# ENHANCED PERFORMANCED OF CIRCULAR POLARIZED ANTENNA BY USING METASURFACE

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**This report submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunications Electronics) With Honours**

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**DEDICATION**

Special dedication to my beloved parents,

**CHEW KONG FACT & CHONG YUEN YEN**

*To my supervisors*

**PM. DR MOHAMAD ZOINOL ABIDIN BIN ABD. AZIZ**

*My friends and my fellow lecturers*

*Thank you for all your care, support and believe in me*

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# ABSTRACT

Antenna is the most important component to transmit signal trough the free space in the wireless communication system. Circular polarization is one type of method to enable communication between antennas that has the benefit of reduce signal loss. However, those antennas that usually used to design circular polarization are had some limitations on the performances. There are also a lot of studies, such as multiple patch configuration, stacked multiple patch, and frequency selective surface had been done to improve the antenna performances. However, those techniques will have some shortcomings, like produce unstable radiation and increase the overall size of antenna. Meta-surface is 2D periodic planar structure of meta-materials that recently widely used in antenna communication. In this report, the method of loading meta-surface to enhance circular polarization antenna was proposed and presented. The designed circular polarized antenna was loaded with both one layer and two layers meta-surface to compare the results. One layer meta-surface is loaded a meta-surface on the source antenna, while two layers meta-surface is loaded two same structures of meta-surface on the source antenna. This method of meta-surface had been proved by some researchers to improve the performances of antenna. However, most of the researchers only focus either to improve or to convert the linear polarization antenna to become circular polarization. Therefore, this project will not only focus on all the antenna parameters but also remained the circular polarization of antenna. The simulation software, CST Studio Suite was used to simulate for the whole design process. The designed antenna and meta-surface were then fabricated and measured to verify the simulation result. By using two layers meta-surface, the bandwidth of designed antenna was improved while the gain and directivity had improved from 3.67dB to 6.66dB and 4.7dBi to 7.49dBi respectively at 2.4GHz.

# ABSTRAK

Antena adalah komponen yang paling penting untuk menghantar dan menerima siknal isyarat dalam system komunikasi tanpa wayar. Polarisasi pekeliling merupakan salah satu cara antenna berkomunikasi yang dapat mengurangkan kehilangan siknal. Namun begitu, jenis-jenis antenna yang biasaya digunakan untuk merekan bentuk antenna yang beroperasi dalam polarisasi pekeliling ada kelemahan dalam prestasinya. Pelbagai jenis cara seperti tindaan patch, dan frequency selective surface telah dijelajahi untuk meningkatkan prestasi antena, tetapi wujudnya kelemahan seperti membesarkan size antenna dan wujudnya ridiaksi yang tidak stabil. Meta-surface merupakan sejenid meta-material yang dalam 2D struktur. Oleh itu, meta-surface digunakan untuk meningkatkan prestasi antena dalam projek ini. Dalam projek tersebut, antena yang telah direka akan dibebankan dengan satu lapisan meta-surface dan dua lapisan meta-surface. Hasilan daripada dua cara akan dibandingkan. Cara ini telah ditunjukkan oleh para penyelidik bahawa meta-surface boleh meningkatkan prestasi antena. Walaubagaimanapun, kebanyakan para penyelidik cuma meningkatkan antena jenis linear polarisasi. Dalam projek ini, prestasi antenna akan ditingkatkan dan jenis polarisasi kekal pada jenis pekeliling. Perisian CST akan digunakan dalam projek ini untuk process kajian parametrik bagi menyiapkan keseluruhan projek ini. Selepas itu, antenna akan dikarangkan untuk menyemak hasil daripada simulasi. Melalui cara dua lapisan meta-surface, bandwidth antena dapat diluaskan, gain dan directivity antena juga tingkat dari 3.67dB hingga 6.66dB dan dari 4.7dBi hingga 7.49dBi masing-masing pada frekuensi 2.4GHz.

