UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF DUAL POLARIZED ANTENNA FOR MOBILE COMMUNICATION

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (JTKEK) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology in Electronics (Telecommunications) (Hons.). The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Projek ini difokuskan kepada mereka bentuk antenna jalur lebar dua polarisasi yang berfungsi pada frekuensi 2.4GHz untuk sistem komunikasi mudah alih. Antena ini direka khas agar boleh menghasilkan dua jenis polarasi iaitu polarisasi mendatar dan juga polarisasi menegak dengan menggunakan dua liang. Motivasi untuk reka bentuk antena ini adalah disebabkan untuk mengurangkan gangguan yang berlaku semasa menghantar dan menerima isyarat kepada dan daripada antena. Gangguan penghantaran isyarat yang sering berlaku disebabkan oleh cuaca dan menjadi kritikal semasa cuaca buruk. Oleh itu, kemahuan ini menyebabkan kelajuan rendah daripada isyarat penghantaran dan tidak memenuhi permintaan pengguna masa kini. Untuk memenuhi syarat ini, antena jalur lebar yang lebih luas diperlukan. Antena dua polarisasi adalah reka bentuk untuk mengurangkan gangguan semasa memancar atau menerima isyarat sebagai jenis dua polarisasi digunakan iaitu polarisasi yang menegak dan polarisasi mendatar. Kepelbagaian polarisasi adalah salah satu teknik yang berguna untuk meningkatkan prestasi antara antena pemancar dan penerima gelombang mikro kerana ia boleh mengurangkan hubungan ruang yang boleh mengurangkan prestasi sistem. Proses reka bentuk boleh dibahagikan kepada dua langkah reka bentuk. Pertama, antena polarisasi dual adalah mereka bentuk dengan menggunakan perisian *CST Microwave Design* dan langkah lain adalah antena yang direka fabrikasi di papan FR4 dan diukur. Kemudian, ukuran simulasi dan ukuran cetakan diukur, dianalisa dan dibandingkan.

ABSTRACT

This project is focused on dual polarized antenna design that operates at frequency of 2.4 GHz for mobile communication system. This antenna is able to generate two types if polarizations which are horizontal polarization and vertical polarization by using two ports. The motivation for this antenna design is due to reduce the interference that occurred during transmitting and receiving the signal to and from the antenna. The interference of the signal transmission often happens due to the weather and become critical during the bad weather. Therefore, this will causes low speed of transmission signal and does not satisfy the users demand nowadays. To satisfy this condition, the wider bandwidth antenna is needed. The dual polarization antenna is design in order to reduce the interference during transmitting or receiving signal as two type of polarization is being used which are vertical polarization and horizontal polarization. Polarization diversity is one of the handy techniques to improve performance between the transmitter and receiver microwave antennas because it can reduce spatial correlation that can decrease system performance. The design process can be divided into two design steps. First, the dual polarization antenna is designing by using the CST Design Microwave software and another step is the designed antenna being fabricated on FR4 board and measured. Then, the measurements in simulation and hardware antenna is being measured, analyzed and compared.

DEDICATION

A special feeling of gratitude to my loving parents, Azizan Bin Abdullah and Norma Binti Hat for their endless love, support and encouragement. A special thanks to my supervisor, En. Abdul Halim Bin Dahalan and my co-supervisor, En. Mohamad Zoinol Abidin bin Abd. Aziz.

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VSWR	- Voltage Standing Wave Ratio
3D	- 3 Dimension
e-plane	- electric field plane
h-plane -	- magnetizing field plane

CHAPTER 1
INTRODUCTION

This section basically covered the introduction to the project work. It consists of background, problem statement, objective, scope, project significant and also the overall summary in this chapter.

1.1 Background

A specialized transducer that converts radio-frequency (RF) fields into alternating current (AC) is called antenna. There are two basic types of antenna. The first one is the receiving antenna where the intercepts RF energy and delivers AC to electronic equipment. The second type of antenna is the transmitting antenna which is fed with AC from electronic equipment and generates an RF field.

