Millimeter Wave Array Antenna for 5G Communication

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CERTIFICATE OF CORRECTIONS & APPROVAL

Certified that work contained in this thesis titled **"Millimeter wave array antenna for 5G communication"**, carried out by GC Bilal Saeed, GC Zayyad Bin Tariq, GC Sheharyar Khan and GC Omer Farooq under the supervision of Lecturer Maryam Rasool for partial fulfillment of Degree of Bachelor of Electrical Engineering, in Military College of Signals, National University of Sciences and Technology, Islamabad during the academic year 2019-2020 is correct and approved. The material that has been used from other sources it has been properly acknowledged / referred.

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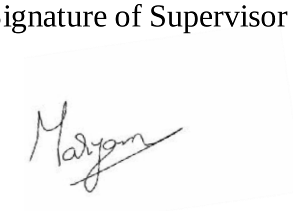

Lec Maryam Rasool

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Abstract

Our project "Millimeter Wave Array Antenna for 5G Communication" is an antenna structured for 5G communication. This frequency range involves Millimeter Waveband (30-300GHZ) spectrum which have applications in Satellite communication and for high-speed transmission. Also the Millimeter Wave band offers greater bandwidth, relieving network congestion. The high band provides an opportunity for high throughput services, localized developments and low latency use cases both for indoor and outdoor applications. Fixed wireless access points will also be benefited in case of high capacity. The Antenna provides high speed, lower latency and greater capacity of remote execution. Its simple structure and compact design makes it ideal to use in any portable indoor or outdoor applications, which require higher bandwidth to improve its overall communication efficiency. Moreover, the multi band operation is really in demand for wireless mobile communication or by multipurpose devices.

Key Words: *Millimeter Waveband, Multi band operations, Greater bandwidth*

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ABBREVIATIONS

MMWB	Millimeter Waveband
NIE	National Institute of Electronics

CHAPTER 1: Introduction

1.1. History of Communication:

History of Communication starts from ancient man who portrayed information using symbols and paintings. With the Evolution of Mankind, the modes of communication also became better with the help of science and technology.
Today we can communicate among ourselves using smart devices. In today world the communication is more easy, comfortable, quality based and mobile than it was in past or in early stages of humanity.

1.1.1 : History of Telecommunication and Wireless Communication

The main purpose of communication is to send or share information, it took ages for man to get the mobility of communication as it is in today. Telecommunication is communication of individuals using different modes, it maybe electromagnetic or through radio waves or by using different types of wire media. The history of communication starts from Smoke signals followed by Pigeon posts, Acoustic telephone, Semaphore lines, Signal lamps, Morse codes and the invention of Telephones in 1876 by Sir Graham Bell. The advent in wireless communication started in 1990s by making wireless devices like cellphones, laptops and it driven by the advancement in Radio and Microwave frequency. In order to meet these advancements Antennas were designed which communicated with each other through these fields[2].

1.2: Types of Antennas:

Antenna is a device that communicates through Radio waves. It acts both as receiver and as a transmitter.

1.2.1. Wire Antenna:

It is the antenna that uses a single wire to transmit and receive radio waves and to carry out communication between devices. Mainly it can be found on vehicles, ships, aircrafts and buildings[2]

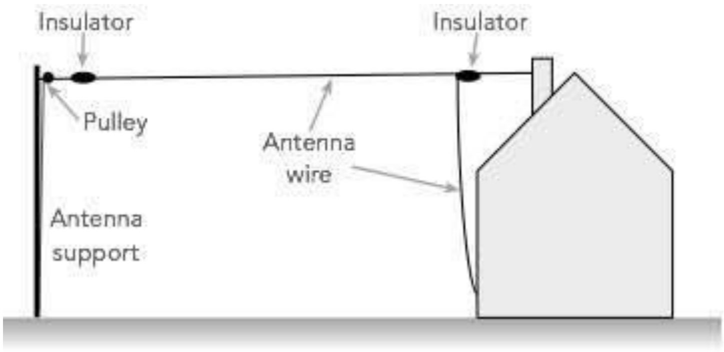

Figure 1: antenna workings

1.2.2. Dipole Antenna:

It belongs to simplest form of antenna; its structural view contains two equal conducting rods or bars connected end to end with the feed of antenna. Mainly they are used for receiving television services[2].

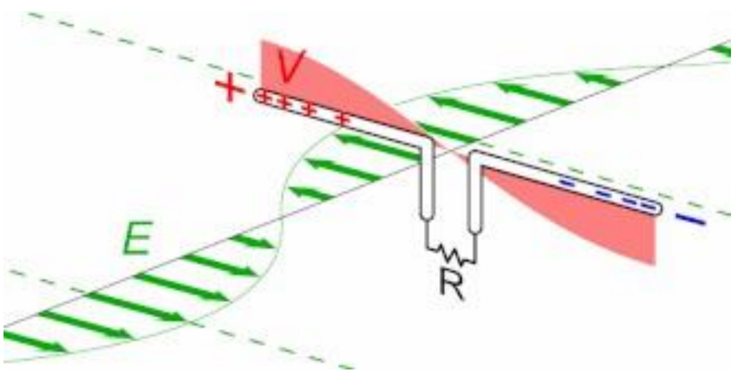

Figure 2: structural view of antenna

1.2.3. Loop Antenna:

It is the antenna that uses a coil of wire to transmit and receive radio waves.

The circumference of this structural coils is close to wavelength of antenna. They are used for reception of broadcast signals found in medium wave (AM) and long wave bands[2].

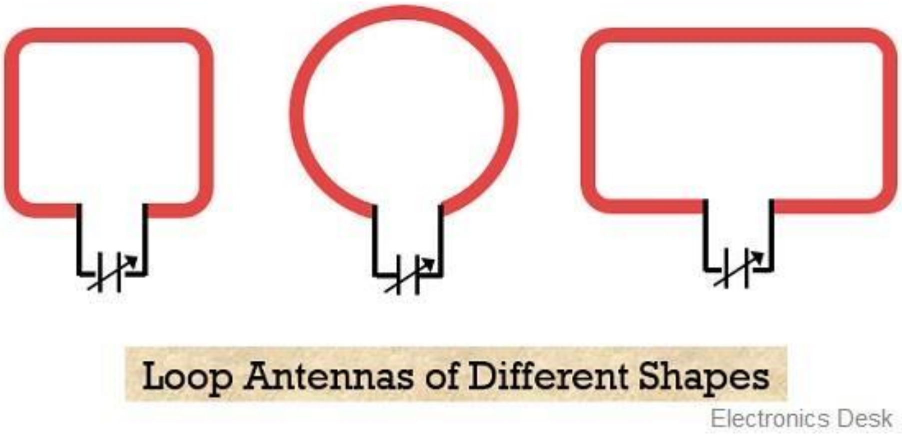

Figure 3: loop antennas

1.2.4. Array Antenna:

It is the combination of antennas in order to increase the productivity, results and to get better services from that antenna type. The signal strength, gain and directivity increase with low power wastage.

Mostly the individual entities (Antennas) are connected to single receiver or transmitter[2].

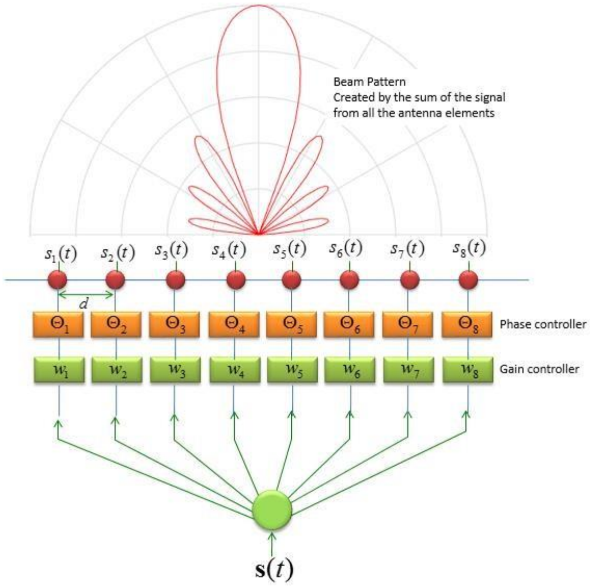

Figure 4: antenna results

1.2.5. Reflector Antenna:

The main theory of this antenna is that it contains a reflecting surface that will converge the coming electromagnetic waves on the face of antenna. The transmission process is also done by this reflecting surface which will throw the electromagnetic waves into outer environment[2].

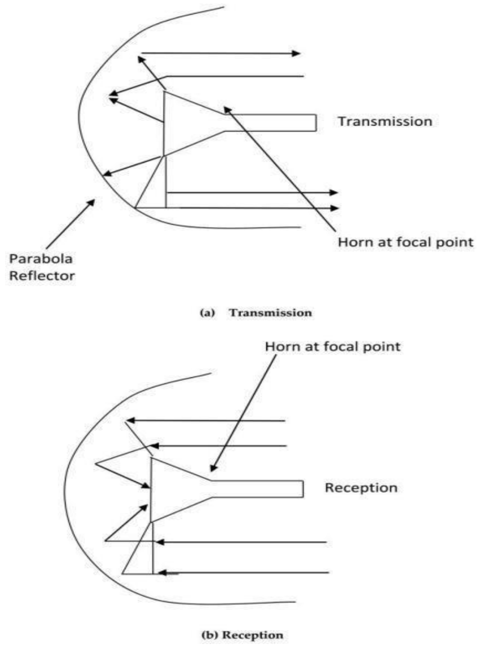

Figure 5: parabola antennas

1.2.6. Monopole Antenna:

It is a single rod-shaped conductor often mounted perpendicularly on a conductive surface. Often used as resonant antenna for radio waves. Its half of dipole antenna as it contains a single rod unlike dipole which has two conducting rods[2].

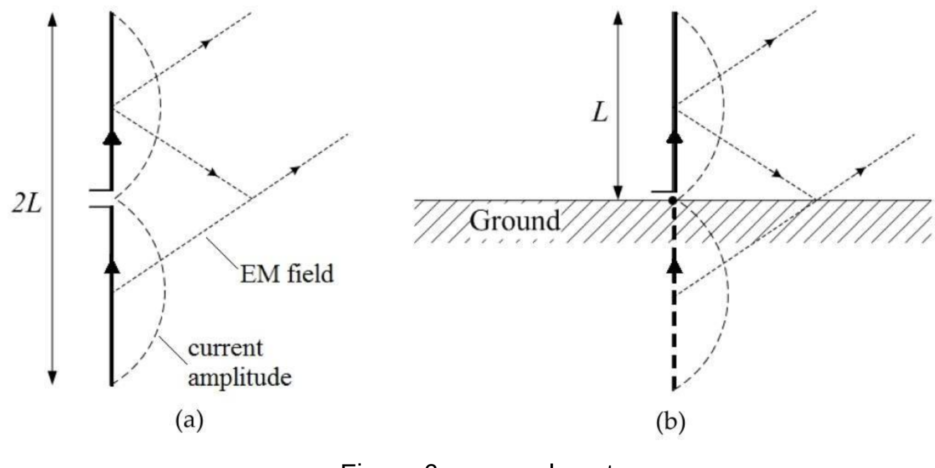

Figure 6: monopole antenna

1.2.7. Micro strip Antenna:

An Antenna used for microwave frequencies; it consists of a patch of metal foil fabricated on a surface of printed circuit board.
Despite having small size, it is significantly important in today world. It serves a big role in wireless communication and mobile communication[2].

