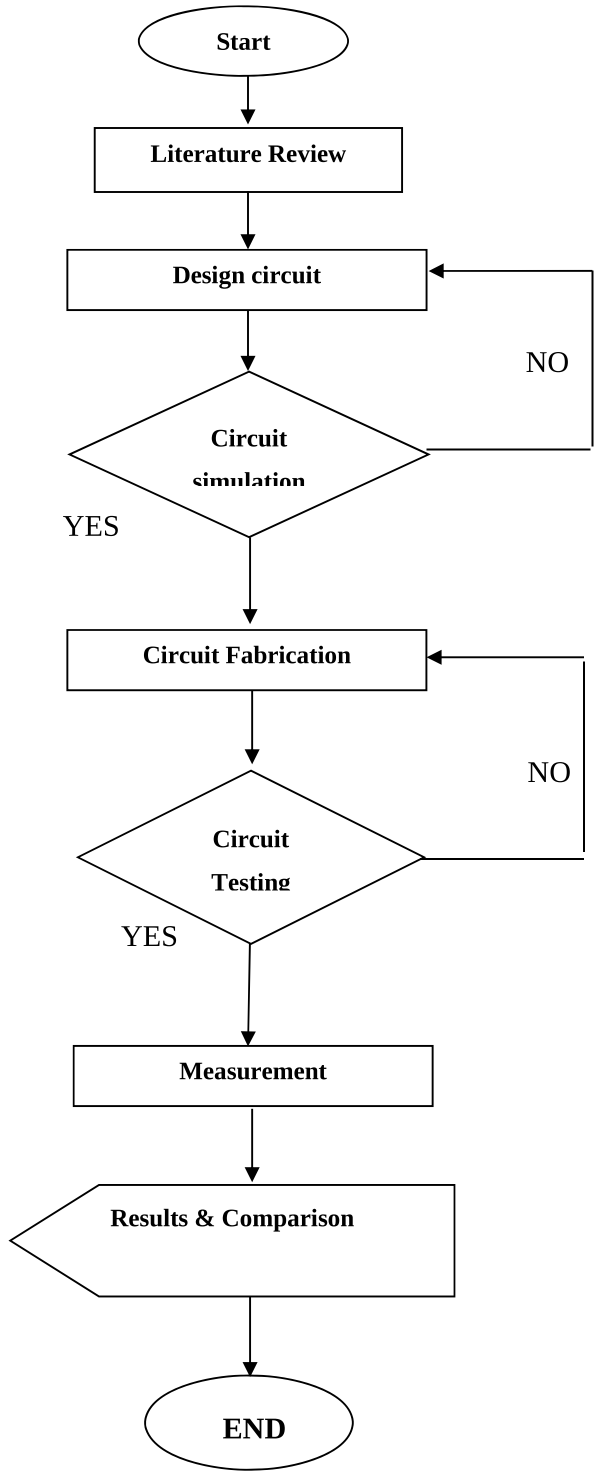


Figure 1.3**:** Flowchart of project

1.6 Contribution of Project

A few years when the first investigation on ultra-wideband (UWB) wireless system, considerable project efforts are place into the design of UWB antenna and systems for communications. This UWB antenna is essential for providing wireless broadband communications supported the utilization of terribly narrow pulses on the order of nanoseconds, covering a really wide bandwidth within the frequency domain, and over terribly short distances at very low power densities. During this project, new models of U slotted UWB antenna proposed by finding out its current distribution characteristics. The wideband behaviour is due to the actual fact that the currents on the perimeters of the slot introduce an extra resonance, which, in conjunction with the resonance of the most patch, turns out an overall broadband frequency response characteristic. This antenna is considerable small than others listed within the references, that its size is a smaller amount than a wavelength, compact, and appropriate for several UWB applications. [15]

The miniaturization of vertical type U slotted antenna will be realized by narrowing the patch and inserting the slots while retaining the UWB characteristics. The proposed antennas are simple in design, small in size and easy to manufacture.

CHAPTER II

LITERATURE REVIEW

3.1 Introduction

In this chapter, a brief history of UWB antenna technology has been reviewed. The UWB antenna concept has been investigated since many decades. From the literature reviews, the researched journals that were reviewed about designing Ultra-wideband (UWB) antenna at frequency of (3.15-3.7) GHz with notch filter. The UWB technology has knowledgeable about several important developments in recent years. However, there are still challengers in creating this technology live up to its full potential. One specific challenge is that the UWB antenna design. UWB technology has had essential impact on antenna design. The UWB antennas need to be ready to transmit pulses as accurately and efficiently as doable. The spectrum allocated definitely needs transmitters and receivers with band antennas. After correcting the desired journals, Comparisons were carried among them. In addition, this chapter covers a detail theory about an antenna and its parameters that determine its performance.