The polarization of an antenna definition is the polarization of the radiated fields produced by an antenna. It is evaluated in the far field. Hence, antennas can be classified as "Linearly Polarized" or a "Right Hand Circularly Polarized Antenna". To understand the concept of polarized antenna is the first, a horizontally polarized antenna will not communicate with a vertically polarized antenna. The antennas transmit and receive in exactly the same manner due to the reciprocity theorem. Therefore, transmitting and receiving vertically polarized fields occurs due to a vertically polarized antenna. Consequently, there will be no reception if a horizontally polarized antenna is trying to communicate with a vertically polarized antenna.

Dual polarized antenna is the antenna that can operate in horizontal polarization and also vertical polarization. The device can transmit data on one polarization and receive data on the other simultaneously by using dual polarized antenna.

Nowadays, our mobile telecommunication technology has grown up tremendously. The global cellular handset market is the most highly scalable technology market. Today, mobile communication applications such as the handset manufacturers are seeking an effective antenna solution suitable for implementing the next generation of cellular handset technologies. Currently, they are unable to achieve physically the desired antenna performance in a size that fits a cellular handset package at an acceptable volume cost.

Dual polarized antennas are design to improve communication capacity and quality by using the techniques of polarized diversity. By using this technique, these antennas are capable to eliminate the soldering process and limiting interfering with radiation from the radiation patches to the feed network. However, the problems are the slot radiates both in the patch direction and in the back direction which causes low gain and low front-to-back-ratio.

Therefore, this project discusses the design issues for dual polarized antenna for mobile communication applications for example in DCS, PCS and 3G mobile communication systems. The project will be conducted in software by using CST software and also the hardware by fabricate the circuit. The resulting performance of the parameters is compared and discussed.

1.2 Problem Statement

In order to improve the mobile communication applications system, we are craving for the great antennas but the antennas nowadays have weakness of resulting in low gain and low front-to-back ratio. This problems happened because of the slot radiates both in the patch direction. Therefore, to improve the antennas performances, the project is conducted to show the improvement in isolation between the polarization ports while maintaining a broad impedance bandwidth at 1.71-2.17 GHz.

1.3 Objective

The main objective of this project is to:

- Able to design, simulate and fabricate of dual polarized antenna in mobile communication application.

1.4 Scope

In this project, it would only covering existing mobile communication systems that operating at the frequency range 1.71-2.5 GHz. Furthermore, the parameter that will be measured are the return loss and isolation, and be able to simulate the radiation patterns at various angle. It is impossible to carry out the project to make a research on that investigate everything about the project topic.

1.5 Project Significant

From this project, the mobile communication application capacity and quality can be improved. In addition, this project will have a great contribution to the mobile manufacturers industry. This is because the project will improve the low gain and low front to-back ratio problems in dual polarized antennas. This will results in better mobile communication application such as in DCS, PCS, 3G and WLAN mobile communication system.

1.6 Conclusion/Summary

As a conclusion, this project is very important in order to improve our mobile communication applications system. This project will definitely contribute to our mobile manufacturers industry and the society with better communication system.

CHAPTER 2
LITERATURE REVIEW

A literature review is an evaluative report of studies that aims to find the literature that are related to this project. It also provides current knowledge as well as describes, summarize, evaluate and clarify this literature. It should be included a theoretical basis for the project. Besides that, literature review also used to generate knowledge and gather information used in this project by provide a context for the research, justify the research and outline gaps in previous research. In addition, literature review also helps to refine, refocus or even change the topic.

