DEFECT PIFA ANTENNA

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"For both my beloved parents, Basiron Bin Abu Halif & Siti Sarah Binti Abdullah"

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Lots of love,

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ABSTRACT

PIFA antenna is particularly suitable for cellular telephone systems since it has the advantages of small size and light weight. The PIFA antenna is composed of radiating patch, feeding pins and shorting plate which is connected to the ground plane. The reasons for defect antenna are that it allows additional functionality of the antenna, makes it more applicable for other technologies and also can obtain more properties without the need for multiple antenna. Basically the properties that can be configured are frequency, pattern and polarization. Through this project, the concept of Defect PIFA Antenna will be verified and the defect technique is used to give dual-band operations in the range of 1.9GHz and 2.4GHz, to be utilized on different technologies of GSM1900 and WiFi. A substrate of FR4 with thickness of 1.6mm and dielectric constant of 4.4 is used in fabricating process of an antenna because it is easy to be fabricate and low cost compare to other types of substrate. The designed antenna has been simulated using the CST Microwave version 2014 software. The simulated and measurement results for return loss, gain, directivity and radiation pattern are presented and well discussed. The gain of 0~5dB is achieved on the basis of -10dB return loss as an acceptable reference in mobile phones applications.

ABSTRAK

Antena PIFA adalah sangat sesuai untuk sistem telefon bimbit kerana ia mempunyai kelebihan iaitu bersaiz kecil dan ringan. Antenna PIFA terdiri daripada tampalan pemancar, pintasan pin dan pintasan plat yang disambungkan kepada satah menjadikan ia lebih diguna pakai untuk teknologi-teknologi lain dan juga boleh mendapatkan lebih banyak ciri-ciri tanpa keperluan bagi pelbagai antenna. Pada dasarnya sifat-sifat yang boleh dikonfigurasikan adalah kekerapan, corak dan polarisasi. Melalui projek ini, konsep kecacatan antena PIFA akan digunakan dan teknik kecacatan yang digunakan bertujuan untuk memberikan operasi dua puncak dalam lingkungan 1.9GHz dan 2.4GHz yang akan digunakan pada teknologi yang GSM1900 dan WiFi. Substrat FR4 dengan ketebalan 1.6mm dan pemalar elektrik 4.4 digunakan dalam proses reka bentuk antenna kerana ia mempunyai kos yang rendah berbanding dengan lain-lain jenis substrat. Antena yang direka telah disimulasikan menggunakan perisian CST Microwave versi 2014. Simulasi dan pengukuran keputusan untuk pulangan kerugian, gandaan, direktiviti dan corak sinaran dibentangkan dan dibincangkan dengan sebaiknya. Gandaan 0 ~ 5dB dicapai atas dasar -10dB pulangan kerugian sebagai rujukan diterima dalam aplikasi telefon bimbit.

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LIST OF ABBREVIATIONS

PCB	-	Printed Circuit Board
FR-4	-	Flame Retardant
PIFA	-	Planar Inverted-F Antenna
VHF	-	Very-high Frequency
UHF	-	Ultra-high Frequency
GSM	-	Global System for Mobile
WLAN	-	Wireless Local Area Network
WiMAX	-	Worldwide Interoperability for Microwave Access
PTFE	-	Polytetrafluoroethylene
IEEE	-	Institute of Electrical and Electronics Engineers
PSM	-	*Projek Sarjana Muda* (Final Year Project)
VSWR	-	Voltage Standing Wave Ratio
RL	-	Return Loss
dB	-	Decibels
f_c	-	Center Frequency
CST	-	Computer Simulation Technology

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Nowadays, wireless communication becoming an essential and integral part of human beings. It is used for internet, video conferencing, video calls and voice calls. Lots of improvements have been made in this field due to the demand of a better and faster wireless communication system. The most important and essential component or device needed for wireless communication system is an antenna which transmits or receives an electromagnetic wave [1].

Basically, this project is related to an antenna which is widely used in mobile communication device like handset. The vital function of using an antenna on handset because it's can receive and transmit signals by traveling on a conductor into an electromagnetic wave in a free space. There are a few types of an antenna such as loop, array, microstrip, PIFA and horn. In recent years, with the development of the mobile communication terminal handset technology, the terminal is generally required small size, light weight and low profile [2].

Planar inverted-F antenna (PIFA) is the most promising type antenna due to its advantages of small in size and lightweight. PIFA is chosen for this project among other types of antenna because it provides an extra parameter which is wider bandwidth which is enough for mobile phone operations. The geometry of an antenna look like inverted F which consists of a ground plane, shorting pins, radiating patch and feed point. The antenna used to cover the applications of GSM1900 and some modification have been made on the ground plane by adding defect structure of DGS. The parameter like gain, directivity, bandwidth and return loss were observed and analyze.

