A STUDY ON THE RADIAL SLOT LINE ARRAY ANTENNA WITH EBG STRUCTURE AT 28 GHZ

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering (Telecommunication Electronics) with Honours

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Date : 2nd June 2017

DEDICATION

I dedicate this research work to my beloved parent, Mat Nor bin Mat Din and Robiha binti Abu Bakar who always giving me supports both mentally and financially. To my supervisor, Dr. Imran bin Mohd Ibrahim who has taught and guided me throughout this whole year with patient and to all my friends who has been with me during this journey. Thank you.

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ABSTRACT

Nowadays, people around the world are excited with the technology evolution that keep move in the fast speed throughout the years. The birth of the 5G or the fifth generation are the most anticipated because of the advantages that it will offer. That is why this project is focus on the 28 GHz which is in the frequency range of the 5G based on the IEEE standard which are from 26.50 GHz to 40.00 GHz mobile communication system for the Radial Slot Line Array Antenna (RLSA). RLSA antenna is known based on its characteristic which is has high gain, durable, simple structure and high efficiency. This project is focus on the study of the RLSA antenna with the EBG structure at the 28 GHz and to analyze the effect of EBG structure on the RLSA antenna. The designing process is using the Computer Simulator Technology (CST) Microwave Studio Software for the simulation of the design. Based on the result, the parameter of the antenna being analyzed to known the suitability of the EBG structure with the RLSA antenna. The parameters that being study is the loops, gain, directivity, return loss and efficiency of the antenna. This study also can prove the suitability of the design to operate on the 5G mobile communication system.

ABSTRAK

Pada zaman sekarang ini, masyarakat di seluruh dunia sedang teruja dengan evolusi teknologi yang sedang bergerak pantas dari masa ke semasa mengikut peredaran zaman. Kewujudan 5G atau generasi kelima amat dinanti-nantikan kerana kelebihan yang ditawarkan oleh generasi tersebut. Projek ini menekankan pada frekuensi 28GHz dimana ia adalah didalam lingkungan julat frekuensi 5G berdasarkan standard IEEE yang bermula dari 26.50 GHz sehingga 40.00 GHz berdasarkan sistem komunikasi mudah alih untuk Radial Slot Line Array Antenna (RLSA). RLSA antena terkenal dengan sifatnya yang mempunyai keuntungan yang tinggi, tahan lama, struktur yang mudah dan kecekapan yang tinggi. Selain itu, projek ini juga mengfokus pada kajian antena RLSA dengan struktur EBG di 28 GHz dan juga bertujuan untuk menganalisis kesan struktur EBG pada antena RLSA. Proses mereka bentuk antena ini adalah dengan menggunakan Simulator Teknologi Komputer (CST) Microwave Software Studio. Berdasarkan kepada keputusanyang dikumpulkan, parameter antena yang diperolehi akan dianalisis untuk mengetahui kesesuaian struktur EBG dengan antena RLSA. Antara parameter yang menjadi kajian adalah gain, keuntungan, directivity, kehilangan pulangan dan kecekapan antena. Kajian ini juga dapat membuktikan kesesuaian reka bentuk untuk beroperasi pada sistem komunikasi mudah alih 5G.

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EBG	-	Electromagnetic Band Gap
RLSA	-	Radial Line Slot Array Antenna

CHAPTER 1

INTRODUCTION

1.1 Project Background

Antenna is a device that convert the radio frequency (RF) to the alternative current (AC). Antenna is an electromagnetic radiator that create electromagnetic field that proceed out from the transmitting antenna to the receiving antenna which convert the electromagnetic wave into the electric signal [1]. Antenna also can be classified into several types which is Omni-directional antenna that propagate to all direction, Semi-directional antenna that defied by specific angle and Hi-Directional antenna that have narrow beam that allow highly directional propagation. Radial Line Slot Array Antenna or known as RLSA is one of the example under the categories of Hi-Directional Antenna. RLSA are attractive antenna solutions thanks to their compactness, planetary and high efficiency. In Malaysia, the research about RLSA antenna is more focus on the latest application possible on RLSA and on simplifying the design and fabrication process and reducing the antenna size but maintaining the directivity of the characteristic [2]. According to Mohd Faizal Jamlos in his journal about A Reconfiguration Radial Line Slot Antenna for WiMAX application, for high gain purpose, a radial line slot array (RLSA)

antenna design is more beneficial and an RLSA antenna has as much as 50% higher gain than the conventional micro-strip antenna [3].

