UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MICROSTRIP SOLAR-PATCH ANTENNA FOR WIRELESS RADIO COMMUNICATIONS

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronic Engineering Technology (Telecommunications) with Honours.

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor's Degree of Electronics Engineering Technology (Telecommunications) with Honours. The following are the members of supervisory committee:

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Mr. AHMAD FAUZAN BIN KADMIN

ABSTRAK

Pada masa kini dengan pemanasan global yang sangat mempengaruhi iklim dunia dan meningkatkan penggunaan tenaga digabungkan dengan jumlah bahan api fosil yang berkurang, perubahan besar diperlukan dalam cara permintaan penggunaan tenaga dipenuhi. Kebimbangan alam sekitar global dan permintaan yang semakin meningkat untuk tenaga, bersama-sama dengan kemajuan berterusan dalam teknologi tenaga boleh diperbaharui, membuka peluang baru untuk penggunaan sumber tenaga boleh diperbaharui. Tenaga solar adalah yang paling banyak, tidak habis-habis dan bersih dari semua sumber tenaga boleh diperbaharui sehingga sekarang. Kajian ini bertujuan untuk membangunkan antena patch solar untuk komunikasi radio tanpa wayar di kawasan luar bandar. Reka bentuk dan integrasi panel solar dengan antena tampalan yang direka dengan 2.4GHz dibentangkan. Arus antena patch dengan keuntungan yang tinggi direka dan dijangka mengurangkan keperluan menara yang hampir memerlukan kos pembinaan yang tinggi. Untuk mencapai kuasa yang tinggi, antena yang dicadangkan dibina oleh patch berbentuk oktagon 2x2 disertai oleh rangkaian penyusunan mikrostrip talian yang dibangunkan menggunakan teknik impedans gelombang λ / 4 suku. Struktur antena kemudiannya dibangunkan di atas substrat dielektrik Flame Retardant (FR) 4 Epoxy yang masing-masing mempunyai ketebalan dan pemalar dielektrik sebanyak 1.6 mm dan 4.3. Beberapa parameter antena termasuk kehilangan pulangan, voltan berdiri voltan (VSWR), corak sinaran dan keuntungan dicirikan melalui simulasi mendapatkan reka bentuk antena optimum. Walaupun untuk pengukuran, ia menunjukkan bahawa ciri-ciri array antena patch solar memenuhi perjanjian dengan keputusan reka bentuk di mana kuasa diukur 8.31dB di frekuensi pusat dengan kehilangan kembali -23.64dB yang sepadan dengan VSWR 1.14 dan respons jalur lebar daripada 90MHz berkisar dari kekerapan 2.34GHz - 2.43GHz.

ABSTRACT

Nowadays with global warming deeply affecting the climate of the world and increasing energy consumption combined with decreasing amounts of fossils fuels, a major change is required in the way the demand of energy consumption met. Global environmental concerns and the escalating demand for energy, along with ongoing progress in renewable energy technologies, are opening up new chances for utilization of renewable energy resources. Solar energy is the most abundant, inexhaustible and clean of all renewable energy resources till now. This study is to develop a solar patch antenna for wireless radio communications in rural area application. The design and integration of solar panel with fabricated patch antenna with 2.4GHz is presented. The patch antenna array with high gain is designed and expected to reduce the need of tower that almost requires high cost of construction. In order to achieve high gain, the proposed antenna is constructed by 2x2 octagon shaped patches fed by microstrip line corporate feeding network which is developed using a λ/4 quarter-wave impedance technique. The antenna structure is then developed on a Flame Retardant (FR) 4 Epoxy dielectric substrate which the thickness and dielectric constant of 1.6mm and 4.3, respectively. Some antenna parameters including return loss, voltage standing ratio (VSWR), radiation pattern and gain are characterized through simulation obtain an optimum design of antenna. While for the measurement, it shows that the characterized of solar patch antenna array meets the agreements with the design result in which the measured gain of 8.31dB at the center frequency with the return loss -23.64dB which corresponds to VSWR of 1.14 and bandwidth response of 90MHz ranges from frequency of 2.34GHz – 2.43GHz.

DEDICATION

Special dedication to my family members, my friends, my fellow colleague and all faculty members. For all your care, support and believe in me.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

List Abbreviations, Symbols and Nomenclatures

AUT	-	Antenna Under Test
DC	-	Direct Current
EM	-	Electromganetic
FeCl3	-	Iron Trichloride
FR4 Epoxy	-	Flame Retardant 4 Epoxy
KOH	-	Potassium Hydroxide
MW	-	Microwave
PCB	-	Printed Circuit Board
RF	-	Radio Frequency
S11	-	Reflection Coefficient Parameter
SMA	-	SubMiniature version A
UAV	-	Unmanned Aerial Vehicle
USB	-	Universal Serial Bus
UWB	-	Ultra Wideband
VNA	-	Vector Network Analyzer
VSWR	-	Voltage Standing Wave Ratio
WiMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless Local Area Network

CHAPTER 1
INTRODUCTION

1.0 Introduction

This chapter focused on preparing the entire report content including project introduction, project background, problem statement, objectives, project scopes, project methodology and thesis structure. The development of solar patch antenna for radio communication in rural area applications will be briefed more in detail in this paper including the method used to complete the project. This project was conducted as to overcome the issues come from the problem statement. This chapter provides the sense of purpose and the reasons to proceed with the project. The further studies for this project also will be included in this chapter as to gain more knowledge.

