

5G MICRO-STRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION

Major Project Report

Submitted for the partial fulfillment of the degree of

Bachelor of Technology

In

Electronics Engineering

Submitted By

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0901EC201038

UNDER THE SUPERVISION AND GUIDANCE OF

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माधव प्रौद्योगिकी एवं विज्ञान संस्थान, ग्वालियर (म.प्र.), भारत

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January - May 2024



ABSTRACT

In this project focused on proposed the simulation performance evaluation of the designed microstrip patch antenna, configured for wireless simulation use in single and quad arrays, operating at two different frequencies, 3.5 and 4.7 GHz, is presented.

The antenna is made by the substrate of FR-4 with a thickness of 1.6 mm and dielectric constant of 4.3. The return loss (S₁₁) of a patch antenna is -40.161774 dB at 3.4472 GHz whereas it is -24.584526 dB at 4.7006 GHz; This indicates near-perfect impedance matching of an antenna, the patches are put together.

The company's power supply ensures equal power and phase integrity across the antenna, also the same feedline ensures the performance of the device. This feed design helps minimize integration and demonstrate integration of benefits selection options.

This research will give an integral, comprehensive analysis and techniques for the design of microstrip patch antenna arrays for various uses in the field of communication that is based on wireless.

Keywords used in this project: -

Slot of rectangular shape

Feedline of the patch

Array of patch

Microstrip patch antenna

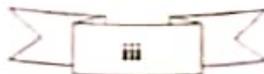
Radiation Efficiency of the proposed design

Gain (farfield)

The VSWR

S-parameters also known as Return loss

Directivity (in the farfield)





ACKNOWLEDGEMENT

I take great pleasure in expressing my deep sense of gratitude to my esteemed institute **MADHAV INSTITUTE OF TECHNOLOGY AND SCIENCE, GWALIOR (M.P)** for providing us the opportunity to fulfill my project.

I gratefully acknowledge with heartfelt gratitude and profound ineptness towards esteemed project mentor **PROF. DEEP KISHORE PARSEDIYA** for their valuable help and encouragement given throughout the course of the project.

I gratefully acknowledge with heartfelt gratitude to **Dr. VANDANA VIKAS THAKARE** (Head Department of Electronics Engineering) for her active and productive guidance throughout the whole span of time.

I also acknowledge with gratitude to our director **Dr. R.K. PANDIT** for providing the facilities needed for the accomplishment of this project.

The environment at MITS has been a valuable experience for me. It has provided an opportunity to learn at my own pace in the discipline of interest. The present project is an ample testimonial of the face. Lastly, I would like to thank all those who helped me during different stages of completion of this project as without them it would not have been possible.

Deepak

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PLAGIARISM CHECK CERTIFICATE

This is to certify that I (Deepak Bhardwaj) a student of B.Tech. in Department of Electronics Engineering have checked my complete report entitled "5g Micro-strip Patch Antenna for wireless communication" for similarity/plagiarism using the "Turnitin" software available in the institute.

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Assistant Professor
Electronics Engineering
MITS, Gwalior

ACRONYM

CST - Computer Simulation Technology

VSWR - Voltage Standing Wave Ratio

MPA - Micro-strip Patch Antenna

MIMO – Multiple Input Multiple Output

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- 24) Directivity of 4.7 GHz array
- 25) Gain of 4.7 GHz array

CHAPTER 2: SOFTWARE USED

CST Studio Suite is a computational electromagnetics tool developed by the expert software engineers and researchers of Dassault Systèmes Simulia to meet the industries requirement of high accuracy at low turn around time.

Multiphysics can be used, as well as many different simulation methods, including Finite Integration Technique (FIT), Finite Element Method (FEM), Transmission Line Matrix (TLM), Multilevel Fast Multipole Method (MLFMM), and Particle Element Method (PIC). Other physics analyzers related to electromagnetics can provide simulation results with less simulation time and more.

CST Studio Suite, formerly MAFIA, is sold by CST, a subsidiary of the Technical University of Darmstadt, founded in 1992 to commercialize the FIT initiative created by Thomas Weiland in 1977. Although the software was designed for particle accelerator laboratories, it quickly found application in Microwave engineering; therefore, FIT was used in CST Microwave Studio (CST MWS) in 1998 and became CST Studio Suite in 2005.

