ANALYSIS OF MULTI BEAM TECHNIQUE FOR ARRAY ANTENNA AT 28 GHZ

NAJWA IZAATI MOHD YATIM

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ANALYSIS OF MULTI BEAM TECHNIQUE FOR ARRAY ANTENNA AT 28 GHZ

NAJWA IZAATI MOHD YATIM

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

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Analysis Of Multi Beam Technique For Array Antenna At 28 GHz

Sesi Pengajian : 2018/2019

Saya NAJWA IZAATI MOHD YATIM mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.
☐	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: No 18 Blok C1 Felda Air Tawar 4, 81900 Kota Tinggi Johor

Tarikh : 31 May 2019 Tarikh : 31 May 2019

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this report entitled "ANALYSIS OF MULTI BEAM TECHNIQUE FOR ARRAY ANTENNA AT 28 GHZ" is the result of my own work except for quotes as cited in the references.

Signature : ………………………………….

Author : ………………………………….

Date : ………………………………….

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature	:	…………………………………
Supervisor Name	:	Dr Imran Bin Ibrahim
Date	:	31 May 2019

DEDICATION

I specially dedicate this thesis to my beloved mother Jamilah Binti Mohd Yatim and to my father Mohd Azami bin Mislam, my siblings Muhammad Saiful and Muhammad Nazmi, my other family and cousins for their encouragement and support.

ABSTRACT

High-speed and rapid evolution of wireless technology connectivity are very relevant today. Consequently, applications of the fifth generation (5 G) have been designed to meet the user's requirement for technology and business areas these day. High bandwidth, high directivity, high data transmission speed enables customer experience with high efficiency that decreases signal losses at a distance from the antenna. The objective of this project is to design the multi-beam antenna and analyze its angle, gain, radiation, pattern, and impedance bandwidth for 5 G operating frequency applications at 28 GHz. In CST Studio Suite Software, a multi-beam antenna is designed. In terms of antenna parameters such as gain, return loss, bandwidth, efficiency and radiation pattern, the performance of the antennas is carried out after the simulation processes are finalised. The multi beam will be able to reduce the signal-to-noise interference ratio to accomplish the high signal. The antenna's signal will be capable of carrying the maximum communications traffic. And the important aspect is that the multi-beam antenna can provide necessary coverage and capacity in the particular high-traffic area without disrupting with the other signals.

ABSTRAK

Pada masa kini, evolusi teknologi tanpa wayar berkelajuan tinggi dan pantas sangat penting. Oleh itu, aplikasi generasi kelima (5G) telah dibina untuk memenuhi permintaan pengguna untuk bidang perniagaan dan teknologi pada masa kini. 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. Tujuan projek ini adalah untuk mereka bentuk antena pancaran (multi beam) dan menganalisis sudut rasuk, keuntungan, radiasi, corak, dan lebar jalur impedans pada 28 GHz untuk kekerapan operasi 5G. Antena pelbagai pancaran direka dalam perisian di dalam perisian CST Studio Suite. Setelah proses simulasi selesai, prestasi antena dibawa dari segi parameter antena seperti keuntungan, pulangan kerugian, bandwidth, kecekapan dan corak sinaran. Untuk mencapai isyarat tinggi, (multi-beam) akan dapat mengurangkan gangguan bunyi. Isyarat antena akan dapat mengurangkan lalu lintas dalam komunikasi. Dan bahagian penting ialah pancaran multi beam antenna mampu memberikan liputan yang diperlukan dan kapasiti di kawasan lalu lintas tinggi yang spesifik tanpa gangguan dari isyarat lain.

ACKNOWLEDGEMENTS

Firstly, I would like to express my gratitude to the Almighty of His blessing and grace in giving me strength to complete my Final Year Project, entitled “Analysis Of Multi-Beam Technique For Array Antenna At 28 GHz”. With the strength given, I could finish this research and able to overcome all the obstacles that occur during the research periods.

Secondly, I would like to take this opportunity to express my profound gratitude and deep regards to my supervisor for the Final Year Project I & II, Dr. Imran Bin Mohd Ibrahim for his exemplary guidance, monitoring and constant encouragement throughout the course of this thesis. The blessing, help and guidance given by him from time to time shall carry me a long way in the journey of life on which I am about to embark.

A particular line of appreciation is extended to my parents, for their unflagging encouragement and support throughout my study. I would like to thank all senior students who helped and encouraged me though out my studies. I would also like to give my appreciation to my boyfriend and bestfriends, for always being there for me through my ups and downs and never failing to give me endless moral support and love. May Allah SWT bless all those who have helped me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

CST	:	Computer simulation technology
CDMA	:	Code division multiple access
dB	:	Decibels
FNBW	:	Full null bandwidth
GSM	:	Global system for communication
GPS	:	Global positioning system
RFID	:	Radio frequency identification
TDMA	:	Time division multiple access
WLAN	:	Local wireless network

CHAPTER 1

INTRODUCTION

In this project, the multi beam antenna and its performance is being analysed at 28 GHz frequency. High speed and connectivity are very important that require in the development of the wireless technologies. 5G (Fifth-generation) technologies has undergo a huge research to meet the fast growing wireless communication in order to fulfil the demand from the users. CST (Computer Stimulation Technology) is being used in this project to simulate the result of antenna design. This chapter will discuss about general overview and briefly explain the objectives, problem statement, scope of projects and organization of thesis of this project.

1.1 Background of Project

The 5G technology has utilized the millimeter wave which is (mm Wave) of band to make the boost impact for the wireless communication system, but the narrow receiver and transmitter developed a limited area of beam coverage. To overcome the restriction of the mm Wave band, a fixed beam switching technique is implemented. The antenna array of configuration will be designed to look at how the performance of the application's 5 G operating frequency on its forming angle of beam, the pattern of the radiation, the gain of the antenna, and bandwidth of impedance at frequency of 28 GHz. [1]

The multi-beam antenna is widely used in the several application ranging from the communication up to radar. The uses of the multi-beam are to validate a sub array which will let the array to get the signals on from the different channel within the used of the antenna while at each time, only one pattern can be generate in the involved transmission. [2]

1.2 Problem statement

In the future, the huge demand for the high data rate wireless services will exist and will meet the upcoming 5G mobile networks. The world will need the availability of the larger channel bandwidths at higher frequencies boosted the development of communication systems at millimetre waves (mm-waves). [3]

In this project the multi-beam antenna systems are designed and it conducted in mm wave band of frequency and it will support to the bigger of transmission rate, to the better of from any distracted ratio noise, with higher spectral, with the efficiency of energy and the shaping of the style of beam in order to enabling the forming of the beam in order to achieve the mission of the critical of infrastructure nowadays.

1.3 Objective

i. To analyzed the multi-beam antenna at 28 GHz and the effective coverage angle.

ii. To research the most effective multi beam technique for mm Wave array antenna.

iii. To investigate the strategy of sub array where the array can simultaneously receive the signals on different channels when the antenna is used.

1.4 Scope of project

To develop the multi beam antenna at the frequency of 28 GHz and to evaluate the performance parameter by using the CST (Computer Simulation Technology) that required to analyzed the result of the multi beam antenna.

1.5 Project planning

The project begins with the study of literature review which are associated to the project title that are chosen. The research is about investigation of the multi beam technique array antenna beam at 28 GHz. The design specification and parameter of the antenna was obtained from the research had been done. Then, using the software Computer Simulation Technology (CST) Design Environment software, the multi-beam antenna is designed. Antenna simulation process can be done when all the specification meets the requirement. All the experimental results are included in this thesis report.

1.6 Organization Report

Chapter 1 is the part of the introduction which consist the project background, problem statement of the project, and what to achieve in this project and it scope.

Chapter 2 consists of literature review of the pass projects that is 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 the part of methodology that discusses on how the project flows, the antenna design specification and also the simulation process that use the (CST) Microwave Studio software in this project.

Chapter 4 consist the combination of discussion and the result obtained on this project based on the objectives. The gain, efficiency, directivity, and the radiation pattern for the multi beam antenna will be discussed in this project.

Chapter 5 conclude the summarization of the project and also the future work that could be done.

CHAPTER 2

BACKGROUND STUDY

Study is the most important parts for the literature review where can clarify the evolution of the multi-beam antenna and the mm wave of antenna use. This chapter further discusses multiple analytical multiple of working, a series of important design and engineering research that have interpreted by various analyst to improve this project's performance.

2.1 Introduction

In this literature review, the investigation from other researchers had been explained into this chapter that are related to the design and development of this project "Analysis of Multi-Beam Technique for Array Antenna at 28 GHz". This chapter also focuses the different techniques, amount of critical configurations and terms of planning investigations being conducted for this project by different experts.

2.2 Analysis of multi-beam antenna

The multi-beam can offer to increase the wireless communication with improved spectral efficiency and better service quality. One of the approach that can be made in the design the antenna will includes the use of multi-access space division (SDMA). SDMA methods deliver high user capacity without any major technology in a limited frequency spectrum. [6]

SDMA techniques used by most wireless service providers to optimize from the usage of spectrum that are available usually restricted to 360-degree of 3 industries of the coverage area. However, with a multi-beam of antenna system, the number of industries enclosed can be risen to 48. While the system of the beamforming can be reuse the amount of the specified frequencies needed and reduce interference, this can result in a greater amount of the subscriber with superior service performance in the coverage area of a wireless system network. Without the need for transmitter stations, the signals of the video that include the data network and voice can be transferred in different directions at further distance. The outcome is a reduction in network operating expenses and a major increase in terms of performance, the reliability and number of users. A long-range which have great range directional narrow-beam antenna is used instead of using a short-range with low gain of omnidirectional antenna. An increase of the antenna with long of distance will usually greater in one path the number of subscribers, but does not enable users using the network in certain directions. [7]

The solution of the issue in this articles is suggested by using multi- beam techniques that can continuously by using a broad beam of the antenna with strong gain or sequentially using it to effectively achieve omnidirectional antenna spherical coverage in all preferred locations with a significant improvement in the users. With the technique of the frequency, additional capacity will be obtained. The multi-beam system is one of the solution of hardware based on antenna (phased array) and the beamforming of networks established by Electromagnetic Technologies Industries, Inc. [8]

The antenna and the network of the beamforming are the key components of the multi beam antenna that is suggested. The antenna is designed for small antenna elements organized in an array that include of dipole or patch antennas. All the antenna elements are provided with the beam former with the required signal stage of generation of beams in random directions. The parameters of design are vitally important for both elements of the components. for the performance required for the multi- beam antenna system. For each antenna shape is chosen carefully to achieve a voltage ratio of less than 1.50:1 frequency for the point of feed. The feed point in the range of frequencies of interest was determined to be substantially higher than the centre point for better performance. Table 2.1 shows the additional patch antenna element design parameters:

Table 2.1: The design parameters and description

Design parameters	**Description**
The frequency of resonant	3.7
The height of substrate GHz	0.030 in.
The dielectric constant of substrate	2.2
Length of patch antenna	1.575 in.
Width of patch antenna	0.710 in.
The polarization structure	vertical
Feed point is slightly greater than the centre point of the antenna patch.	