2.1 Mobile Communication

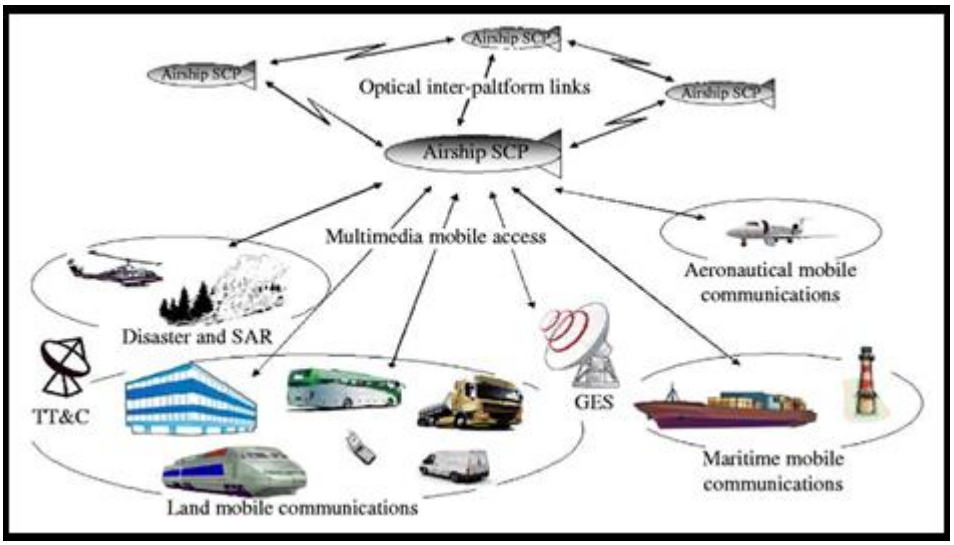


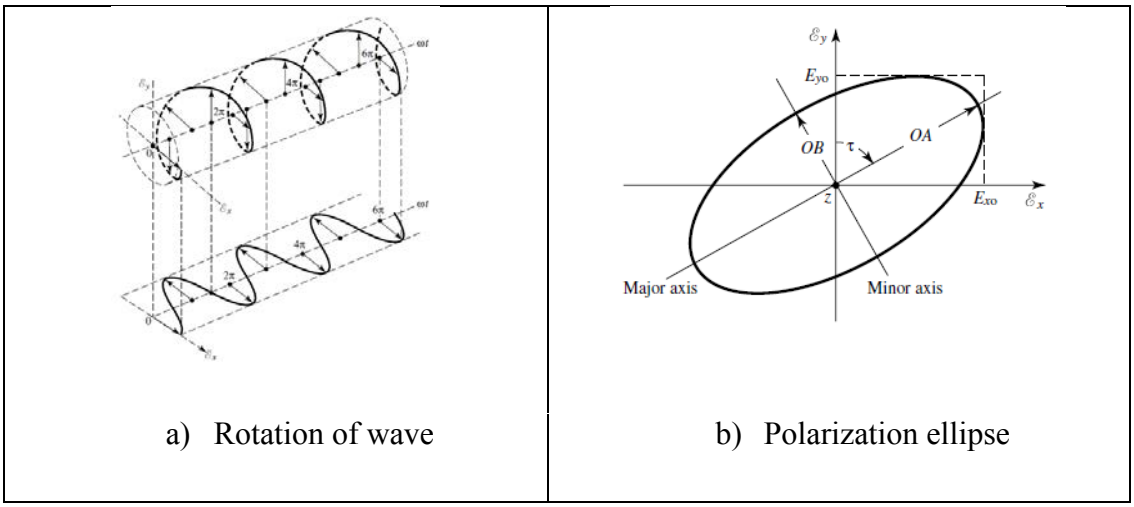
Figure 2.1: The diagram of difference type of mobile communication. [1]

The growing demand for mobile communication nowadays makes the inventions of many technologies. Mobile technology is the technology used for cellular communication. Mobile code division multiple access (CDMA) technology has evolved rapidly over the past few years. Since the start of this millennium, a standard mobile device has being invented such as a mobile phone, GPS navigation device, an embedded web browser and instant messaging client, and a handheld game console. Therefore, many experts argue that the future of computer technology rests in mobile computing with wireless networking. In every wireless device required antenna to transfer the signal.

2.2 Polarization

According to Constantine A. Balanis in the Theory of Antenna states that polarization of an antenna in a given direction is defined as "the polarization of the wave transmitted (radiated) by the antenna. [2]

When the direction is not stated, the polarization is taken to be the polarization in the direction of maximum gain. In practice, polarization of the radiated energy varies with the direction from the center of the antenna. Therefore, different parts of the pattern may have different polarizations.



a) Rotation of wave

b) Polarization ellipse

Figure 2.2: Rotation of a plane electromagnetic wave and its polarization ellipse at $z = 0$ as a function of time. [2]

One way to address the capacity increase is by employing polarization diversity. [3], [4] Recent results in communication theory [5] have demonstrated that deploying dual-polarized antennas at the transmitter and/or receiver can dramatically increase both the capacity and diversity of wireless communication links. For example, in the richly scattering environments considered in [5], a dual-polarized

antenna at the transmitter can increase capacity by more than 50% over a single transmit antenna; employing dual-polarized transmit and receive antennas can increase capacity threefold over a comparable system with single antennas at the transmitter and receiver.