CST was acquired by Dassault Systèmes in 2016, making CST Studio Suite a Simulia product by now, since that time. The time domain FIT method uses a meshing technique known as Perfect Boundary Approximation (PBA) to represent the field in the hexahedral mesh and also has a frequency domain FEM solver.

Alternative methods include MLFMM and radiation therapy. There are also many solutions such as PIC, Wakefield, Thermodynamics and Process Systems. Nvidia GPUs and Intel Xeon Phi both provide hardware acceleration

CHAPTER 4: WORKING OF 3.45 & 4.7 GHz

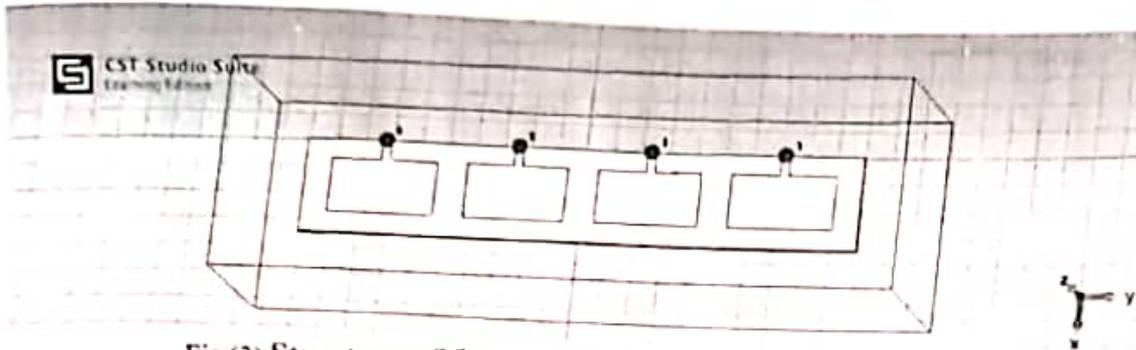


Fig (3) Structure of four element antenna array for 3.45 GHz

Component name	Length (unit)	Width (unit)	Height (unit)
Ground	35mm	44mm	0.035mm
Substrate	35mm	44mm	1.6mm
Patch	14.192mm	27.4126mm	0.035mm
Feedline	7.342mm	3mm	0.035mm

Table (3) Dimensions of the single Element MPA at 4.7 GHz

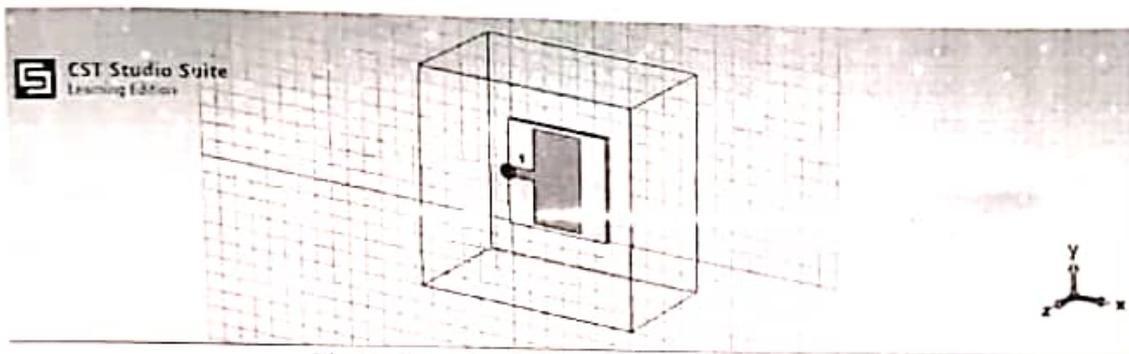


Fig (4) Structure of single element antenna for 4.7 GHz

Component name	Length (unit)	Width (unit)	Height (unit)
Ground	29mm	140mm	0.035mm
Substrate	29mm	140mm	1.6mm
Patch	14.389mm	27.813mm	0.035mm
Feedline	7.416mm	3mm	0.035mm