3.2 Need for (UWB) filters and challenges

The main challenge in UWB antenna design is achieving the extremely wide impedance bandwidth while still maintaining high radiation efficiency. By definition, an UWB antenna must be operable over the entire 3.1 GHz - 10.6 GHz frequency range. As in conventional wireless communication systems, filter plays a vital role in UWB systems also. Filters are required in the UWB systems for the following reasons: [13]

a. Reshaping the UWB signal in order to meet the FCC spectrum regulations.
b. Suppressing the interference from the Narrowband (NB) services such as Worldwide Interoperability for Microwave Access (WiMAX) and WLANs.
c. Suppressing harmonics and spurious of oscillators and amplifiers, also to eliminate the out band noise.

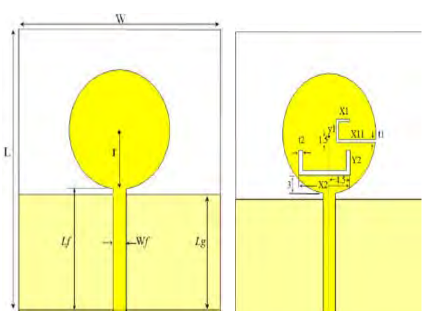
3.3 Critical Literature Review

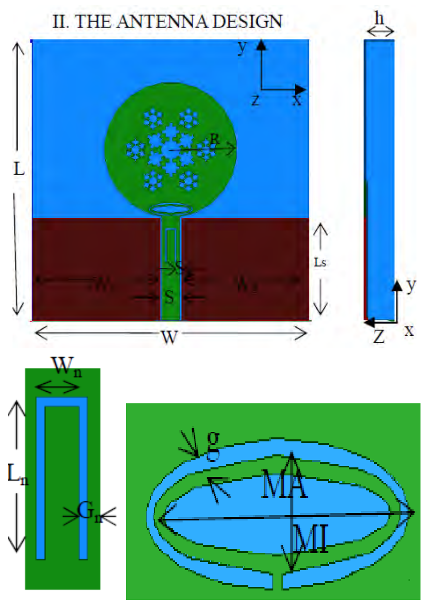
The literature review examined a comprehensive background of other related research works and the fundamental antenna parameters that should be considered in designing UWB antenna using Micro-strip patch with single notch filter, and potential technologies for physical construction. However, the literature review is performed on journals to collect related information and facts that can be used in the design process of this project prior to design process.

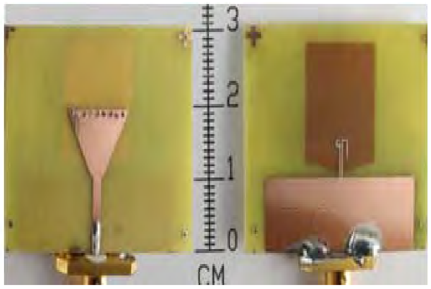
3.4 Results and Analysis

Result and analysis of previous literature papers is given in literature review table given in below.

Table 2.1Summary of the sample journals literature review

No	TITLE	Remark
1.	Design of Circular Patch Micro-Strip Ultra-Wideband Antenna With Two Notch Filters [1]  	**Specifications** –The notched frequency bands (3.1 GHz to 10.6 GHz) except WiMAX (3.15-3.7GHz) and WLAN (5.15-5.85 GHz) –Small size UWB patch antenna with two notch filters. U-shaped and J-shaped slots are loaded in the patch of the antenna for WiMAX and WLAN frequency band rejection. –The simulation using the commercially availabled CST Microwave Studio software. –The patch antenna printed on a standard FR4 substrate. –permittivity (εr) of 4.4. –dielectric loss tangent (tan δ) of 0.019. –substrate thickness of 1.6 mm. –The antenna substrate and ground plane sizes equal 47×40 mm2 and 19.3× 40 mm2 respectively. –The circular patch has a microstrip feed line with dimensions 20.3 × 2.6 mm2. **Advantages** – The antenna has good performance over the entire working frequency band (3.1 GHz to 10.6 GHz). **Disadvantages** –