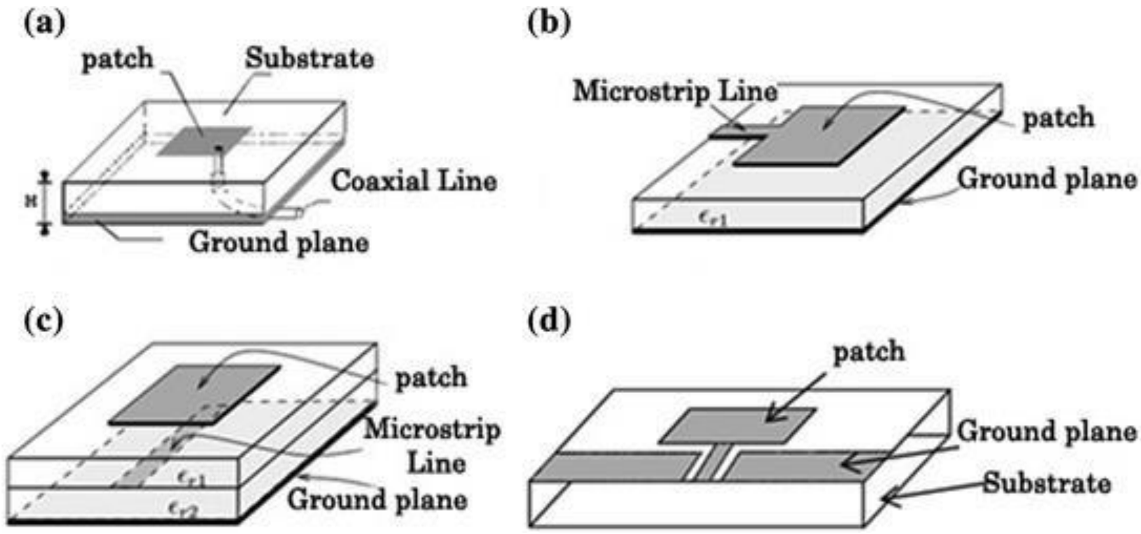

Figure 7: different element of micro strip antenna

1.3: Antenna Basic Parameters:

1.3.1. Gain:

The strength of the signal received or sent by an antenna in a specified direction is called antenna gain. It's the comparison between transmitted power and received power in specified direction. Higher the gain means higher propagation of signal in one direction and low propagation in other direction[2].

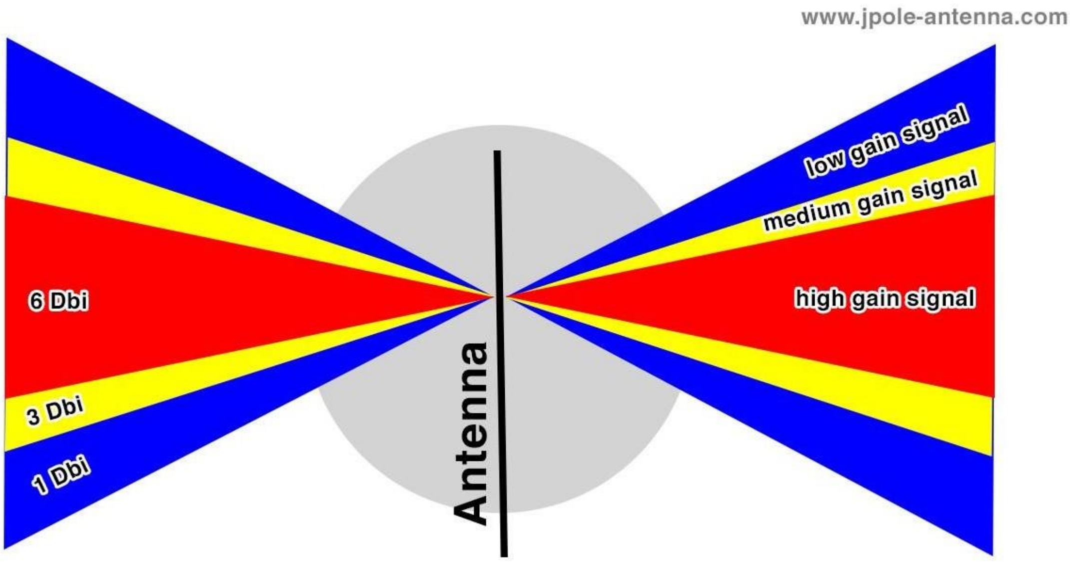

Figure 8: gain properties

1.3.2. Directivity:

Concentration of antennas radiation in a specified direction is called Directivity. A highly concentrated radiation pattern means high directivity and it means that beam will travel further[2].

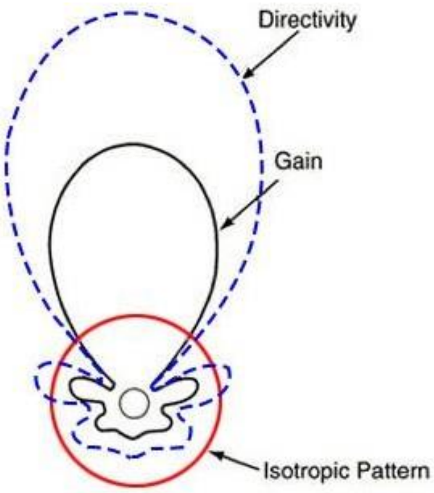

Figure 9: directivity pattern

1.3.3. Aperture Efficiency:

It is a dimensionless parameter that measures the closeness of antenna with using the radio waves that entered its physical aperture. In mathematical terms its effective aperture divided by the geometrical area of antenna[2].

1.3.4. Antenna Efficiency:

Antenna efficiency is the measure of electrical efficiency that enables the antenna to convert radio frequency to the power accepted at its terminals. It is measured in an echoic chamber by giving power to antenna feed pads and measure the strength of radiated electromagnetic in surrounding space[2].

1.4: Field Pattern of Antenna:

Field pattern is a disturbance that occurs in space-time microstructures and propagates along a characteristic line and does not evolve into cascade of disturbances and retains its form along a characteristic line[2].

1.4.1. Near Field:

The closest region to antenna where electromagnetic fields are being radiated is called Near Field. This region is really close to antenna so due to unpredictable behavior of electromagnetic waves no calculations are made in this region[2].

1.42. Far Field:

This region is after the Near Field region and it's the region where measurements are taken and in this region the behavior of electromagnetic waves are normal. Mostly the far field exists at 2*D*D/wavelength, where D is the maximum dimension of antenna[2].

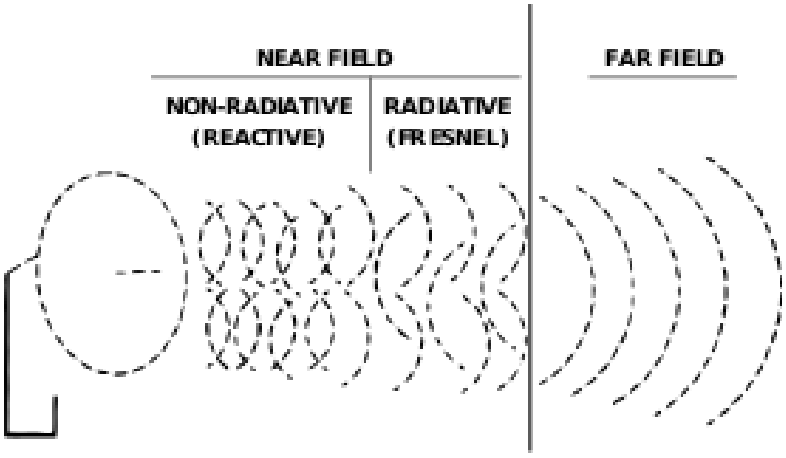

Figure 10: near field,farfield

1.5: Radiation Pattern:

This term defines the directional dependence of strength of radio waves from antenna or its source.

1.5.1. Field Pattern:

Field pattern is a disturbance that occurs in space-time microstructures and propagates along a characteristic line and does not evolve into cascade of disturbances and retains its form along a characteristic line.

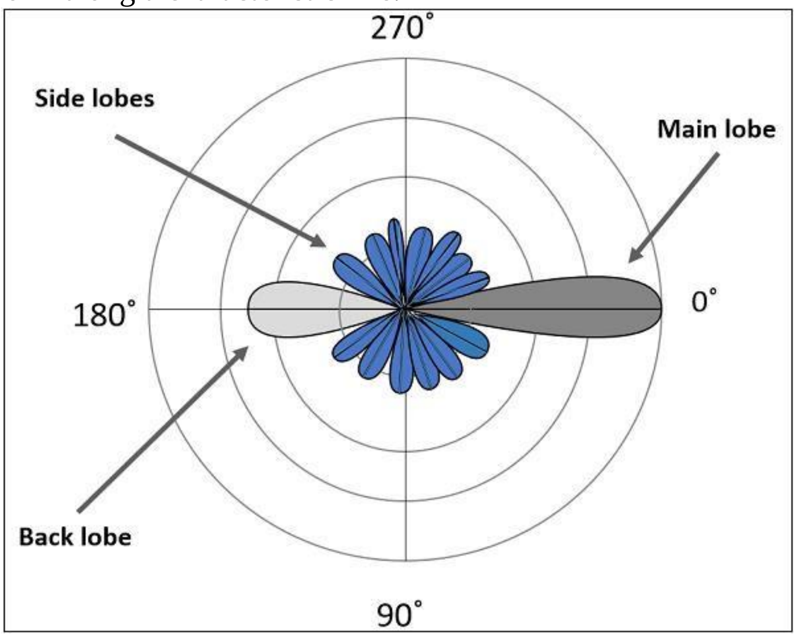

Figure 11: field pattern

1.5.2. Power Pattern:

Power patterns are patterns that are plotted as a function ofsquare of magnitude of electric and magnetic fields, commonly plotted o logarithmic or dB scale.

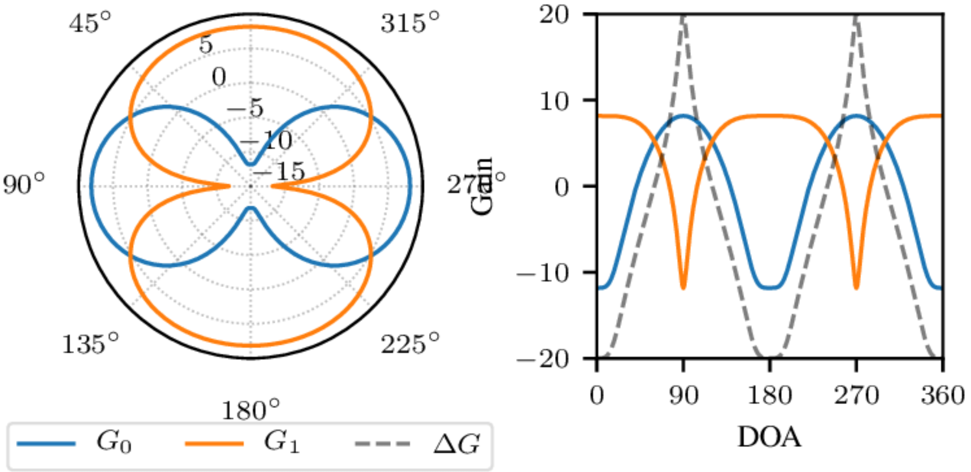

Figure 12: power patterns

1.6: Antenna Polarization:

Antenna polarization means the polarization of the electromagnetic waves radiated by an antenna in the far field region[2].

1.6.1. Circular Polarization:

Circular polarization is the state in which the electromagnetic wave of constant magnitude rotates at a constant rate in a plane perpendicular to direction of wave[2].

