BAND-NOTCHED ULTRA WIDEBAND (UWB) ANTENNA FOR INDOOR AND WEARABLE WIRELESS COMMUNICATION

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Dedicate to my beloved family and supervisor, Dr. Mohd Saari bins Mohammad Isa.

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ABSTRACT

Currently, there is an increased interest in ultra-wideband (UWB) technology for use in several present and future applications. UWB technology received a major boost especially in 2002 since the US Federal Communication Commission (FCC) permitted the authorization of using the unlicensed frequency band starting from 3.1 to 10.6 GHz for commercial communication applications. The FCC allocated an absolute bandwidth up to 7.5 GHz which is about 110% fractional bandwidth of the center frequency. This large bandwidth spectrum is available for high data rate communications as well as radar and safety applications to operate in. However with the large frequency spectrum that UWB technology cover there are some of operating frequency for other application. This paper will be discuss about design a band-notched UWB antenna for indoor and wearable wireless communication. In the raging 3.1 GHz to 10.6 GHz there are some indoor application operation frequency in the UWB frequency spectrum. The operation frequency is belong to WLAN that operate at 5.25 GHz. The band-notched function in antenna is to rejecting the selected frequency such as WLAN operating frequency to avoid interfering in UWB technology.

ABSTRAK

Pada masa kini, terdapat peningkatan minat terhadap teknologi jalur lebar ultra (UWB) untuk digunakan di dalam beberapa aplikasi pada masa kini dan masa depan. Teknologi UWB menerima ransangan terutama pada tahun 2002 sejak Suruhanjaya Komunikasi Persekutuan Amerika Syarikat (FCC) ynag memberi kebenaran penggunaan tanpa lesen pada jalur frekuensi bermula pada 3.1 HHz sehingga 10.6 GHz untuk applikasi komersial. FCC telah meperuntukan jalur lebar sebanyak 7.5 GHz iaitu kira-kira 110% jalur lebar pada frekuensi pecahan pusat. Spectrum jalur lebar yang besar ini diperuntukan untuk kegunaan komunikasi data laju serta radar dan juga pemohonan keselamatan untuk beroperasi. Namun degan spektrum frekuensi yang besar meliputi technologi UWB terdapat beberapa frekuensi operasi untuk aplikasi lain. Kertas kerja ini membincangkan tentang reka bentuk antenna UWB "band-notched" untuk kegunaan dalaman dan juga boleh pakai. Dalam jarak frekuensi 3.1 GHz sehingga 10.6 GHz terdapat beberapa frekuensi aplikasi dalaman dalam spektrum frekuensi UWB. Frekuensi operasi ini adalah kepunyaan WLAN yang beroperasi pada frekuensi 5.25 GHz. Fungsi "band-notched" ini adalah untuk menolak frekuensi terpilih seperti frekuensi operasi WLAN untuk mengelakan gangguan terhadap technology UWB.

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CHAPTER I

INTRODUCTION

This project is mainly focusing on design, simulate, fabricate and measure the UWB antenna for wearable and wireless communication that can operate in frequency range from 3.1 GHz to 10.6 GHz while rejecting the WLAN operation frequency at 5.25 GHz and achieve a better reflection loss or S11 for wearable by using CST Studio Suite software with some banding angle. The environment of this project is methodically elaborated in this chapter. This chapter also outlined the objectives, scope and methodology of the research.

1.1 INTRODUCTION

In 1890s, there only a few antennas in the world. This basic antenna were primarily a part of experiment that demonstrated the transmission of electromagnetic waves. The World War 2 has made the antenna become so popular where the army or researcher saw the advantage of antenna. By the 21st century, thanks to the growth of wireless communication the average person today carries more than one antenna wherever they go (cell phone). In addition, the strong growth in RFID device may cause the number of antenna in use may increase to one antenna per object in the world. This number would dominate the number of antenna in use today.

What is the origin of antenna? The first experiment was involve the coupling of electricity and magnetism to show the relationship between them and was done by Faraday somewhere around 1830s where he slid the magnet around coils of a wire that attach to a galvanometer. While moving the magnet, he was in effect creating a time-varying electric field where the coil acted as loop antenna and receive electromagnetic radiation then the galvanometer detected. Interestingly, the concept of electromagnetic waves had not even been through up at this point.

