DESIGN CIRCULAR POLARIZED ANTENNA WITH MULTILAYER METASURFACE

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Supervisor Name	:	Dr. Mohammad Zoinol Abidin Abd. Aziz
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DEDICATION

Specially dedicated to my parents and my friends for their helping and support for this project

ABSTRACT

For wireless communication system, antenna is one of the most important component. A good design of antenna can meet the system requirement and improve the performance of the system. In this project, design and analysis of Circular Polarized (CP) Antenna with multilayer Metasurface (MS) structure is presented. Firstly, the antenna was designed based open slot is formed by an L-shape directed connected at the center of the ground plane as a way to create the circular polarization. After optimization, axial-ratio achieved 1.632dB which is less than 3dB for circular polarization at frequency 5GHz. Then designed antenna is added with metasurface with air gap between the patch and metasurface layer with a distance of 20 mm. With the additional of the MS the gain increased by 1.084dB. The coaxial feed technique is applied in this antenna with 50Ω probe feed SMA connector. Computer Simulation Technology (CST) Microwave Studio Suite software is used as the simulation tool for the design and simulation process for the antenna. The antenna parameter include return loss (RL), bandwidth (BW), gain, directivity, axial ratio (AR) and total efficiency for the proposed antenna are analysed. The resonant frequency for this antenna design is the Wireless Local Area Network (WLAN) application which operates at 5GHz frequency.

ABSTRAK

Untuk sistem komunikasi tanpa wayar, antena adalah salah satu komponen yang paling penting. Reka bentuk antena yang baik boleh memenuhi keperluan sistem dan meningkatkan prestasi sistem. Dalam projek ini, reka bentuk dan analisis Antena Pekeliling Polarisasi dengan struktur pelabagai lapisan meta-permukaan dibentangkan. Pertama, antena direka berdasarkan slot terbuka dibentuk oleh bentuk L yang diarahkan terhubung di tengah-tengah lapisan ground sebagai cara untuk mencipta polarisasi pekeliling. Selepas pengoptimuman, nisbah paksi mencapai 1.632dB yang kurang daripada 3dB untuk polarisasi bulat pada frekuensi 5GHz. Kemudian antena yang direka ditambah dengan meta-permukaan dengan jurang udara antara patch dan lapisan meta-permukaan dengan jarak 20 mm. Dengan tambahan MS, keuntungan meningkat sebanyak 1.084dB. Teknik suapan sepaksi digunakan dalam reka bentuk antena ini dengan penyambung SMA feed 50 Ω. Perisian.Computer Simulation Technology (CST) Studio Studio Suite Microwave digunakan sebagai alat simulasi untuk reka bentuk dan proses simulasi untuk antena yang dicadangkan. Parameter antenna termasuk kehilangan pulangan, bandwidth, keuntungan, directivity, nisbah paksi dan jumlah kecekapan untuk antena yang dicadangkan

dianalisis. Aplikasi sasaran untuk reka bentuk antena ini ialah Rangkaian Kawasan Wayarles Wayarles (WLAN) yang beroperasi pada frekuensi 5GHz.

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LIST OF SYMBOLS AND ABBREVIATIONS

h	:	Thickness of the substrate
εr	:	Dielectric constant
$tan\ \delta$	:	Tangent loss
t	:	Copper thickness
H_1	:	Height of the monopole patch
W_1	:	Width of the monopole patch
Wt	:	Width of bent feeding structure
Lt	:	Length of bent feeding structure
W	:	Width of inverted L-shaped
L	:	Length of inverted L-shaped
W_f	:	Width of feeding line
G	:	Length of ground plane
WLAN	:	Wireless Local Area Network
MPA	:	Microstrip Patch Antenna
CP	:	Circular Polarization
MS	:	Metasurface
BW	:	Bandwidth
AR	:	Axial Ratio

RL	:	Return Loss
CPW	:	Co-planar Waveguide
RHCP	:	Right Hand Circular Polarization
LHCP	:	Left Hand Circular Polarization
DGS	:	Defected Ground Structure
PBS	:	Photonic Bandgap Structure
FSS	:	Frequency Selective Surfaces
CSRR	:	Complementary Split Ring Resonator
JC	:	Jerusalem Cross
MNS	:	Mu-Near-Zero
ZIM	:	Zero Index Metasurface
UV	:	Ultraviolet
VNA	:	Vector Network Analyzer
CST	:	Computer Simulation Technology
AUT	:	Antenna Under Test

