

MICROSTRIP ARRAY ANTENNA DESIGN WITH EBG STRUCTURE AT 28GHz

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I hereby declare this report entitle “ Microstrip Array Design with EBG Structure at 28GHz “
is my the result of my own research except cited in the reference

Signature : _____

Name of Author : _____

Date : _____

To my beloved parents,
Saadon Mat Saad and Wan Khairani Wan Muhammad.

To my talented supervisor ,
Dr Imran bin Mohd Ibrahim

And to my caring,
Friends and Siblings.

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I would like to thank Allah S.W.T who give me strength to complete my Final Year Project. Alhamdulillah with deepest gratitude and appreciation. To my beloved parents, Saadon bin Mad Saat and Wan Khairani binti Wan Muhammad who always support me , financially and morally , who always supply my needs and understand me.

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ABSTRACT

The emerging technology demands high speed data. 5G will provide unbelievable fast broadband speed and capacity to perform every function without drop in connection. The design of microstrip array antenna at 28GHz with EBG structure can meet the demand required by our next generations. The performance and advantages of microstrip patch antennas such as low weight , low profile and low cost made them a perfect choice for 5G application. The main objective of this research is to design the microstrip array antenna with electromagnetic band gap at 28GHz .However in arraying an antenna surface wave current and mutual coupling will naturally occur as one of electromagnetic phenomena between radiating element, which will degrade the gain and antenna performance. The focus of this project is about the Electromagnetic Band Gap (EBG) structure which is used to suppress the side lobe and increase the gain to enhance the antenna performance. The EBG structure is integrated with the microstrip array antenna in CST Simulation Tools. The type of EBG structure and the best arrangement and number of EBG structure integrated with microstrip array antenna were investigated. For the antenna array, the presence of EBG reduces the mutual coupling between two radiating elements. Thus, the final result should be more than 16.5 dB according to the standard ITU-R WP 5D which specify for 5G application.

ABSTRAK

Teknologi masa kini memerlukan data yang berkelajuan tinggi. Kini teknologi 5G menyediakan jalur lebar yang berfungsi sepenuhnya tanpa ada kegagalan dalam menghubungkan data. Reka bentuk mikrostrip antenna pada frekuensi 28GHz struktur EBG dapat memenuhi permintaan yang diperlukan oleh generasi terkini. Seterusnya, terdapat banyak kelebihan pada mikrostrip seperti struktur yang ringan, berprofil rendah dan berkos rendah sekali gus menjadikan mereka pilihan yang tepat untuk aplikasi 5G. Objektif utama projek ini adalah untuk menghasilkan antenna array mikrostrip yang diintegrasikan dengan struktur EBG.

. Walau bagaimanapun masih terdapat beberapa kelemahan pada mikrostrip antenna, contohnya masih terdapat “surface wave current” dan “mutual coupling” yang akan muncul sebagai fenomena asli elektromagnetik. Hal ini akan mengganggu prestasi antenna dan memberi batasan kepada peningkatan “gain”. Maka, untuk membaiki kelemahan ini, fokus projek ini adalah untuk mengenai struktur ‘Electronic Band Gap’ yang digabungkan dengan mikrostrip antenna dapat mengurangkan side lobe, dan menambah efisiensi dan meningkatkan prestasi antenna. Dalam projek ini, pelbagai struktur EBG telah dilaksanakan untuk menilai kesan akhir reka cipta EBG tertentu. Lokasi EBG diintegrasikan dengan mikrostrip antenna dan juga bilangan EBG yang diletakkan atas sesuatu antenna disiasat. Konklusinya, dapatan akhir projek ini adalah untuk menepati standard yang telah pun dikeluarkan oleh ITU-R WP5D bagi aplikasi 5G iaitu untuk memperoleh “gain” melebihi 16.5 dB.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Antenna is one of the important elements in our daily life. Antenna is one of the RF system for receiving or transmitting the radio wave signals from and into air as a medium. The signal will be not generated by the system as it will not received and transmit without the proper design of the design. Many types of antenna with various frequency has ben design to meet the applications that suitable for human needs.