In addition, the Electromagnetic Band Gap or EBG structure in the antenna has been a new research direction in the community. It is usually being used to improve the gain of the antenna. The EBG structure are being divided into three categories according to their geometric configuration which is three dimensional volumetric structures, two dimensional planar surfaces and one dimensional transmission lines [4]. The main feature of EBG structures is their capability to affect the radiative dynamics within the structure so that there are no electromagnetic modes available within the dielectric. This feature is analogous to periodically arranged atomic lattice of a semiconductor which gives rise to the allowed values of energy that an electron can have at the valence band and at the conduction band, with an energy band-gap separating the two [5].

Nowadays, the 5G has become more popular because the it is the foundation for a lot of new technology application. Besides, the state-of-the-art fourth generation (4G) mobile communication systems do not largely fulfill the technical requirement of the Textile Internet [6]. Based on journal written by Suresh Borkar and Himangi Pande (2016), Application of 5G Next Generation Network to Internet of Things, the IoT is a necessary for the upcoming service and application environment and require large capacity, big number of device nodes, wide range of bandwidth from narrow band to broadband and energy efficient designs [7]. The 5G also known as an enabler for IoT because of the destructive enhancement in the radio and antenna systems, spectrum, and network architecture. According to Jose Marco Camara Brito in his journal, Trends in Wireless Communications Towards 5G Networks – The Influence of E-health and IoT Applications, it stated that for 5G is at the beginning of the standardize process and the higher data rate are necessary [8].

1.2 Problem Statement

Nowadays, the technology is more advance so the design will be more related to the 5G application in the Telecommunication Industry. The characteristic of 5G which is high speed of data transmission, bigger bandwidth, high directivity is what the user will be looking for. Other factor for the antenna that support 5G technology is high efficiency to reduce the losses of the signal. The signal-layer radial line slot antenna (RLSA) is designed for receiving direct broadcast from satellites because high gain characteristic is needed. Besides, the way to enhance the antenna reading and reduce the loop are by using new substrate, which is EBG structure. Thus, this research can be used to find out whether the EBG structure suitable to increase the performance of the RLSA antenna.

1.3 Objectives

The purpose of this project is stated below,

a) To study the effect of the EBG structure to the Radial Line Slot Array antenna at 28GHz.

b) To analyze the design of EBG structure on the RLSA antenna at 28 GHz.

1.4 Scope of Project

There will be many research that will be done before the designing process can be start from the material, structure and the measurement. The designing process will be start by using the CST Software which is by using the simulation. This is because all the data need to be collected before the final decision to choose which material and substrate that will be used. Besides, the EBG structures usually are realized by the arrangement of

dielectric materials and metallic conductors periodically. The function of EBG in this project is to reduce the side loop and enhance the antenna reading. The analysis from the simulation will be collected to get the best result.

1.5 Organization of Report

There are five chapter in this project and the outline are as following:

Chapter 1, consist of the introduction part which are consist of project background, the problem statement, objectives and the scope of the project.

Chapter 2, consist of the literature review of the project which is discussed based on the project title that had been done by the previous researcher.

Chapter 3, consist of the methodology part that discussed about the flow of the project start with the design specification and the design process. The simulation of the design will be done in the CST Microwave Studio.

Chapter 4, consist of the result and the discussion that obtained from the simulation process based on the objective of the project. The results will be included the antenna parameters which is return loss, efficiency or gain and the directivity.

Chapter 5, consist of the conclusion of the project regarding the result and the discussion that had been done in the previous chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

From the past researcher, there is some explanation that can be related to the design and development of this project which is “Radial Line Slot Array antenna with EBG structure at 28.00 GHz”. This project is successfully developing by continuously finding the information for the literature review until the design of the antenna complete. Several comparisons with several types of the antenna had been developed at 28.00GHz.

2.2 5G Technology

5G is a short form for the fifth generation. The 5G is still in the development and it is still not open for any user. Various mobile company have done research about the 5G technology and its application as they can see the future market. The range for 5G technology is from 10GHz until 49GHz [9].