Table (4) Dimensions of the Four Elements MPA at 4.7 GHz

CHAPTER 5: RESULTS OF 3.45 & 4.7 GHz

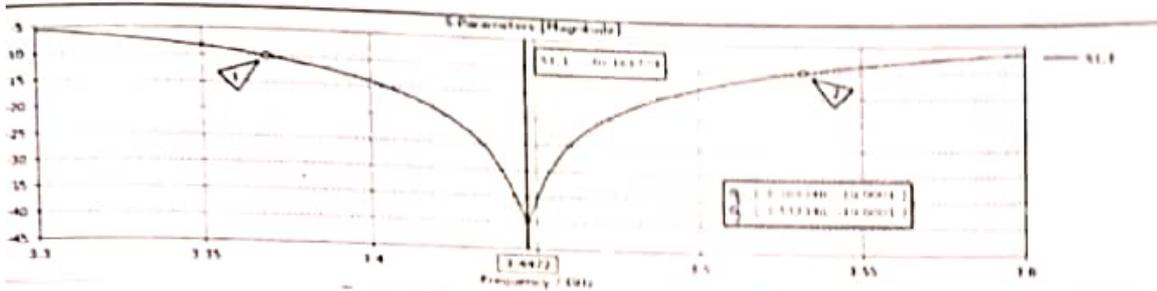


Fig (6) S-parameter of 3.45 GHz single element

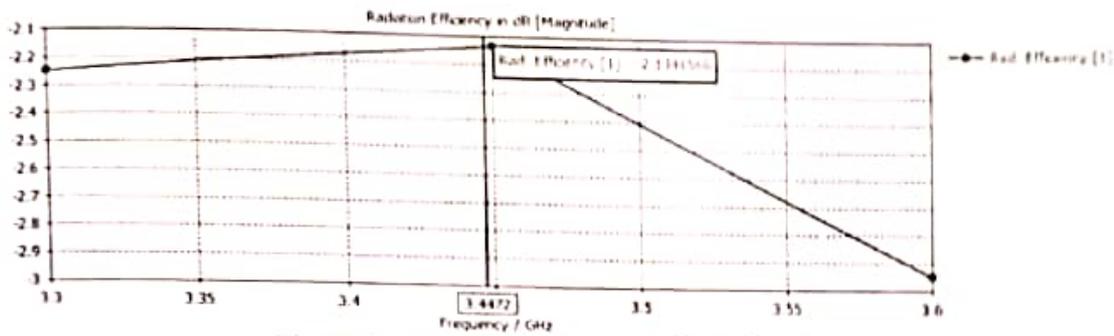


Fig (7) Radiation Efficiency of 3.45 GHz single element

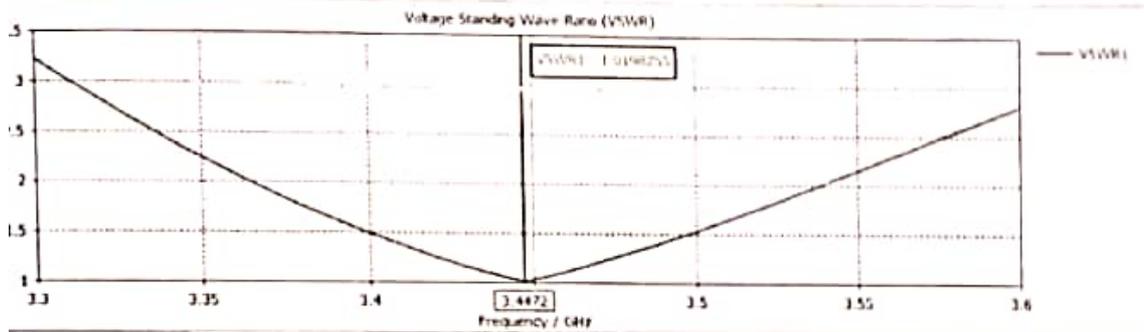


Fig (8) VSWR of 3.45 GHz single element

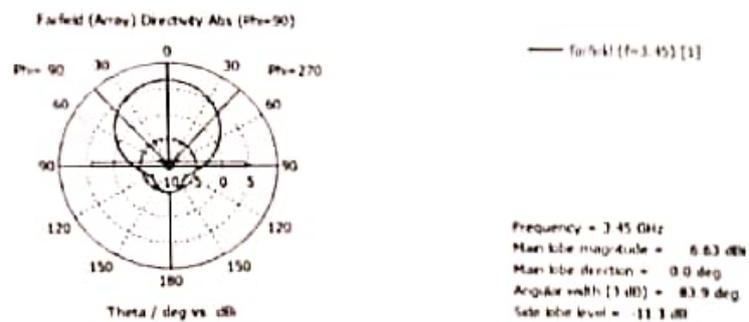
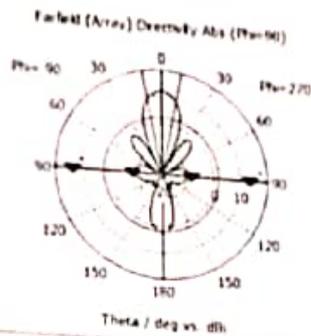