		Results – The gain of the UWB patch antenna decreases to 2 dB at 5 GHz. – the notch filter parameters were optimized to give a good band-reject on the WLAN bandwidth (5.15 to 5.85 GHz) and WiMAX bandwidth (3.2 to 3.7 GHz). – Measured H-plane has gain magnitude of 2.5dB at 266° where was at 7 GHz, also the E-plane has a gain magnitude of 3.5 dB (at Theta = 90°). Finally, a gain of 7.2dB where was shown for E-plane at 9.6 GHz (at Theta= 90°).
2.	Design and Development of UWB notch antenna with fractal geometry [2] 	**Specifications** – The design of coplanar waveguide fed ultra-wide band Antenna with fractal geometry. – The designed antenna has a dual band notch characteristic. – circular monopole. – The antenna performance depends on the ground plane width and the feed gap. – Elliptical type of slot, sierpinski fractal dual band elimination monopole UWB antenna. – The impedance bandwidth ranges from 1.8 to 11.5 GHz. – FR-4 epoxy substrate having thickness h=1.6 mm, loss tangent (tan δ)=0.02 and dielectric constant εr=4.4. **Advantages** – The antenna is good suppression capacity at the 5.2GHz wireless LAN by using elliptical type of slot in the main radiator. – Elliptical type of slot helpful for achieving notched band centered at 5.2 GHz for WLAN rejection. Results – the resultant bandwidth of 1.8-11.5 GHz with VSWR<2. – Measured H-plane and E-plane. – Resonance dip around 3.1 GHz corresponding to a quarter wavelength of the disc diameter. – Subsequent resonance dips around 5.9 GHz and 7.7 GHz correspond to the higher order harmonics of the fundamental mode.
3.	A Band-Notched UWB Monopole Antenna with High Notch-Band-Edge Selectivity [3]	**Specifications** – The proposed antenna consists of a radiation patch and an embedded second-

		order bandstop filter. – proposed antenna with a second-order maximally flat bandstop filter at 5.5 GHz is presented. – UWB antenna provides good notch-band suppression from 5.15 to 5.95 GHz, – the normalized total radiated powers in the notch band are lower than 12 dB. – high band-edge selectivity andflat return loss in the notch band and it has Stub resonator. **Advantages** – Good radiation performance with radiations patch from 3.1 to 10.6 GHz. – Obtain a uniform rejection performance over the whole interference band. – High-quality factor. **Disadvantages** – The single null of the insertion loss at the center frequency of the bandstopfilter does not benefit the band-edge selectivity. **Results** – Band notch from 5.0 to 6.0 GHz. – Measured H-plane has gain 0 dBi at frequencies in the passband and below -10 dBi. – The measured 10-dB return loss bandwidth covered the range from 2.4 to over 11 GHz with a 3-dB notched band from 5.0 to 6.0 GHz
4.	Dual Band-Notch UWB Antenna with Single Tri-Arm Resonator [4] 	**Specifications** – Microstrip line-fed planar antenna with dual notched bands of 3.3–3.7 and 5.15–5.825 GHz.. – The dual band-notch characteristic is achieved by etching a single tri-arm resonator below the patch. – Bandwidth (return loss 10 dB) ranging from 2.98 to 10.76 GHz with two notched bands operating at 3.5 and 5.5 GHz. **Advantages** – Achieved good gain and exhibits omnidirectional radiation patterns except at notched band. **Disadvantages** – The performance of the UWB antenna is greatly dependent on the size of the ground

		plane. **Results** – dual notched bands at 3.5 and 5.5 GHz with an aim to avert the interference withWiMAX and WLAN in ultrawideband – Measured radiation patterns of the proposed antenna at 3.2, 5.5, and 9.4 GHz in xz-plane and yz -plane.
5.	A Novel Reconfigurable Notch-Band UWB Antenna [5]  (a) (b) (c)	**Specifications** – Novel ultra-wideband (UWB) antenna with the reconfigurable notch band. – Elliptical-shaped patch, a 50-Ohm CPW feed line, and a tapered ground plane. – Two-notch-band UWB antenna (3.3GHz~3.6GHz, 5.15GHz ~ 5.825GHz). – The antenna are (unit: mm) L=50,ER=28, SW=0.5, R=4.3, SD=0.5, F1=17, F2=10, RP=21.5, EL1=16, EL2=10, FW=5. – The FR4 substrate (r=4.5, h=1.524mm). **Advantages** – increase the bandwidth of the UWB antenna. **Results** – The notch band covers either WiMAX (3.3GHz~ 3.6GHz) band or WLAN for (5.15GHz~5.825 GHz) band.

3.5 Antenna theory

An antenna is an electrical device which converts electric currents into radio wave or radio wave into electric currents. Antenna usually used with a radio transmitter or radio receiver. In transmission, radio transmitter applies an oscillating radio frequency electric current to the antenna’s terminals and the antennas radiate the energy from the current as electromagnetic waves. Antennas that excite an electrical field are referred to as electrical antennas; antennas exciting a magnetic field are called magnetic antennas. The oscillating electrical or magnetic field generates an electromagnetic wave that propagates with the velocity of light, c. In reception, an antenna intercepts some of the power of electromagnetic waves in order to produce tiny voltage at its terminals. An antenna can be used for both transmitting and receiving.

In other words, an antenna only converts an electromagnetic signal to an electrical signal at receiver or transmitter. If there is 100 percent of efficiency, they radiate no more