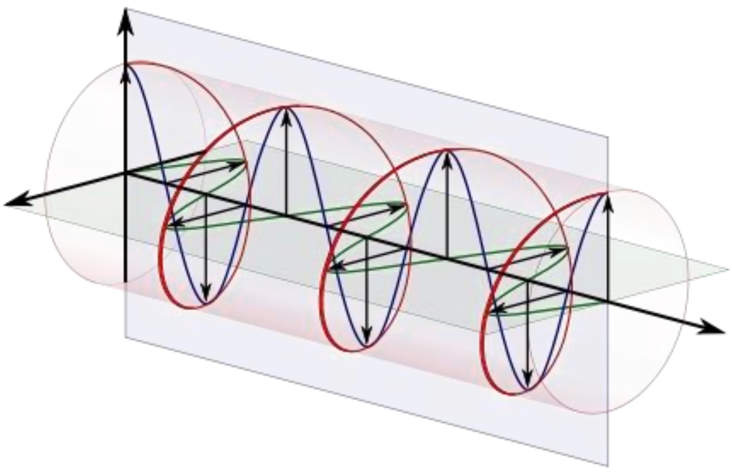

Figure 13: circular polarization diagram

1.6.2. Vertical Polarization:

In vertical polarization, the electric field of the electromagnetic wave radiated by an antenna propagates in vertical direction whereas, the magnetic field is at right angles to it.

1.6.3. Horizontal Polarization:

This kind of polarization has electric field parallel to earth surface, mostly they move from left to right.

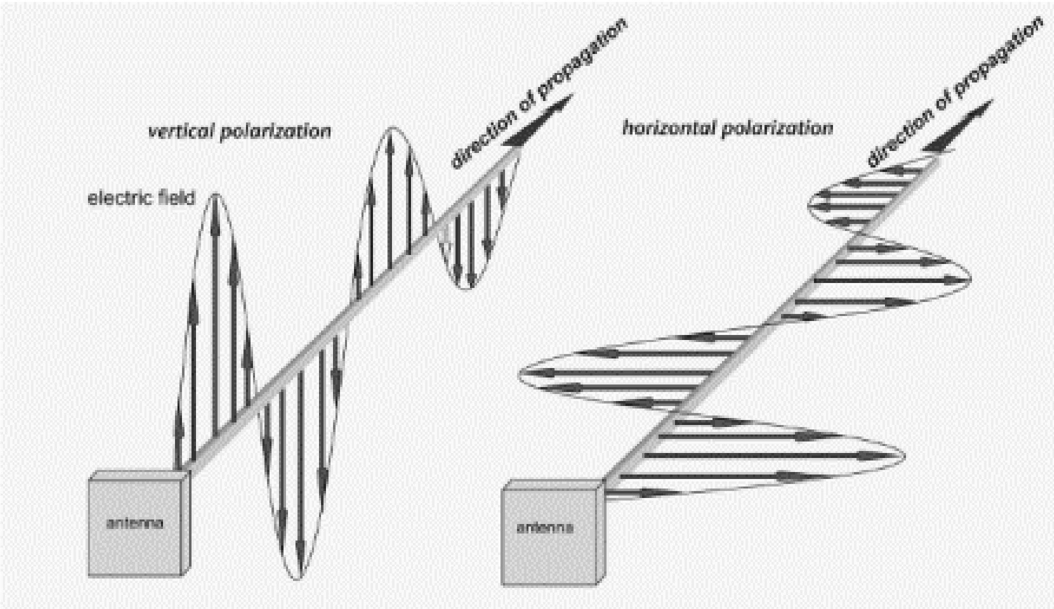

Figure 14: horizontal and vertical polarization

1.7. Problem Statement:

As the wireless technology progress its demand also expands and, in that demands, high data rates, more application of wireless networks using a single device also increases. In order to cater the huge amount of data rates Millimeter wave frequency band has caught attention and is a new field for researchers and is used as a primary frequency band for 5G communication. Moreover, antennas operating at multi band are preferred for mobile communication or multi operation devices for 5G communication

1.8. Proposed Solution:

Communication is the key to future in modern day, with faster and reliable communication humankind is now getting information from millions of miles away through satellites.

This project antenna will be a handful piece in understanding the behavior of new 5G technology Millimeter wave band. The Millimeter wave band will help us to achieve high Gain and Antenna Efficiency and will result in better antenna performance with low latency and high data transmission. Moreover, the antenna being multi band is going to cater more 5G applications with low latency.

CHAP 2: Literature Review

Research Papers:

2.1 :5G MIMO Conformal Micro Strip Antenna Design :

One of the research papers is 5G conformal antenna design with MIMO development for better results and high antenna strength.5G is upcoming technology in wireless communication, which enables us to achieve high data rate and better communication for future purposes. The conformal design is used to describe antenna array with some prescribed shape and angles. Conformal design can be easily designed on surface of carrier without any damage to carrier and can save space too.

The initial frequency is going to be 35Ghz with 60∘angle between carrier axis and main lobe of antenna[1].

2.1.2 : Antenna Design:

The initial design is based on Rectangular Micro Strip Patch Antenna
As we are working on Millimeter Wave Band Spectrum whose frequency range is from 3- 300 GHz and inside it our focus is Ka band whose frequency range is 26.5-40 GHz. As, the loss of micro strip in millimeter wave band is very large which is a combination of conductor loss and dielectric loss so, we will use substrate with low tangent to minimize the loss[1].

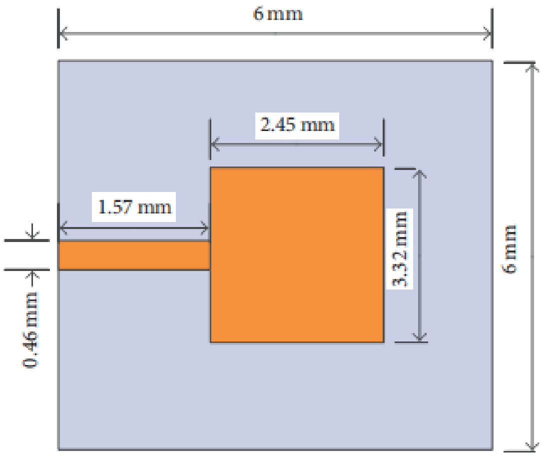

FIGURE 1: The model of rectangular microstrip patch antenna.

Figure 15: model of rectangular patch antenna

2.1.3 : Results:

For Conformal nature antenna thinner and flexible substrate is best so we will use RT/Duriod 5880 and height about 0. 5mm.The width of patch antenna is going to determine the Directivity factor, radiation resistance and other characteristics of antenna. Initially the nature is going to be SISO and single band we will change it for multi band resonant frequency[1].

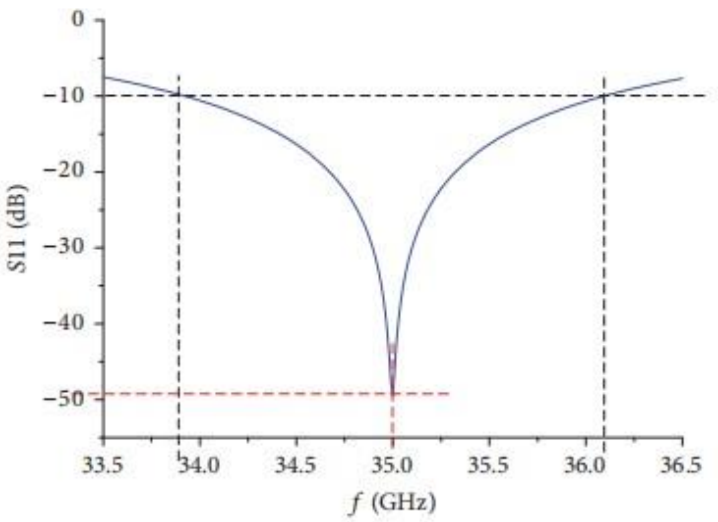

FIGURE 2: S-parameter of rectangular microstrip patch antenna.

Figure 16(a): S (1,1) parameters showing return loss.

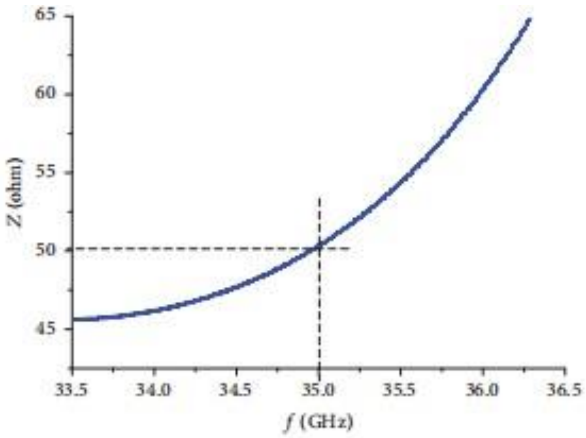

FIGURE 3: The input impedance of rectangular microstrip patch antenna.

Figure 16(b): impedance graph

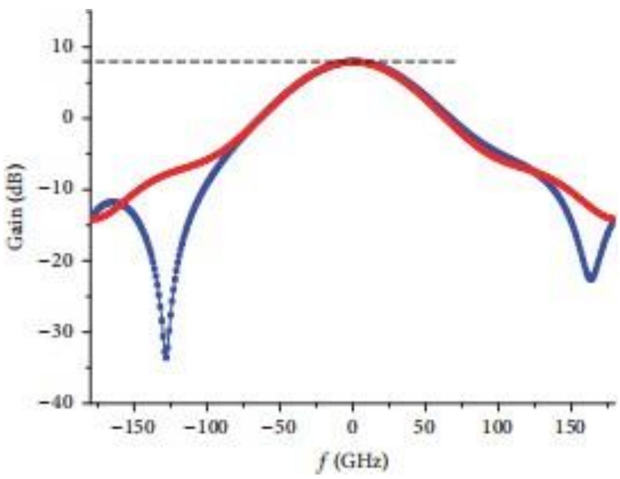

Figure 16(c): gain graph

2.2: Single Band Antenna for Millimeter Waveband for 5G Communication:

Single band millimeter wave band antenna is used for 5G communication and will operate on 38 GHz. The single band contains 50-ohm micro strip line feeding and FR4 dielectric as substrate with relative permittivity 4.4, loss tangent 0.02 and height 1. 6mm.Single band antenna works only on a single frequency.

2.2.1 : Antenna Design:

As told before FR4 dielectric is used as substrate with thickness of 1.6mm with relative permittivity at 4.4.

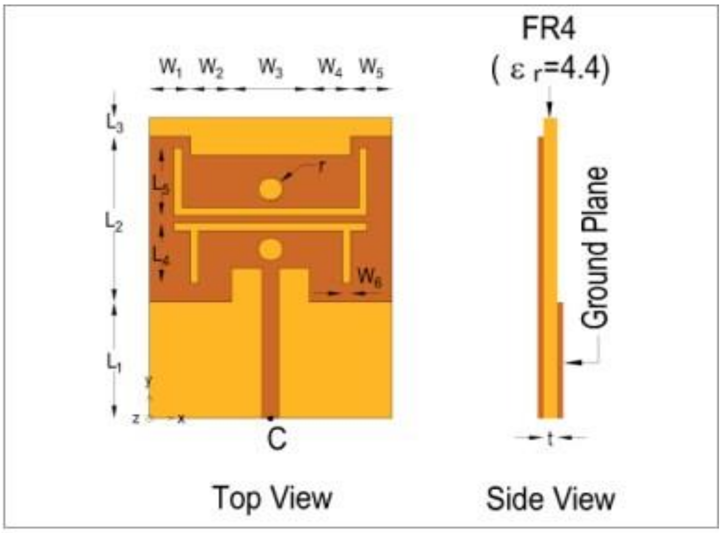

Figure 4. Structure of proposed single band antenna.

Figure 17: model of micro strip antenna

2.2.2 Measurements and Results:

The Antenna measurements and results are defined below in figures.

Table 1: dimention graph of antenna

Table I. Dimension of proposed antenna.

Parameter	mm	Parameter	mm
L_1	3.1	W_3	1.9
L_2	4.4	W_4	1
L_3	0.5	W_5	1
L_4	1.4	W_6	0.2
L_5	1.6	r	0.3
W_1	1	t	1.6
W_2	1		

Table II. Return loss and bandwidth of the proposed antenna.

