5.8 GHz of Circularly Polarized Microstrip Array Antenna for Point-to-Point Application

by

Nurasma Husna Binti Mohd Sabri
(1830812968)

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LIST OF ABBREVIATIONS

CP	Circular Polarization
RF	Radio Frequency
BS	Base Station
dB	Decibels
CST	Computer Simulation Technology
MSA	Microstrip Antenna
RMPA	Rectangular Microstrip Patch Antenna
AR	Axial Ratio
RHCP	Right Hand Circular Polarization
LHCP	Left Hand Circular Polarization
ISM	Industrial Scientific and Medical
GSM	Global System for Mobile
MIMO	Multi Input Multi Output
SMA	Surface Mount Adapter
VSWR	Voltage Standing Wave Ratio
RL	Return Loss
HPBW	Half Power Beam Width
VNA	Vector Network Analyzer
PCB	Printed Circuit Board
UV	Ultra Violet
DAMS	Desktop Antenna Measurements Software
AUT	Antenna Under Test

WLAN	Wireless Local Area Network
IP	Internet Protocol
AP	Access Point
DHCP	Dynamic Host Configuration Protocol
SSID	Service Set Identifier
WPA	Wi-Fi Protected Access

LIST OF SYMBOLS

c	Speed of light
f	Frequency
fr	Resonant frequency
G	Gain
h	Height
W	Width
ε	Permittivity
ε_r	Relative permittivity
λ	Wavelength
λg	Guided Wavelength
Γ	Reflection coefficient
Ω	Ohm
η	Efficiency
S_{11}	Reflection Coefficient

5.8 GHz Tatasusunan Antenna Mikrojalur Terkutub Secara Bulatan untuk Aplikasi Titik ke Titik

ABSTRAK

Projek penyelidikan ini tertumpu pada perkembangan tatasusunan antenna mikrojalur terkutub secara bulatan untuk aplikasi titik ke titik. Antena untuk aplikasi ini dibangunkan untuk menghantar dan menerima isyarat komunikasi yang biasanya digunakan pada komunikasi titik ke titik. Aplikasi ini memerlukan dua stesen untuk berkomunikasi antara satu sama lain seperti yang terdapat pada stesen pangkalan. Antena stesen pangkalan biasanya diletakkan di tempat yang tinggi untuk mengelakkan sebarang gangguan. Dalam penyelidikan ini, antena mikrojalur telah di reka kerana strukturnya yang ringan dan ini telah memudahkan pemasangan antena di stesen pangkalan. Gelombang terkutub bulat telah diusulkan bagi mengatasi kekurangan yang terdapat pada gelombang terkutub lelurus yang kurang prestasinya terhadap antena stesen pangkalan. Antena terkutub secara bulatan direka untuk membolehkan penerima sentiasa menerima daya pada setiap sudut gelombang arah serta memastikan komunikasi antara dua antena secara berterusan dan sekata. Antena terkutub bulat direalisasikan dengan menerapkan 3 teknik yang berbeza dalam reka bentuknya iaitu potongan berlubang ditengah, potongan tepi bucu dan jalur masuk disisi. Tatasusunan antena mikrojalur dihasilkan dalam penyelidikan ini bagi meningkatkan gandaan antena yang diperlukan dalam aplikasi stesen pangkalan. Reka bentuk telah dibandingkan dengan tiga konfigurasi susunan yang berbeza, ia terdiri daripada tatasusunan 1x1, tatasusunan 2x1 dan tatasusunan 2x2 serta dilekatkan bersama substrat Rogers RT 5880 dengan masing-masing mempunyai pemalar dan ketebalan dielektrik 2.2 dan 0.51 mm. Penambahan lapisan pada substrat dibuat untuk meningkatkan ketebalannya dengan dilapisi oleh 3 lapisan Rogers RT 5880. Ini menjadikan jumlah ketebalan antena dalam projek ini adalah sebanyak 1.53 mm. Semua reka bentuk dalam penyelidikan ini telah menghasilkan antena terkutub bulat dengan memperoleh nisbah paksi di bawah 3 dB. Tatasusunan antena 2x2 menghasilkan keupayaan gelombang terkutub secara bulatan dengan mempunyai nisbah paksi 1.54 dB dan mempunyai gandaan antenna sebanyak 13.27 dB. Antena ini beroperasi pada frekuensi 5.8 GHz iaitu frekuensi yang ideal untuk aplikasi titik ke titik yang digunakan dalam aplikasi stesen pangkalan.

