INVESTIGATION OF RADIAL LINE SLOT ARRAY (RLSA) ANTENNA WITH BEAM STEERING SYSTEM

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

Dedicated to my late father, Mahmud bin Ali, to my beloved mother, Faudziyah binti Zainal, to my late sister Noorashikin binti Azlan, to my family and friends for always being there to support and pray for me

ABSTRACT

Nowadays, the evolution of wireless technologies with high speed and fast connectivity are really needed. Hence, the fifth generation (5G) applications were built to fulfil the demand from the users which are currently towards businesses and technologies area. The high speed of data transmission with bigger bandwidth and high directivity enables an experience by the user at a distance away from the antenna with high efficiency that reduce the losses of the signal. A beam steering radial line slot array (RLSA) antenna is proposed in this thesis as it has reconfigurable feeders to feed the signal into the radiating surface and perform the configurability of the beam steering antenna. The centre frequency of 28 GHz was chosen because it is in the range of Ka band frequency based on IEEE standards which are from 26.50 GHz to 40.00 GHz for 5G mobile communication system. The RLSA antenna has good characteristics such as reduces the cost of production, low profile, ease of installation and simple structure. Besides that, this type of antenna also produces smaller side lobe level in terms of production of signal and radiation with high directivity and gain. This investigation is conducted to see how the radiation pattern will change due to the position and number of the feeder. In this design the antenna will have three feeders at the centre of the antenna. The Computer Simulator Technology (CST) Microwave Studio has be used as an antenna simulator to simulate with carrying out the results. The investigation will be concerning on the gain, return loss and beam directivity improvement.

ABSTRAK

Pada masa kini, evolusi teknologi tanpa wayar dengan kelajuan tinggi dan sambungan cepat sangat diperlukan. Oleh itu, aplikasi generasi kelima (5G) telah dibina untuk memenuhi permintaan pengguna yang pada masa ini ke arah bidang perniagaan dan teknologi. Kelajuan tinggi penghantaran data dengan jalur lebar yang lebih besar, berkearahan tinggi dapat diperoleh oleh pengguna jika berada jauh dari antena dan kecekapan tinggi untuk mengurangkan kerugian isyarat. Antena 'Radial Line Slot Array' (RLSA) yang dicadangkan di dalam tesis ini kerana mempunyai penyuap yang boleh dikonfigurasikan untuk menyuap isyarat kepada permukaan radiasi dan melaksanakan konfigurasi arah radiasi. Frekuensi pusat 28 GHz yang dipilih kerana ia berada dalam pelbagai frekuensi Ka-band berdasarkan piawaian IEEE yang dari 26.50 GHz hingga 40.00 GHz untuk sistem komunikasi mudah alih 5G. Antena RLSA mempunyai ciri-ciri yang baik seperti mengurangkan kos pengeluaran, profil terselindung, kemudahan pemasangan dan struktur mudah. Selain itu, antena jenis ini juga menghasilkan tahap lebar alur sisi yang lebih kecil pada isyarat sinaran dengan kearahan yang tinggi. Kajian ini dijalankan untuk melihat bagaimana corak sinaran akan berubah bergantung pada kedudukan dan bilangan penyuap. Dalam reka bentuk ini antena akan mempunyai tiga penyuap di bahagian tengah antena. 'Computer Simulator Technology (CST) Microwave Studio' telah digunakan sebagai simulator untuk melakukan simulasi bagi mendapatkan keputusan. Kajian ini memberi tumpuan kepada peningkatan gandaan, kehilangan balikan dan peningkatan kearahan.

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LIST OF SYMBOLS AND ABBREVIATIONS

CST	:	Computer Simulation Technology
GHz	:	Giga Hertz
IEEE	:	Institute of Electrical and Electronics Engineers
MCMC	:	Malaysian Communication and Multimedia Commission
MHz	:	Mega Hertz
RLSA	:	Radial Line Slot Array
UTeM	:	Universiti Teknikal Malaysia, Melaka
WLAN	:	Wireless Local Area Network

