CIRCULAR POLARIZATION FOLDED REFLECTARRAY ANTENNA FOR 5G APPLICATIONS

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Specially dedicated to

My beloved mother, father, sisters, brothers and all peoples that I love

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ABSTRACT

Fifth-generation (5G) is a wireless connection built specifically to keep up with the rapid increase of devices that need a mobile internet connection. A system working on 5G band can provide higher bandwidth and faster data rate as compared to fourth-generation (4G) band. Thus, an antenna with higher gain and lower profile is required to support this system. On the other hand, the performance of circular polarization antenna is better than linear polarization antenna due to its ability to accept wave from different direction. In this project, a low profile circular polarization folded reflectarray antenna with operating frequency of 28 GHz is studied. This project is divided into two parts. In the first part, a linear polarization folded reflectarray antenna is designed. In this second part, a meander lines polarizer is used to convert the linear polarization antenna to circular polarization antenna. The antenna is fed by a linear polarized waveguide. Each radiating element of the antenna is in rectangular shape. The size of the radiating elements are selected according to obtain required phase delay to form a planar phase front in the far-field distance. Both of the antennas are simulated by using Computer Simulation Technology (CST) software. The bandwidth and the directivity of the circular polarization folded reflectarray antenna are 6.5 GHz and 19.4 dBi respectively. In short, this antenna is suitable for 5G applications.

ABSTRAK

5G adalah rangkaian tanpa wayar yang dibina untuk menyelesaikan masalah peningkatan bilangan peranti mudah alih di seluruh dunia. Sistem 5G mempunyai jalur lebar dan kadar data yang lebih tinggi berbanding dengan 4G. Oleh itu, antena yang mempunyai gandaan yang lebih tinggi dan saiz yang lebih kecil diperlukan untuk membina sistem ini. Selain itu, prestasi antena polarisasi pekeliling adalah lebih baik berbanding dengan antena polarisasi linear kerana ia boleh menerima gelombang dari semua arah. Dalam projek ini, antena reflectarray dilipat yang mempunyai polarisasi pekeliling dan frekuensi 28GHz telah dikaji. Projek ini dibahagikan kepada dua bahagian. Di bahagian pertama, antena reflectarray dilipat yang mempunyai polarisasi linear telah direka. Di bahagian kedua projek ini, polarizer telah digunakan untuk menukar antena polarisasi linear kepada antena polarisasi pekeliling. Antena diberi dengan gelombang polarisasi linear. Setiap elemen radiasi antena adalah dalam bentuk segi empat tepat. Saiz elemen radiasi dipilih berdasarkan kelewatan fasa yang diperlukan untuk membentuk fasa planar di jarak jauh. Kedua-dua antena telah disimulasikan dengan menggunakan perisian CST. Jalur lebar untuk antena reflectarray dilipat yang mempunyai polarisasi pekeliling ialah 6.5 GHz. Manakala, directivity untuk antenna ini adalah 19.4 dBi. Antenna ini sesuai untuk aplikasi 5G.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

4G	-	Fourth-generation
5G	-	Fifth-generation
ITU	-	International Telecommunication Union
RF	-	Radio frequency
BW	-	Bandwidth
PEC	-	Perfect electric conductor
PMC	-	Perfect magnetic conductor
CST MWSF	-	Computer Simulation Technology Microwave Studio
HPBW	-	Half power beam width
WR	-	Waveguide
PEC	-	Patch-excited cup
FR-4	-	Fire retardant type 4
GHz	-	Giga Hertz
dB	-	Decibel
dBi	-	Decibel isotropy
mm	-	Millimeter
bps	-	Bit per second

LIST OF SYMBOLS

λ_0	-	Wavelength of the operating frequency
ε_r	-	Dielectric constant
π	-	Radial measure
ϕ_{inc}	-	Incident wave phase
ϕ_{ref}	-	Antenna phase
ϕ_{pol_grid}	-	Linear polarizing grid phase
$\phi_{primary\_source}$	-	Primary source phase
$\phi_{array\_element}$	-	Reflected phase of each array element
E	-	Electric field
H	-	Magnetic field
S_{11}	-	Return loss

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Fifth-generation (5G) wireless communication is expected to release by year 2020. As compared to the current generation of wireless communication, 5G wireless communication has significant improvement in term of the system performances. According to International Telecommunication Union (ITU), 5G wireless communication should be able to provide latency on millisecond level, traffic volume density of 10 Tbps/km^2, connection density of 1 million per square kilometer and so on [1]. Therefore, a suitable antenna with high gain, operating frequency and bandwidth is required in order to provide these services.