The patch antenna is mostly organised linearly on the substrate of single dielectric to obtain a beam width of 15 deg azimuthal and a beam width with vertical of 7 deg. The design of the four-beam antenna needs minimum four arrays of elements patch involved. 4] The techniques proposed by system of four beam was designed for gain of antenna with the value of 26 dB, a front-to-back ratio of more than 30 dB and with 20 dB of levels of side lobe lower than the main lobe. Using an advertising VNA microwave calibration, the design of four beam efficiency was verified for a full sweep of 2.0 to 4.5 GHz. The range operates of the antenna system with a VSWR of less than 1.50:1 was discovered to be between 3.2 and 4.2 GHz. [9]

2.3 The beamformer design

Beam former as the comprehensive network consisting mainly of components of the microwave that have passive characteristic are used to deliver the necessary of the signal stage and amplitude which is between the system and antenna transceivers. [10] A network of the beamforming create the antenna beams formed and direct the paths electronically without any mechanical movement [11]. Such the digitally guided system of beamforming can indeed be prevaricated by means of thinking about time-or recurrence area examination of the reception equipment aspects and related electronic segments. [12] For the proposed multi-beam radio wires framework, recurrence space examination used to be linked to the shape of beamforming structures for broadband applications. [13] [14]

2.4 Antenna parameter

Different parameters of concepts are essential for explaining the antenna of execution. Parameter such as the impedance, efficiency, bandwidth, directivity as well as gain, polarization, beam width and radiation pattern might be antenna characteristics that would follow certain requirements

2.4.1 The impedance

It is required to provide the transmission line and the energy transfer among them and an antenna, impedance of the input of the antenna and the characteristic of impedance of the transmission line. If the match continues to fail, the antenna terminal will have reflected waves and return to the source of energy. The maximum power ratio to the wave could be calculated and will referred as Wave ratio of standing wave (SRW) with the ideal 1. The impedance difference is reduced and matching is key to reducing the SWR and enhance the transmission of power across each part of the antenna system.

2.4.2 Bandwidth

Bandwidth is known as "the vary of frequencies under which the antenna's reliability complies with a specified standard with respect to certain characteristics" [4] The upper to low of the frequency ratio of suitable operation and the percentage of the frequency difference. There are two ways to measure the bandwidth of the narrowband antenna and the antenna broadband. The bandwidth percentage can be measured as:

$$BW\ (\%) = fH - fLfC \times 100\% \qquad (2.1)$$

Where $fc = fH + fL2$ (2.2)

whereas:

fH = Frequency with high value

fL = Frequency with low value

f_c = Frequency centre/Frequency operating

2.4.3 Efficiency

There are several efficiencies in any type connected with antenna. In the input terminals and within the antenna system, to take into account failures, the efficiency of all the antenna e_o will be used. Generally, the total of the efficiency is written as:

e_o = dimensionless of the efficiency of total

e_r = mismatch of efficiency reflection =

$(1 - |\Gamma|2)$ where it dimensionless (2.3)

e_c = efficiency of conductor where it dimensionless

e_d = dielectric of efficiency where it dimensionless

Γ = coefficient of reflection of voltage at antenna of terminals input

$\Gamma = Zin - ZoZin + Zo$ whereas, (2.4)

Z_{in} = the antenna of input impedance

Z_o = the characteristic transmission impedance line

VSWR (Voltage Standing Wave Ratio) = $1+|\Gamma|1-|\Gamma|$ (2.5)

$Eo = e_{recd} = e_{cd} (1 - |\Gamma|2)$ (2.6)

whereas $e_{cd} = e_{ced}$ = efficiency of radiation of antenna involved between the directivity and parameter gain of antenna directivity and gain.

The radiation intensity percentage in a specified overall average path from the antenna to radiation of the intensity directivity. In addition, the average intensity radiation is comparable to the radiated total power radiated from antenna divided by 4π. If the direction is not indicated, the path of optimum radiation intensity is implied. In a particular direction, the non-isotropic is approximately equal to the proportion of an isotropic source in its radiation strength.

$D = UUo = 4\pi UPrad$ (2.7)

$D_{max} = D_o = U|maxUo = UmaxUo = 4\pi UmaxPrad$ (2.8)

whereas,

D = dimensionless of directivity

D_o = dimensionless directivity maximum

U = intensity of radiation with (W/unit solid angle)

U_{max} = intensity of radiation(maximum) with (W/unit solid angle)

U_o = isotropic source of radiation intensity (W/unit solid angle)

P_{rad} = total of power radiated (W)

Gain is one of the perimeter in the antenna that important in to analyse performance of the antenna in the result. The gain parameter and the directivity of antenna are antenna-related and measured in terms of efficiency and directional capabilities.

Directivity defines the measurement of antenna's directional characteristics and that being controlled by the pattern. As mentioned, radiation that is gained from the ratio of intensity of radiation to the antenna from intensity if the power recognised by the antenna isotopically radiated.

Gain = 4π of intensity radiation and the total input is accepted

$power = 4\pi\ U\ (\theta, \emptyset)\ Pin$ with dimensionless (2.9)

In most cases, the reference antenna is a lossless isotropic source. The power gain will normally have taken at the FNBW if the direction is not mentioned. It also defines as the main lobe in the direction of the radiation which is maximum.

2.4.4 Radiation Pattern

The antenna radiation is being characterized as a mathematical operation or some visual rationalization of the radiation characteristics of the antenna as a feature of space coordinates. In addition, some far-field region defined from from the pattern of the antenna radiation and the directional coordinates demonstrated. Additionally, radiation had its own properties such as density of power flux, phase of direction which is known as polarization, intensity of radiation and strength of field.

The antenna's radiation characteristics represented by the angular position. The spatial variation trace of the power received or radiated in a continuous radius from the antenna is the antenna's power pattern. The spatial magnitude of the electromagnetic (magnetic) field in a continuous radius from the antenna field pattern. The radiation pattern tends to be normalized to achieve the maximum value for the field and pattern of the power in decibels (dB).

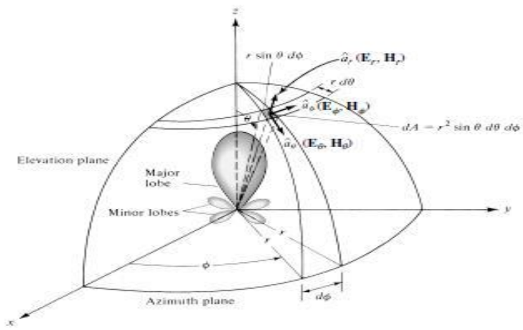

Figure 2.1: System Coordinate of Antenna Analysis

2.4.5 Pattern Beamwidth

The linearly polarized antenna's 2-dimensional pattern is also one of the main patterns where it could be evaluated in the E-plane and H-plane. Plane parallel which is E-plane to the E vector have the maximum of radiation direction whereas plane parallel which is H-plane to the vector of H.

Separation of the angular on opposite sides of the maximum pattern between two identical points is known as the beamwidth pattern. The pattern of the beamwidth was shown in the figure below. The vectors of two angles are derived from the flow of the pattern that passes through the main lobe point whereas the intensity of the radiation is half maximum known as half-power beamwidth (HPBW). First-null beamwidth (FNBW) which is known as the main lobe is The angle between two parameters from the descent of the pattern and the main beam at its base. Figure 2.2 shows the pattern beamdwidth of the antenna. The half power of the beamwidth which is knowns as (FNBW) half-power angle which the value of (-3 dB) of the main lobe point.

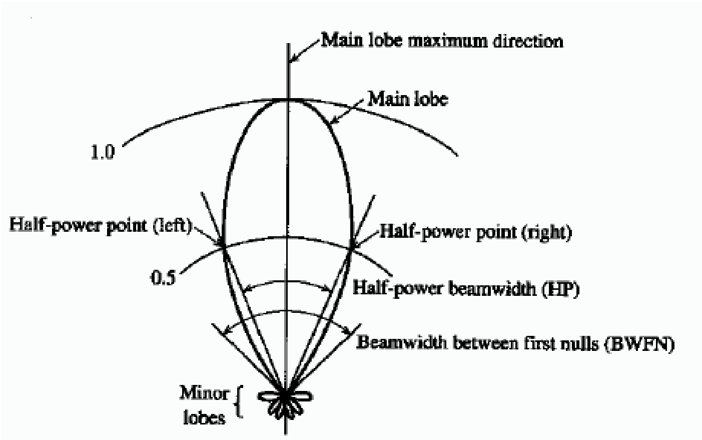

Figure 2.2: Pattern beamwidth

2.5 The antenna design

Figure 2.3 illustrates microstrip antenna front view capable of generating a 2.45 GHz frequency with a gain of 5.269 dB and an 11.09 dBi guidance. The size of the antenna is 60x 80 mm. FR-4 is used in this antenna as the substrate material. FR-4 is a grade designation for sheets, tubes, rods and PCBs with glass-reinforced epoxy laminate. It is composite material that are made of woven fiberglass flame retardant, chemical resistance and absorb water. [5]

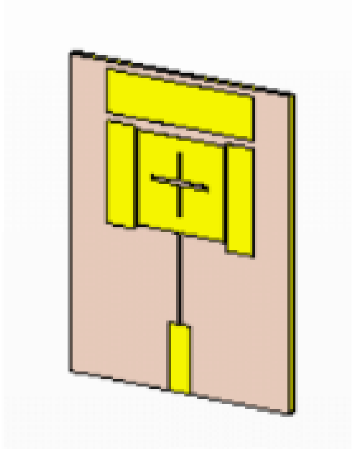

Figure 2.3: Front view of antenna

Figure 2.4 shows the antenna dimension which classified the length (L) and width (W) of the antenna.

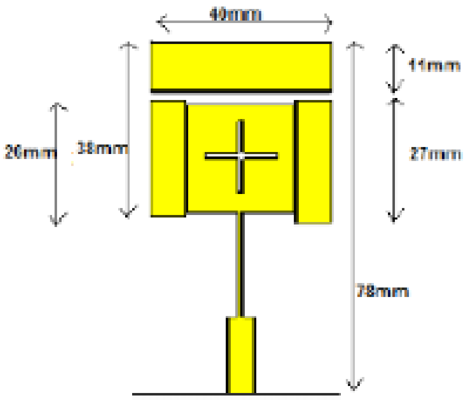

Figure 2.4: Dimension of the antenna

Figure 2.5 and Figure 2.6 shows the result of the antenna design and the radiation pattern of antenna with aluminium plate and without aluminium plate respectively. The simulation result is on the frequency of 2.4578 GHz with the gain of -37.82 dB.