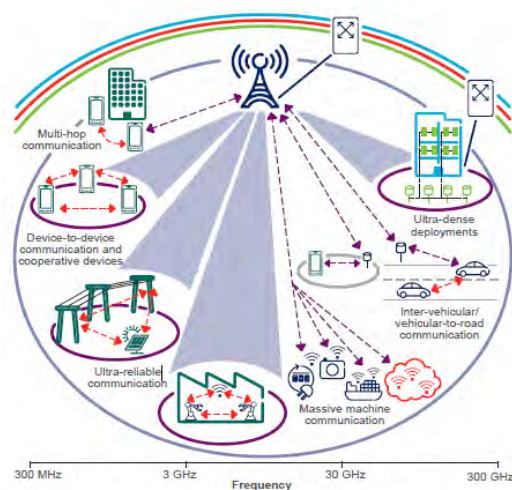


Figure 1.1 : Antenna application

The illustrations shows that the antenna with different frequency is used for many application such as a device to device communication and cooperative devices which can connect peoples. Other than that antenna is used for ultra-dense deployment, massive machine communication in industry and inter-vehicular to road communication. Antenna also had wide application in biomedical application. All this application consists of many types of frequency which controlled by the highest frequency of antenna. This is because the process of receiving and transmitting controlled by the high gain antenna.

1.1.1 History of 5G

5G is the name currently given to the next generation of the mobile data connectivity that will come after the generation of 4G. It will provide unbelievable fast broadband speed and more importantly it have the capacity to perform every function you want without drop in speed or connection no matter how many people connect it on the same time. Antenna has revolve from years to years from 1G to 5G. Description below will explain what is the properties of 1G until 5G.

- 1G was used for basic phone calls but was a very weak, insecure signal.
- 2G was a step up from 1G, adding digital phone calls and messaging, but too slow to manage Internet access in most cases.
- 3G offered messaging and data on top of 2G, bringing about a better mobile Internet experience. 3.5G enhances this further, bringing the standard to the level of low-end broadband Internet.
- 4G offered full IP services, with an even faster broadband connection with lower latency compared to previous generations. The peak speed of this standard is 1Gbps, which translates to between 1 Mbps and 10 Mbps for consumers.

- 5G's goal is to be the ultimate wireless experience with wireless speed from 10Mbps to 100Mbps and higher.

One of the main benefits of 5G over 4G is the latency. At present 4G is capable of between 40ms to 60ms, which is low in latency but not enough to provide real time response. For the example, in a multilayer gaming, requires a low latency to ensure that the remote server response instantly when we hit the button.

5G prospective ultra low latency could occur in the range of 1ms to 10ms. With this technology, a spectator in a football stadium can watch a live stream of an alternative camera angle of action that matches what is going on the pitch ahead with no perceivable delay. Another important factor of is the capacity of the data, with the Internet of Things being used more and more over time, where gadgets and objects employ smart, connected features that they have never had before, the strain on bandwidth will continue to grow. 5G also benefits to the society and it is one of the energy adapted solution.

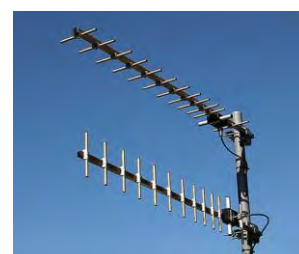
1.1.2 High Gain Antenna

High gain antenna or known as directional antenna is an antenna with a narrow radio beam that is used to increased signal strength. High gain antenna provide a precise way to target radio signals. This antenna is used in space missions as well as in flat, open areas where geography won't disturbs the radio waves. A low gain antenna is an omnidirectional antenna with a broad radiowave beam width that allows for the signal to propagate well even in mountainous regions and thus more reliable regardless of terrain. High gain antenna transmits more power to the receiver, increasing the strength of the signal it receives. As a results of their directivity, directional antennas send fewer signals from a direction other than the main beam. This property reduced interference. There are many types of high directional antenna such as

i) Parabolic antenna



ii) Yagi Uda Antenna



iii) Horn Antenna



iv) Phased array antenna

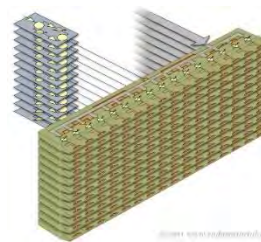


Figure 1.2 High Gain Antenna

1.2 Problem Statement

One of the problems faced nowadays is there is congested data usage because there are millions of things connected to the internet. The gain of current antenna cannot support the device connecting to the antenna and the demand by emerging technology needs a high gain antenna. Next, in the microstrip antenna design, the main problem faced is the propagation of the surface wave in the substrate which occurs because of the increment of side lobe and backlobe. In the array design, another problem occurs which is mutual coupling occurs when more than one element is placed near each other and the existence of side lobe. In this thesis, an EBG structure is introduced to reduce the effect of surface wave and mutual coupling.