CHAPTER 1

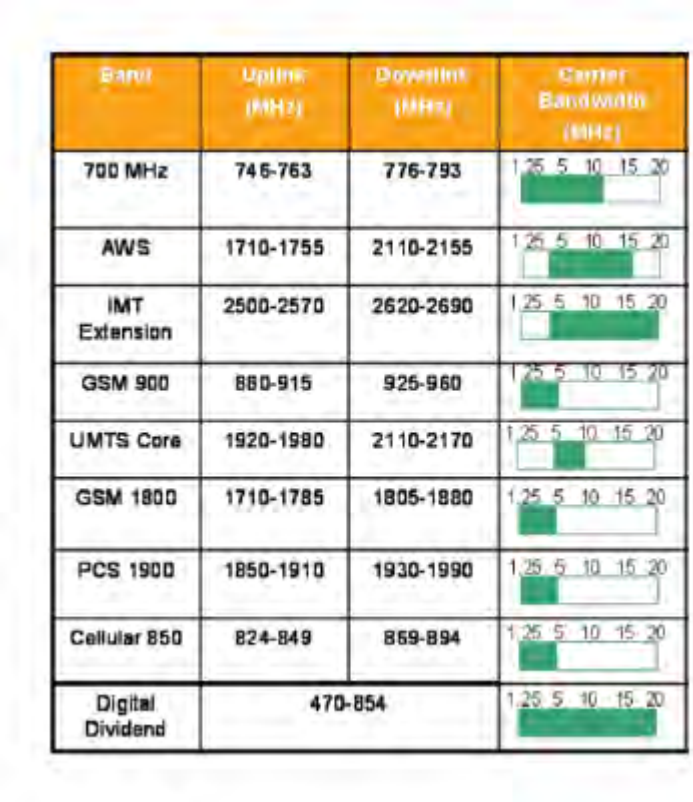
INTRODUCTION

1.1 Project Background

In this age of advance technology, most of us depend on our mobile phones for constant telecommunication hence the increasing demand for faster internet/network speed. This shows why in just the past year, preliminary interest and discussions about a possible fifth generation (5G) standard have evolved into a full-fledged conversation that has captured the attention and imagination of researchers and engineers around the world.

As today's cellular providers attempt to deliver high quality, low latency video and multimedia application for wireless devices, they are limited to a carrier frequency spectrum ranging between 700 MHz and 2.6 GHz. As shown in Table 1, the global spectrum bandwidth allocation for all cellular technologies does not exceed 780 MHz,

where each major wireless provider has approximately 200 MHz across all the different cellular bands of spectrum available to them [1][1].



Band	Uplink (MHz)	Downlink (MHz)	Carrier Bandwidth (MHz)
700 MHz	746-763	776-793	1.25 5 10 15 20
AWS	1710-1755	2110-2155	1.25 5 10 15 20
IMT Extension	2500-2570	2620-2690	1.25 5 10 15 20
GSM 900	880-915	925-960	1.25 5 10 15 20
UMTS Core	1920-1980	2110-2170	1.25 5 10 15 20
GSM 1800	1710-1785	1805-1880	1.25 5 10 15 20
PCS 1900	1850-1910	1930-1990	1.25 5 10 15 20
Cellular 850	824-849	869-894	1.25 5 10 15 20
Digital Dividend	470-854		1.25 5 10 15 20

Figure 1.1 Current 2G, 3G, 4G, & LTE-A Spectrum & Bandwidth Allocation [1]

5G is currently a new wireless technology in communication networks that consists of first generation (1G), second generation (2G), third generation (3G) and fourth generation (4G). 5G is still to be defined officially by standardization bodies. According to Jonathan Rodriguez [2], it will be a system of super high capacity and ultra-high-speed data with new design requirements tailored towards energy elicited systems and reduced operational expenditure for operators. In this context, 5G envisages not only one invented technology, but a technology ecosystem of wireless networks working in synergy to provide a seamless communication medium to the end

user. Thus, we can say that moving from 4G to 5G means a shift in design paradigm from a single discipline system to a multi discipline system.

The 5G mobile communications systems was invented to provide wide bandwidth that can use new frequency band to avoid the overflow of traffic volume[3]. In the frequency range of 10.00 GHz – 40.00 GHz, mm Wave band was used for Giga Korea (GK-5G) mobile communication system. The patch array antenna was used for mm Wave band for GK-5G because it can withstand large path loss result from multi-beams.

The Quality of Services (QoS), energy efficiency, data rate, latency and capacity were defined all needs for 5G wireless communication systems. Increasing number of users will affected the data roaming and it makes the interruption, so used high frequency to get wider bandwidth with many frequency band insides. Concepts 5G emerging common features evolving for future.