An antenna is a metallic device which used for radiating and receiving radio waves. In other word, the antenna is the interface between free-space and a guiding device. There are two types of antenna, which are transmitting antenna and receiving antenna. A transmitting antenna converts electric current to electromagnetic wave (radio wave) and propagates the electromagnetic wave in free-space, while a receiving antenna performs the reverse processes of the transmitting antenna. Figure 1.1 shows the antenna as a transition device [2].

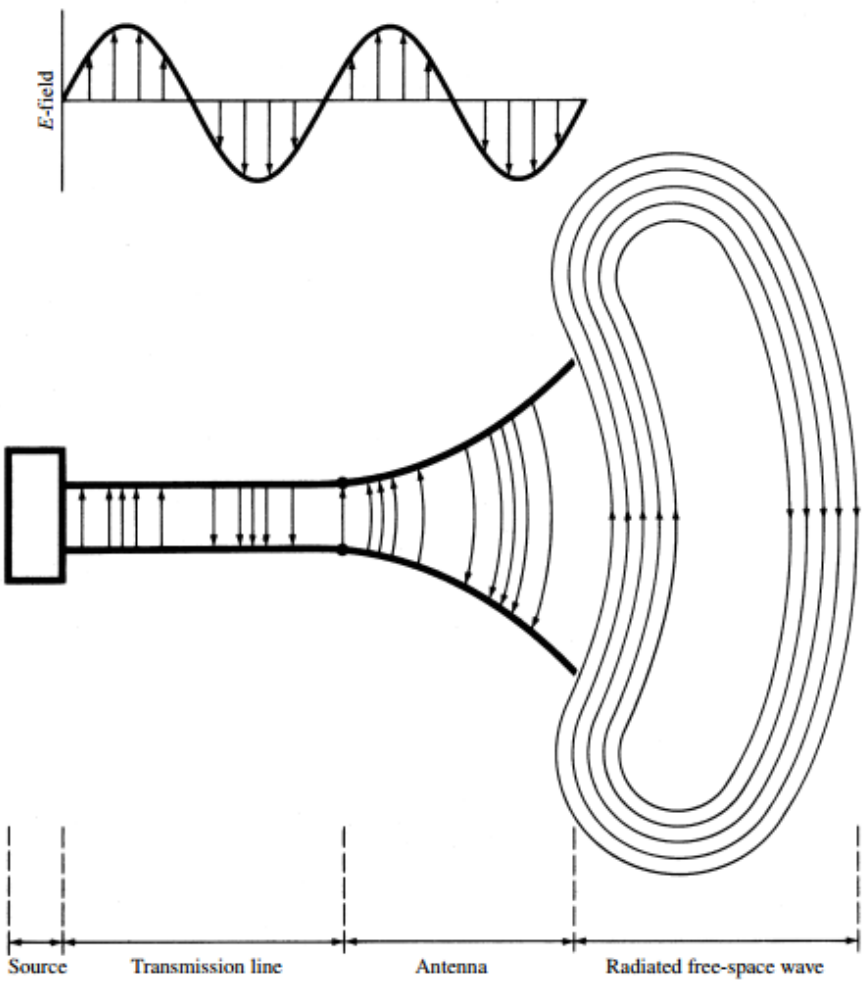

Figure 1.1: Antenna as a transition device [2]

There are various types of antenna, such as wire antennas, aperture antennas, microstrip antennas, array antennas, reflector antennas, lens antennas and so on. These antennas are used in different applications according to their characteristics and properties [2]. A reflectarray antenna is a class of antennas that combines some of the advantages of reflector and of array antennas. The reflectarray antenna utilizes an array of radiating elements to provide a focused and shaped beam without using a complex corporate feed system. Therefore, the reflectarray antenna have higher gain, lower profile, lower mass and lower cost as compared to reflector and array antennas [3-5].