1.3. Objectives

The main objective is to design an antenna at 28GHz which is a Microstrip Antenna Array with EBG Structure on CST software. Next, the objective is to analyse the output of the microstrip array antenna with EBG structure. Finally, by introducing the EBG structure, the target is to reduce the antenna side lobe of the microstrip array, thus increase the gain performance up to 16.5dB according to standard ITU-R WP5D.

1.3 Scope of Work

The project focuses on the development of the antenna to meet the satisfied performance of high gain antenna at 28 GHz. The first part of the project is to study the concept of the antenna properties, microstrip patch antenna , microstrip array antenna , microstrip antenna with various type of feeding techniques and electromagnetic band gap (EBG) structure.

In the second part of the project of the performance of the EBG structure, microstrip array antenna with and without EBG will be investigated by performing simulation in CST software. This antenna will be designed to operate at frequency of 28 GHz. The antenna is at very high frequency , thus an array 2x1 , 2x2 , 4x2 , 16x2 design was done to meet the specification. However there is still side lobe found on the radiation gain.

In the third part of the project, an EBG structure is implemented in the microstrip array antenna. The EBG type of structure was investigate and the best location of EBG structure on the microstrip array was then discovered.

Lastly , the result obtained from the simulation is tabulated and discussed. The antenna was not fabricated because of the limitation of the equipment in Malaysia which cannot

1.4 Organization of Thesis

This thesis consists of five chapter that describing the work done in the project. The thesis organization is generally described as follows.

The first chapter explains the introduction of the project , the problem statement and objectives of the project. Other than that , this chapter explain about the scope of work and the chapter's flow.

Chapter two discussed about the theory of the properties of antenna and high gain antenna . Next , this chapter discussed about microstrip antenna theory and the mathematical equations needed to implement the microstrip antenna . This

chapter explain the basic parameter of the antenna and theoretical about EBG structure.

Chapter three which is methodology discussed about the steps in designing the microstrip array antenna, EBG structure and the combining of EBG Structure to the microstrip antenna. The design start by the calculation and followed by the simulation

Result and analysis are presented in chapter four . The performance of the antenna is tabulated and discussed The last chapter concludes the project with some suggestion of future work to improve the designs if the antenna and EBG structure.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

As the activity of 4G cellular accelerates, there is an increasing interest in that will define the next generation 5G telecommunication. A key feature of 4G, is ability to support high data rate, thus the focus of emerging technology is coverage and user experience. To ensure that, the best design of antenna must be produced by enhancing the properties of the antenna and overcome the problem faced by the antenna.

2.1 Standardization of 5G

A standardization is a must to every antenna introduced. This is because to make sure the antenna is authorized by standard body and can be used world wide. 5G is a future step in moile technology. It is enabling a seamless conncted society in 2020 timeframe and beyond to bring people along with things, data , application , transport system and cities in smart network communication environment. In this context ITU (International Telecommunication Union) and his partners IMT (

International Mobile Telecommunication) are working on realizing the future vision of mobile broadband 5G. [31]

In early 2012, ITU-R embark on a programme to develop “ IMT for 2020 and beyond” and through the leading role of Working Party 5D , ITU’s radiocommunication sector (ITU-R) has finalized its view a timeline towards 2020