1.1 Project Background

In radio communication, antenna plays role as an electrical device which converts electric power into radio waves. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an electric current oscillating at radio frequency to the antenna‘s terminals, and the antenna radiates the energy from the current as electromagnetic waves. Antennas are essential components of all equipment that uses radio. Antennas are used in systems such as radio broadcasting, broadcast television, cell phones and satellite communication.

In this project, the solar patch antenna is proposed for radio communication in rural area. Microstrip patch antenna is proposed to be used in this project as it brings

many benefits to the project. Patch antenna is a low-profile antenna, it is lightweight, inexpensive and electronics can be integrated with these antennas quite easily (Orban and Moernaut, 2009). Basically, in rural area there is lack of the grid of electricity. So this project enhances the energy harvesting antenna. Renewable energy sources can provide an energy source such as biomass, solar, wind hydropower and geothermal which is naturally available for almost all the time (Panwar et al., 2011). This antenna operates by harvesting the solar energy which can easily scavenge during the day and the energy can be stored in battery to be applied in the night day.

This project focus on development of a high gain with 2.4 GHz patch antenna for wireless radio communication in rural area application. The frequency band for radio communication is commonly in range of 3kHz to 300GHz. Furthermore, for wireless communication application in rural area, instead of having a high gain, the antenna should have good enough directivity to ensure the reliability of communication from one point to another can be maintained properly. Figure 1.1 shows an illustration of application of antenna in radio communication. By attaining the antenna with high gain and good directivity, it is expected to minimize the need of tower in rural area communication that usually requires high cost of construction. Some attempts to achieve those characteristics are by configuring some patches in an array, known as patch antenna array (Aji et al., 2016).

Figure 1.1: Illustration of antenna application in radio communications.

1.2 Problem Statement

Communication systems in rural area are not efficiently functioned due to the lack of electricity grid connection. According to Pali and Vadhera (2016), there are so many such remote and rural areas, which still have no or lack of electricity like shown in Figure 1.2. Even in rural India, there are about 72 million households who have no access to electricity. The lack of electricity will not allow the communications system to works properly at one area as antenna cannot perform well. Any device needs power supply to operate for any applicable application. Furthermore, battery of the device does not have long lasting operation as battery will die after been used for a long time. So the antenna cannot operate continuously especially in the area which has no grid electric connection. Besides, the problem of antenna with low gain and not good radiation will give the high cost for maintenance to build more towers in rural area to obtain a good communication system.

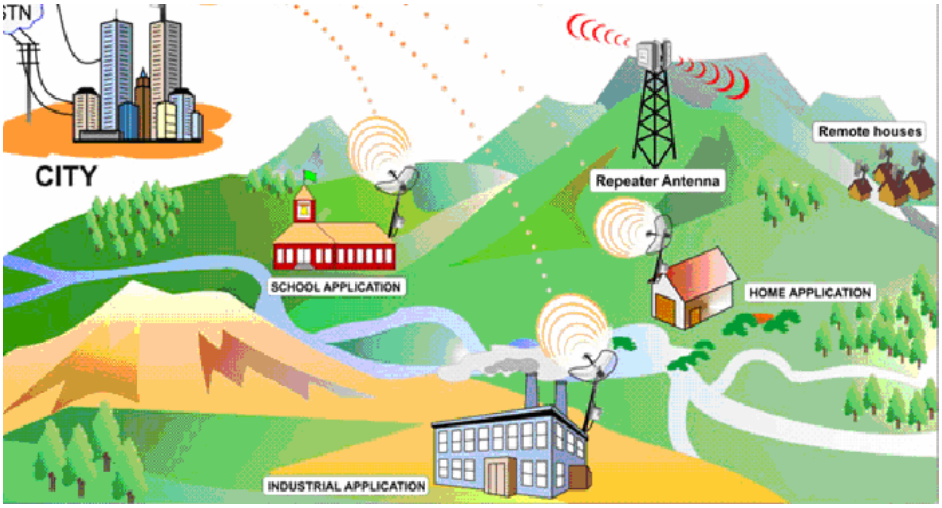

Figure 1.2: Illustration of antenna application urban and rural areas.

(Source :< https://www.researchgate.net/figure/267298329_fig8_Fig-9-WiMAX-Solution-in-Rural-areas>)

1.3 Objective

The main objectives of this project are deeply concentrated on the aspect below:

i) To develop a new solar patch antenna design for wireless radio communication application.

ii) To analyze the antenna in terms of antenna transmission performance and energy harvesting in power conversion capabilities.