1.2 Problem Statement

The 5G applications were built to fulfil the demand from the users which nowadays are leaning towards business and technology areas. The high speed of data transmission with bigger bandwidth, high directivity and high efficiency can be received by the user even from a distance away from the antenna. Furthermore, high efficiency data transmissions are capable to reduce the losses of the signal. The Radial Line Slot Array (RLSA) antenna has good characteristics such as reduces the cost of production, low profile, ease of installation and simple structure. Moreover, this type of antenna also produces smaller side lobe level in terms of production of signal and radiation with high directivity and gain. Most RLSA antenna uses one feed in the

middle hence resulting in a quite bulky radiation peak. Beam steering radial line slot arrays is applied to overcome this problem. Beam steering is about changing the direction of the main lobe of a radiation pattern. In radio systems, beam steering may be accomplished by switching the antenna elements or by changing the relative phases of the RF signals driving the elements

1.3 Objective

The purpose of this project is to design and develop a beam steering of Radial Line Slot Array (RLSA) Antenna at 28.00 GHz as the following:

i. To design an RLSA beam steering antenna with more than one feeder
ii. To compare whether the position of the feeder will affect the performance of the antenna
iii. To simulate variations of active feed ports at a time

1.4 Antenna Design Specification

Referring to the literature review in the chapter 2, the specification references in Table 1.1 are obtained. This specification will be the main references that must be followed to develop the prototype of the antenna.

Table 1.1 Antenna Parameter

Parameter	Value
Centre Frequency	28.00 GHz
Cavity Thickness	2.500 mm and 3.200 mm
Radius of Antenna	100.000 mm
No of Slots	172
Thickness of radiating surface (copper)	0.035 mm
Thickness of ground (copper)	0.035 mm
Relative Permittivity of RT DUROID 5880	2.2
Relative Permittivity of Air Gap	1.0

1.5 Scope of Project

This final year project is started with the literature review to make sure that the overview of this project title is clearly understood. It is focused on the investigation of radial line slot array (RLSA) antenna with beam steering system to meet the desired performance that can be used at 28 GHz for 5G communication.

The research is focused about the beam steering technique. The antenna efficiency, radiation pattern, gain and side lobes need to be studied first for array slot antenna. There are several advantages of the radial line slot array by placing on the FR-4 board or RT DUROID 5880. That is why the literature review is very important element before started to design and develops the antenna.

For simulation part, CST 2016 software will be used to design the RLSA antenna. Antenna design will be the accurate an efficient computational with using CST software by providing varieties tools, shapes etc. insides the software. When starting to design the antenna, need to obtain the frequency resonance or center frequency of 28 GHz and the range of bandwidth that need to arrange depends of the frequency that used which is from 23 GHz to 33 GHz

1.6 Project Planning

The project begins with the study of literature review which are associated to the project title that chosen. The research is about investigation and experiment of beam steering radial line slot array (RLSA) antenna at 28 GHz. The comparisons between the various types of antenna and beam steering antenna have been made with RLSA. The design specification and parameter of the antenna was obtained from the research had been done. Then, design and developed the RLSA antenna using CST 2016 software. The results will then be compared to a basic RLSA antenna at 28GHz and other beam steering antenna at different frequencies. The fabrication process of the antenna can be done when all the specification meets the requirement. Lastly, the result between the simulation and measurement of the antenna is compared. All the experimental results are included in this thesis report.

1.7 Organization Report

There are five (5) chapters in this project and the outline as the following:

Chapter 1 consist of the introduction part which acquires the project background, the problem statement, and the goals of this project and the scope of this project.

Chapter 2 consists of literature review of the projects discussed about the particular title of the project that was completed by past researchers which is identified to the title of the project.

Chapter 3 consists of methodology part that discusses on how the project flows, how the design and simulation is done by using CST Microwave Studio as well as how the antenna will be fabricated.

Chapter 4 will consist of results and discussion obtained based on the objectives of this project. The results in terms of gain or efficiency and directivity for Radial Line Slot Array will also be discussed.

Chapter 5 will consist of explanation regarding the conclusion and recommendation for future work.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

In this chapter, the work from other researchers that are related to the design and development of this project which is "Investigation and Experiment of Beam Steering Radial Line Slot Array Antenna at 28.00 GHz" has been explained. Only the very few important researches are explained in detail. The success of this project is achieved by continuously referring to other projects and doing the literature review. By doing comparison between other RLSA and other beam steering antenna developed at different frequencies.

2.2 2.2 Antenna Parameter

To describe the execution of an antenna definitions of various parameters are vital. Antenna characteristics which should follow to certain requirements might be