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ABSTRACT

These research project is mainly focused on the development of Circularly Polarized Microstrip Array Antenna for Point-to-Point Application. The antenna for point-to-point application is develop to transmit and received the communication signal. Usually, the point-to-point application required two station to communicate to each other like a base station. The antenna at a base station are placed at a high place to avoid out the interferences. In this research, microstrip antenna which have light weight characterize is design to ease the installation for the base station. The circular polarization is proposed to limit the limitation of linear polarization which is less reliable in base station antenna. The circular polarization antenna is made to allow the receiver constantly receive the power at any wave angle and make the transmission between two antennas are more constant. The circular polarization antenna is realized by applying 3 different techniques in the design which are truncated-edge, inclined slot and side feed. The array antenna is implement in this research in order to increase the antenna gain which is required in point-to-point application. The proposed design was compared by 3 difference array configuration which are 1x1 array, 2x1 array and 2x2 array etched on Rogers RT 5880 substrate with 2.2 and 0.51 mm of dielectric constant and thickness respectively. Multilayer substrate antenna is made to increase the thickness of the substrate which is layered by 3 layers of Rogers RT 5880 which makes the thickness of the antenna is 1.53 mm. These 3 design produced circular polarization antenna since obtained the axial ratio below than 3 dB. The 2x2 array antenna produce circular polarization capability which have the axial ratio of 1.54 dB and also obtained are high gain of 13.27 dB. The antenna is operated at 5.8 GHz which is an ideal frequency for point to point communication that used in base station application.

CHAPTER 1 : INTRODUCTION

1.1 Research Background

Presently, research advancement and use of microstrip antenna with circular polarization have been grown quickly in point-to-point applications. Polarization is essential to restrict the transmission of wireless communication causes from the subsequent wave having precise angular variation. Circular polarization is created to continually receive power at any wave angle (Kingsuwannaphong & Sittakul, 2018). A high gain antenna is used since it is more focusing on narrow beamwidth and it allows more exact concentrating of the radio signal and generally is put at the open territory so the radio waves to be sent will not interfere. The RF wireless antenna is designed to function more efficiently than in others. Directional antenna networking is better to compare to Omni-directional networking as it delivers a lot of benefits including extended range, improved capacity, superior power efficiency and less susceptible to interference. (Yun et al., 2018) and (Meagher et al., 2011). The important of directionality is for reducing the interference as well as improve the transmission and reception of the communication signal.

The antenna that have wide band impedance matching, great cross- polarization and stable radiation pattern in desired frequency band are required in point-to-point application (Rahim et al., 2006) (W.-S. Chen et al., 2002). In this research, a circularly polarized (CP) microstrip patch antenna is designed since it is suitable for this applications. The CP antenna has been created which permit the receiver boundlessly receive the power at any points. Besides, with CP ability will make the two antennas

transmission are more constant. To design a circular polarization antenna, the patch will go through some modifications and applying some technique such that cutting a slot or slit and by truncating edges of the rectangular patch design (Goyal et al., 2016) and (Karvekar et al., 2014). Normally, two edges oppositely to each other will be truncate off the corner. CP is obtained by optimizing width and length of the truncated part. Besides, the location of the feed point on this line has also been adjusted to make the polarization better. The purpose of the truncation method at the edge is realized to improve the impedance and axial ratio bandwidth of the modified antenna (Sekra et al., 2012) (Kingsuwannaphong & Sittakul, 2018).