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| | |
|---|---|
| **CST** | **- Circuit Simulation Tool** |
| **GHZ** | **- Giga Hertz** |
| **AR** | **- Axial Ratio** |
| **FCC** | **- Federal Communication Commission** |
| **RFID** | **- Radio Frequency Identification** |
| **MTM** | **- Meta-material** |
| **AMC** | **- Artificial Magnetic Conductor** |
| **EBG** | **- Electromagnetic Band Gap** |
| **PRS** | **- Partial Reflective Surface** |
| **RIS** | **- Reactive Impedance Substrates** |
| **FSS** | **- Frequency Selective Structure** |
| **LHCP** | **- Left Hand Circular Polarization** |
| **RHCP** | **- Right Hand Circular Polarization** |
| **AUT** | **- Antenna under Test** |
| **mm** | **- millimeter** |
| **dB** | **- decibel** |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Project Introduction

Communication system is the system that enable human to communicate between each other. In the early stage of communication system, human used signal fire to communicate with others. Then, optical telegraph was proposed in the year of 1684. Followed by the trend, Morse code is introduced in the year of May 1844. After that, with the rapid development of communication system, wireless communication was born in the year of 1894. The trend was kept implemented until now where many types of modern application of communication such as mobile phone, computer and tablets had been introduced. In this situation, antenna had become an important component to transmit and receive signal in this wireless communication system.

Due to the trend of the development, an antenna with high good performances was needed in the wireless communication system. A good performances antenna mean the antenna can use for many types of applications and also can operate in a long distance. In order to make the antenna operate with high performances, the antenna parameters must be improved. Those parameters are operation bandwidth, gain, and directivity of antenna.

Meta-surface is one of the famous techniques that can use to improve antenna performances. The technique was still considered new in the antenna environment. Meta-surface is the periodic 2D structure that can be designed by referring to any shape of structure.

## 1.2 Problem Statement

Wireless communication system was introduced and implemented in the year of 1894 and kept developing until now. The rapid development of wireless communication system, including commercial or military communication, remote sensing, and various point-to-point communication links, has brought in the demand of high performance antenna. The basic requirements for a good antenna are able to receive clear signal and able to function in several types of application. A good antenna normally can transmit and receive signal in a wide coverage range with strong strength of signal. In order to increase the signal strength, a high gain antenna with a narrow radio beam was needed. High gain antenna can provide a precise way to target signal, so it is essential to long-range wireless network. Then, the operating bandwidth of an antenna must be wider for a multiple applications antenna.

In the antenna communication system, polarization is the fundamental concept of antenna. Those antennas are classified by the types of polarization. This defined the type of plane wave polarization that the antenna was most sensitive to. Most communications system use eithers vertical, horizontal or circular polarization. As an essential part of communication system, many kind of antenna have been studies since Federal Communication Commission (FCC) assigned the 3.1GHz to 10.6GHz band to become the purpose of commercial in 2002. Among those antennas, circular polarization antenna is one of the essential candidates for several communication systems. Circular polarized antennas are widely used in radar, RFID, wireless and satellite communication and sensor system due to their characteristics of stability and smashing mobility. This is because circular polarization will produce a less loss compared to linear polarization, which is only -3dB. In this case, a lot of techniques and developments had been studies to produce circular polarized antenna. Although there are many types of techniques can used to produce circular polarized antenna, but not all the techniques will produce a good performances antenna. Therefore, a lot of studies still conduct by researches to find the most effective technique for improving the antenna performances.