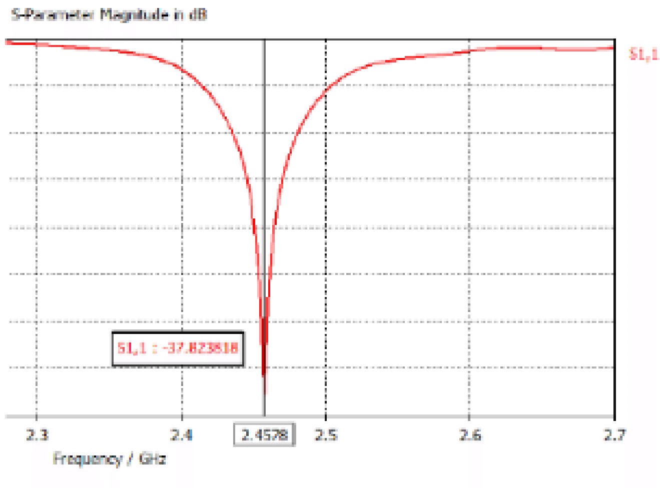

Figure 2.5: S_{11} parameter of the antenna

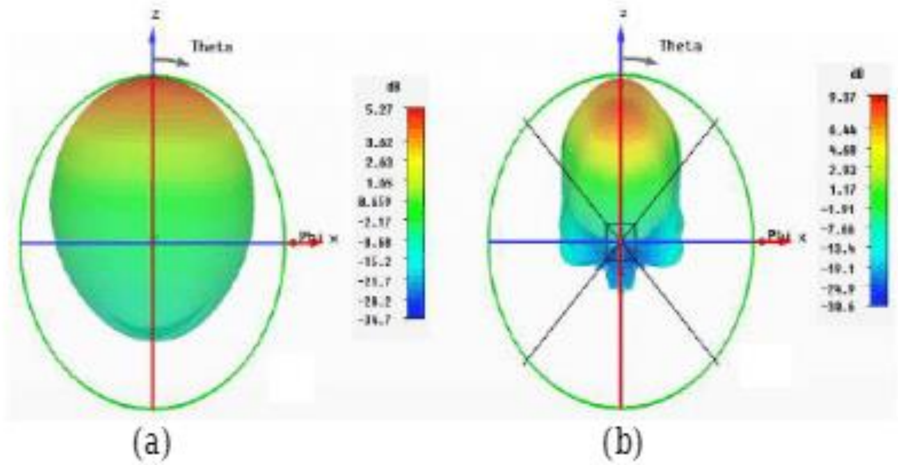

Figure 2.6: (a)Antenna without aluminum plate (b)Antenna with aluminum plate

2.6 5G Fixed Beam Switching on Microstrip Patch Antenna

2.6.1 Millimeter-wave communication system

Narrow beam are used in millimetre wave communication systems to remove interference from neighbouring beams using narrow beams It significantly reduces the angular distribution of the waves and limits the multi-path components of millimetre waves. Thus beam-forming weights can be adapted by establishing the beam to the desired field. There are two types of technology for beam forming. The former is fixed beams and the latter is adaptive beams.

Adaptive beam forming forms efficient beams by adjusting beam width and beam direction depending on the state of the radio channels around them. It requires high hardware complexity and requires additional feedback for the formation of beams. The switched beam forming is therefore introduced because it is simpler and less functional than the adaptive beam forming. Beam control or beam shifting concepts are developed for scanning antennas. For aviation, marine and aeronautical applications, scanning antennas were initially developed. Different technologies such as Bluetooth, the radio frequency identification (RFID), traffic management and crash prevention radars and the local network of the wireless which is (W-LAN) were used in the development of indoor location. [1]

Figures 2.7 (a), (b), (c) and (d) show the antennas proposed to compare their performance with four different configurations. Each antenna consists of three layer. The first layer is the lower layer which is a copper plane that covers the rectangular substratum completely ground. The medium substratum is Rogers Duroid 5880 with dielectric constant, π r = 2,2 and tangent dielectric loss, tan=0,0009, and a substrate height, h=0 The thickness of the copper is 0,017 mm.

The top layer is the patch antenna. The rectangular patch size is € 4.52 3.52 mm (width length of €). Two patches of antenna distance are almost µ/2 (calculation of the patches from centre to patches of the centre. To match a microstrip line impedance input of 50 tons, a quarter wave transformer with power division method is used. All designed antennas have an operating frequency of approximately 28 GHz and are suitable for use with 5 G. [1]

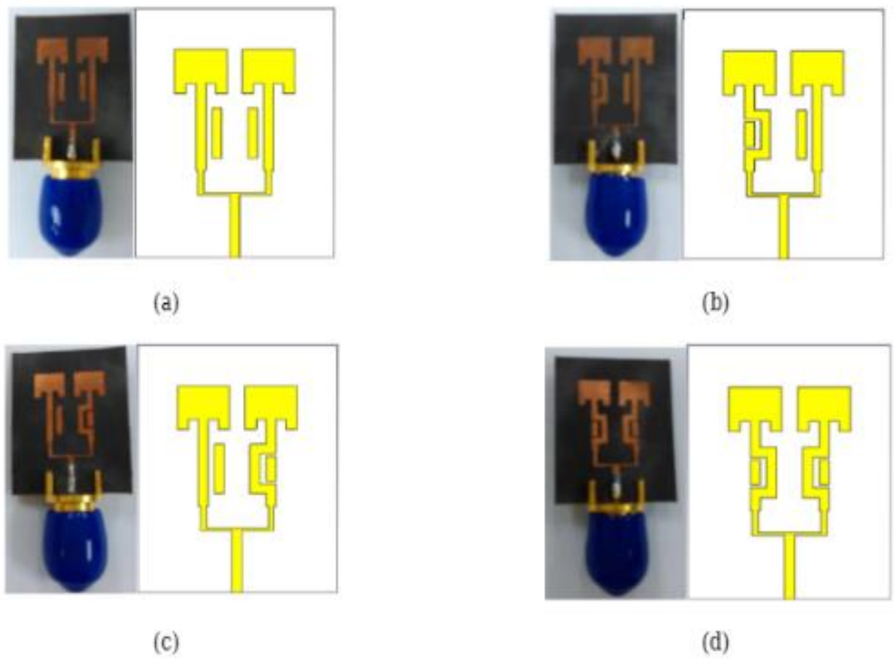

Figure 2.7: Four different configurations of patch array antennas designed

The patch antenna was originally designed with a single radiant element as shown in Figure 2.7. Equations (2.19) -(2.25) show below the calculations on the dimensions of the rectangular patch antenna which is the single element. Patch width calculation, W:

$$W = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r+1}{2}}} \tag{2.10}$$

$c = 3\times 10^8$, fr=28GHz and ε_r=2.2; W=4.24 mm. (2.11)

Calculation of dielectric constant(effective), ε_{eff}:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{1}{2}} \quad (2.12)$$

Substitute, which is W =4.24 mm and h =0.254; εeff =2.06.

Calculation of the Effective length: $L_{eff} = \frac{c}{2fr\sqrt{\varepsilon_{eff}}}$ (2.13)

Calculation of extension of length:

$$\Delta L = 0.412h\,\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} \quad (2.14)$$

Calculation of L (the actual length of antenna):

$$L = L_{eff} - 2\Delta L \quad (2.15)$$

Calculation of feed length insert:

$$y_0 = \frac{L}{\pi}\left\{\cos^{-1}\sqrt{\frac{Z_0}{Z_1}}\right\}$$

$$Z_1 = \sqrt{Z_0 Z_{in}} \quad (2.16)$$

2.6.2 Design and optimization using software CST Microwave Studio

The results of the simulated of antennas designed for the S-parameter are being compared to results measured by the performance analyzer of the network. For each simulated distant radiation pattern, the antenna design configuration is also displayed. The differences in simulated results are caused by the change in resonant frequency [9]. This change in frequency is because of the loss of Cu microstrip insertion tolerance of manufacturing during etching and gravure processes.

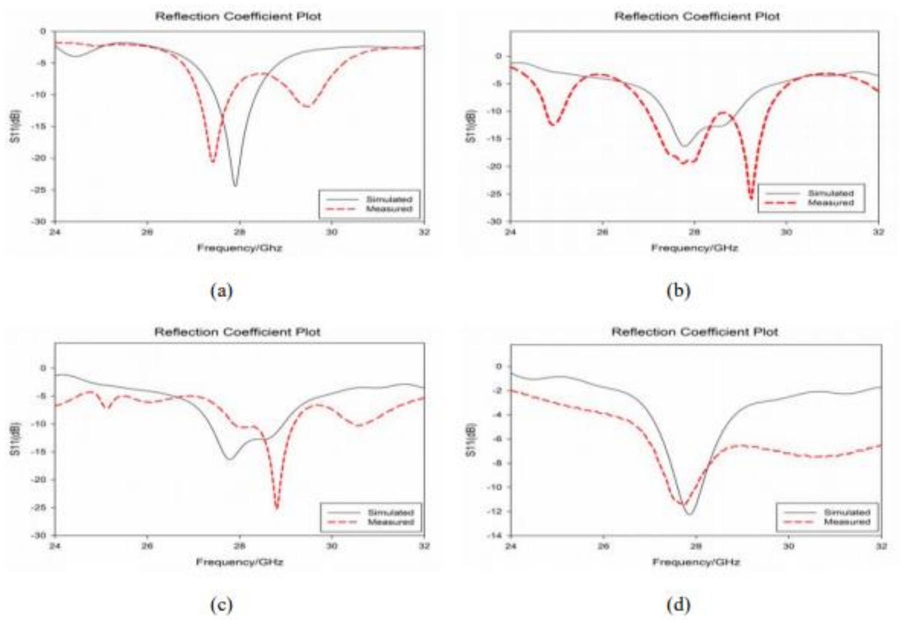

Figure 2.8: Four different configurations of patch array antennas designed for measured and simulated return loss

2.7 Comparative studies on 3G,4G and 5G wireless technology

2.7.1 Wireless network study

2.7.1.1 The third generation 3G wireless Network

3G of the wireless technology nowadays being combination of different 2 G wireless network systems into a single unified satellite and terrestrial component system. The main aspects of 3 G wireless technology their proficiency to standardize existing cellular standards, such as CDMA, GSM, and TDMA. The following three air configuration modes obtain this result by CDMA broadband, CDMA2000 and UWC-136 (Universal Wireless Communication interface). Wideband of CDMA (W-CDMA) is consistent in Europe and parts of Asia with existing 2 GSM networks. A bandwidth between 5 MHz and 10 MHz is needed in W-CDMA to make it as a suitable platform for achieve high application in the capacity. It is possible to overlay the current of GSM and also TDMA (IS-36) and IS95 networks. Subscribers are likely to have 3 G access. Wireless services are initially supplied through terminal of devices which have dual band. Digital wireless applications are used for high-capacity WCDMA of networks and voice calls are used in 2 G systems [3]. The fourth generation 4G wireless Network

(4 G) which is known as fourth generation is a high-speed wireless network that able to transmitting multimedia and data and wireline of the backbone interface that are needed for the conceptual framework and discussion for the future. In 2002, the network was perfectly built up. 3G and 4G, services, ways of transmission, the access of internet and the interface of wireline compatibility being the factors of the data rates ways and have been the backbone network, quality of service, and security. mobility peaks of at least 100 Mbps is supported by 4G. Wide area coverage and low mobility local area coverage of 1 Gbps [3,5]. The velocities

of 3G is slower than 4G because it just can be high as 2 Mbps, which is much slower than 4 G velocities. [1] [3]

2.7.1.2 The fifth generation 5G wireless Network

Software-defined radios and modulation systems and new Internet downloadable error control systems in applied in 5G terminals. The user terminal development is visible as a 5 G on the mobile networking devices. Various wireless technologies will be available at the terminals. The terminals will be equipped with various wireless technologies. At the terminal, different flows can be combined from various technologies. The network will manage the user mobility then the terminal decides the final choice between various wireless / mobile network access providers for a given service. The choice is based on middleware for open smart mobile phones.