Usually, the point-to-point communication required two station to communicate to each other like as base station application. The antenna at a base station is located at an uncluttered area or at a height residence to evade interference and will lead to easy for power transmission. The microstrip patch antenna is selected in this project since it is more reliable and also has a lot of benefits such as low profile, low cost, lightweight, easy to construct or installed at a height placed, and thus, make it suitable used in point-to-point application.

The main point-to-point network is usually provided with antennas having the highest gain economically possible, this reduces the number of points needed, improves in-building penetration, and make it useful in an urban area as well as the rural area (Z. N. Chen & Luk, 2009). The array antenna is designed for improving antenna performance in point-to-point applications (Midasala & Siddaiah, 2016). In this project, a rectangular microstrip patch array antenna is designed with applied some CP technique for successfully implemented in this application.

The unidirectional antenna is designed to function more effectively than the omnidirectional antenna. The use of omnidirectional antennas in a point-to-point application usually limited to small in-fill stations because their ability to support only a single cell limits their capacity and frequency re-use capabilities (Z. N. Chen & Luk, 2009). So, a unidirectional antenna is designed to overcome the limitation in omnidirectional antenna so that it can reduce interference when transmit and receive of signal communication (Fauzi & Hariyadi, 2018). Besides, unidirectional antenna are reliable in point-to-point communication since it will transmit in a direction of the other point of the antenna and thus make the connection of two points are more constant. The antenna is operating at 5.8 GHz frequency uses for point-to-point application.

1.2 Problem Statement

There are numerous studies in the technology of antenna in point-to-point applications. The antenna is worked as a transmission and reception for worldwide communication industries. This application usually placed and installed the antenna on a rooftop or at a height place for avoiding interferences. Somehow, it is difficult to handle and install. Moreover, presence capable to attain respectable of immunity to noise and signal to noise ratio, they should have depicted compact structure, and can be simply fabricated and attached to numerous devices. Based on the demands, Microstrip antenna is one solution to satisfy all these requirements. Besides, to ease the installation of the antenna, the low profile antenna is required. Microstrip antenna meets these requirements since it has a small size, easy to install, lightweight, low cost and has the best performance in terms of transmitting and receiving communication signals (Goyal et al., 2016). Thus, microstrip antennas are very suitable in telecommunication industries.

However, the single microstrip antenna has a limitation for instance a low gain and low efficiency as well as narrow bandwidth which are not suitable in point-to-point application. For point-to-point wireless communication, it is needed that the antenna has a low beam width, which is inflexible to accomplish by using a single element antenna. Usually, the point-to-point communication required a high gain antenna in order to make a good performance in the transmission and reception of communication signals. To overcome this problem, the antenna should have an enhance design by creating more than one patch antennas in an array arrangement. The array will increase the antenna gain and can avoid out interfering from any specific directions and thus make it suitable to be used in this applications (Fertas et al., 2016) and (K. K. Singh & Gupta, 2013).

Moreover, the uses of linear polarization in point to point communication are not suitable in this application. The linear polarization is less reliable which only can radiate in a specific direction since it needs to point the antenna towards the direction of the other point. If the other antenna slightly moves to the other direction, the signal cannot be transferred well (Kirar et al., 2013). To solved this problem, the circular polarization (CP) antenna is implemented to make the connection between two antennas is more constant and has many chances to receive and transmit a signal between the antennas. The CP antenna is realized when making the result of the axial ratio is below 3dB (3dB~0dB) at the desired frequency.

1.3 Objective

The main objective of this research is to realize a 5.8 GHz circularly polarized microstrip array antenna for point-to-point application. The design is simulating using Computer Simulation Technology (CST) Software with uses of Rogers RT 5880 as a substrate. The following are the objective for this project:

i. To design and optimize the 5.8 GHz circular polarized microstrip array antenna for point-to-point application with different CP technique which are truncated-edge, inclined slot and side feeding by using CST software.

ii. To integrate and analyze of CP technique into three design of array configuration which are (1x1) array, (2x1) array and (2x2) array.

iii. To fabricate and characterize the designed of CP array antenna performance such as S-parameter, gain, axial ratio, bandwidth and radiation pattern in anechoic chamber.