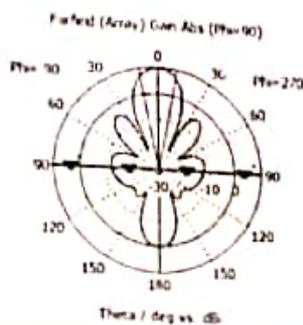
Fig (9) Directivity of 3.45 GHz single element

CHAPTER 5: RESULTS OF 3.45 & 4.7 GHz



Frequency = 3.45 GHz
 Main lobe magnitude = 11.9 dB
 Main lobe direction = 0.0 deg
 Angular width (3 dB) = 22.0 deg
 Side lobe level = -9.9 dB

Fig (14) Directivity of 3.45 GHz array



Frequency = 3.45 GHz
 Main lobe magnitude = 9.71 dB
 Main lobe direction = 0.0 deg
 Angular width (3 dB) = 22.0 deg
 Side lobe level = -9.9 dB

Fig (15) Gain of 3.45 GHz array

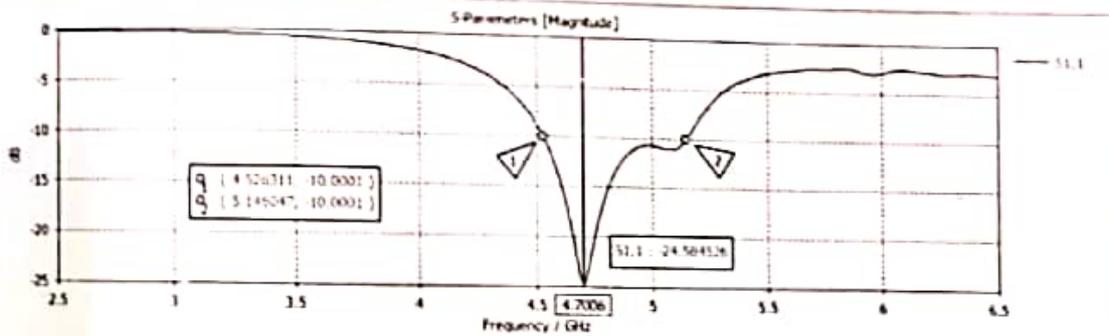
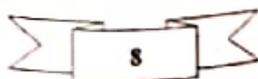