2.7.1.3 The 5G Nano core

5 G Nano core is a convergence of the technologies listed below. These technology has its own impact on the 5 G exiting wireless network. It is Cloud Computing, Cloud Nanotechnology and IP Platform. Nanotechnology is the application of nanotechnology for the I.e. scale nanometer control process.

In this field, it also known as nanotechnology of the molecular that deals with atom-by-atomic and molecular engineering-based control of the material structure MNT. The influence of nanotechnology on both smartphone and network of core has been demonstrated. It also has its own effect on both sensor and safety.

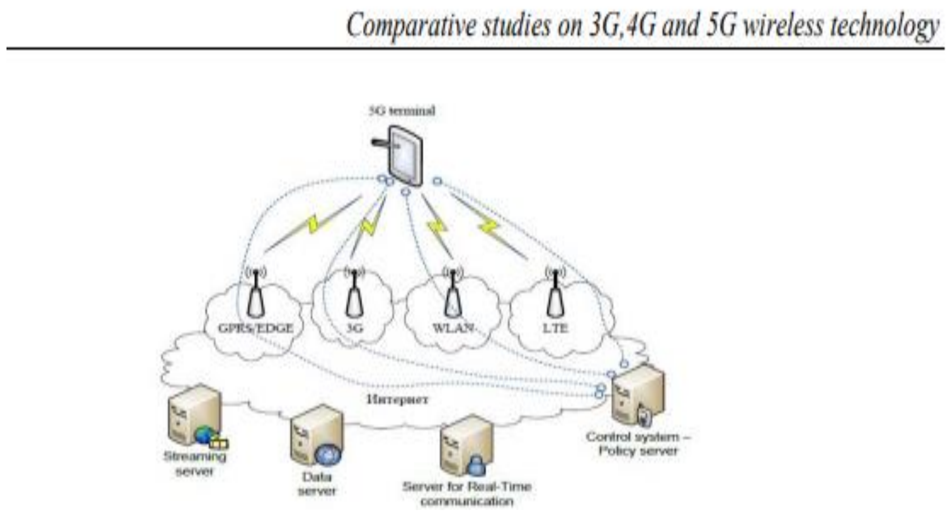

Figure 2.9: Functional Architecture for 5G Systems

2.7.1.4 Comparative quotient between 5G and 4G

Comparative quotient of 5G to 4G and 5G wireless access technologies provide mobile devices with Ethernet speed to experience the as explained above, triply play services. LTE and WiMAX are two different technologies with a definition of 4 G Velocities. New standard proposals or publications beyond 4 G are submitted to standard organizations such as 3GPP and WiMAX Forum or R-ITU. The ideal 5 G model will meet the challenges and tackle the short drops of the 4 G Experiences in technology and 4 G deployment.

Table 2.2: Differences between 3G and 4G network

Major requirements driving architecture	**3g (Include 2.5G, Sub 3G)**	**4G**
	Mainly voice driven(the data is add on always)	Voice over IP and data is converged
Architecture of network	Wide area of cell based	Hybrid which is the integration of wide area and LAN(Bluetooth and Wi-Fi)
Speeds	384 Kbps- 2Mbps	20-100 Mbps in mobile mode
Band of frequency	Depend on the country which have 1800-2400 MHz	Have higher bands of frequency from 2-8 GHz
The bandwidth	From 5-2 Mhz	More than 100 MHz
The basis of switching design	Packet and circuit	All the digital that have packetized voice
Access of technology	1 xrRTT,edge and W-CDMA	MC-CDMA and OFDM (multi carrier CDMA)

Error correction of forward	The antenna design, optimization, adapters of multi band	Multiband software, smart antenna and radios wideband
IP	Protocols of air link number including IP 5.0	All IP (IP6)

2.7.2 Advantages of 5G communication systems as a future preferred network

5 G seeks to provide a myriad of high-speed services to end users. These services are strongly customer-friendly and reduce user-to-user communication have been developed to use the applications. As example, integrating voice recognition technology into user interfaces would make it easier for every layman to use the applications. [3]

2.7.2.1 User personalization

5G network coverage would enable users to access large database of data and services. The users can filter the data and services by setting up the operational mode of their device according to their preferences so that the service can be preselected the features that they needed. For instance, users can know of various of discounts on clothes. [3]

2.7.2.2 Terminal and Network heterogeneity:

Terminal heterogeneity is referred as terms of the size, weight, display functions, electricity consumption etc. to the different terminal types. Network heterogeneity implies the various types of network access such as WiMAX, Wi – Fi, UMTS (Universal Mobile) telecommunications system.

2.7.2.3 High Performance

4G that have low signal will limit the user's ability to take advantage of wealthy multimedia content across wireless networks. Different with 5G, which can download speeds above Local Area Network (LAN) 1 GBps and Wide Area Network (WAN) 500 Mbps. [3]

2.8 Summary

Overall in this chapter, various type development and design with the information of antenna at 28.00 GHz have been studied. The frequency operating at 28.00 GHz is actually achieve the characteristic of 5G communications is to operates at high frequency with having the wide bandwidth, high gain and high directivity.

Table 2.3 shows the application based on the previous thesis that being conducted for the research in this chapter. It consists of the author name, the title of the research that they have made, year of the publication and the application.

Table 2.3: Application based on previous thesis

Author	Title	Year	Application
(1)Muhammad Ramlee Kamarudin, L	5G Fixed Beam Switching on Microstrip Patch Antenna	2017	Millimetre wave communication systems using narrow beams on the transmitter and receiver to remove interference from neighbouring beams. Beam-forming weights

			can thus be adapted by forming the beam to the desired location or location. There are two forms of innovation for beam formation. The first is the formation of specified beams and the second is the formation of adaptive beams.
(2)K.Gowtham, S.Hariharan, Dr. D.Mohana geetha.	Design And Performance Analysis Of Multibeam Antenna	2014	The idea of antenna multi-beam with multiple array patterns. The structure of the antenna and its components are detailed. Several of them describes and anticipates the steps of the design process computer simulation performance values are submitted.
(3)Olumuyiwa Oludare	The comparative of studies	2014	Differentiate the performance of the

	between 3G,4G and 5G technology		previous wireless communication systems in this study that discovered that they could still solve endless communication problems such as limited of network coverage, poor interactivity, poor service quality and flexibility. The introduction of 5 G will radically change the communications sector and bring the wireless expertise to the whole new and provide a wealth of features and services making the world a smaller place to live.
(4)Chao Yu	Multi-beam Antenna Technologies for 5G Wireless Communications	2017	Antenna technology to support high data transmission rates, reduced the interference ratio of noises, risen the spectral and the efficiency of energy and

			durable of the beam shape., making it a great promise to serve as the critical enabling infrastructure.
(5)M.P. Lotter ; P. Van Rooyen	An overview of multiple access techniques in cellular systems for space division	2012	Provides a comprehensive of the basic concepts of smart antenna methods for multi-access space division (SDMA) introduction Methods for new mobile radio networks and Personal Communications Services (PCS) and the Universal Mobile Telecom System (UMTS).
(6)A John Wiley	Third edition of Antenna Theory Analysis and Design	2012	Introduce the basic rules of antenna principle in a unified way and apply them to antenna analysis, design and measurement. Different analytical and design methods are applied to some of the

			most simple and the configurations practical.
(7)J.Logothetis,	Beamformers: broadband RF technology for integrated networks	2012	Electromagnetic energy radiation and reception due to network beamforming in antenna arrays forming beams and digitally steering their direction and the motion of the mechanical is not required. In addition, beam formers are used for spatial filtering of interference signals.
(8)DavidR. Jackson	Overview of Microstrip Antennas	2015	Insert multiple paths of resonance into the antenna. (Multiple resonances can be used using the same technique to increase bandwidth)
(9)Jasmin Desai, Dr. John Howard	Multibeam Antenna Serves	2015	Explain on SDMA-based multi-beam antenna system such as the design

	Broadband Wireless Coms		presented to achieve the network of the communication which have the large range. The design approach is intuitive, with performance validated in an outdoor setting through advertising electronic components. The measured results then is being differentiate with MATLAB software simulations.
(10)Pier Avenue	Multibeam Antenna Systems	2015	Antenna systems industry that find the solution by making the greater available bandwidth for an area. Design is intended to generate up to 96 sectors across the base to achieve the result.
(11)Mahiman Dasila	Multi-beam Antennas Deliver	2016	The 3G or 4G network must able to make the interference of the multi

	Excellent Wireless Performance for Special Events		beam antenna to make the target on achieving the high signal to noise ratio. It must be capable of carrying greater traffic to adjacent cells with smooth transfers. Optimal coverage and capacity in the antenna also needed in desired high traffic area without interruption in the cluster's at neighboring sites.
(12)Dr.Mohamed Nadder Hamdy	Multibeam antennas planning- limitations and solutions	2016	Multi-beam antennas add instantaneous cost-efficient capacity, eliminating the need for new spectrum and sites building, in a minimized overlap pattern design. In this application note, we highlight some of the major challenges and concerns with the deployment of multi-beam

			antennas deployment—together with recommended solutions.
(13) Rolf Berge	Developments in automatic beam switching	2016	As fleets are supported with satellite networks, further complexity is added when considering the management of available capacity on the network. This is where legacy ABS systems suffer as they may be able to switch to another satellite but are unaware of whether the satellite is at full capacity or not. By building network intelligence into the system, Harris Cap Rock's ABS solution selects networks with available capacity to switch to so a customer has full access to their bandwidth with

			minimal switching interruptions.
(14) Shu Sun, Theodore S. Rappaport	Multi-beam antenna combining improvements in urban environments for 28 GHz cellular connections	2013	This article demonstrates on the performance of the multi beam antenna to improvise the quality of link in achieving the millimeter wave cellular system in the future by using the observational information from New York City's 28 GHz propagation observations The pairing between two, three and four of beams are demostrated so it can significantly make the propagation link better, either not consistently or consistently at the receiver of antenna mobile. The average path loss improvement of 28.1 dB can be attained through a coherent combination of

			the greatest four obtained signals equated to the scenario of the signals received using receiver of single beam.
(15)Mobile mark comor	Antenna Terminology Defined	2017	Explain on how the phase is the complex function in the antenna and also the environment in this articles, it will cover the general idea. Phase is one of the main factor and a little understanding of its role and the phase in the system should be available before antenna placement. It can either be destructive or constructive.

CHAPTER 3

METHODOLOGY

The methodology or procedure will be discussed in this chapter for completing this project. On this chapter, everything that is important will be discussed specifically. In addition, the flowchart shows the ability to know what the project plan is. This chapter shows how the multi beam of patch antenna operation.

