

CIRCULAR POLARIZATION FOLDED REFLECTARRAY
ANTENNA FOR 5G APPLICATIONS

LIM JIT MIN

UNIVERSITI TEKNOLOGI MALAYSIA

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LIM JIT MIN

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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

| CHAPTER | TITLE | PAGE |
|----------|---------------------------------|-------------|
| | DECLARATION | ii |
| | DEDICATION | iii |
| | ACKNOWLEDGEMENT | iv |
| | ABSTRACT | v |
| | ABSTRAK | vi |
| | TABLE OF CONTENTS | vii |
| | LIST OF TABLES | x |
| | LIST OF FIGURES | xi |
| | LIST OF ABBREVIATIONS | xv |
| | LIST OF SYMBOLS | xvi |
| | LIST OF APPENDICES | xvii |
| 1 | INTRODUCTION | |
| | 1.1 Introduction | 1 |
| | 1.2 Problem Statement | 3 |
| | 1.3 Objectives | 4 |
| | 1.4 Scope of Work | 4 |
| | 1.5 Organization of the Project | 4 |
| | 1.6 Summary | 5 |

| | | |
|----------|---|----|
| 2 | LITERATURE REVIEW | |
| | 2.1 Introduction | 6 |
| | 2.2 5G Wireless Communication Technology | 6 |
| | 2.3 Folded Reflectarray Antenna | 8 |
| | 2.3.1 Basic Principle of Folded Reflectarray Antenna | 8 |
| | 2.3.2 Primary Source | 10 |
| | 2.3.3 Linear Polarizing Grid | 11 |
| | 2.3.4 Twist Reflectarray Reflector | 12 |
| | 2.4 Meander lines Polarizer | 15 |
| | 2.5 Summary | 17 |
| 3 | METHODOLOGY | |
| | 3.1 Introduction | 19 |
| | 3.2 Design Procedure | 19 |
| | 3.3 Design specification | 21 |
| | 3.4 Primary source design | 21 |
| | 3.5 Linear Polarizing Grid Design | 22 |
| | 3.6 Twist Reflectarray Reflector | 25 |
| | 3.7 Linear Polarization Folded Reflectarray Antenna | 29 |
| | 3.8 Meander Lines Polarizer | 30 |
| | 3.9 Circular Polarization Folded Reflectarray Antenna | 33 |
| | 3.10 Gantt Chart | 34 |
| | 3.11 Summary | 35 |
| 4 | RESULT AND DISCUSSION | |
| | 4.1 Introduction | 36 |
| | 4.2 Primary Source | 36 |

| | | |
|----------|---|-------|
| 4.3 | Linear Polarizing Grid | 39 |
| 4.4 | Twist Reflectarray Reflector | 40 |
| 4.5 | Linear Polarization Folded Reflectarray Antenna | 41 |
| 4.6 | Meander Lines Polarizer | 44 |
| 4.7 | Circular Polarization Folded Reflectarray Antenna | 47 |
| 4.8 | Summary | 51 |
| 5 | CONCLUSION AND RECOMMENDATION | |
| 5.1 | Conclusion | 52 |
| 5.2 | Future Works | 53 |
| | REFERENCES | 54 |
| | Appendices A-C | 57-63 |

LIST OF TABLES

| TABLE NO. | TITLE | PAGE |
|------------------|--|-------------|
| 2.1 | Summary of previous works on folded reflectarray antenna | 17 |
| 3.1 | Design specification of folded reflectarray antenna | 21 |
| 3.2 | Technical specification of WR-34 waveguide | 22 |
| 3.3 | Design specification of linear polarizing grid | 23 |
| 3.4 | Design specification of linear polarizing grid | 25 |
| 3.5 | The required phase delay for the 11x11 array elements at 28 GHz | 28 |
| 3.6 | The dimension for the 11x11 array elements at 28 GHz | 29 |
| 3.7 | Design specification of the meander lines polarizer | 30 |
| 3.8 | Parameters of the meander lines polarizer | 31 |
| 3.9 | Gantt chart of master project 1 | 34 |
| 3.10 | Gantt chart of master project 2 | 35 |
| 5.1 | Summary of the linear polarization and circular polarization folded reflectarray antenna at 28 GHz | 53 |