In order to enhance the performances and applications, several researches had proposed numerous techniques to improve the gain and directivity of the antennas in recent decades. Meta-materials (MTM), artificial magnetic conductor (AMC),

electromagnetic band gap (EBG), high impedance electromagnetic surfaces, partial reflective surface (PRS) structure and reactive impedance substrates (RIS) are some of the more widely used artificial materials for antenna applications. Meta-materials are broadly defined as artificially homogeneous or inhomogeneous electromagnetic structures with unusual properties, which are commonly engineered by arranging a number of electrically small scatters in regular or irregular periodic array throughout a region of space so as to obtain some desirable bulk electromagnetic behavior. Meta-materials can be separated in different classes which are negative index, single index, band gap, and meta-surface, the latter of which has wide potential applications, such as absorbers, harvesters, and detector of microwave radiation. Among these several types of meta-material, it is a well-known that meta-surface can be used in the design of planar antenna to enhance the antenna's performances. Meta-surface is a two dimensional meta-material structure that has been attracting attention for researches in the past few years due to the advantages of succinct planar structure and low cost. Considering the aforementioned studies and investigations, a uniform distributed meta-surface structure can enhance the performance of circular polarized antenna with the effect of desired bulk electromagnetic behavior.

## 1.3 Objectives

The objective of this study is to design, simulate and fabricate circular polarization antenna by using meta-surface which can operate in the frequency of 2.4GHz.

## 1.4 Scope of the Project

There are four parts, which are design, simulate, fabricate and measurement included in this study. For the design part, a circular polarized antenna that operated at 2.4GHz will be designed. The frequency of 2.4GHz was chosen because many applications such as WIFI and Wireless LAN are operated in this frequency. Then, the structures of meta-surface will be study and design for the purpose to improve the performances of the antenna. In the simulation part, CST Studio Suite will be used to simulate the 3D structure design for the both antenna and meta-surface. The results of simulation included the reflection loss$|S_{11}|$, axial ratio (AR), gain, directivity and,

radiation pattern. The material of substrates used for the both antenna and meta-surface was FR-4. Next is the measurement part. In this part, the results simulated in the software are then measure by using the equipment. Spectrum analyzer will used to measure the gain of the antenna, while network analyzer used for measurement of reflection loss$|S_{11}|$. The radiation pattern of the antenna will be observed in the anechoic chamber.

## 1.5 Thesis Outline

The thesis will discuss the design process and the findings for enhancing performances of circular polarized antenna by using meta-surface. In the first chapter, the title will be explained and the objective of the projects will be stated. In Chapter 2, all the studies that done by previous researchers that related to the title will be reviewed. The idea to do the project will generate after the review on the chapter. Then, the next chapter will explain the process to design the circular polarized antenna and meta-surface. After that, all the results and findings of the project will be show on Chapter 4. The discussion and problems faced when doing the report will be explain in the chapter. Last will be Chapter 5. Chapter 5 will conclude the project by discussion on project sustainability, potential of commercial and some future work will be suggest.

# CHAPTER 2

# LITERATURE REVIEW

In the chapter, all the journals that related to this project will be reviewed, including the study of polarization, types of antenna, techniques to improve antenna's performances and types of meta-surface. All will be studied and review to understand the ideas of design new modified structure of antenna.

## 2.1 Basic Antenna Parameter

Antenna is an important component to enable the communication of the wireless communication system. The IEEE Standard Definition of Terms for Antennas had stated that antenna is designed to transmit and receive signal by emitting and receive electromagnetic waves (IEEE Std 145-1993). When talk about antenna, there are some important parameters that defined the antenna performances, such as return loss, operation bandwidth, gain, directivity and antenna polarization.

Return loss is the measure of signal that reflected back from system to antenna. In the antenna designed process, the signals that can be reflected back to the system was 10%. This meant the 90% of the energy was received by the antenna to radiate out as the electromagnetic wave. In this case, the maximum acceptance return loss when designed an antenna is -10dB. [30]

$$\mathrm{RL} = 10\log_{10}\left(\frac{\mathrm{P_{in}}}{\mathrm{P_{ref}}}\right)\mathrm{dB} \qquad (2.1)$$

where

$P_{in}$= power incident

$P_{ref}$= power reflected