3.1 Introduction

This chapter discusses the method of designing and implementing the 28 GHz multi-beam antenna. During the process of antenna development, this project requires the theoretical concept and experimental approach. Figure 3.1 illustrates the flow of the project to be explained in this chapter.

The methods used to finalize this project are through studies of the journal, internet, books, and other related sources. Journals and topics related to multi-beam antenna such as the method to use as a basic design and calculations. Journals related to the beam steering antenna have also been obtained to improve performance of different methods of steering the beam.

Radiation of antenna gain more power in specific directions that could allow high performance and less interference from unwanted sources is known as beam antenna or specifically a directional antenna. Directional antennas can generate great performance over dipole antennas which is known as omnidirectional antenna, incase if some direction is desired to have higher radiation concentration.

3.2 Basic introduction

As far back as 1953. the microstrip radiator concept was proposed. After twenty years, the practical antenna has produced better theoretical models and photographic method. With constructed a large variety for interfacial constants. For the clad of gold dielectric substrates and copper, the thermal that considerable and also mechanical characteristics and low loss tangent. Howell and Munson produced the very first of the practical antenna mictrostrip at 1970s. His various advantages are deceived as follows after comprehensive of his research and development of the array antenna and the microstrip.

Table 3.1: The antenna advantages and their disadvantages

	Disadvantages
Feedlines and matching networks can be produced at the same time	Isolation is poor and radiation elements between the feeding network
The narrow profile	The bandwidth of the antenna is narrow
Have light of weight	
Fabrication loss is low	

Conformability	
Polarization linear or circular	
Dual operation of the frequency	

3.2.1 Microstrip patch antenna

The single layer of the design in the microstrip antenna are design with four parts consisting of patch, ground plane, the substrate and the feeding part in the antenna. It is very easy to construct using conventional microstrip line feed. Patch be shaped so well in any method but uses mostly rectangular and circular configurations. The ground plane can be finite or infinite depending on the model (transmission line model, cavity model, full wave model or moments process).

The two main features of the feed part of antenna and substrate is height and relative permittivity and relative permittivity applied in this way-microstrip line, a coupling aperture and feed of proximity coupling.

Antenna is one of the main component in radio communication system to transmit and to receive the signals with different uses and properties. The elements of patch are more than two in the microstrip patch antenna array. To attain improved performance over a single antenna, transmissions are synthesized from individual patch elements. In order to obtain strong directive patterns, fields from array elements must be added in the desired direction positively and terminated in other directions.

When the feed mechanism excites the patch, it dissipates charges at the edge of the patch. These charges produce fringing fields and at the edge of the microstrip antenna, these fringing fields add up in phase and generate microstrip antenna radiation.

3.2.2 Rectangular patch

The rectangle is the geometric shape that always being used to create microstrip patch antennas. An open-ended transmission line region of length L and width W can be considered as a size of the rectangular patch.

3.2.3 Antenna feed

It is possible to use a number of methods to feed the microstrip of antenna patch. All the technique involved can be divided into two classes that are contacting and non-contacting. Using a connecting element such as a microstrip line, the RF power is fed directly to the radiating patch for the contacting method. Meantime, the electromagnetic field coupling is performed for non-contacting purposes to exchange the power between both the radiating patch and microstrip line. The coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes) are frequently used in the microstrip line.

3.2.4 Microstrip line feed

By directly connecting a microstrip line to the edge of the patch is the most of the common steps to feed the microstrip of patch antenna [14]. Input impedance matching can be obtained by attempting to modify the insert cut depth across the patch or by putting the transformer quarter wave of it before feeding to it patch of edge.

Though, at discontinuities, the spurious radiation will boost both the level of the polarization of level cross and lobe side within the radiation of pattern of the far-field is degrading. The advantage that can get from this type of feed arrangement of it are the feed can be etched to provide a planar structure on the same substrate.

An insert cut can be developed into the patch to get better impedance of the antenna. This is done by adequately managing the position of the inset. This is therefore a simple feeding technique and as it offers easy of fabrication and modelling simplicity as well as impedance matching.

Table 3.1 represent of the antenna patch of the rectangular microstrip fed. It consists of the substrate with the ground plane and the microstrip feedline at the bottom of the patch.

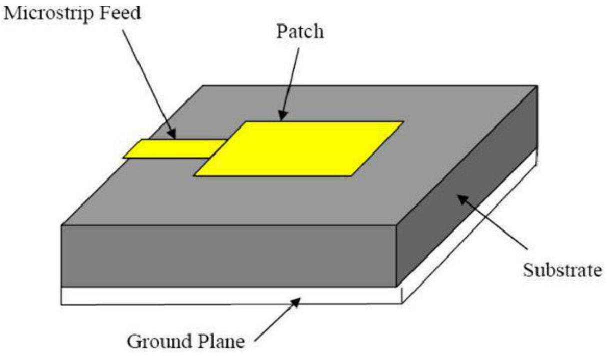

Figure 3.1: Microstrip-fed antenna rectangular patch

3.3 Flow chart of methodology

The flowchart is the important part for the future planned got the project. It acts as a guidance for the further for the project. The representation of the diagram that have been made will solve answers to a specific problem. Flowcharts are used for the design, some analysis of the project, documentation or management of a process or program in different areas. Figure 3.3 shows the work progress of the flowchart in this multi beam antenna project.

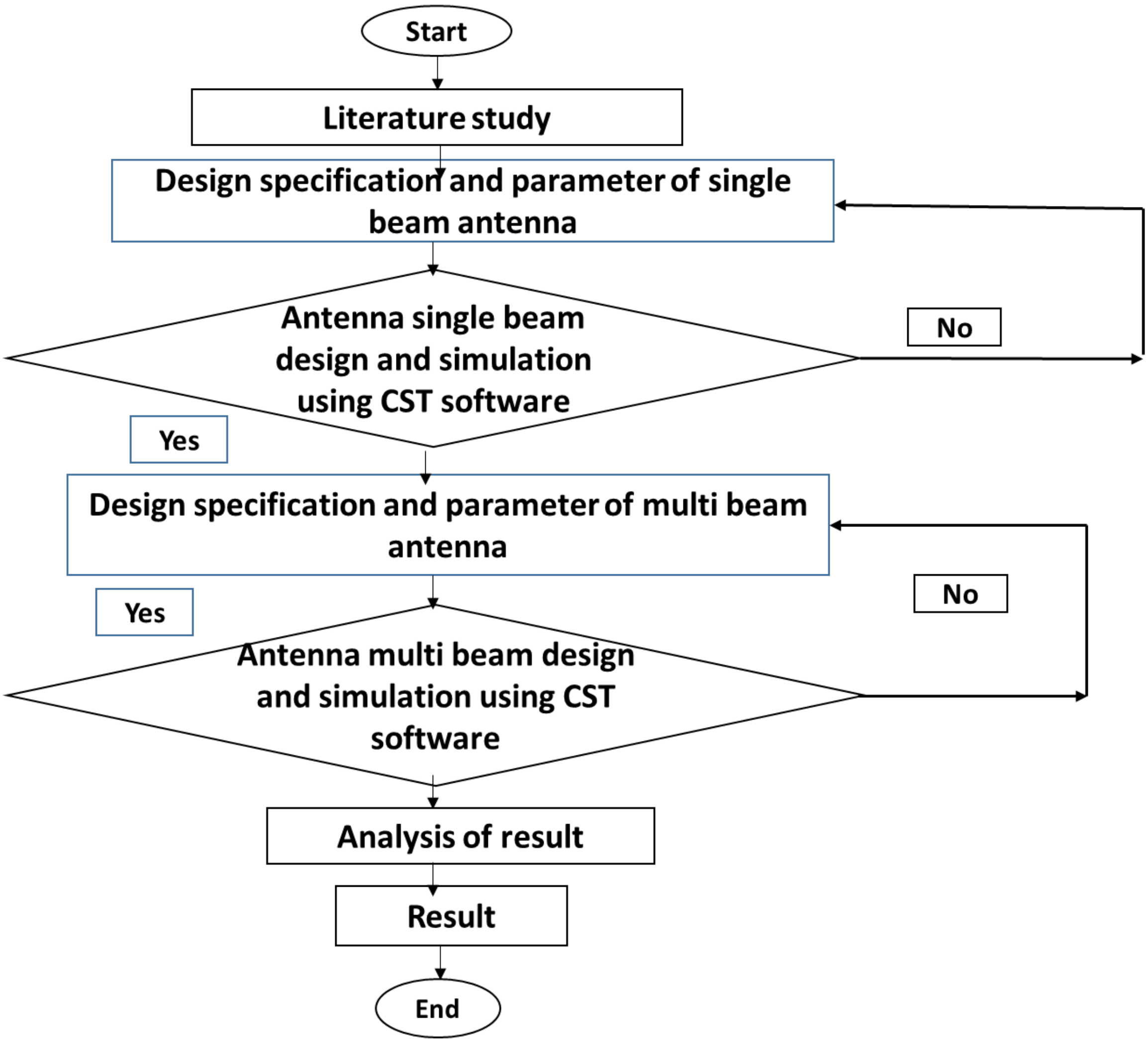

Figure 3.2: Work progress flowchart.

3.3.1 Detail Description of Research Methodology

3.3.1.1 Software Configurations

The CST (Computer Simulation technology) software is used for this project to simulate the designated antenna while analysing parameters such as radiation pattern, gain value and bandwidth of impedance.

3.3.1.2 The literature study on the selected references

A technique that can switch the antenna signal beam with durable material that is sustainable makes the signal stronger. The reason for switching the signal to the place where the unwanted signal is to reduce unused energy. It can also use the location that only authorizes people in search for security reasons. Some research has also been carried out on the design of the antenna and focused more on the performance of the antenna in terms of bandwidth, frequency, gain, loss of return and others.

3.3.1.3 Define the specifications and parameter of the antenna

(a) **Calculation of Width (W)**

For efficiency radiation to radiator:

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \qquad (3.1)$$

(b) **Effective Dielectric Coefficient calculation (εr):**

The dielectric constant effective:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + (\frac{\varepsilon_r-1}{2})/(\sqrt{1+\frac{12h}{w}}) \qquad (3.2)$$

(c) **Effective Dielectric Coefficient calculation (εr):**

The efficient dielectric constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + (\frac{\varepsilon_r-1}{2})/(\sqrt{1+\frac{12h}{w}}) \qquad (3.3)$$

(d) **Effective Length calculation (Leff):**

The effective length is as follows:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$ (3.4)

(e) **Length extension calculation (L)**

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}$$ (3.5)

(f) **Actual patch length calculation (L):**

The actual radiation patch length is obtained:

$$L = L_{eff} - 2\Delta L$$ (3.6)

(g) **Ground Dimension Calculation (Lg, W_g)**

For the ground of infinite and finite, the same results can be obtained if the ground plane size is greater than dimensions of the patch by an approximately six times the substrate thickness. Thus, the ground plane dimensions are:

$$Lg = 6h + L$$ (3.7)

$$Wg = 6h + W$$ (3.8)

3.3.1.4 CST (Computer Simulation Technology) design software

The software used in this project to design the antenna is Computer Simulation Technology (CST). After the design is fully completed, the simulation will start before the design to know whether the design is successful or not. Then, from the result, some analysis can be made from the graph of S-parameters. The accuracy and performance will be revealed from its graph.