LIST OF FIGURES

| FIGURE NO. | TITLE | PAGE |
|-------------------|--|-------------|
| 1.1 | Antenna as a transition device | 2 |
| 1.2 | The side view of a folded reflectarray antenna | 3 |
| 2.1 | Evolution of wireless communication technology from 1G to 5G | 7 |
| 2.2 | Service requirements and enabling technologies for 5G wireless communication technology | 8 |
| 2.3 | Combination of (a) reflector antenna and (b) array antenna which produces (c) reflectarray antenna | 9 |
| 2.4 | The configuration of a folded reflectarray antenna | 9 |
| 2.5 | The linear polarizing grid showing (left) key parameters, and (right) a perpendicularly polarized incident field for transmission and a parallel-polarized incident field for reflection | 12 |
| 2.6 | Various array elements, (a) identical patches with variable length phase delay lines, (b) variable-size dipoles or loops, (c) variable-size patches, (d) variable angular rotations | 13 |
| 2.7 | Example of reflection phase angle of periodic arrangement of printed patches as a function of length and width | 14 |

| | | |
|------|--|----|
| 2.8 | Single cell/patch and vector decomposition of incident and reflected electric field for 180 °of phase difference | 14 |
| 2.9 | Working principle of meander lines polarizer | 16 |
| 3.1 | Flow chart | 20 |
| 3.2 | Simulation model of WR-34 waveguide | 22 |
| 3.3 | The (a) front view and the (b) side view of the linear polarizing grid | 24 |
| 3.4 | Simulation model of polarizing grid unit cell | 24 |
| 3.5 | Boundary conditions of (a) parallel e-field and (b) perpendicular e-field | 25 |
| 3.6 | The (a) front view and the (b) side view of the twist reflectarray reflector | 26 |
| 3.7 | Simulation model of array element | 27 |
| 3.8 | Boundary condition of array element | 27 |
| 3.9 | The linear polarization folded reflectarray antenna | 30 |
| 3.10 | The configuration of the meander lines polarizer | 31 |
| 3.11 | The (a) top view and the (b) side view of the meander lines polarizer | 32 |
| 3.12 | Simulation model of meander lines polarizer unit cell | 33 |
| 3.13 | Boundary conditions of (a) E_x and (b) E_y | 33 |
| 3.14 | The circular polarization folded reflectarray antenna | 34 |
| 4.1 | Return loss of the opened-ended rectangular waveguide | 37 |
| 4.2 | Directivity of rectangular waveguide (E-plane) | 37 |
| 4.3 | Directivity of rectangular waveguide (H-plane) | 38 |

| | | |
|------|---|----|
| 4.4 | Maximum gain of the rectangular waveguide over frequency | 38 |
| 4.5 | Simulation result of s-parameter (in magnitude) of linear polarizing grid for parallel e-field | 39 |
| 4.6 | Simulation result of s-parameter (in phase) of linear polarizing grid for parallel e-field | 39 |
| 4.7 | Simulation result of s-parameter (in magnitude) of linear polarizing grid for perpendicular e-field | 40 |
| 4.8 | Simulation result of s-parameter (in phase) of linear polarizing grid for perpendicular e-field | 40 |
| 4.9 | The reflection phase angle as a function of the patches length and width | 41 |
| 4.10 | The return loss of the linear polarization folded reflectarray antenna | 42 |
| 4.11 | The radiation patterns of the linear polarization folded reflectarray antenna | 43 |
| 4.12 | The 3-dimension radiation pattern of the linear polarization folded reflectarray antenna at 28 GHz | 43 |
| 4.13 | Simulation result of s-parameter (in magnitude) of the unit cell of meander lines polarizer for E_y | 44 |
| 4.14 | Simulation result of s-parameter (in magnitude) of the unit cell of meander lines polarizer for E_x | 45 |
| 4.15 | Simulation result of s-parameter (in phase) of the unit cell of meander lines polarizer for E_y | 45 |
| 4.16 | Simulation result of s-parameter (in phase) of the unit cell of meander lines polarizer for E_x | 46 |
| 4.17 | The return loss of the circular polarization folded reflectarray antenna | 47 |

| | | |
|------|---|----|
| 4.18 | The radiation patterns of the circular polarization folded reflectarray antenna | 48 |
| 4.19 | The 3-dimension radiation pattern of the circular polarization folded reflectarray antenna at 28 GHz | 48 |
| 4.20 | The axial ratio of circular polarization folded reflectarray antenna versus frequency with variable h | 50 |
| 4.21 | The axial ratio of circular polarization folded reflectarray antenna versus theta with $h = 5.855$ mm | 50 |

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

| APPENDIX | TITLE | PAGE |
|-----------------|--|-------------|
| A | Rectangular waveguide datasheet | 57 |
| B | Table of reflection phase angle of array element with different size | 58 |
| C | MATLAB code to identify the dimensions of the array elements | 59 |

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/km², 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].