In 1886, Heinrich Hertz had developed a wireless communication system in which he forced an electric spark to occur in the gap of dipole antenna. He used a loop antenna as a receiver, and observed a similar disturbance. In 1901, Marconi was sending information across the Atlantic. For a transmit antenna, he used several vertical wires attached to the ground. Across the Atlantic Ocean, the receive antenna was a 200 meter wire held up by a kite. In 1906, Columbia University had an Experimental Wireless Station where they used a transmitting aerial cage. This was a cage made up of wires and suspended in the air, resembling a cage.

Today wireless communication is a fast growing segment in the communications industries. It has caught the attention of the media and the creative ability of the general population. Cellular system have encountered exponential development in the course of the most recent decade and there are as of now billion of users around the world. Now the researcher had their interest in the ultra-wideband (UWB) technology.

Currently there is an expanded enthusiasm for ultra-wideband (UWB) technology to use in several application. This technology noteworthy support particularly in 2002 since the US Federal Communication Commission (FCC) allowed the approval of utilizing the unlicensed recurrence band beginning from 3.1 to 10.6 GHz for communication application. FCC had allocate up to 7.5 GHz bandwidth for the UWB that give about 110% fraction bandwidth of center frequency. The large bandwidth spectrum is for the safety application, high data rate communication and radar operation. The UWB technology had another advantage in power consumption view. According to FCC spectral mask the UWB antenna maximum power is 5 mW due to the large bandwidth. This power is considered to be a small value and it is actually very close to the noise floor compared to what is currently used in different radio communication systems.

1.2 OVERVIEW PROJECT

This project is all about design of flexible antenna for wearable UWB area network applications. The antenna prototype was expected to be operate in a UWB frequency spectrum ranging from 3.1 GHz until 10.6 GHz. It is due to allocation of UWB frequency by FCC. This project mainly focused on band-notched the WLAN operation frequency at 5.25 GHz [1].

The UWB antenna need a filter to avoid interference. However the usage of filter will increase the cost and the complexity of UWB system. Because of it the researcher need to find the filtering technique for antenna that need to be simple, effective and cheap method and small size antenna with band rejecting function are able. In order to design the UWB antenna that can rejecting some of frequency band there are some band-notch technique have been purpose, including etching C-shape, L-shaped, T-shaped, H-shaped, U-shaped, E-shaped, and half-circle slots on the radiation patch or on the ground plane

One of the main target in this project is wearable antenna. In order to fulfil this target, the antenna prototype must be design using flexible substrate. It is because;

flexible substrate is needed so that it can perform a better result as wearable antenna. Permittivity and loss of tangent of this textile must be considered before it can be use in this prototype.

1.3 OBJECTIVES

The objectives of this project:

- To research the suitable substrate for the wearable antenna
- To research the suitable antenna type for wearable purpose
- To design, simulate, fabricate and measure a band-notched UWB antenna for indoor and wearable wireless communication

1.4 WORK SCOPE

First of all, the research on substrate, antenna type and design must be conducted. Then, all parameters with the design specification must be stated as guidelines for the result. There are few design specification that needed to be concern such as center frequency, gain, bandwidth, and directivity. A research need to be conducted in order to know some technique that can be used to improve specification that stated above.

The priority of UWB antenna is the band-notched function. The band-notched function is needed to make sure the UWB system can filter the unwanted frequency so that this system can be use without interference. In this project the UWB system need to filter the WLAN operation frequency at 5.25 GHz. The reason of this rejecting frequency because this project need working as wearable and indoor application and will not interfere with indoor WLAN application.

This project is focused on flexible antenna. So, effect of antenna performances under bending condition need to be know. In order to create a flexible antenna, suitable substrate must be use. So the research of suitable antenna need to do in order to know the best substrate that have flexibility so that the antenna can be fabricate on it.