3.3.1.5 Simulation and analysis of result

CST (Computer Stimulation Technology) is used to simulate the antenna after calculating all the parameters of the antenna design. The simulation and the result of overall will be analyze and recorded.

CHAPTER 4

RESULTS AND DISCUSSION

Computer Simulation Technology (CST) software are used to design this project throughout the project. The results of the simulation were discussed in this chapter in terms of loss of return, he radiation pattern and the gain of antenna. The antenna shape has been proposed based on various microstrip antenna array structures that could radiate at 28 GHz of the frequency. Overall of this discussion also will illustrate more about the outcome based on the results from the return loss, gain and radiation pattern to determine and fulfil the antenna design necessity for 5 G application systems.

4.1 The design specification

Because of its planar structure, a rectangular patch microstrip antenna is chosen and easy to model. Using Roger DUROID 5880, the antenna is designed to operate at 28 GHz frequency.

4.2 Single patch design of multi beam antenna

Before design the full multi beam of antenna, the single patch antenna has been designed to analyze it performance at 28 GHz. The patch antenna cam be attached at surface which have the flat structure. The edge of the patch antenna will radiate and will causes the antenna to act electrically slightly bigger than the physical dimensions, the microstrip transmission line length at the frequency is used for the antenna to be resonant. Figure 4.1 illustrates the design of the single patch antenna in this project.

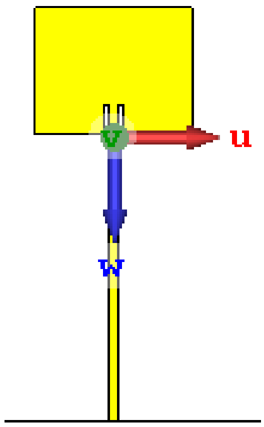

Figure 4.1: The single patch antenna design

Figure 4.2 and figure 4.3 shows the perspective view of the single patch antenna and also the back view of the single patch antenna respectively.

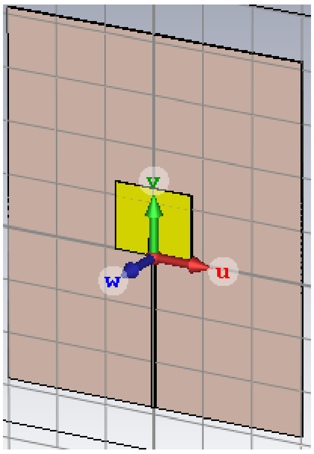

Figure 4.2: The perspective view of single patch antenna

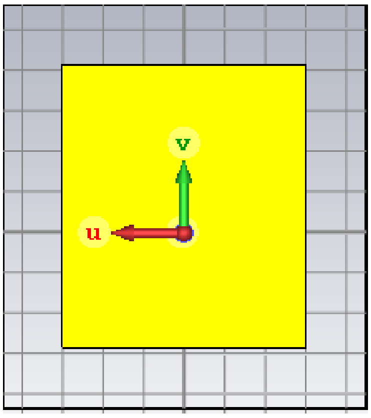

Figure 4.3: The back view of the single patch antenna

4.2.1 Single patch antenna parametric study

A parametric study is described by examining some of the result that have the parameter basic which represent the return loss (S-parameter), standing voltage wave ratio (VSWR), the impedance of reference involved and gain of the far field.

4.2.1.1 Return loss

Figure 4.4 indicates the coefficient of the simulation result of the single antenna patch designed in CST software. The coefficients of reflection for the single patch antenna are approximately shows the value of -20 dB and it affects the element of the radiant in terms of the return loss.

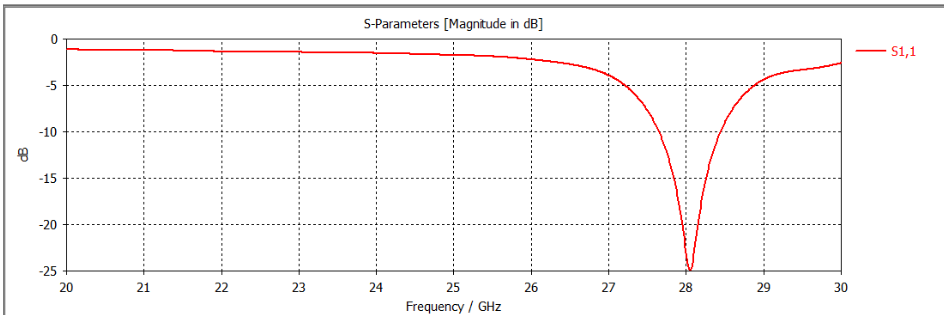

Figure 4.4: S_{11} parameter of return loss

4.2.1.2 Gain

The gain of antenna characterizes the amount of the power transferred to an isotropic source in the peak direction. In the specification of the specified antenna, antenna gain is frequently mentioned than directivity of the antenna because it takes into account that is occur in the losses of it. Figure 4.5 illustrates the Figure 4.5 shows the gain result of the single patch antenna from the front view.

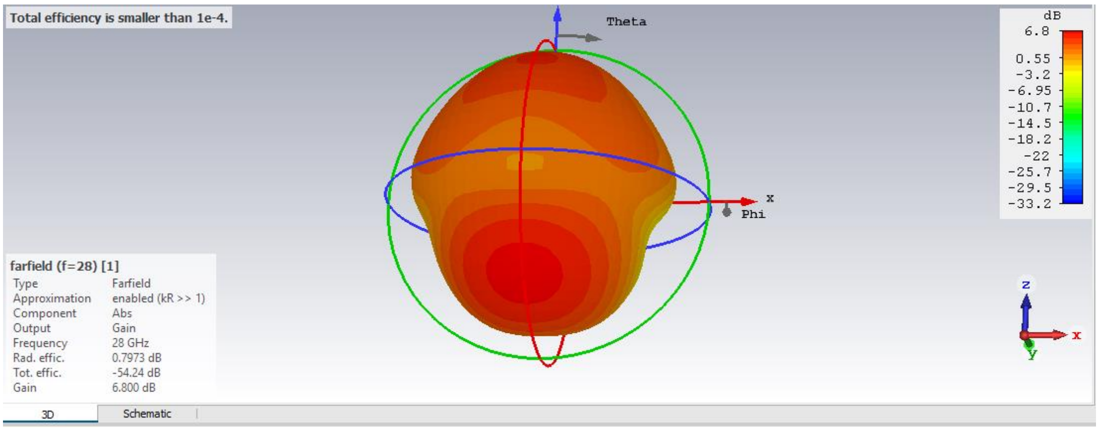

Figure 4.5: The gain from front view of single patch antenna

Figure 4.6 and figure 4.7 is illustrates the gain results of the single patch antenna from the right view and back view respectively. The gain is 6.8 dB with the frequency of 28 GHz and have the radiated efficiency of 0.7973 dB and the efficiency total of -54.24 dB

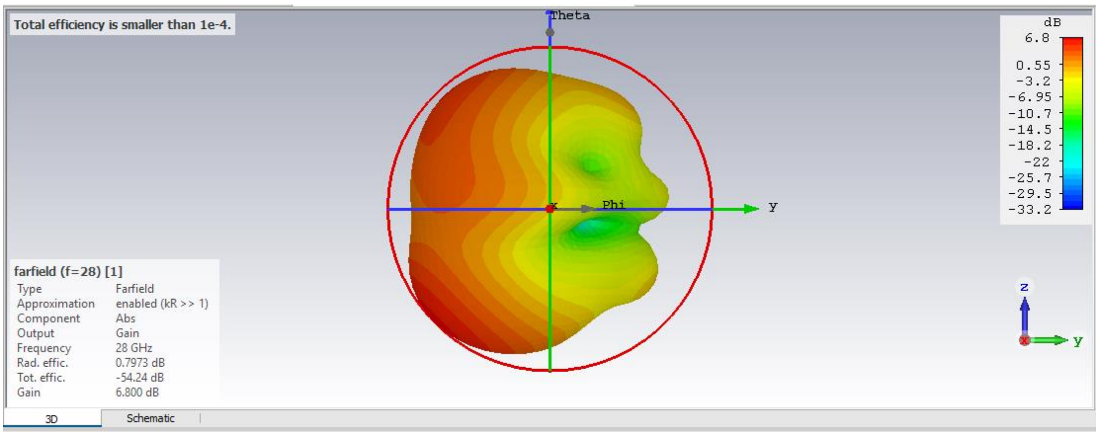

Figure 4.6: The gain from right view of single patch antenna

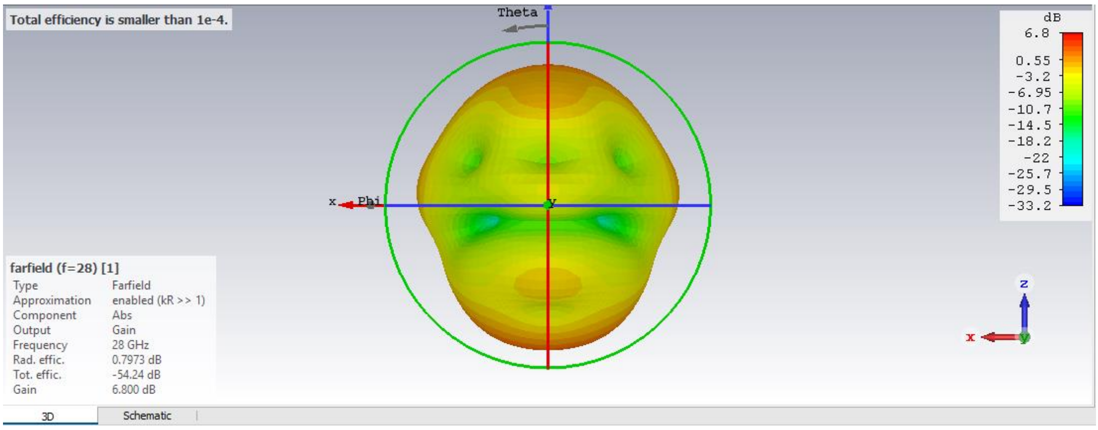

Figure 4.7: The gain from front back of single patch antenna

4.2.1.3 Radiation pattern and directivity

One of the main important in the antenna parameter study result is the directivity. It is a measure of on pattern of the directional antenna radiation that is being analyzed. An antenna that radiates in all directions fairly would result the directionality of zero A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna.

Figure 4.8 and figure 4.9 shows the radiation of pattern for the single patch antenna in the polar form when phi=90 and phi=0 respectively.