CHAPTER 1:

INTRODUCTION

1.1 Project Background

Anything related transfer of information without using electrical conductor can be said as wireless communication system. For wireless communication system, antenna is a main component as it convert the electrical signal to electromagnetic. In order to design an antenna, Microstrip Antenna (MPA) is better choice where it have low profile, inexpensive and easy to fabricate. Circular Polarized (CP) Antenna is particularly useful for this project in order to improve the efficiency of polarization radiation of antenna. Furthermore, multilayer metasurface structure is proposed in this project to enhance gain of antenna. The proposed antenna operated at 5GHz band for the WLAN application system.

1.2 Problem Statement

The technology of wireless telecommunication communication devices develop quickly in the most recent years. Wireless application can perform better if the important part especially the antenna can transmit and receive the signal with low signal losses according to the misalignment. When the device is located in different position and orientation, there is misalignment angle between receive and transmit antenna. This is called polarization mismatch. This condition will cause only small percentage of signal will be received by the antenna. To overcome this problem, the Circular Polarization (CP) antenna is preferable in term of polarization parameter where it can transmit the signal in all plane. With CP radiation, the efficiency of transmission can be increased. However CP antenna has the disadvantages which are more complex and more expensive.

MPA is chosen for easy fabrication and smaller in size. The low cost FR-4 at microwave frequency has relative high dielectric constant leads to declining of MPA performance such as narrow bandwidth, low gain and poor efficiency. The low gain is the primary issue that limit the data rate in system

Metasurface (MS) have been studied can improve the performance of antenna include the efficiency, gain and larger bandwidth (BW).MS has succinct structure with low profile, so MS structure is propose to combine with CP patch in order to enhance performance, yet retaining the low profile structure.

1.3 Objectives

- Design, simulation and fabrication of circular polarized antenna with multilayer meta-surface for wireless communication system.
- To achieve the axial ratio (AR) value less than 3dB to create circular polarization
- To achieve the gain of the antenna more than 4dB for the improvement of performance of the antenna

1.4 Scope of work

This project is to design circular polarized antenna with multilayer metasurface for wireless communication system. In design process, CP antenna will be designed using any technique. The polarization can be either left-hand circular polarization (LHCP) or right-hand circular polarization (RHCP). Then, the antenna will be designed using the multilayer metasurface structure.

Then simulate the value of the antenna parameter by using CST software tools. Antenna parameters include input impedance, bandwidth, efficiency, gain, and polarization and radiation pattern.

For the fabrication process, the material is FR4 substrate with a thickness of 1.6 mm, a dielectric constant of 4.4, and a loss tangent of 0.019 with chemical etching technique. The value of the antenna parameter such as resonant frequency, return loss (RL), gain, bandwidth (BW), directivity, efficiency and radiation pattern will be measured after the fabrication process. This value will be analyzed to compare the value measured and simulation.

1.5 Thesis Outline

In Chapter 1, the chapter introduces the background of circular polarized antenna with multilayer metasurface, the problem statement, the objectives, the scope of the work and the thesis outlines.

Next, Chapter 2 covers literature review related to basic principle of MPA, polarization and metasurface. This chapter is actually covers the previous design that accomplished by the researchers includes the design of the circular polarized antenna and structure of metasurface.

Chapter 3 presents the methodology used in the completing the project and the process flow of the project. Initially CP antenna is designed, then combine the antenna with MS. Investigation on different type of design and structure of metasurface. The simulation, fabrication and measurement process are well explained in this chapter.

Chapter 4 presents the result from the simulation and measurement for the antenna parameter include return loss, axial ratio, gain, efficiency, directivity and radiation pattern. The results will be discussed and analyzed for the performance done of this project.

Finally, Chapter 5 deduces the result achieved and objectives desired. Recommendation on future works or improvements that can be made for the project are also suggested by this chapter.