1.5 PROBLEM STATEMENT

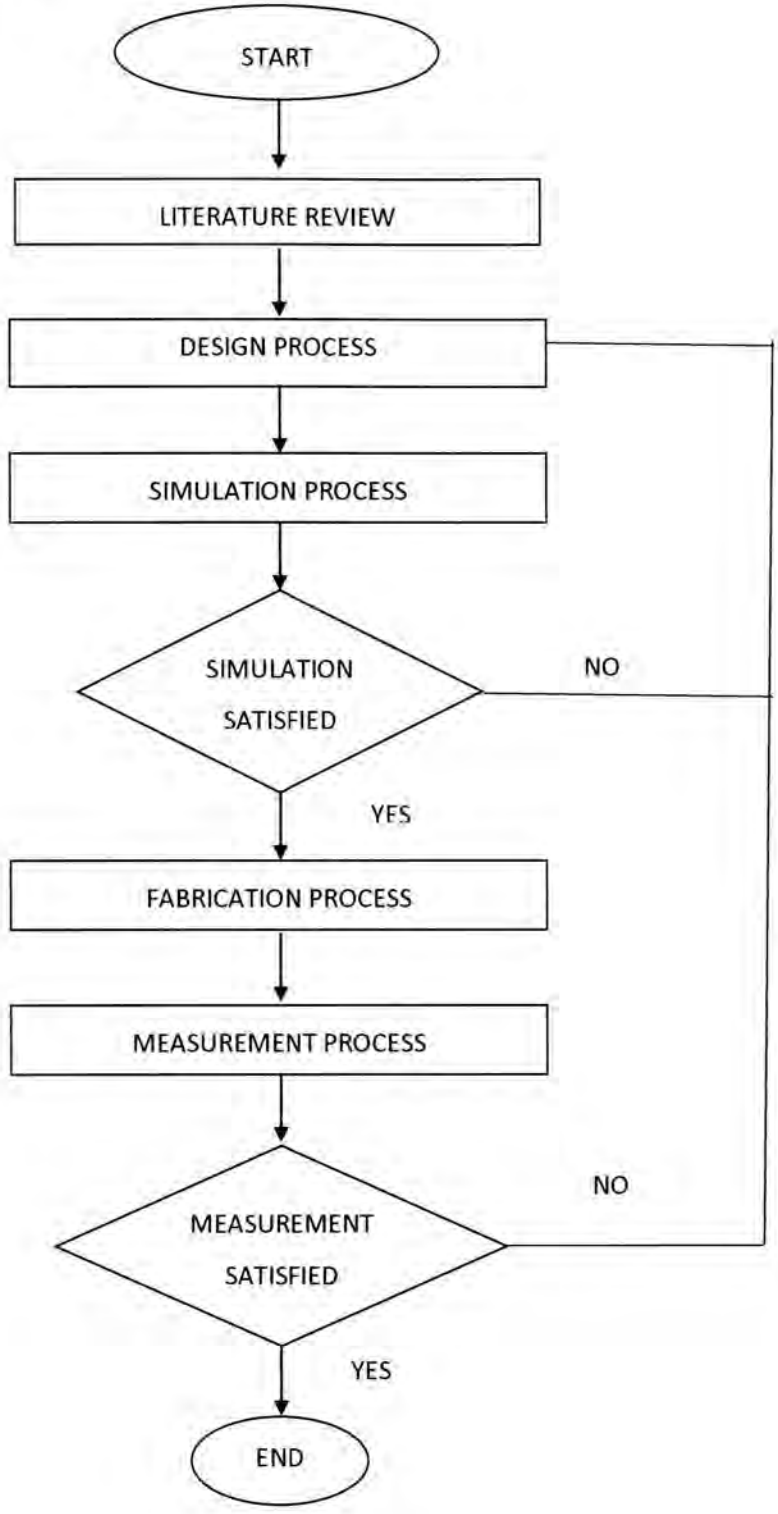
Wearable antenna has been utilized for a long time as a part of a few applications. Wearable antenna brings lots of advantage to users. One of them is mobility. Users simply need to wear the antenna, and then they can use the application everywhere they goes. Unfortunately, wearable antennas likewise have some negative part.

The wearable antenna was worn on the human body. So, the first problem statement is the loading effect of due to lossy tissue that makes the design of a with high radiation efficiency antenna challenging. Lossy tissue is defines as human body parts such as skin, muscle, fat and bone. Layers of human body are very thick thus making it difficult for signal to penetrate. So, wearable antenna will have low performance due to this problem.

The second problem statement is the band-notched function. As mention UWB is operate in frequency ranging from 3.1 GHz to 10.6 GHz so an for the wearable and indoor application this antenna need have to rejecting the WLAN operation frequency at 5.25 GHz. Band-notched also known as band stop, but actually this band-notched is a cheap method use to filter the unwanted frequency.

Lastly the third problem statement is the flexibility of the wearable antenna. The wearable antenna was place on human body, so the flexibility is a crucial part for the antenna. So, it is important task to find a suitable material that have a great flexibility thus efficient for antenna performances. The research on permittivity of several substrate need to be done in order to know which substrate that can produce great wearable antenna. Weight of material also must be considered in order to make it as wearable antenna.