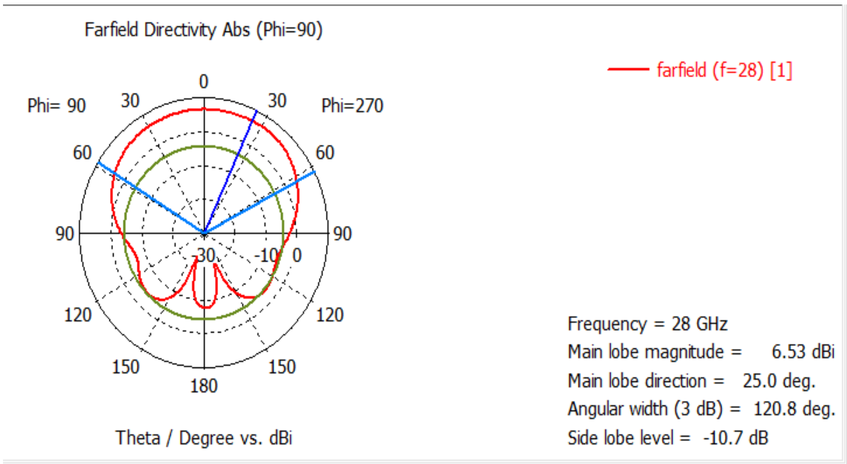

Figure 4.8: Radiation pattern in polar form when phi=90

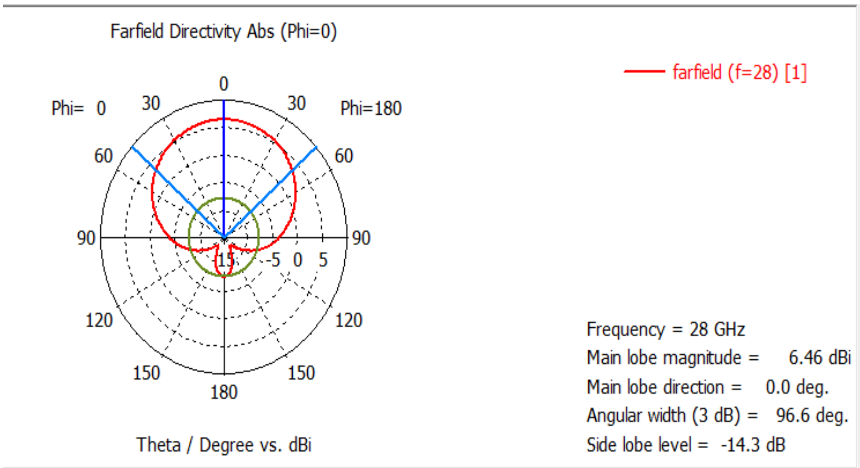

Figure 4.9: Radiation pattern in polar form when phi=0

4.3 Design of the L patch antenna

After the single patch antenna has been design in figure 4.1, the design is continuing with the adding the L patch antenna to make it as multi beam antenna. Figure 4.10 illustrates the design of the L patch antenna design.

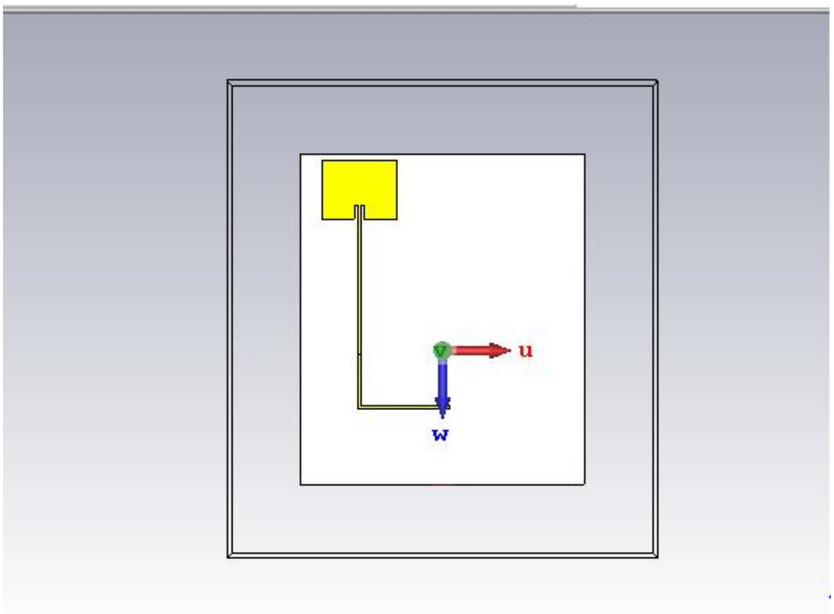

Figure 4.10: The L patch antenna design

4.4 Design of the multi beam antenna

After completed the single patch design and L patch design, multi beam now can be designed. The multi beam is designed. These results is providing the obtainable enhancements in path loss by combining all the beams combining beams. Figure 4.11 is illustrating the multi beam antenna result from the front view.

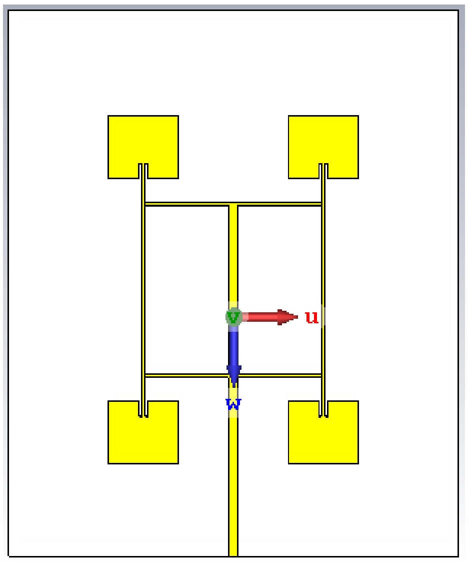

Figure 4.11: Front view of the multi beam design

Figure 4.12 and figure 4.13 shows the view of the perspective and the back of the multi beam antenna that have been designed in this project.

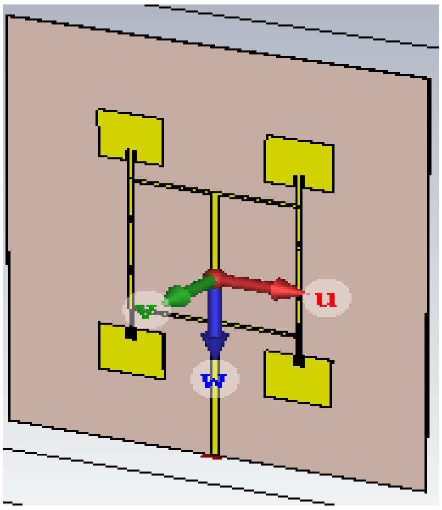

Figure 4.12: Perspective view of the multi beam antenna

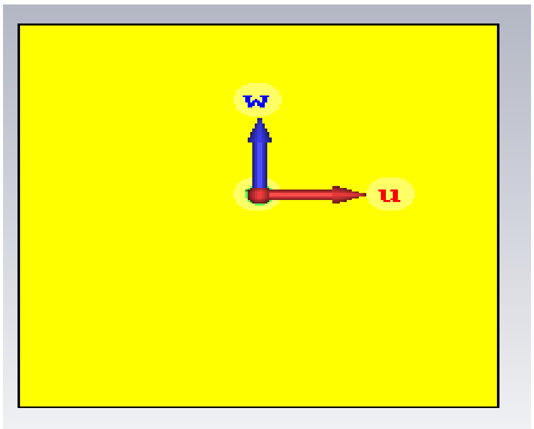

Figure 4.13: Back view of the multi beam antenna

4.4.1 Multi-beam antenna parametric study

4.4.1.1 Return loss

In order to obtain the desired response of return loss at the targeted frequency, paramedic study is carried out. The patch length affects the resonance frequency shift, this shift is happening due to the loss of power and lack of efficiency of the Duroid Rogers board. The frequency shifts of simulation and the resulting loss of return. Figure 4.14 shows the return loss (S_{11} parameter) of the multi beam antenna design.

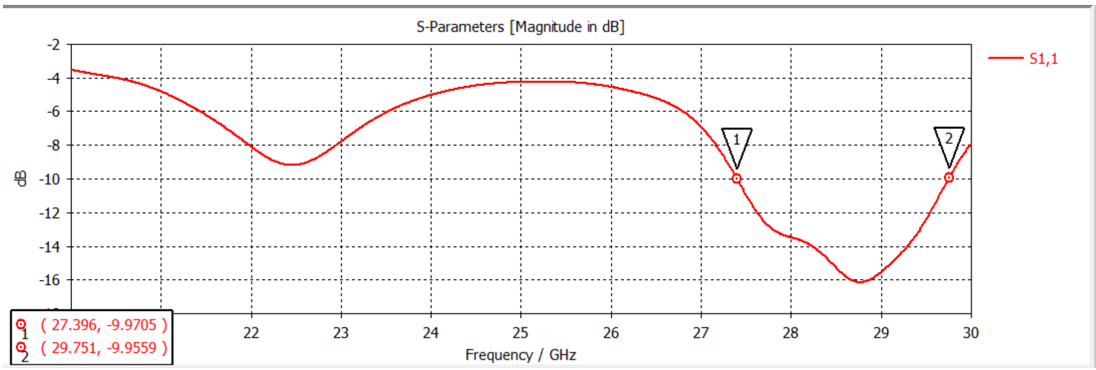

Figure 4.14: Return loss for S_{11} parameter

4.4.1.2 Gain

The gain in the simulation process for the patch antenna db. This gain allows the antenna to work more efficiently as receiver for the signal. It is therefore observed that the processes in the Rogers board of Duroid offer different gains due to power loss. Figure 4.15 is illustrating the gain result of the multi beam antenna design from the front view.

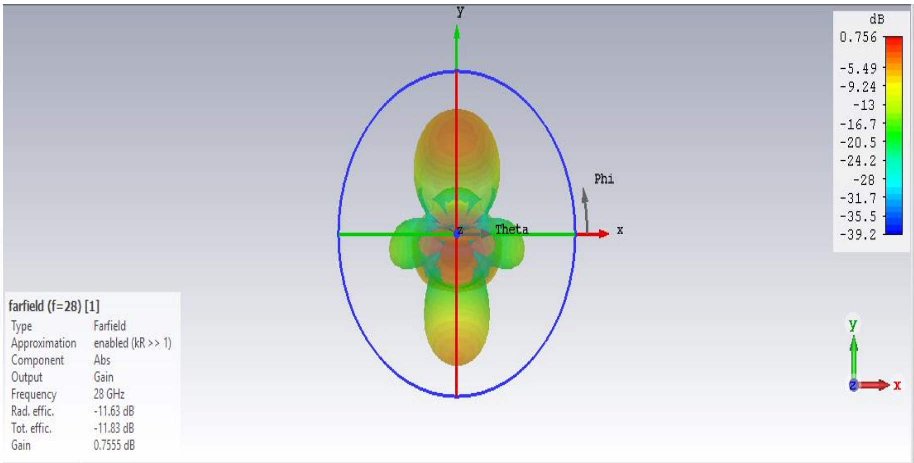

Figure 4.15: The gain from front view of multi beam patch antenna

Figure 4.16 and figure 4.17 shows the gain result of the multi beam design antenna from the right view and back view respectively. The gain measured for this design is 0.756 dB with the frequency of 28 GHz and have the radiation efficiency of 11.63 dB