In this project, a circular polarization folded reflectarray antenna with operating frequency of 28 GHz is studied and designed. 28 GHz is one of the frequencies announced by ITU for 5G wireless communication. The folded reflectarray antenna is a more compact antenna compared to the reflectarray antenna

due to its reduced height [6]. Figure 1.2 shows the side view of a folded reflectarray antenna. From Figure 1.2, the folded reflectarray antenna consists of three main components, which are a primary source, a linear polarizing grid and a twist reflectarray reflector.

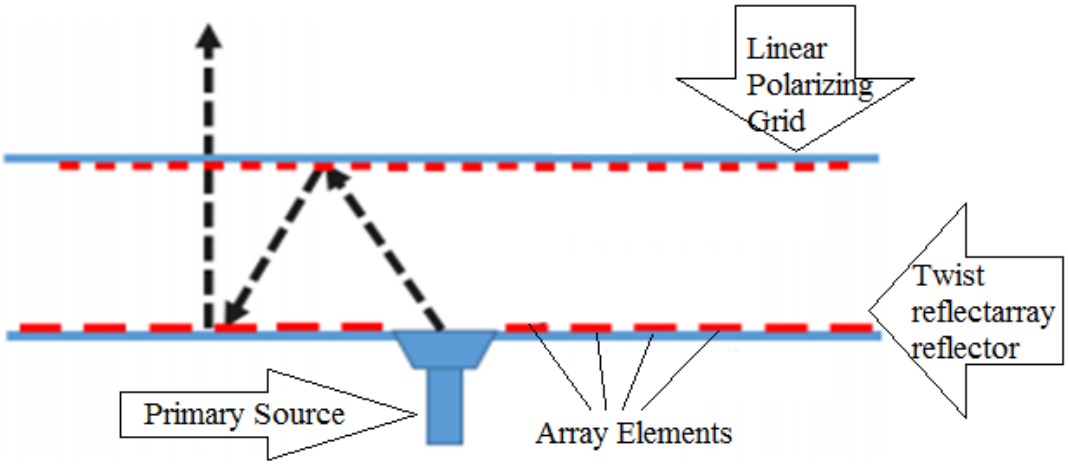

Figure 1.2: The side view of a folded reflectarray antenna [7]

1.2 Problem Statement

5G wireless communication technology has operating frequency range of 20 GHz to 80 GHz [8]. A system working on 5G band can provide higher bandwidth and faster data rate as compared to fourth-generation (4G) band. Therefore, the antenna used in 5G applications should have high gain and low profile to guarantee the performance of the systems. In this case, a circular polarization folded reflectarray antenna that can offer bigger bandwidth and higher gain compared to reflector and array antennas is purposed. The proposed antenna has reduced block effect and lower profile compared to reflectarray antenna. On the other hand, circular polarization antenna has some advantages over linear polarization antenna. For instance, the circular polarization antenna is independent of the direction of wave and it has lower rain attenuation than linear polarization antenna.

1.3 Objectives

The objective of the project is as follow:

1. To design a linear polarization folded reflectarray antenna.
2. To convert a linear polarization folded reflectarray antenna to circular polarization using meander line polarizer.

1.4 Scope of Work

The scope of this project includes:

1. To simulate a waveguide with operating frequency of 28 GHz.
2. To design and simulate a linear polarizing grid.
3. To design and simulate unit cells with different reflected phase.
4. To combine all together into a linear polarization folded reflectarray antenna.
5. To design and simulate a meander lines polarizer.
6. To convert the folded reflectarray antenna from linear to circular polarization using meander lines polarizer.
7. To analyse the performances of the both antennas.

1.5 Organization of the Project

This project consists five chapters. In Chapter 1, an introduction to the work is presented and the project background is discussed. This is followed by the problem statement, objectives and the scope of work. In Chapter 2, a review on the recent works related to the wireless communication system and the folded reflectarray antenna are given so as to obtain a clear direction of the project. In Chapter 3, a methodology on how the project is carried out is presented, where all the design specifications are highlighted. In Chapter 4, all the simulation results of the folded reflectarray antenna by using CST software are analysed and discussed. In Chapter 5,

conclusions are drawn from the entire project and recommendations based on how the project can be improved are stated.

1.6 Summary

Overviews of 5G wireless communication system and folded reflectarray antenna were presented in this chapter. Besides, the problem statement, objectives and scope of works of this project were highlighted. The direction of the project was clearly stated in this chapter.

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