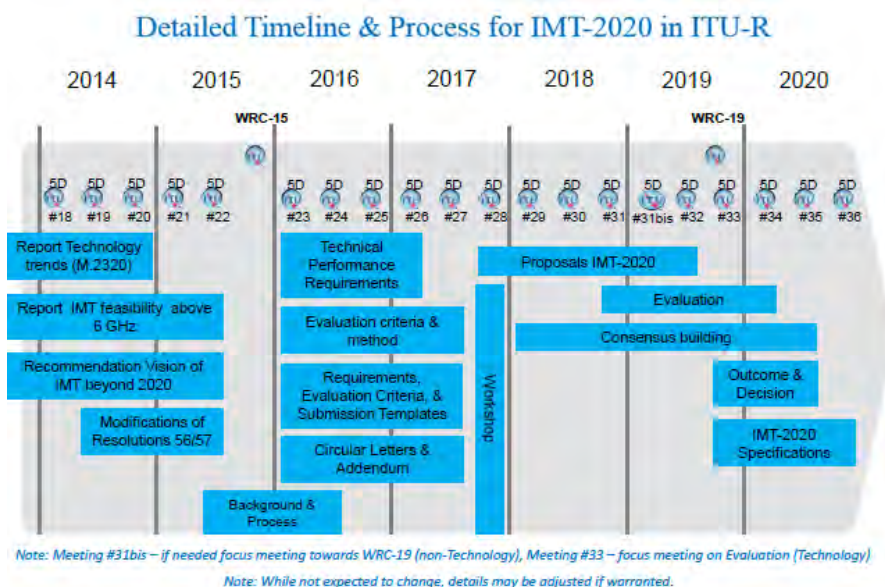


Figure2.1: The timeline plan of 5G Development

Figure above show the timeline plan of 5G development by ITU-R WP5D. Thus , the 5G draft report shows that the 5G frequency is from 6 GHz to 60 GHz. However the 60 GHz is unlicensed , 38 GHz with 3.4GHz band, and 28 GHz is LMDS .

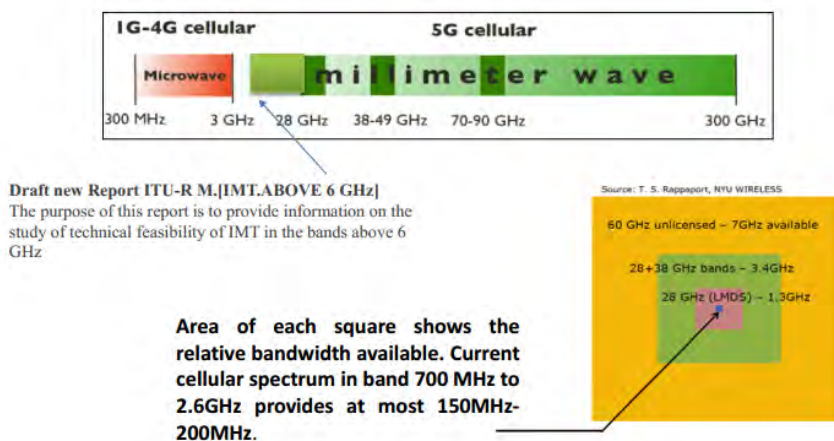


Figure2.2: Standard frequency of 5G

Table 2.1: Standard parameter for 28GHz (Ref :ITU-R WP5D, Auckland ,27 Feb-4 March 2015

Parameter	Value
Frequency	28GHz
Bandwidth	1.3GHz
Return Loss	<10 dB
Gain	>16.5dB

In figure 2.2 above shows that the area of each square shows the relative bandwidth . Current cellular spectrum in band 700 MHz to 2.6 GHz provide at most 150 MHz to 200 MHz. Thus , according to the standard figure above , it explain that in 5G at 28 GHz, the bandwidth must be 1.3 Ghz , the return loss must be below -10 dB and the gain of the antenna must be at least -16.5 dB. Thus in this project , the standardize will be followed.

2.2 Antenna Properties

Antenna is a device that convert a guided electromagnetic wave on transmission line into a plane wave propagating in free space. Thus, one side of antenna appears as electrical circuit element , while the other side as an interface with propagating plane wave. Antenna can be used for both transmit and receive function [1]. A variety of antennas have been developed for different function

1. Wire antennas - used at low frequency such as dipole, monopole and horns
2. Aperture Antennas - mostly common used at mocrowaves and milimeter wave frequency (rectangular and waveguide)
3. Printed antennas – Can easily arrayed for high (microstrip patch antenna)
4. Array antennas - consists of regular arrangement with feed network (phased array)