According to C. Liu, J.L. Guo, Y.H. Huang, and L.Y. Zho (2012), the new design of a dual-polarized antenna with high isolation and low cross polarization is comprised two pairs of petaloid patches, which are fed by coaxial lines. Behind the patches, a U-shaped ground is placed to improve the front-to-back ratio of the antenna. Stable and symmetric radiation patterns at slanted ±45º polarization have been obtained within the frequency band 1.71-2.17 GHz. A return loss of |14| dB is achieved and measured isolation between the two input ports is over 31 dB. The 3 dB beamwidths of the two polarizations is stable (65±) and the average gain of the proposed antenna is about 9 dBi across the whole frequency band.[6]

In order to improve communications capacity and quality, many techniques are developed and applied. One of the most commonly used techniques is polarization diversity which is the antenna of the system should have dual polarization. The advantages are eliminating the soldering process and limiting interfering with radiation from the radiation patches to the feed network. But the slot radiates both in the patch direction and in the back direction, which results in low gain and low front-to-back ratio.

The antenna produces a low cross-polar level. Measured results show improvement in isolation between the polarization ports while maintaining a broad impedance bandwidth covering existing DCS, PCS and 3G mobile communication systems operating at 1.71-2.17 GHz. The 3 dB beamwidths of the two polarizations vary only several degrees over the frequency band. By contrast with aperture coupled antennas, this proposed antenna has the advantages of simple structure and low cost.

2.3 Antenna Design

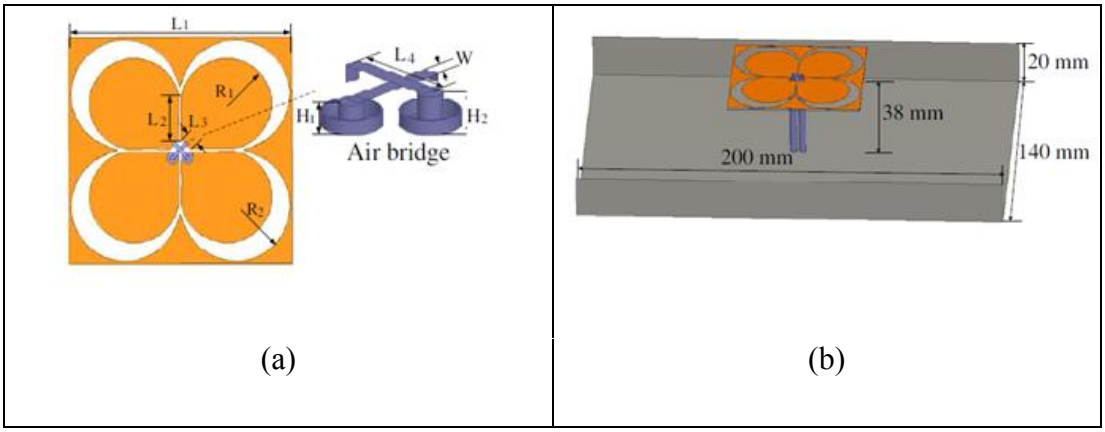


Figure 2.3: Geometry of proposed antenna element.

The basic configuration of the proposed antenna is illustrated in Figure 2.3. Two pairs of petaloid patches are printed on the FR4 substrate with a thickness of 0.8 mm. In an attempt to restrain the cross polarization generated by the petaloid patches, the squared metal fence with a side length of L1 is introduced and printed on the same substrate with the radiation patches. Four parts are dug inside the square patch in order to contain the petaloid patches.

Thus, all patches are printed on a single layer. The positions of feeds are symmetrical at the patches shown in Figure 2.3. There is a small gap with a length of 0.7mm between the adjacent patches. The U- shaped ground is utilized to generate the required front-to-back ratio for cell sector design. The radiation patches are separated from the ground with a height of 38mm which is ¸=4 at the center frequency 1.94 GHz.

Figure 2.4 presents the photo of the fabricated antenna. The whole structure was modeled using commercial software Ansoft HFSS with the following parameter details, L1 = 62 mm, L2 = 13:9 mm, L3 = 3:6 mm, L4 = 6 mm, w = 1 mm, R1 = 12:6 mm, R2 = 14 mm, H1 = 1:3 mm, H2 = 1:8 mm.