The 5G technology also has its own characteristic that according to Group Special Mobile Association (GSMA) [10] which is

- One to 10Gbps connection to end point in field
- One millisecond end-to-end round trip delay
- 1000x bandwidth per unit area
- 10 to 100x number of connected devices
- Perception of 99.999 percent availability
- Perception of 100 percent coverage
- 90 percent reduction in network energy usage
- Up to ten-year battery life for low power, machine-type devices

2.2.1 Previous Technology

The previous technology such as 1G, 2G, 3G and 4G are the generation that the lead to the creation of the 5G technology. The 1G or first generation is known as the analogue phone calls. The weakness of this generation is the poor spectral efficiency and the major security issues. Then, there is 2G or second generation. It provides digital phone calls and messaging. It is also more secure compare to the first generation. However, the

weakness of this generation is the limited data rates which makes it difficult to support demand for internet or the email [11].

For the 3G or third generation, the primary services that it provides are phone calls, messaging and data. The 3G has a better internet experience, but the real performance has failed to match the hype and it is a failure of the WAP for the internet access. After that the 3.5G had been develop which provides phone calls, messaging and broadband data services. However, during this generation, the weakness that shown is it tied to legacy, mobile specific architecture and protocols.

Nowadays, the world is using the 4G or the fourth generation. It is all IP services which including voice and messaging. Besides it has faster broadband internet and lower latency the weakness of this generation has not be listed as there is still no new generation that can overcome the 4G generation. The table below is the summary of the evolution of the technology generation [12].

Table 2.1: Evolution of technology generation [10]

Generation	Primary services	Key differentiator	Weakness (addressed by subsequent generation)
1G	Analogue phone calls	Mobility	Poor spectral efficiency, major security issues
2G	Digital phone calls and messaging	Secure, mass adoption	Limited data rates – difficult to support demand for internet/e-mail
3G	Phone calls, messaging, data	Better internet experience	Real performance failed to match hype, failure of WAP for internet access
3.5G	Phone calls, messaging, broadband data	Broadband internet, applications	Tied to legacy, mobile specific architecture and protocols
4G	All-IP services (including voice, messaging)	Faster broadband internet, lower latency	?

2.2.2 Advantages and Disadvantages of 5G

The 5G technology is still in the research and has not been used by anyone. Based on many research, the 5G for sure will be significantly faster than 4G. The expected download speed of the 5G is around 10,000Mbps and allowing for the higher productivity across all the capable devices [13]. Besides, it will have the ability to run more complex mobile internet apps compare to the 4G.

However, the production cost to implement 5G will be high and the newest mobile phones will probably have it integrated while the other handsets could be out of date to support the 5G technology. Despite that, the 5G technology is still the most wait technology in the nearest future [14].

2.3 Radial Line Slot Array Antenna

Radial Line Slot Array Antenna or RLSA antenna is a high efficiency plana array antenna. It is mainly being design to receive direct broadcast from the satellites. When this antenna being compare with another antenna, there is many advantages of the RLSA antenna that can be explored.

The design of RLSA antenna is most probably can produce three type of polarization. They are liner, elliptical and circular polarization. In the radiating plate on this antenna contain slots which produce the radiation pattern. The example design of this antenna is shown in figure below. The researcher usually design this antenna using CST Software and doing the parameter study on the air gap because it has effect on the antenna performance [15].

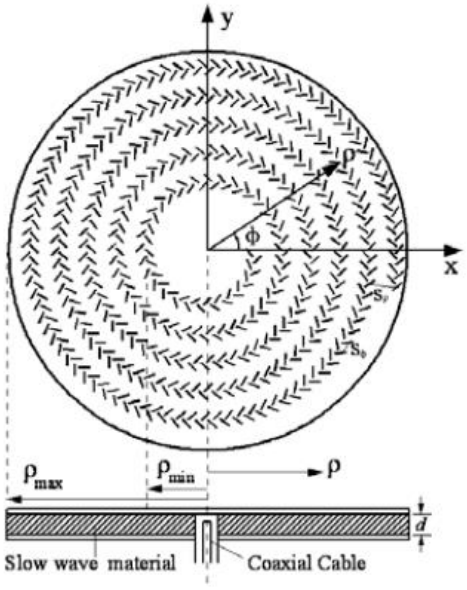

Figure 2.1: the structure of RLSA antenna

The RLSA antenna can be used to improve the return loss (S_{11}), achieve the low side lobes level and the high efficiency. However, the process to reduce the side lobe level