Fig (16) S-parameter of 4.7 GHz single element



CHAPTER 5: RESULTS OF 3.45 & 4.7 GHz

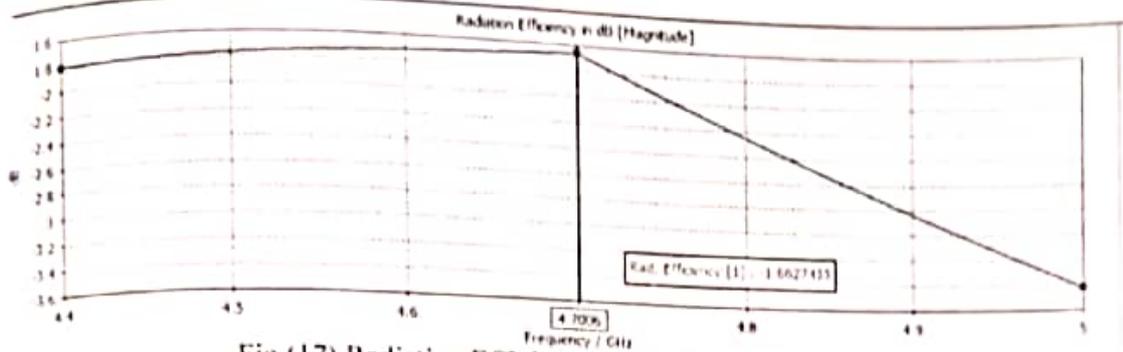


Fig (17) Radiation Efficiency of 4.7 GHz single element

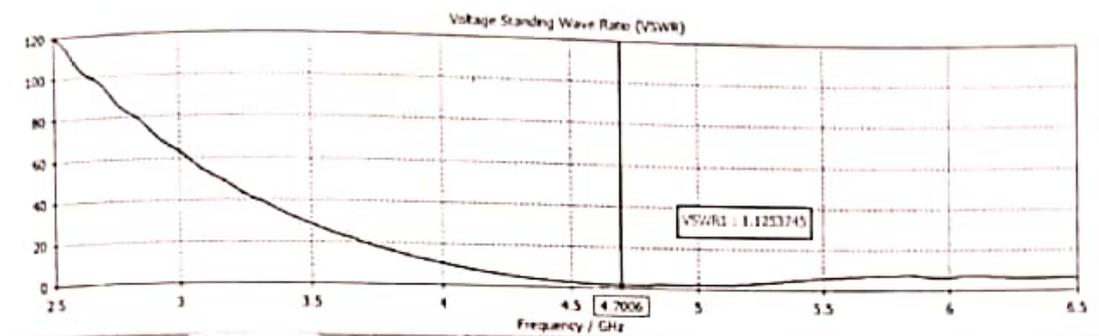


Fig (18) VSWR of 4.7 GHz single element

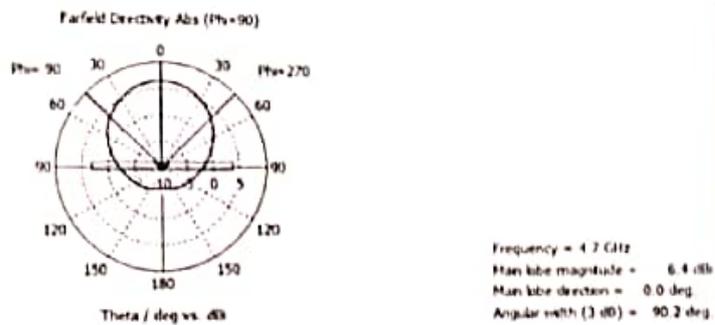


Fig (19) Directivity of 4.7 GHz single element

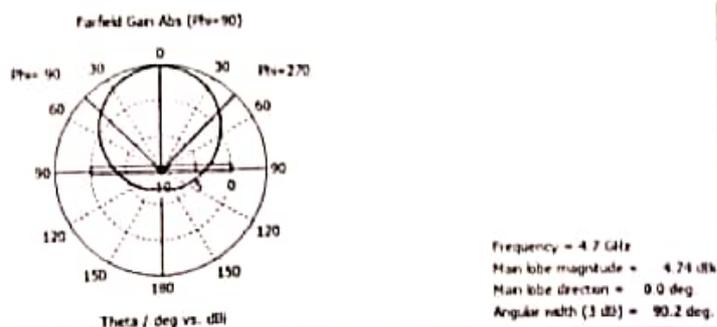


Fig (20) Gain of 4.7 GHz single element

CHAPTER 5: RESULTS OF 3.45 & 4.7 GHz

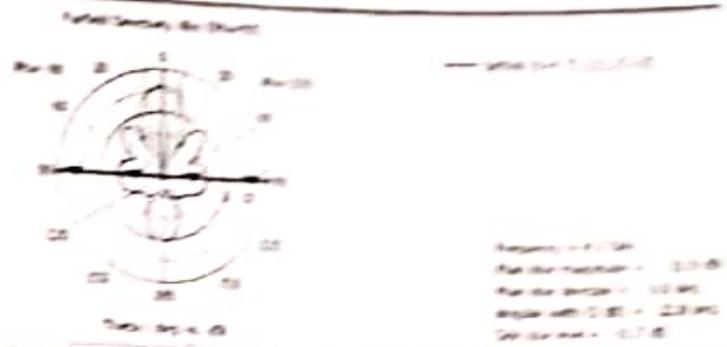


Fig (24) Directivity of 4.7 GHz array

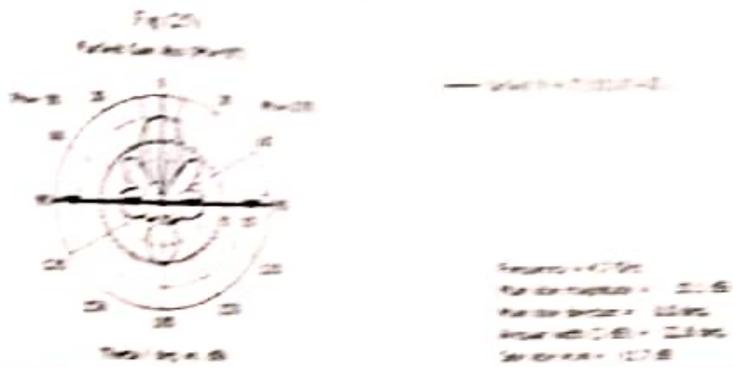


Fig (25) Gain of 4.7 GHz array

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CHAPTER 8 :CONCLUSION

By observing the different results parameters like Return loss, Radiation efficiency, VSWR, directivity and Gain, we can conclude that the proposed design of the micro-strip patch antenna has given the results with the attractive and optimal values for the applications of these signs in practically.