1.6 METHODOLOGY



First task in this project is to gain information about wearable antenna as much as can. A literature review must be conduct in order to gain all information. Literature review in this project will centered on three main things. Firstly, the information about type of antenna that suitable to be use as wearable antenna need to be gather. As know, there are lots of antenna types in today technology. Each of the type of antenna has their own advantages and disadvantages. So, the review of every type of antenna need to do so that can identify of type of antenna which will perform better as wearable antenna.

Next task is to review about band-notched function. As stated in the title of this project, band-notched antenna is the main part in UWB system so it can remove the interference. There are lots of band-notched techniques that be purpose by researcher. So, to ensure which technique is suitable in the design so research need to be conduct. Lastly, the literature review regarding the suitable material that can be use in the design need to be done. This project is about wearable antenna, so the suitable materials that have great performances for antenna need to be use. This substrate must be lightweight and comfortable to be use by users.

After all information have be gather in literature review, design process will be conducted. All the design in this project will be done using CST software. The design process will include three phases. The first phase is about the ground plane. It was really important because ground plane will affect antenna performances. Next phases are about design of substrate. Substrate must be design carefully because it is crucial part for antenna. Last phase is about implementation of band-notch technique. As different shape of band-notch will affect the antenna performances. So, design process must be conducted carefully in order to get precise results.

The simulation procedure will occur when design process complete. This procedure also will do by utilizing CST programming. During this procedure, all specification that expressed in scope of work must be simulating. All outcome from simulation must be same from design specification. If the simulation result is precise, the fabrication process will start. However, design process need to done again if the simulation results are not accurate. If the simulation results are not satisfied, the design

should be alter. There may be some changes can be done in order to get an accurate simulation results.

If simulation results are satisfied, the fabrication process can be proceed. Fabrication process is the toughest one in this project. One mistake in this process it can make a big problem. In this project, fabrication process will be conducted by using copper paste technique. Fabrication process must be done in careful environment so that any errors can be prevented.

Measurement process is the last process in this project. Function of this process is to measure the result based on antenna prototype design. Measurement need to be conducted in order to measure all the design specification that had stated above such as resonance frequency, return loss, gain, and directivity. If the measurement value is not like the expectation, design process need to be undone back. There must be some errors in design process that make inaccurate measurement results. Parameter sweep can be done in order to identify the problem in design.

If there are no errors happen in measurement process, that's mean the project have complete and need to make sure the design can work. So, the antenna need to be inspect carefully to find is there any errors in the design.

1.7 CHAPTER OUTLINE

This report contains of five chapters and the details of this report will be outlined as:

Chapter I – This chapter will outline the introduction for the entire project. The fundamental explanations are mentioned in this chapter. Introduction and overview project is mainly focusing on project's background. Other than that, this chapter also will give an overview about the objectives of developing this project, work scope of the project, problem statement and lastly the process methodologies.

Chapter II – This chapter is described about the previous studies, researches and readings process that have been carried out and also to supported and understand the project. Literature Review explaining about the existing research method that has been used before for this project and also the advantageous and disadvantageous of the method used. Shape and material that can be used to design the wearable and flexible antenna also discussed in this chapter. This chapter also elaborates about suitable band-notched technique that can be used to reject the WLAN operation frequency at 5.25 GHz. Lastly this chapter includes some discussion about material which is suitable for wearable antenna and can work as substrate in this antenna prototype.

Chapter III – This chapter concentrates on the methodology process of this project which is it will be explain on how the project is been carried. This chapter will explain in detail about step on how the development of both of this design by using the CST Microwave Software. The design process and design specification will be explained in details in this chapter.

Chapter IV – This chapter is about result and discussion. This section will explain about the finding of this project and analysis of result. The simulation results are presented. The comparison of reflection loss or S11 between before adding band-notched function and after adding band-notched function will be presenting and analyzed. Result for other specifications such as gain and directivity also will be discussed in this chapter. The discussions for the whole research are related to finding and observation that had been made from the results.

Chapter V– This is the final stage for the overall process and performance of the project. This chapter concludes the entire project finding, improvement achieved and future works that can be improved for future studies based on this project. This chapter also will include some suggestion that can be done to improve the results.

CHAPTER II

LITERATURE REVIEW

In this chapter two emphasizes about the project's background and other relevant input and information which is related to the project. The theoretical and outline details concerning the project have taken as guidance to complete this project. All the input and information were gathered from previous research paper (journals), internet and etc.