Resonant Frequency (GHz)	Band covered	Return loss (dB)	Bandwidth (GHz)
38	Ka	-24.35	1.021

Table III. Directivity in E and H plane at operating frequency.

Resonant Frequency (GHz)	Directivity in E plane (dB)	Directivity in H plane (dB)
38	2.37	2.37

S (1,1) Plot:

The plot here shows the return loss of the upper design. The antenna here is operating at 37.5GHz

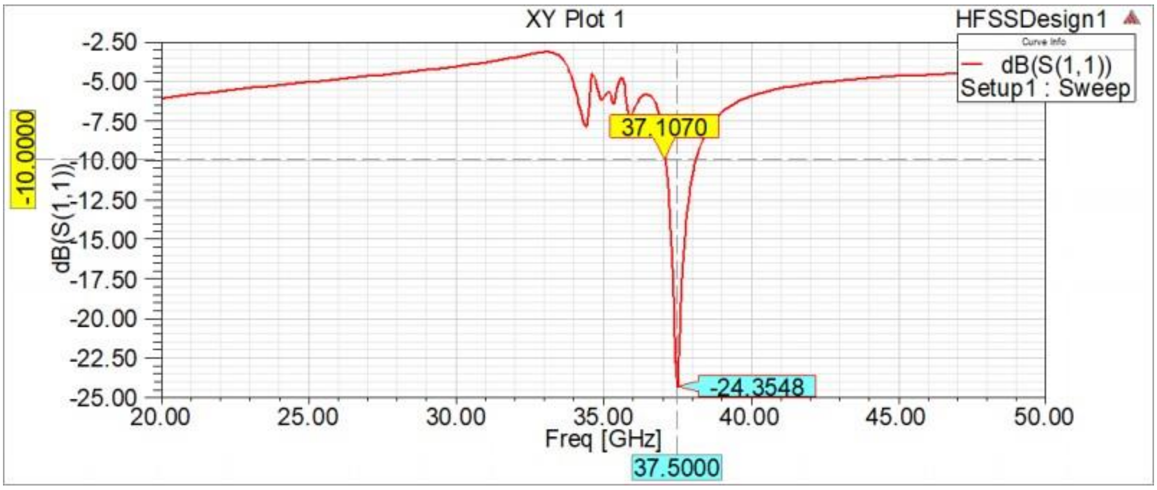

Figure 18(a): S (1,1) plot

3D POLAR PLOT:

Figure 6. Gain of the patch antenna.

Figure 18(b): 3D gain plot

2.3: 60 GHZ MILLIMETER WAVE ANTENNA:

In this paper an inset feed 60Ghz Millimeter Wave Band antenna is made for 5G wireless communication with three different types of Electromagnetic Band gap (EBG). The three types are Cross, Mushroom and Hexagonal as ground planes. The cross-shape design improves gain; the mushroom provides better efficiency. Due to small size of these antennas, they are suitable for medical implants operating in unlicensed millimeter wave band[3].

2.3.1 : Antenna Design:

The antenna is fabricated on 8mm x8mm x0.5mm FR4 epoxy sheet having dielectric constant 4.4, loss tangent 0.02. The antenna geometry is built as figure below followed by EBG geometry and cross, hexagonal, mushroom designs[3].

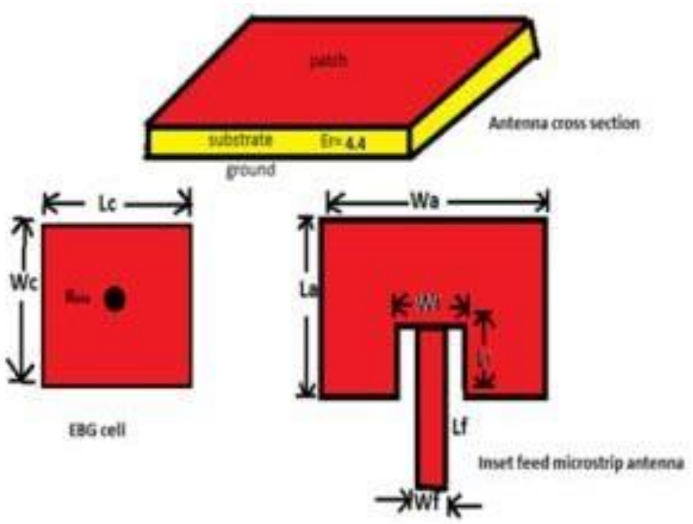

Figure 1 Antenna geometry

Figure 19(a): Antenna Model

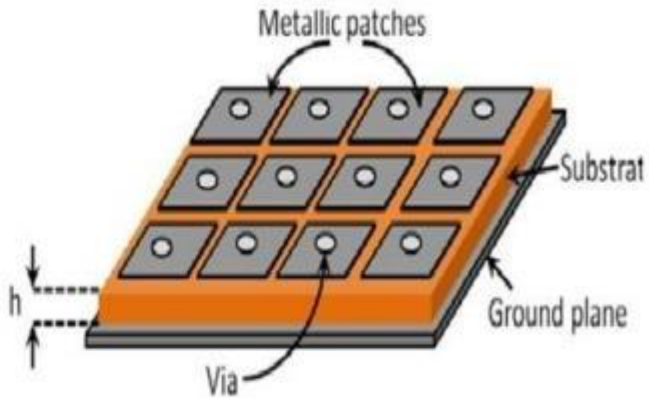

Figure 2 EBG Geometry

Figure 19(b): EBG geometry

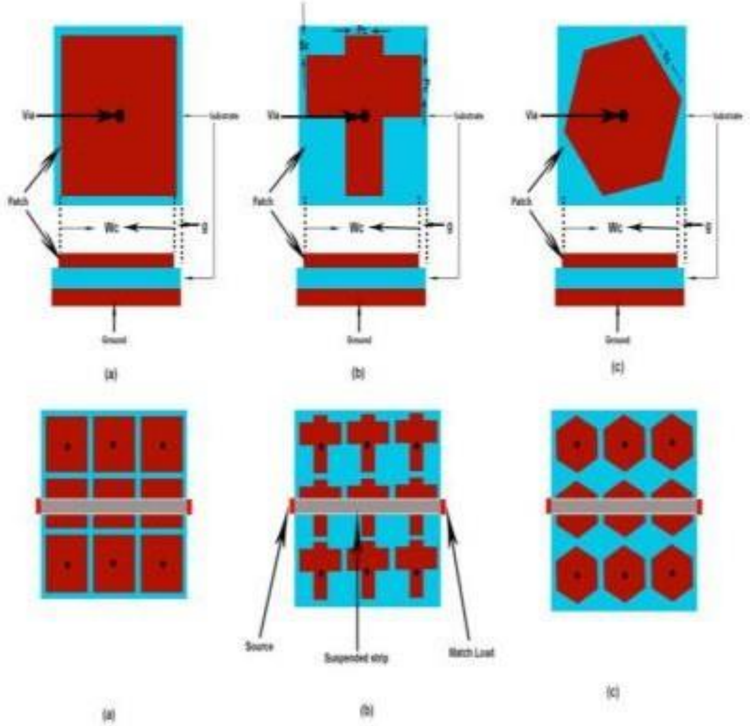

Figure 3 EBG unit cells and Surface Wave Bandgap setup (a) Mushroom (b) Cross (c) Hexagonal.

Figure 19(c): EBG unit cell

2.3.2 : Results:

The antenna with and without EBG results are below.

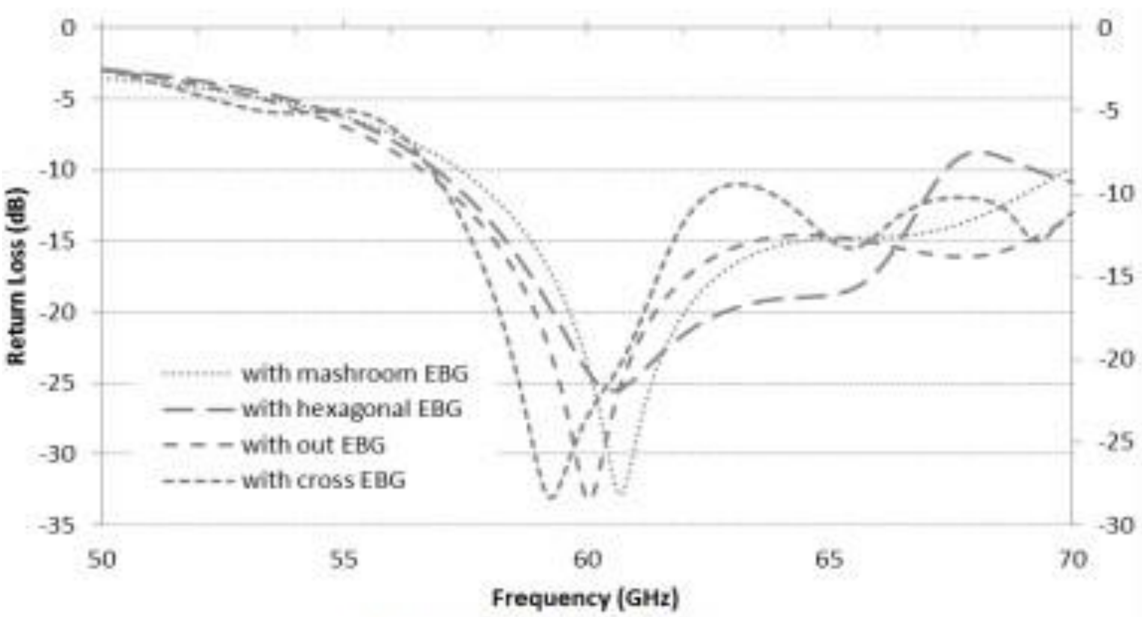

Figure 5 Return loss

Figure 20(a): S (1,1) plot

Table 2: summarized resuts

Table 3 Summarized results

Parameter	Antenna without EBG	Cross EBG	Mushroom EBG	Hexagonal EBG
Gain(dBi)	6.721	8.30	7.83	7.35
Directivity(dBi)	7.36	9.54	8.60	8.21
Efficiency(dB)	4.51	6.01	5.60	5.12

Comparing Results of all research papers we used to find out the research gap and how to improve it considering the present results. The main results compared are to be Gain and Directivity.

2.4: Comparing Results:

Table 3 result table comparison.

Research Papers	Operating Frequencies	Gain	Directivity	Return loss
1:5G Conformal Antenna	**F=35Ghz**	**8**	**2.2**	**-50**
2:5G Single Band Antenna	**F=38GHz**	**1.265**	**2.37**	**-24.35**
3:60 GHz Millimeter Waveband Antenna	**F=60Ghz**	**Without EBG=6.72 Cross EBG=8.30 Mushroom EBG=7.83 Hexagonal EBG= 7.35**	**Without EBG=7.36 Cross EBG=9.54 Mushroom EBG=8.60 Hexagonal EBG=8.21**	**Without EBG= -32.8 Cross EBG= -33.2 Mushroom EBG= -32.4 Hexagonal EBG= -26**

2.5: Research Gap Analysis:

As we have compared the results of research papers, we found out about the bands in which they are operating i.e.: Millimeter waveband and with their design specification we learned how to improve Gain and Directivity by simply changing antenna shape.

The main things these designs were lacking was multi band characters and all these designs are operating on single band with much complex design to handle andall were for 5G Wireless Communication. So, in this regard we will try to design an antenna with multi band operating frequency and with a simple design which is going to be easy for fabrication purposes.

Chapter 3: Antenna Design and Results

Implementing design on HFFS and came across different parameters that are discussed below.