1.2 Objective

The main objective of this project is to design, simulate and fabricate defect PIFA antenna for applications of GSM1900 and WiFi at frequency 1.9 GHz and 2.4 GHz respectively in order to cover dual-band operations through defect structure of DGS.

1.3 Problem Statement

In this era of technology, development of mobile communication devices increase rapidly to fulfill the demands of the users such as lightweight, small size and can cover wider coverage applications. The purpose of having small size and lightweight enable the devices to be easy carrying to everywhere. The devices also must cover wider coverage applications to communicate with each other besides to fit with many applications such as Bluetooth and WiFi. One's of the example for mobile communication device is handset.

The handset must fulfill the criteria of having lightweight, small size and cover wider coverage applications. There are many factors that will influenced the weight of the handset and one of them is the types of material used. The ways to have lightweight devices are by reducing the complexity of the supporting structure and can be readily compatible with its associated electronic components. Besides, one of the method that can contribute to small size and cover wider coverage applications is by inserting antenna into the handset. The antenna design must be small in size to fit into the compact size product since the product size is the effecting factor.

The antenna also needs to cover wider coverage applications in order to ensure good transmitting and receiving signals. Hence, by having very good signal, any network interferences can be avoid. There are various kinds of antenna used to fulfill the criteria of the handset but the most efficient and suitable antenna is PIFA since it's consists of wider bandwidth. In order to make the handset compatible with all the frequency bands, the wider bandwidth antenna is required due to the different frequency bands needed in different applications such as GSM and UMTS.

Even though the PIFA antenna can run lots of applications, it's still need an extra parameters to be more practical in use. Therefore, defective ground structure (DGS) is applied to the antenna to cover dual-band operations for some applications so that the performances of the devices can be more effective and reliable.

1.4 Scope of Works

In this project, the design work is only focusing on designing broadband PIFA antenna that can be operate at frequency of 1.9 GHz and 2.4 GHz for applications of GSM1900 and WiFi. Then, the original structure of PIFA have been modified using DGS on the ground plane in order to cover dual-band operation. The design and simulation process of this antenna will be utilized the CST Microwave Studio version 2014 software. Whereas for the hardware, this designed antenna will be fabricated onto a PCB substrate of a FR4 with thickness of substrate, $ts = 1.6mm$ and relative permittivity, $\varepsilon r = 4.4$. The unwanted layer will be removed by using the etching

technique in fabrication process. The antenna parameters that will be simulate and measure are resonant frequency, return loss, gain, bandwidth, directivity and radiation pattern using CST Microwave Studio version 2014 software and spectrum analyzer respectively.

1.5 Methodology

Briefly, this project comprising of five stages needed to be complete. The project start with literature review by reviewing on antenna, PIFA and defect from journals and books. Most of the books attained are from the library, downloaded from the internet, borrowed from friends and other sources. Through books, the theoretical data and information are obtained and it is cannot be denied. Besides, the other sources of this research is based on an articles and journals and to supports the theory data and enhancing the understanding of the project.

All these sources are attained from magazines published by IEEE organization (Antenna & Propagation Magazine) as well as websites that providing online database services for instance IEEE Xplore, PIER online, ETRI and open access journals for example Hindawi Publishing Corporation under the International Journal of Antennas and Propagation Magazine. There also some open access journal acquire from the library proxy. Most significant factor is that this sources offers data on professionals' analysis and project that related to the project scope and used for improvement of the antenna design. Though most of these articles and obtained are very technical, yet it may well assist in offering and generating ideas and strengthening the understanding of this project.

After collecting all the information, the design process is started by designing PIFA antenna followed by defect PIFA antenna which consists of design structure, design parameter and design process by using software of CST Microwave Studio version 2014. The antenna parameters that will be simulate by using the same software are resonant frequency, return loss, gain, directivity, bandwidth and radiation pattern.

In the design and simulation process, the software will be involved to draw and illustrate the 3D layout of the antenna.

The fabrication process will be proceed if the simulation antenna parameters meet the objective. The PCB board of FR4 with dielectric constant of 4.4 will be used in this project. Lastly, the antenna parameters exactly same like simulation will be measured by using spectrum analyzer thus the result will be compare to ensure the accuracy of the fabricated antenna.