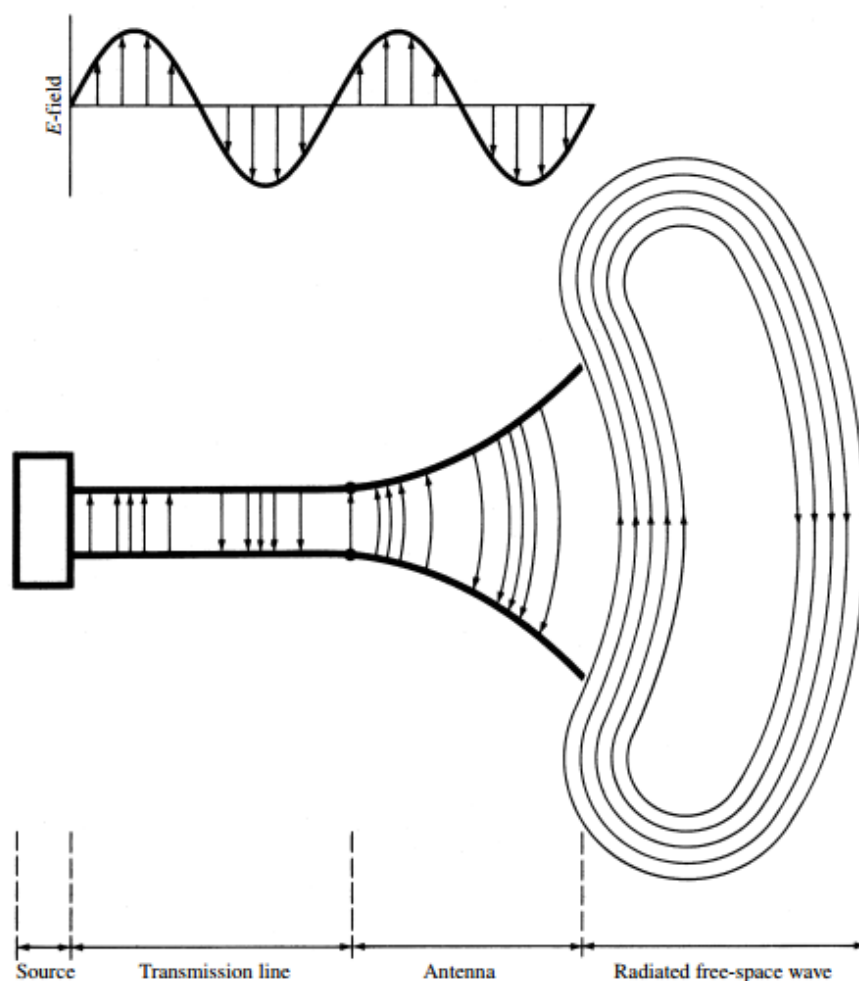


Figure 1.1: Antenna as a transition device [2]

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.

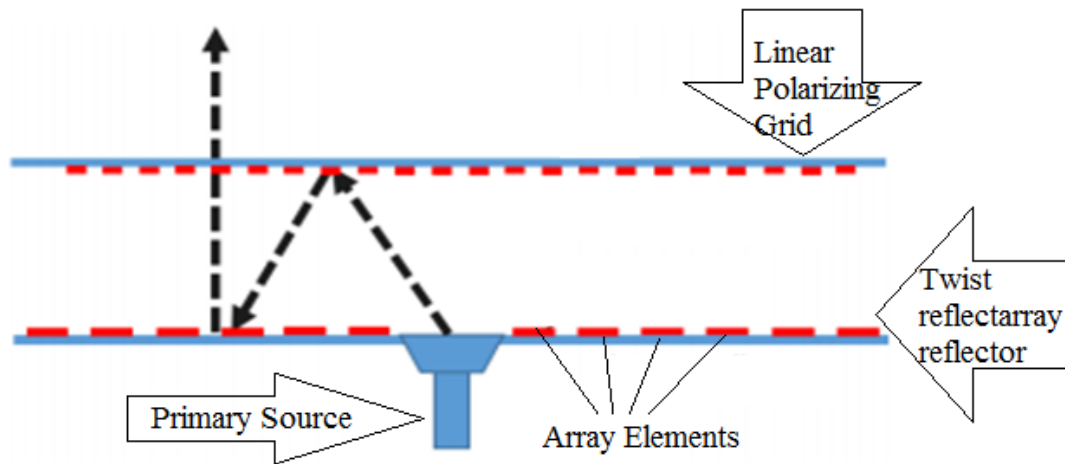


Figure 1.2: The side view of a folded reflectarray antenna [7]

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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