3.1. Substrate Selection:

Substrate is an insulator that is used to give electrical and mechanical strength stability. They are used to decrease the size of antenna and helps to produce displacement currents when in response produces time varying magnetic field.
The thickness of substrate is directly proportional to the bandwidth of antenna[2].
The substrate selection depends on two things.

3.1.1. Loss tangent (tan ((δ):

Loss tangent (**tan** (δ)) or Dielectric loss is measure of signal loss due to dissipation of electromagnetic energy. Loss tangent is for high frequencies, for low frequency dissipation factor is used instead of loss tangent.
A low loss tangent means low losses at certain frequency, loss tangent changes little bit with frequency change.

3.1.2. Dielectric constant (ϵr):

It is the ratio of permittivity of material with respect to the permittivity of vacuum.

$$k = E/E\mathbf{0}$$

K= dielectric constant
E= permittivity of the substance
E0= permittivity of a vacuum

Keeping the parameters of substrate in mind, the substrate chosen is
Rogers RT /droid 5880
This material is highly desirable for high Frequencies to have a better gain and directivity with respect to aperture efficiency.

3.2. Data Sheet (RT Duriod 5880):

Table 4: data sheet of duroid 5880

Property	Rogers Rt/Duriod 5880
Dielectric Constant, ĸ Process	2.20 2.20 ± 0.02 spec.
Dielectric Constant, ĸ Design	2.20
Dissipation Factor, tan δ	0.0004 0.0009
Thermal Coefficient of α	-125
Volume Resistivity	2×10^7
Surface Resistivity	3×10^7
Specific Heat	0.96 (0.23)
Moisture Absorption	0.02
Thermal Conductivity	0.20
Coefficient of Thermal Expansion	31 48 237
Td	500
Density	2.2
Copper Peel	31.2 (5.5)
Flammability	V-0
Lead-Free Process Compatible	Yes

3.3. HFSS design:

The antenna was designed on HFFS software using following parameters:

All simulations are performed using HFFS. Here we have designed the model on HFFS which had given the good results. The substrate used in it is duroid 5880 and dimensions are shown in diagram.

Figure 21: Simple Patch Antenna Design

RESULTS

3.4. Return loss:

This first graph shows the S (1,1) results of the upper design and as we can see here the antenna is working on frequencies between 34 to 36GHz while at 35GHz that return loss is about -24db.

Figure 22: S (1,1) plot

3.5. Radiation Pattern:

This is the radiation plot of the above design:

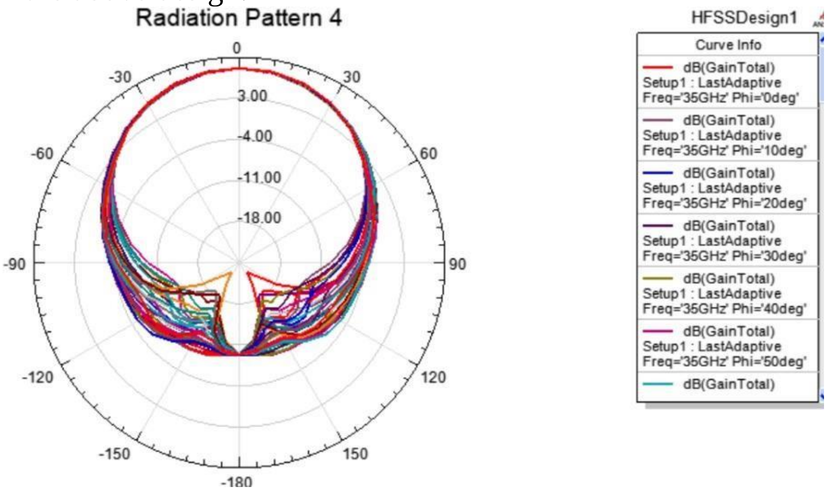

Figure 23: radiation pattern

3.6. 3D Polar Plot:

Now this is the 3D polar plot of the antenna, and it shows the gain of the design, Which is 8.1db.

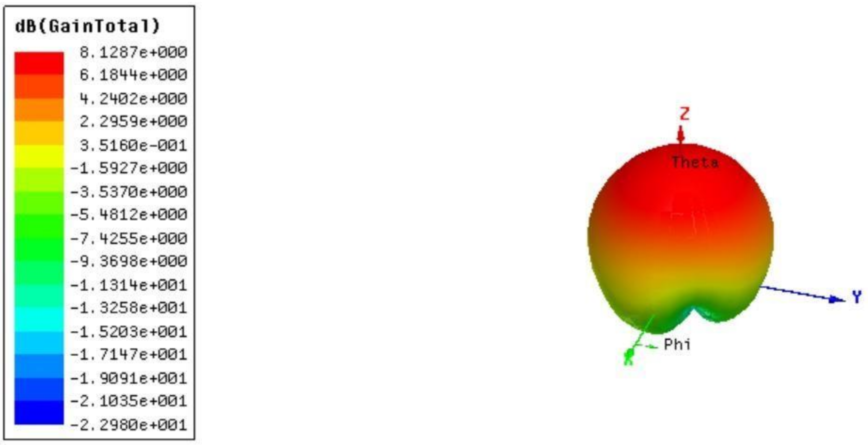

Figure 24: gain plot

The frequency band width of the micro strip antenna is not enough for the whole system. Therefore, in the following we will analyze array to meet the requirementsand to create a new resonant frequency to make our antenna multiple band.

Table 6: results of above design

Operating bands (Single)	34Ghz to 36 GHz
Gain	2.6db at 35GHz

3.7. Engraving Slots in Patch Antenna:

3.7.1. Slot Engraving:

Slots are holes that are usually made in patch structure for several different reasons. Few of them are defined below.

1) To have a new resonance frequency.
2) To increase/decrease the gain of antenna structure.
3) To adjust antenna impedance with cable impedance.
4) For mechanical structure in order to fold or bent the antenna.

3.7.2. Design after Slotting:

So to have a new band we put these 6 slots in the patch due to which we got different results. The design with slots is shown below.

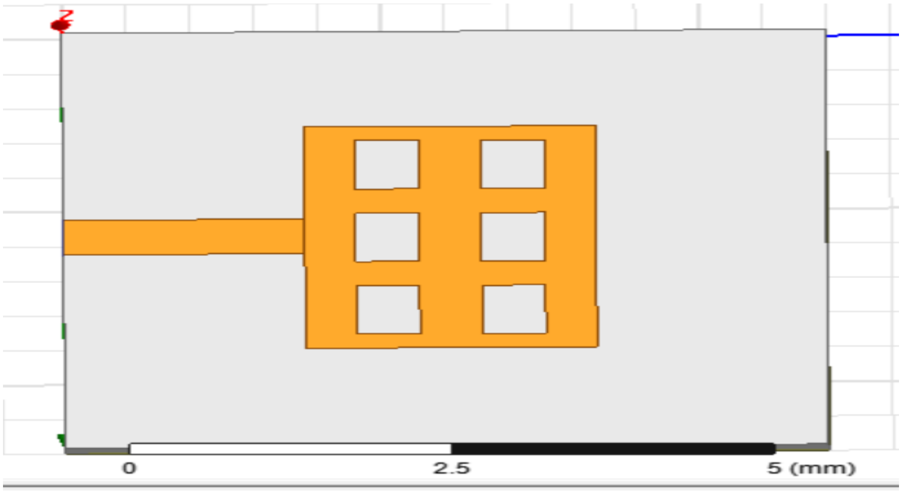

Figure 25: Antenna Slot Design

3.7.3. RESULTS:

Return loss:

The S (1,1) results of the design with slots shows that the antenna is working on 22.5GHz and we are getting second band as well which is near 39GHz but as it is still above -10db so it is not operating on that band.

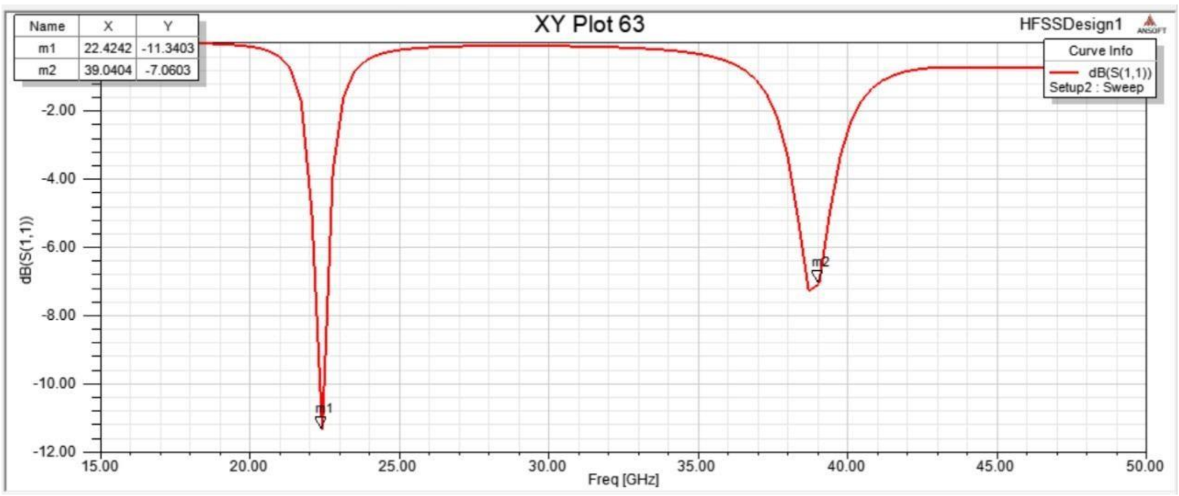

Figure 26: S (1,1) plot of antenna with slots

3D Polar Plot:

Now this graph shows the gain of the antenna now. Which is about 5.9 and is positive.

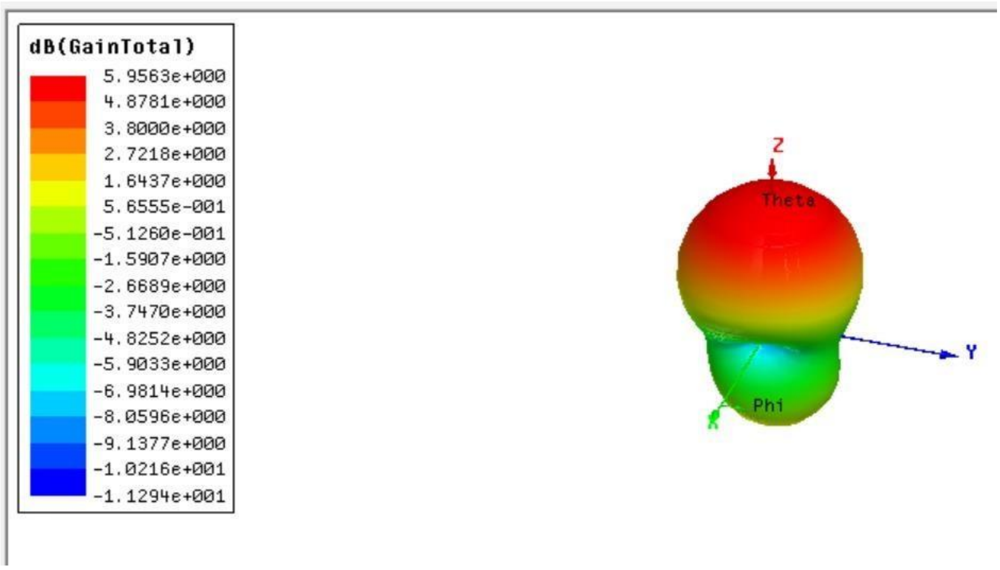

Figure 27: gain plot

The Return loss of micro strip S11 for slot design is -11.6db.and is now operates on 22.5GHz.

Table 7: summarized results of above design

Operating bands (Single)	At 22.5Ghz
Gain	5..963 dB

CHAP 4: MMWB ARRAY DESIGN

Array of Antenna:

The initial design was used multiple times (i.e.: eight times) to make an array that will work together as a single design(antenna).
The pain purpose here for array design is get favorable results like improved gain, diversity reception and low interference.
The type of array used is linear.

