DESIGN OF CIRCULARLY POLARIZED ANTENNA AT 2.45 GHZ WITH HARMONIC SUPPRESSION FOR ENERGY HARVESTING

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DEDICATION

This project is dedicated to my mum and dad

ABSTRACT

Circular polarization is necessary in antenna applications especially for energy harvesting as matching the polarization in both the receiving and transmitting antennas can decrease the transmission losses. To achieve this matching, the transmitter and the receiver should have the same sense of polarization, axial ratio and the same spatial orientation. As the waves in our surroundings could be randomly propagating due to human body or device movements in wireless technologies applications such as RFID, GPS and WLAN, circular polarization comes in handy to reduce the effect of multipath reflections, enhances weather penetration and allows for the mobility of both the transmitter and the receiver. The objective of this thesis is to design a circularly polarized microstrip antenna that operates at 2.45 GHz with harmonic suppression for energy harvesting applications. Single feeding technique is used because of its simplicity, cost efficient, easy to fabricate, and compact size. This thesis presents a new design of a circularly polarized antenna with harmonic suppression based on a rectangular microstrip patch.

ABSTRAK

Polarisasi pekeliling diperlukan dalam aplikasi antena terutama untuk penuaian tenaga kerana polarisasi dalam antena penerima dan penghantaran dipadankan, ia mempunyai keupayaan untuk mengurangkan kerugian penghantaran. Untuk melakukan pencocokan polarisasi ini, kedua-dua pemancar dan penerima mesti mempunyai deria polarisasi yang sama, nisbah paksi dan orientasi spasial yang sama. Oleh kerana gelombang di persekitaran kita boleh terbias secara rawak disebabkan oleh pergerakan badan atau pergerakan peranti dalam aplikasi teknologi tanpa wayar seperti RFID, GPS dan WLAN, polarisasi bulat berguna untuk mengurangkan kesan pantulan isyarat dan meningkatkan keupayaan antena. Objektif utama tesis ini adalah untuk merekabentuk antenna strip mikro yang beroperasi pada 2.45 GHz dengan penekanan harmonik dalam polarisasi berputar untuk aplikasi penuaian tenaga. Teknik penyusuan tunggal digunakan kerana kesederhanaannya, kos yang cekap, mudah dibuat, dan saiz yang padat. Pada akhir tesis ini, satu reka bentuk antena baru yang beroperasi dalam polarisasi pekeliling dengan penekanan harmonik berdasarkan pada tampalan strip mikro segi empat tepat.

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LIST OF SYMBOLS AND ABBREVIATIONS

CP	:	Circular Polarization
DGS	:	Defective Ground Structure
MSA	:	Microstrip Patch Antenna
GHz	:	Gigahertz
mm	:	Millimeter
dB	:	Decibel
RFID	:	Radio-Frequency Identification
GPS	:	Global Positioning System
WLAN	:	Wireless Local Area Network

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CHAPTER 1

INTRODUCTION

1.1 Background

Recently, fast growth of wireless energy harvesting application becomes a major cause for engineers to design the most efficient antenna. The antenna mentioned is a compact, cost effective and lightweight microstrip antenna. That is what it is about in this project, designing new circularly polarized (CP) microstrip antennas that are mostly used in various types of wireless co mmunication system nowadays since it was introduced in 1953 [1]. is found to be a very necessary consideration in the antenna design industry as it able to put an end to the need of antenna orientation in the plane perpendicular to the propagation direction. Radio signals are tended to be absorbed and reflected based on the material it contacts with. So, with CP antenna, it gives a much more flexibility to the angle between the signals and the antenna resulting the signals always be recognized [2] [3]. However, the MSA design need to be change for it to be able to generate the circular polarization [4]. For circular polarization to be generated in microstrip antenna, two modes equal in magnitude and 90 out of phase are required [5]. Researchers has found that designing a microstrip patch antenna with good gain and radiation pattern is a major challenge among engineers [6].

The design should be capable to receive RCHP and LHCP simultaneously and also able to filter unwanted harmonic signals. The Computer Simulation Technology (CST) will be used to simulate and optimize the design. Once the best design had been chosen, it will then be fabricated using photo-lithography technique and measured in anechoic chamber or vector network analyzer (VNA). Finally, from the simulation and measurement, the proposed design of the antenna can be verified as a good choice in the future of wireless power transmission (WPT) application in an operating frequency of 2.45 GHz.