1.4 Project Scope

The scope of this project is developing a new solar patch antenna design for wireless radio communication application by study the type of antenna that is suitable to be used in that application. The antenna must be designed to have an ideal characteristic to be applied in rural area as there will be no or less electric grid connection. So, renewable energy sources are applied in this project as the uses of solar energy to supply power to the antenna. Solar cells will be as a source for the antenna to transmit the signal.

Furthermore, this project will also analyze the antenna in terms of antenna transmission performance and energy harvesting in power conversion capabilities. Antenna transmission performance will be analyzed on few parameters for the measurement such as antenna directive gain, return loss, radiation pattern, VWSR and farfield. Comparison between simulation and measurement will also take place. Energy harvesting in power conversion capabilities is analyzed based on the power that transmitted from solar cells to the antenna.

1.5 Project Methodology

In order to achieve the objective of this project, flowchart is a must to be developed to make sure that the project‘s flows can be clearly organized. This project

starts by doing some literature reviews based on the objective of this project. Antenna design selection is made based on the studies and researches. The CST Microwave Studio Software will use to design a microstrip antenna and this design will be fabricated on PCB board if the simulation of the antenna is successful. The fabricated antenna as shown in Figure 1.3 will be attached to a solar cell. So, this project will also take place in studies of type and characteristic of solar cells before do the integration with the patch antenna. The product will be tested by using few equipment such as network analyzer to test the return loss of the antenna, multimeter is used to test the power of the solar cells and spectrum analyzer to measure the gain of the antenna. Comparison between the simulation and measurement will be made to obtain the efficiency of the antenna. Lastly the thesis writing will need to be done in order to enhance the project flows.

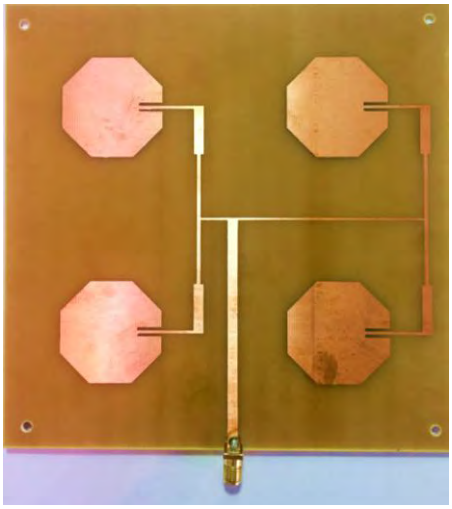

Figure 1.3: Microstrip Patch Antenna fabricated on PCB.

1.6 Thesis Structure

Chapter 1:

The first chapter introduces brief idea of the project. It focused on the overview of the project, detailing the objectives, the problems statement, scope and outcome of the project.

Chapter 2:

Project background is discussed in this chapter. It only concentrates on the literature review that will describe all the information that was referred as a reference in order to finish up the project. Basically literature review will contain the facts or other expect that we need that correspond to the project that will build. This chapter also defines terms used in this project and discussed the concept of the research and how it is related with the theory.

Chapter 3:

Chapter 3 describes the methodology used in this project. The schedule or steps that need to be completed and the detailed reports of studies that were done to achieve the aim of the project are presented. The methodology is the important aspect as it is the beginning process of planning. If the methodology are not organized only then will encountered the problem involve in the project.

Chapter 4:

This chapter is about the result and discussion. All the simulation, data collection and analysis obtained will be discussed in detail. The results will be compared with the objectives outlined in order to arrive to some hypothesis and conclusion.

Chapter 5:

Chapter 5 after through all the process and successful to achieve the objectives as stated in the earlier chapter. The project can be concluded and explain the detail in this chapter.

Other than that, a future recommendation for this project also includes improving this project for the future improvement and upgrade.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter provides understandings of theories and previous researches that are related to this project. This includes an overview of history on antenna, type of antenna, the uses of renewable energy, antenna in UAV application, simulation by using CST Microwave Studio and fabrication of antenna design.

2.1 Introduction of Antenna

An antenna is a device that provides a means for radiating or receiving radio waves (Stutzman and Thiele, 2012). According to Balanis (2016), antenna is also known as a guiding device or transmission line which is used to transport electromagnetic energy from the transmitting sources to the antenna or from antenna to the receiver. Antenna gives benefit in communication system to generate new applications by providing a characteristic of mobility without any required physical connection (Bancroft, 2009). Antennas come in all shapes and sizes. Antenna also can be implemented in any devices that used for communications. Usually, antenna being supplied by using electricity sources which is always needs to be in space or area which always has accessed to electricity grid. Instead of this, the alternative way is by using the renewable energy resources. The renewable energy is called as sustainable or nonconventional energy, which energies are obtained from natural resources and naturally replenished such as wind, solar, hydro, geothermal, biomass and ocean energies (Pali and Vadhera, 2016).