4.1. HFSS design:

The array designing lead to a whole different set of measurements including the ground, antenna and feed followed by several slots engraved in the patch design.
We are using Eight patch design combined in a linear form followed by an open circuit in one end and a linear feed line on other side.
In each initial patch design six rectangular slots are made that led to 8x6=48 slots in total structure of patch.

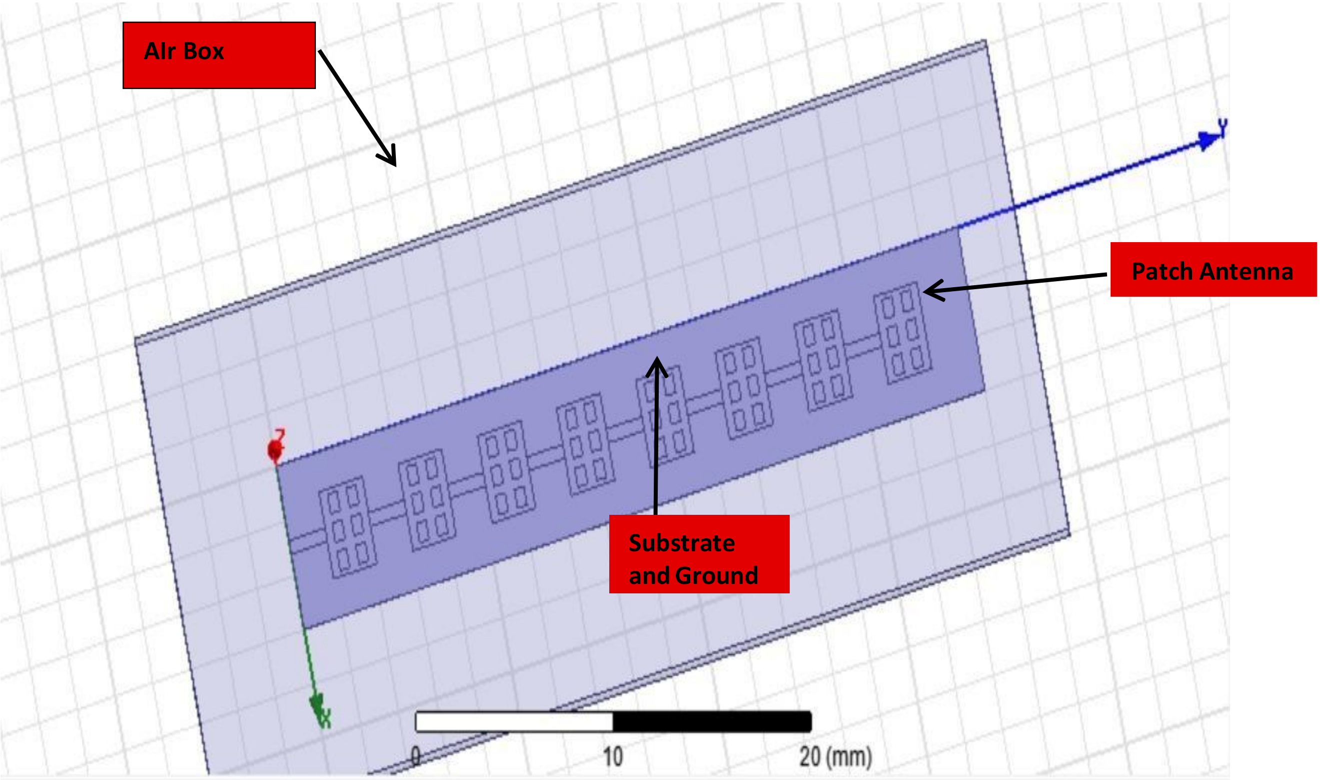

Figure 28(a): array antenna design for multi band on mm waveband

4.1.1. Substrate:

The substrate is going to be same i.e., Rogers RT/Duriod 5880 as it was in initial design. The substrate details are mentioned in chap 3 along with its data sheet.

TOP VIEW:

Figure28(b): top view of array showing patch

BOTTOM VIEW:

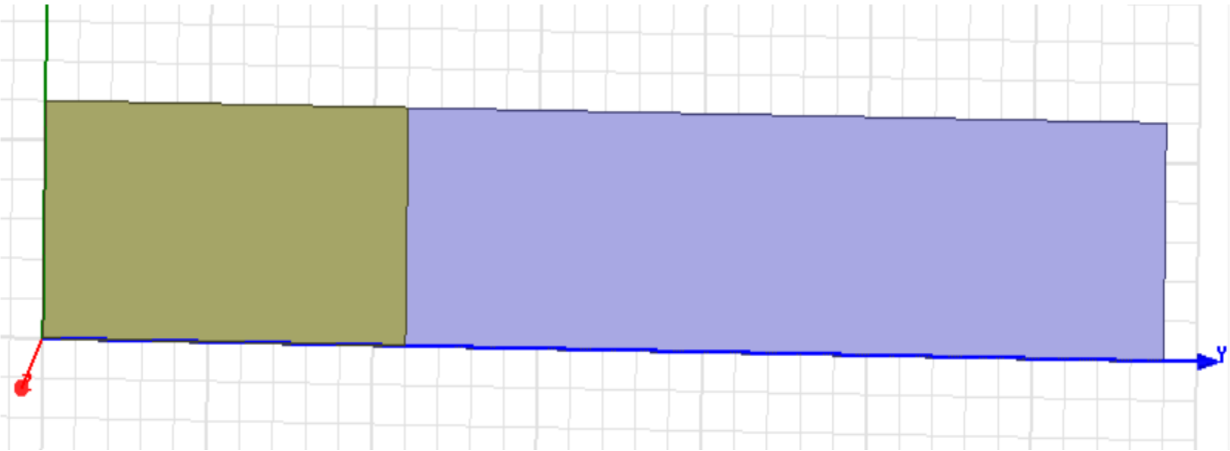

Figure 28(c): rear view of the array showing bottom

4.1.2. Parameters and Positions:

Table 8: parameters of the array antenna

4.2. RESULTS:
4.2.1. Return Loss:

The graph below shows the return loss of the array antenna. It is working on multiple frequency band which was required. The operating bands will be described in the table on coming pages.

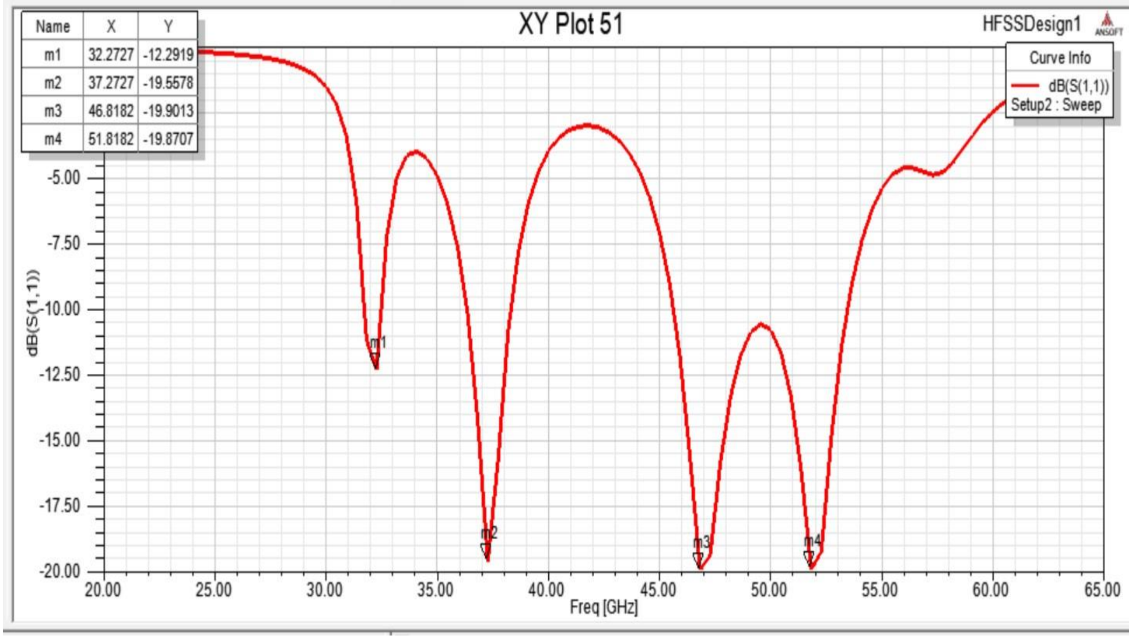

Figure 29: return loss for the array antenna

4.2.2. 3D POLAR PLOT AT 32GHZ:

As we can see we have 3 different operating bands, so we have measured gain for each band. At 32GHz the gain is 5.8db.

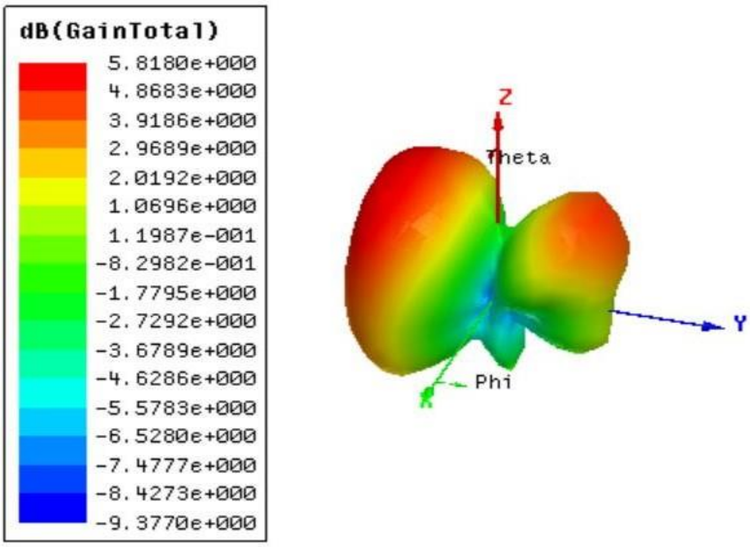

Figure 30: gain at 32GHz

4.2.3. 3D POLAR PLOT AT 37GHZ:

The gain at 2nd operating band is 7.8db as it is shown in the graph below.

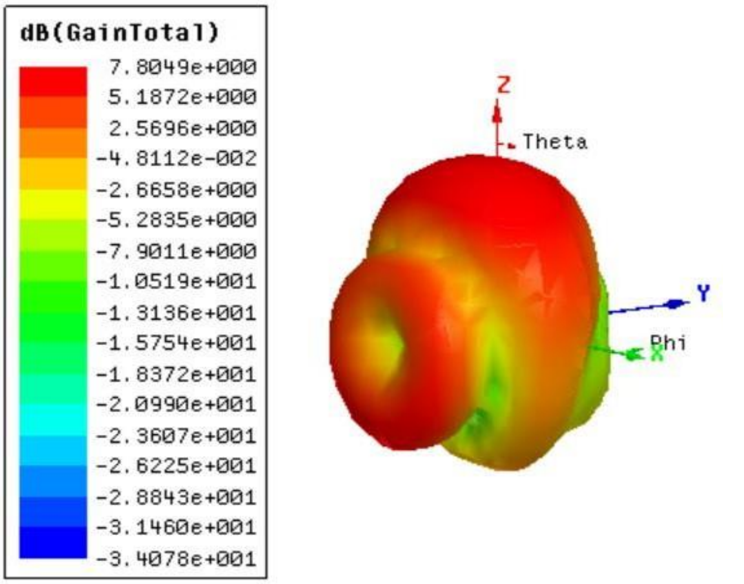

Figure 31: gain at 37GHz

4.2.4. 3D POLAR PLOT AT 47GHZ:

Now for the 3rd operating band we have this gain.