1.2 Problem Statement

Currently, existing design of the antenna unable to produce filtering and radiating element to suppress unwanted signal. Antenna that integrated to diodes or FET will introduce to harmonics of the fundamental frequency. Thus, this presence of harmonics affects the efficiency of the antenna and would cause problems of harmonics re-radiation which are bad for energy harvesting application. To overcome, a LPF is required to reject the harmonics in order to increase the antenna's efficiency significantly as a contribution in improving system performance and also intercepts harmonics interference [7].

1.3 Objectives

There are three objectives in this project that is needed in order to obtain a good result of a harmonic suppressed, circularly polarized antenna that operates at 2.45 GHz.

i. The main objective in this project is to design a harmonic suppressed circularly polarized microstrip patch antenna that operates in 2.45 GHz frequency for energy harvesting. Harmonic suppression is a highlight in the design process to increase the efficiency of antenna.
ii. Next, is to analyze an efficient technique to acquire circularly polarized radiation pattern of the antenna. This objective ensures that the antenna emits radiation in circular polarization to eliminate the Faraday's Effect that can occur in linear polarization.
iii. Finally, after obtaining a final design of the microstrip patch antenna, the last objective is to fabricate and verified the design in the laboratory. Fabrication of the antenna consist of etching process to print the antenna configuration onto FR-4 board. A measurement process is then will be performed to compare the values obtained from simulation.

1.4 Scope of Work

The main goal of this project is to design a circularly polarized microstrip antenna that operates in 2.45 GHz with harmonic suppression for energy harvesting applications. There are 5 scopes that will be covered during the process. Firstly, is to design the geometry of the antenna to make sure it meets the polarization requirement while applying a harmonic rejection characteristic. The harmonic rejection characteristic is achieved through various techniques that explained in detail in Chapter 3: Methodology.

After that, the design will need to be optimized to improve the efficiency, gain and radiating pattern of the antenna. Optimization of the geometry will be perform using CST far-field simulation. Next, the process will be fabrication the microstrip patch antenna by using FR-4 Board with 4.7 dielectric constant and the substrate standard thickness, h is 1.6 mm.

Measurements of the radiation pattern using Vector Network Analyzer and in an anechoic chamber in the laboratory is then performed to obtain the return loss and radiation pattern of antenna. Lastly, investigation of the performance of the antenna in term of return loss values, axial ratio and harmonic suppression is done to verify the design.

1.5 Thesis Outline

The thesis content is distributed into five chapters that covers the complete design process of the MSA. Chapter 1 contains the introduction to the whole project where the history of MSA, the objectives of the project and scope of works are mentioned clearly in this chapter.

Chapter 2 consists of literature review which discuss previous design made by other researchers in order to obtain an optimum geometry of the MSA. Topics on harmonic suppression and transmission line techniques followed by the choices of the antenna shapes and substrate used are explained in detail in this chapter.

Chapter 3 on the other hand, explains about the design methodology which describes the flow of the design process as a step to achieve the best design with better parametric values of the antenna. Process to fabricate the antenna also been illustrated with some explanations of figures.

Chapter 4 brings us to proof the simulation and measurement result. The simulation results are performed and compared between different design of the MSA and then the MSA that shows the best performance is selected to fabricate the layout. Measurement result from the fabricated MSA is then analyzed to verify the design.

Lastly, the contents in Chapter 5 concluded the overall findings and results in this project. There are also some discussions about the accomplishments of the objectives that has been set at the beginning of this project. Future works based on this project is then suggested to complete the energy harvesting system.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

This chapter presents a background about microstrip antennas, circular polarization, feeding techniques, and to suppression of harmonics.

2.2 Advantages and Disadvantages of Microstrip Antenna

The microstrip antenna has several advantages that attracts researchers to perform research in order to develop the most efficient design. The main advantage surely be about its flexibility as a low-profile antenna which can confront a planar and nonplanar surface because the shape design fits the needs of modern communication equipment. The microstrip antenna shape flexibility also enables them to be mounted on a rigid surface which makes them mechanically robust. In the other hand, microstrip antennas can be mass produced using simple and cost-efficient modern