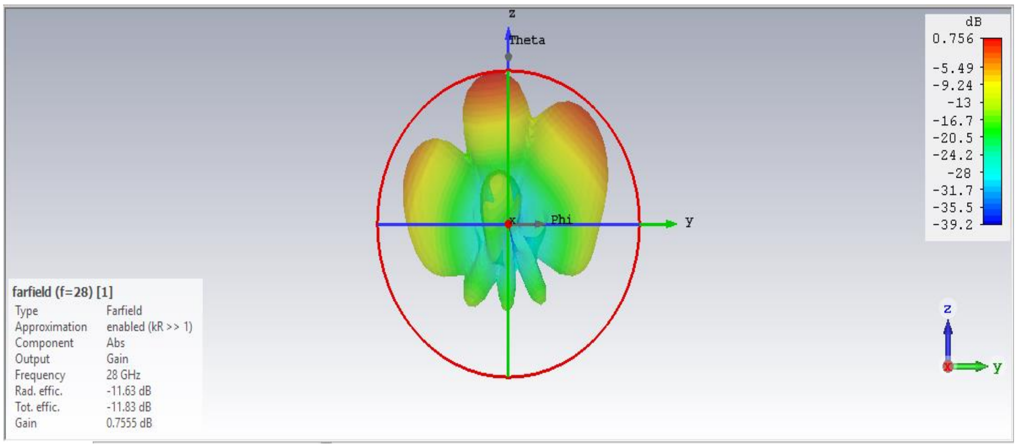

Figure 4.16: The gain from right view of multi beam patch antenna

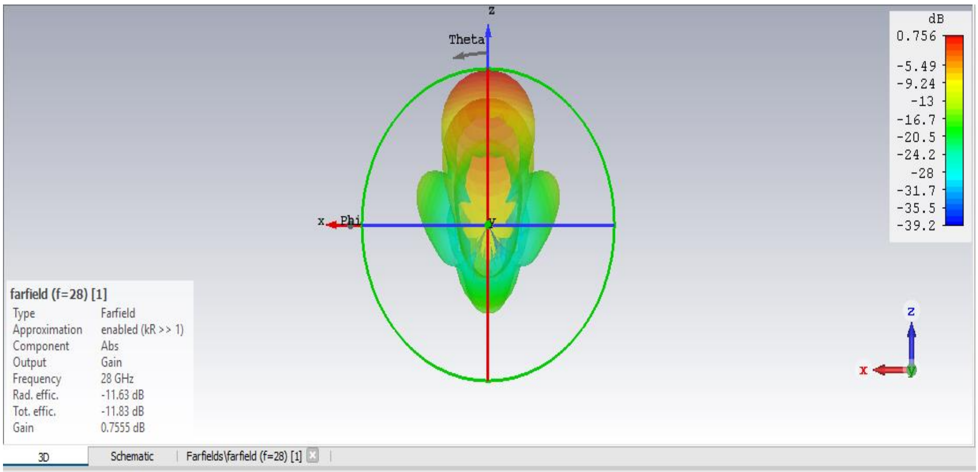

Figure 4.17: The gain from back view of multi beam patch antenna

4.4.1.3 Radiation pattern and directivity

The far-field result acquired through simulation was presented for the designed antenna in terms of radiation pattern and direction. This antenna's characteristic is directional and omnidirectional, indicating that the radiation is focused in one direction and all directions.

Figure 4.18 and Figure 4.19 shows the result of the radiation pattern of the multi beam antenna design when the phi=90 and phi=0 respectively.

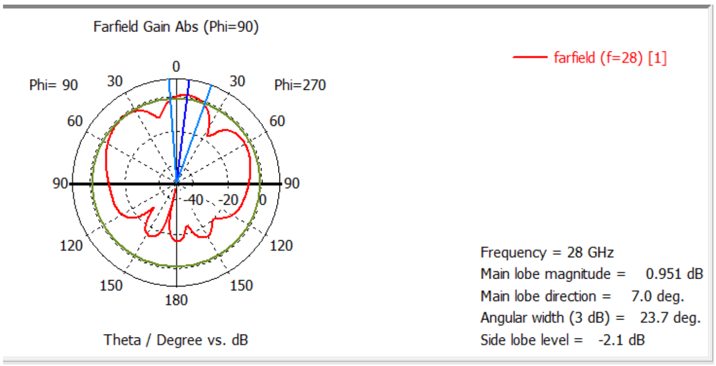

Figure 4.18: Radiation pattern in polar form when phi=90

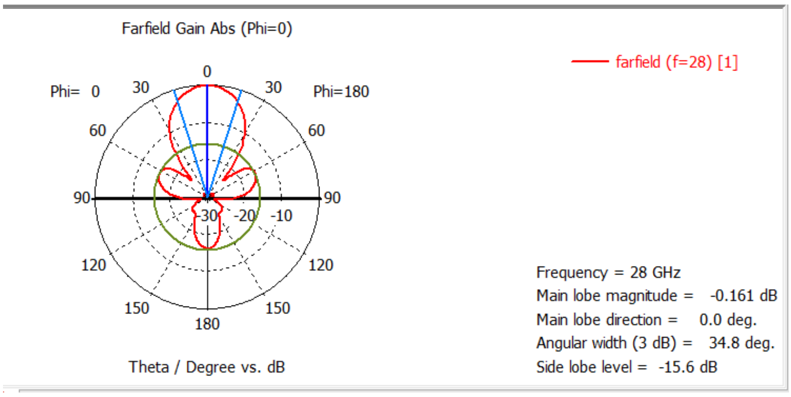

Figure 4.19: Radiation pattern in polar form when phi=0

CHAPTER 5

CONCLUSION AND FUTURE WORKS

This chapter is demonstrating the outline of the overall project. The discussion of the project specification which includes the next planning of this future project.

5.1 Conclusion

CST software is used in this project for get the result of the simulation and th us, the best result of the parameter will be chosen after the designed are made. Parameter study is very delicate, the difference between 0.01 mm can affect the outcome of the antenna that will outrageously effect the parameter such as the directivity of the antenna, gain and loss of return.

5.2 Commercialization

The size for this antenna are in small shape and the weight are light due to the 28 GHz frequency antenna. Because of this, the associated company could save a significant amount of money on maintenance work. Installing the antenna does not need any of the big machine. Rogers Duroid that is used in the substrate of antenna also could provide the great performance and better efficiency and also a larger bandwidth.

5.3 Future work

Rogers DURIOD 5880 with the value of 2.2 permittivity will be used in future. By introducing more array to the antenna, the design can be improved. Apart from that, by increasing the antenna frequency in the future to support more connectivity.

Consequences the knowledge should be implemented where in the market the available of the material needed are very important. In order to obtain a good result to simulation as well as gain knowledge and experiences will be increased. Hence, very good fabrication can be achieved. On top of that, a good quality of Roger Duroid 5880 board is absolutely needed for better performance and precise result.

The antenna measurement for the future measurement, the unavailability of the spectrum analyzer and enclosed chamber in UTeM, Malacca for measuring antenna operating at higher frequencies provides the student and researcher a restraint to conduct a test and measurement of the antenna such as radiation pattern and return loss to them in order to gain a chance to gain valuable experience. The performance of directivity, gain and return loss can be improved as a requirement for 5 G technology and citizen demand such as low latency, high speed and data rates.

REFERENCES

[1] W. Hong *et al.*, “Multibeam Antenna Technologies for 5G Wireless Communications,” *IEEE Trans. Antennas Propag.*, vol. 65, no. 12, pp. 6231–6249, Dec. 2017.

[2] L. Ching Yu and M. R. Kamarudin, “*5G Fixed Beam Switching on Microstrip Patch Antenna*,” *Int. J. Electr. Comput. Eng.*, vol. 7, no. 2, p. 975, Apr. 2017.

[3] K. Gowtham, S. Hariharan, and D. Mohana, “Design And Performance Analysis Of Multibeam Antenna,” 2014.

[4] M. P. Lotter and P. Van Rooyen, “An overview of space division multiple access techniques in cellular systems,” in *Proceedings of the 1998 South African Symposium on Communications and Signal Processing-COMSIG ’98 (Cat. No. 98EX214)*, pp. 161–164.

[5] Institute of Advanced Engineering and Science., *International journal of electrical and computer engineering : IJECE.* .

[6] O. O. Fagbohun, “Comparative studies on 3G,4G and 5G wireless technology,” Ver. I.

[7] S. Shu Sun and T. S. Rappaport, “Multi-beam antenna combining for 28 GHz cellular link improvement in urban environments,” in *2013 IEEE Global Communications Conference (GLOBECOM)*, 2013, pp. 3754–3759.

[8] “ANTENNA THEORY SIMPLIFIED:” [Online]. Available: https://www.mobilemark.com/engineering/antenna-terminology-defined/. [Accessed: 04-Dec-2018].

[9] “Developments in automatic beam switching.” [Online]. Available: https://www.marinemec.com/news/view,developments-in-automatic-beam-switching_44923.htm. [Accessed: 04-Dec-2018].

[10] “Multi-beam Antennas Deliver Excellent Wireless Performance for Special Events.” [Online]. Available: https://www.commscope.com/Blog/Multi-beam-Antennas-Deliver-Excellent-Wireless-Performance-for-Special-Events/. [Accessed: 04-Dec-2018].

[11] J. Howard, J. Logothetis, and J. Wilson, “Beamformers: broadband RF technology for integrated networks,” in *IEEE Antennas and Propagation Society International Symposium. 1996 Digest*, vol. 3, pp. 1632–1635.

[12] “Contact - ET Industries - Broadband Microwave Components and Subsystems DC-67 GHz.” [Online]. Available: http://www.etiworld.com/contacts.html. [Accessed: 04-Dec-2018].

[13] B. C. Wadell, *Transmission line design handbook*. Artech House, 1991.

[14] D. R. Jackson, “Overview of Microstrip Antennas.”

[15] J. R. James and P. S. (Peter S. . Hall, *Handbook of microstrip antennas*. P. Peregrinus on behalf of the Institution of Electrical Engineers, 2009.

[16] P.W.Davis and M.E.Bialkowski, "Linearly Polarized Radial Line Slot Array Antennas with Improved Return Loss Performance Using a Multilevel Coaxial Transition," IEEE Antennas and Propagation Magazines; vol. 41, pp. 52-61,2008.

[17] M. R. U. Islam and T. A. Rahman, "Novel and Simple Design of Multi-Layer Radial Line Slot Array (RLSA) Antenna using FR4 Substrate," 19th International Zurich Symposium on Electromagnetic Compatibility, pp. 843-846, 2008.

[18] C. A. Balanis, Antenna Theory Third Edition Analysis and Design, Canada: A John Wiley & Sons, Inc., Publication, 2005.

[19] I.M. Ibrahim, T. Purnamirza, T.A. Rahman and M.I. Sabran, "Radial Line Slot Array Antenna Development in Malaysia," 7th European Conference on Antenna and Propagation (EUCAP 2013), pp. 174-178, 2013.

[20] W. L. Stutzman and G. A. Thiele, Antenna Theory and Design, United States, America: John Wiley & Sons, Inc., 2012

[21] Y. Lizhi and D. W.B., "Radial Line Slot Array Antenna at Millimeter Wave