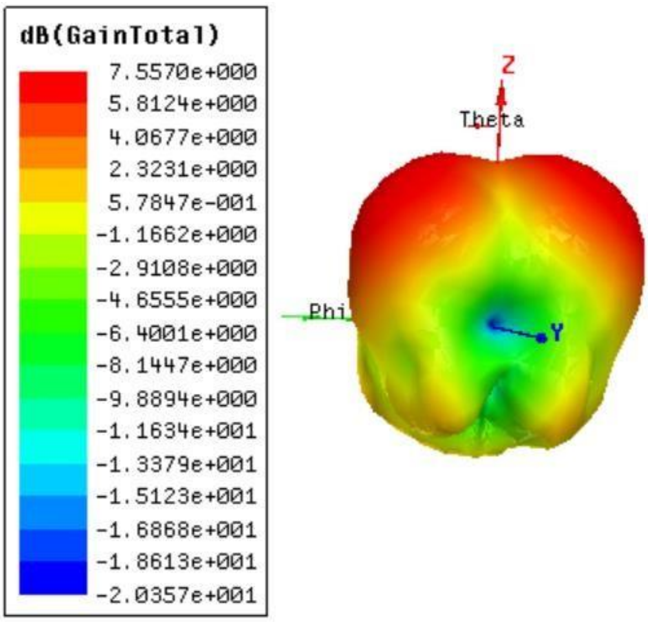

Figure 32: gain at 47GHz

4.2.5. RADIATION PATTERN:

Radiation pattern for the above array antenna is shown below:

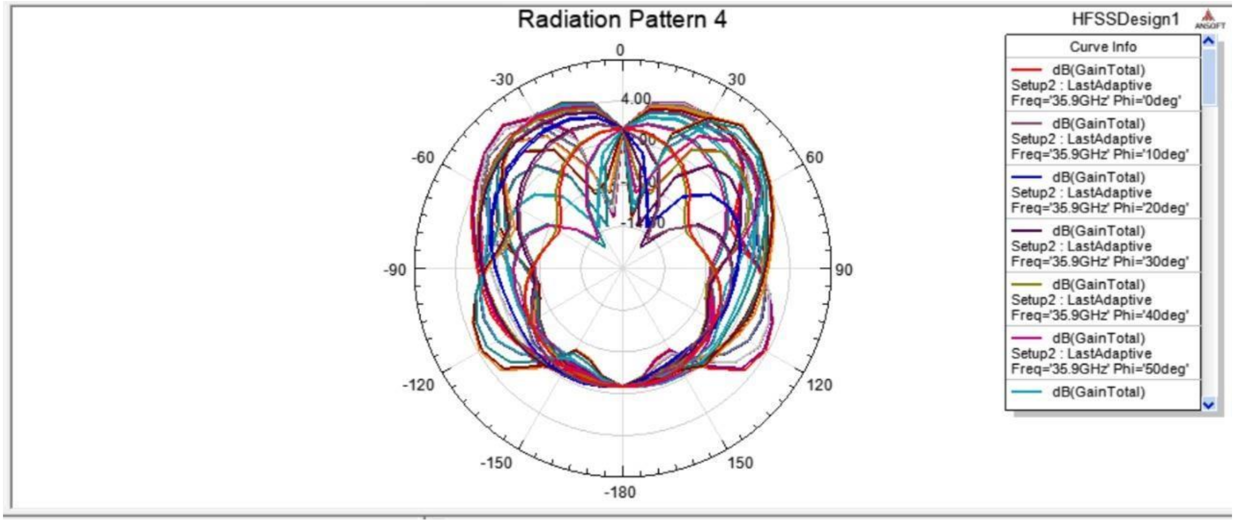

Figure 33: radiation pattern

The S11 for antenna array is different for different frequencies i.e. as it operates on triple band

Table 9: operating bands and the gain on them

Operating bands (Three)	31.8GHz to 32.5GHz	36.2 GHz to 38.2 GHz	45.7 GHz to 53.3 GHz
Gain	5.8dB at 32GHz	7.8dB at 37 GHz	7.5dB at 47 GHz

4.3. Hardware Implementation and Results:

4.3.1. Hardware Implementation or Antenna Fabrication:

Due to Covid we were unable to fabricate our desired antenna using Rogers RT Duriod. So, for testing purpose we have switched our antenna to a new material Substrate FR-4.
After achieving desired results, micro strip patch array antenna was fabricated in NIE (National Institute of Electronics).

Figure 34-a, 34-b defines the background of array antenna with and without connector (coaxial connector)
The dark brown image shows the ground of array antenna.

Figure 34-c,34-d defines the front of array antenna with and without connector and an array of eight patch antennas joined together with uniform spacing and slotting can be seen through naked eye.

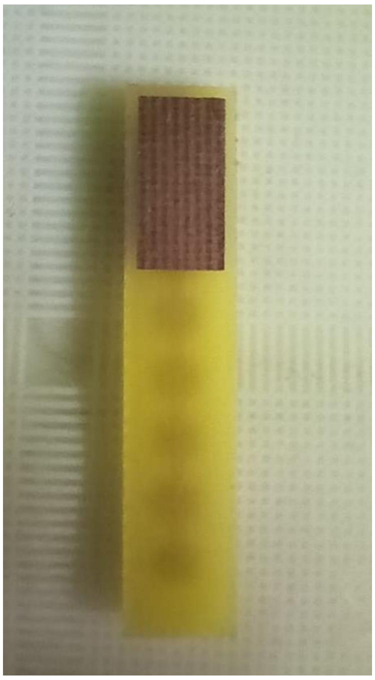

Figure 34(a) Figure 34(b)

Figure 34(c)

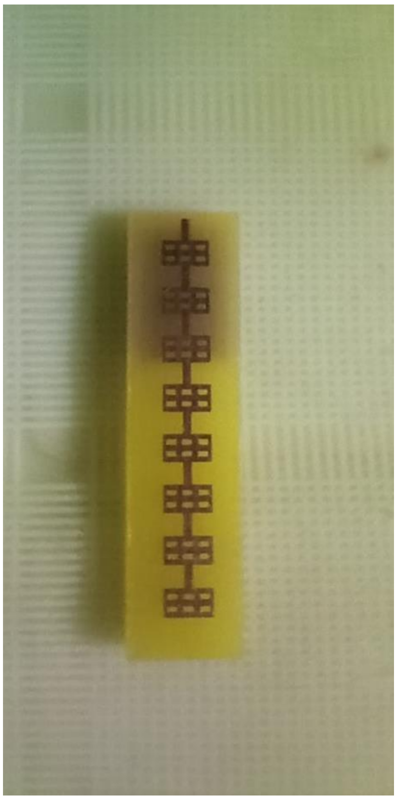

Figure 34(d

4.3.2. Simulated Results:

The HFFS results derived for substrate FR-4 are as follows.

RETURN LOSS:

The return loss of the antenna on this substrate shows that it is working on 5.9GHz to 7.6GHz. And have a return loss of -23dB at 7GHz. This frequency can be tested easily as it is used in televisions and other applications.

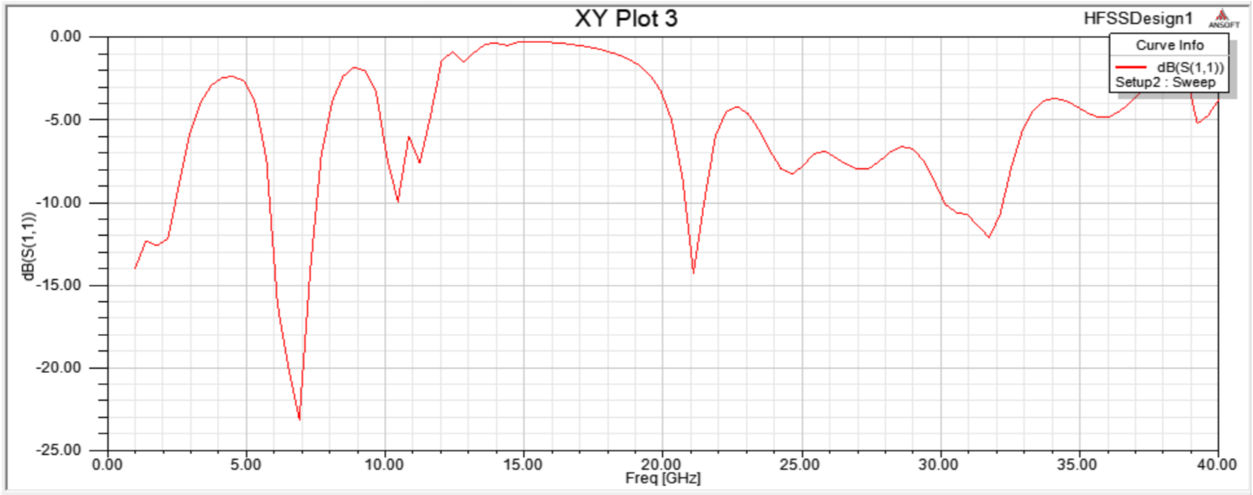

Figure 35: return loss plot for antenna on substrate FR4 for testing purposes

3D POLAR PLOT:

The gain at 7db is also positive which can be seen in the given figure below. As we work on higher frequencies in FR4 the losses also become high. So positive gain was in our favor for now.

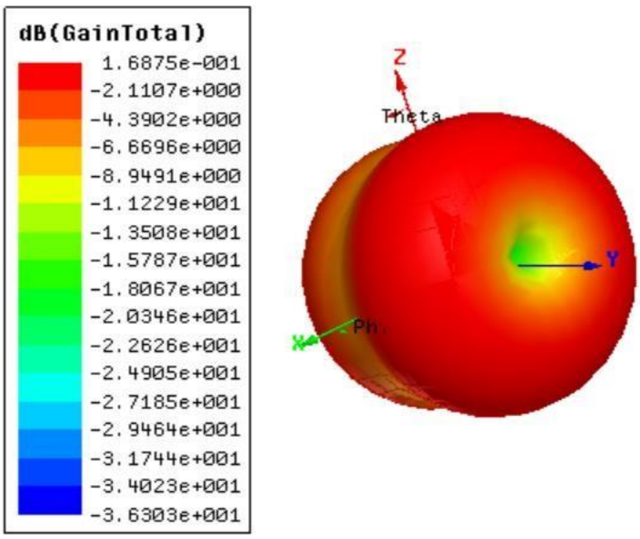

Figure 36: gain plot

RADIATION PATTERN:

Radiation pattern of the present antenna is shown below:

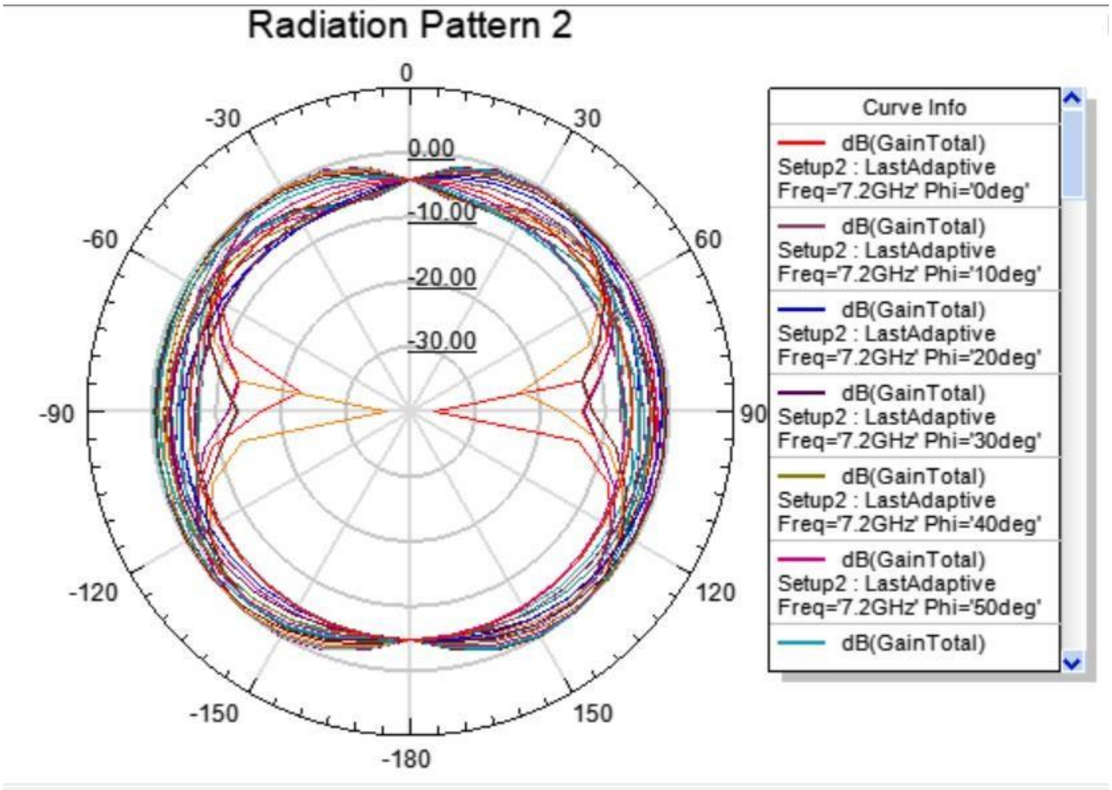

Figure 37 radiation pattern

The simulated results here were quite favorable so we had gone through the process of fabrication and then testing of the particular antenna. Testing had given us some measured results which were quite close to the simulated results.
Measured results are shown below and they meet our requirements.

Measured Results:

Return loss:

The S (1,1) graph of the measured result shows that the antenna is working on a frequency band 6.8 to 7.3GHz.
There is quite a difference between simulated and measured results. But we were expecting this as during testing we do not have ideal conditions and there are chances of minor mistakes.

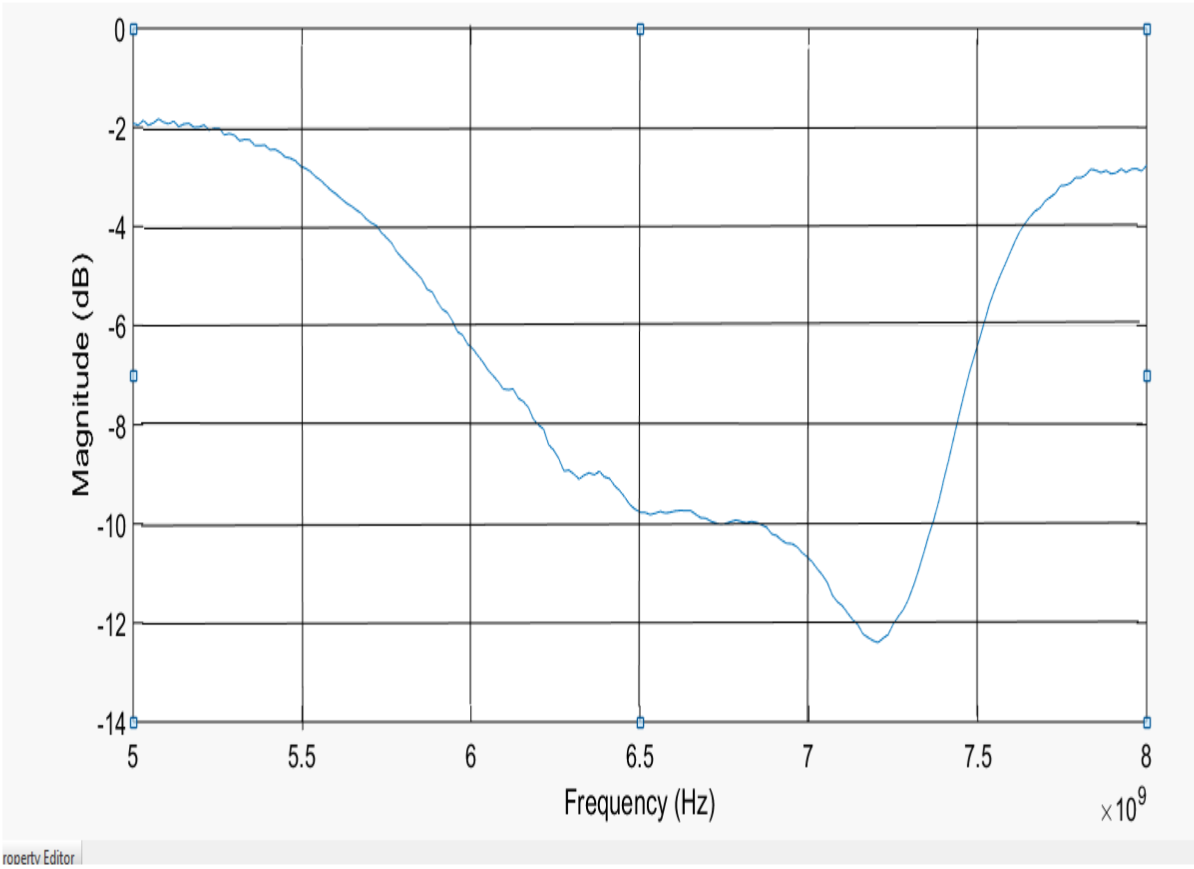

Figure38: measured return loss

The Gain recorded by **RIMMS** was **0.988db.**
Gain was also recorded positive approximately 1db, which is also lower than the gain recorded in simulated results.

Radiation Pattern:

This is an elevation plane where phi=90 degree in radiation pattern. Here we have changed the scale to 6 for getting favorable results.

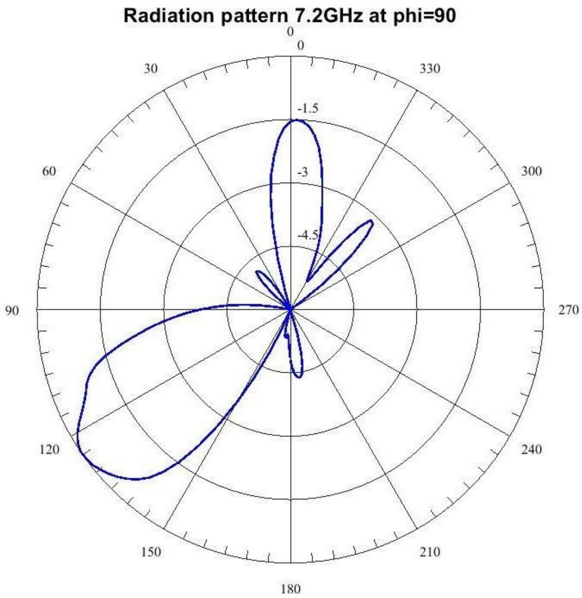

Figure 39 elevation plane pattern with scale 6

This graph below was without changing the scale to 6 in elevation plane.

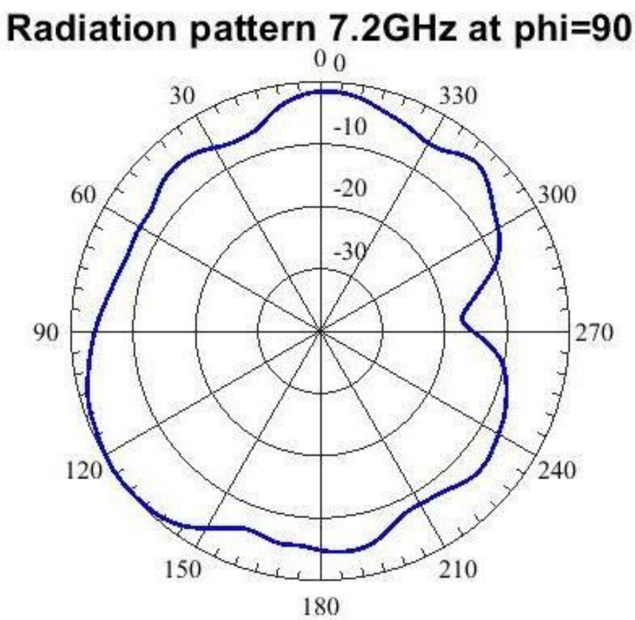

Figure 40: elevation plane without scale changing.

Now this the azimuth plane in radiation pattern where phi=0 degree.
We can see the simulated radiation pattern is quite like this.

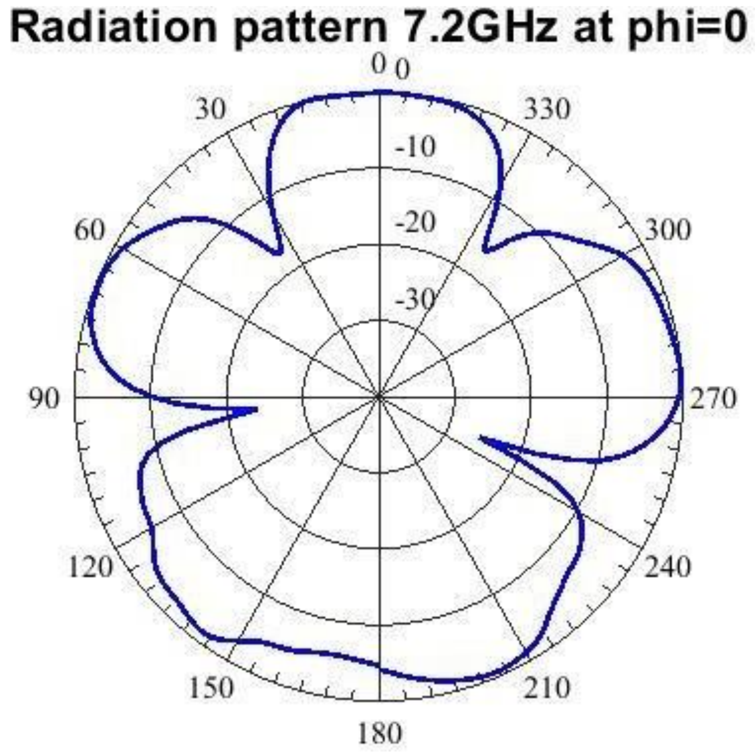

Figure 41: azimuth plane

CHAP 5: FUTURE WORK AND CONCLUSION

5.1. FUTURE WORK:

As the technology processes the requirements and the specifications of a product increases too, Our antenna is basically working on Millimeter Wave Band in which its limited to Q,U and V band .The use of 5G is going to be on vast scale so, for future work we can use this antenna for Satellite Communication in which it can act like a receiver and moreover , we can increase its goodness by including MIMO technology and use better substrates to achieve High Gain, Lower Latency and High Data Rates. And also, by applying different techniques we can also reduce the size of antenna for different purposes.

5.2. CONCLUSIONS:

In this project a linear array antenna operating on Millimeter wave band for 5G communication is proposed, designed, simulated and tested. The antenna has high applications for Q, U and mostly V band and can be used for Satellite communication, Radars, Terrestrial Microwave communication and for radio astronomy studies. Since array antenna uses multiple antennas there is a greater requirement of isolation between antenna elements, which we have achieved in our project by applying different tested techniques available in the literature.

As Millimeter wave band has vast applications for future upcoming technologies like High-Speed Communication, High Data Rates, Radars and many more therefore considerable amounts of work can be done by increasing the no of elements in the antenna and especially reducing the size so that it should be compatible with handheld and portable devices and also including MIMO technology so that it can be used for multipurpose.

Thesis mmwave Antenna GC Zayyad

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CHAP 6: REFERENCES

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