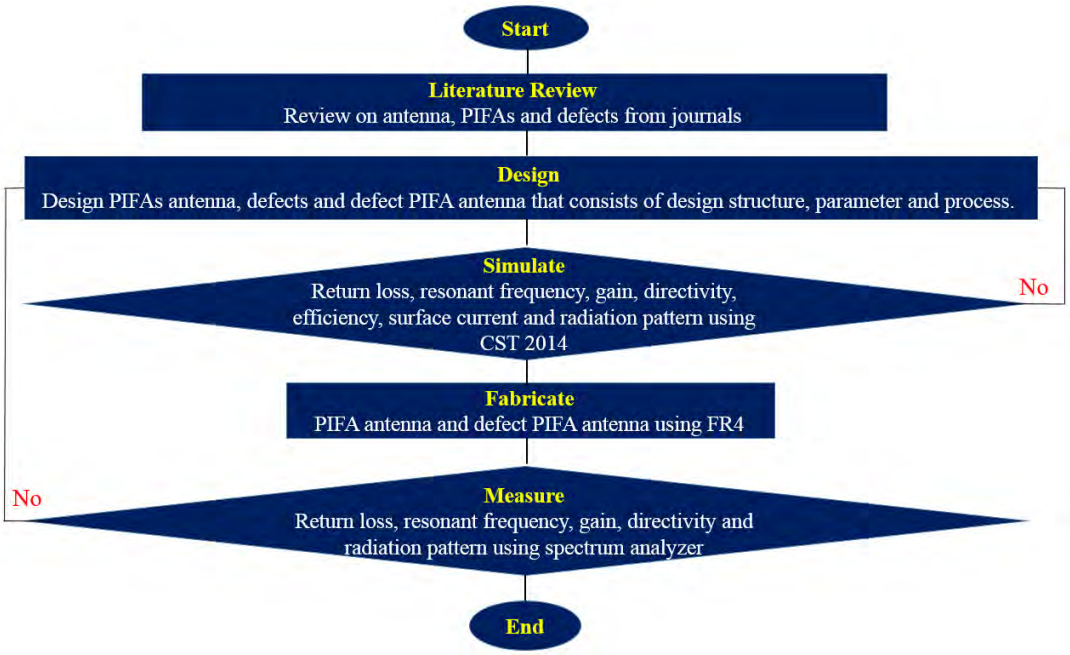

Figure 1: Flow chart of the project

1.6 Summary

The first chapter of this report fleetingly conveying the background, objectives that require to be accomplished, the problem arise in past work that will be disentangled through this project, scope covered throughout project, and brief method used in the project. The second chapter will cover on the background study thru for this project. It will literalize the project's framework by presenting the significant

theory involved. The third chapter clarifying comprehensively the procedures involved for resolving the proposed problem starting from designing until fabrication process. In the fourth chapter, it will explained on the results of this proposed project as well as the discussion on observation from the result and problem arises. Lastly on the fifth chapter, the conclusion and recommendation will be illustrated. In this chapter it will conclude the whole project in addition of recommendation for future study.

CHAPTER 2

LITERATURE REVIEW

This chapter will explain on the fundamental concept and theory of the defect and PIFA antenna. The overall parameters will be further discussed as well as each of its contribution to an antenna performance adding with the techniques used in the preparation and designation of defect PIFA antenna.

2.1 Antenna

In this day and age, wireless communication are gaining its popularity due to the increasing production of new technologies and devices making the growing development of antenna. Starting in the era of World War 2, radio frequency (RF) was made public in which it was being utilized to transform the lives of average person through either television or radio. In addition, in designing a RF gear, antenna was commonly the last component that ought to be well-thought-out. In order to

accomplish good performance, the transmitting and receiving part were directly involved in the wireless atmosphere. Theoretically, antenna is a transducer, operates in a way that transmit and receives electromagnetic waves where it converts electric current into the form of electromagnetic waves to transmit signal and the opposite process in receiving the signal. Each antenna had its own characteristic which includes several basic parameters of impedance, VSWR (voltage standing wave ratio), bandwidth, radiation patterns, gain and polarization. In designing an antenna, all this parameters were vital factor to ensure that the designed antenna had a high efficiency with the aim of it enable to send and reclaim the RF power.

2.1.1 PIFA Antenna

PIFA antenna structure has emerged as one of the most promising candidate in the category of low profile antennas used in handheld devices. Wide range of applications uses PIFA as their basic antenna. For a system to perform optimally, the antennas must have simple construction, high radiation efficiency, small volume, low-loss impedance matching. Vast range of applications uses PIFA as their basic antenna covering wide frequency band of GSM 850, 900, DCS 1800, PCS 1900, WLAN, Wi-Bro, Bluetooth, UMTS, 4G LTE.

There are many advantages of PIFA making its widespread use in devices that is, easy fabrication, simple structure, small volume, low manufacturing cost. PIFA structure is easy to hide in the casing of the mobile handset as compared to monopole, rod & helix antennas. Also, PIFA has reduced backward radiation towards user's head and body which further minimizes SAR and improves performance. They can resonate at much smaller antenna size and by cutting slots in radiating patch, resonance can be modified. Proper shape of the patch and positions of feeding and shorting pins results in multiband operation.

The major drawback of PIFA is its narrow bandwidth; therefore it is important and necessary to widen the bandwidth for using it in mobile phones and other handheld devices. The evolution of the handset antenna structures from a monopole to the PIFA