This simulation work helps us to take a deeper look in the field of MPA by either going for variations and other simulations to get more attractive results.

CHAPTER 7: SCOPE OF IMPROVEMENT

The results can be improved with the deeper curve and more frequency band be cover under the -10dB by the increasing number of iterations and more precise taking of the parameters of the length, width and simulated height of the antenna's patch components. Given that there will be no compromise with the overall gain of the system.

Also, we can go for removing certain portion from the Ground or patch near the feedline, which will make the antenna as defective ground and insert feedline patch Micro-strip patch antenna respectively.

Not only, we are limited to the designing of the antenna, one can try different materials with different dielectric constant instead of FR-4 which has epsilon value of 4.3, one can use Copper in annealed form for the fabrication of patch, ground, and feedline. This some times can give worse results then the pervious selection, but one can do the iteration on patch and ground size to get better results.

As of the different materials has different epsilon values so different values of the patch and ground dimensions will be required to get the same or better results then one from the other.

But there is no limit in this field of Micro-strip Path antenna, one can go out of box and use different designs instead of single and array, like there are options for MIMO i.e. Multiple Input Multiple Output.

CHAPTER 5: RESULTS OF 3.45 & 4.7 GHz

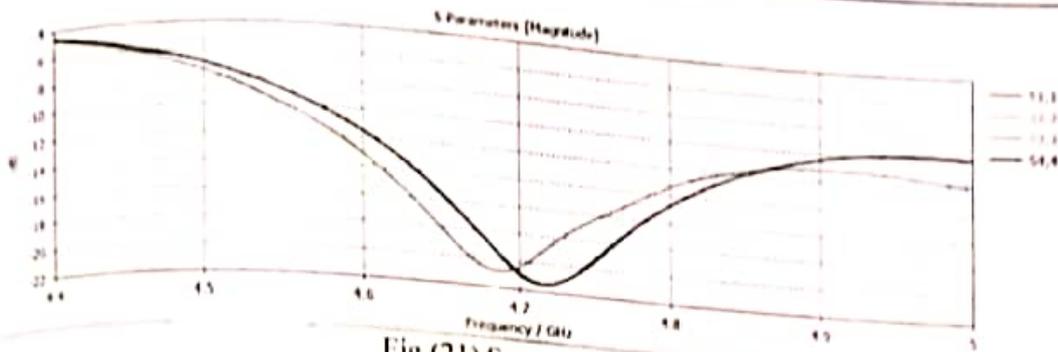


Fig (21) S-parameter of 4.7 GHz array

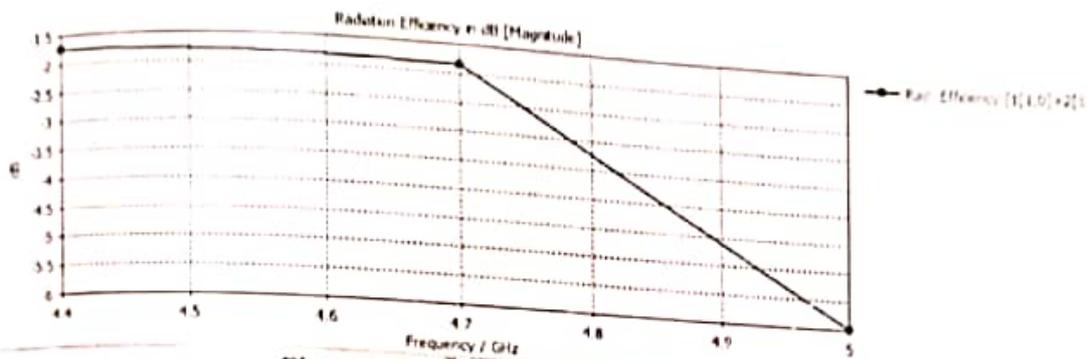


Fig (22) Radiation Efficiency of 4.7 GHz array

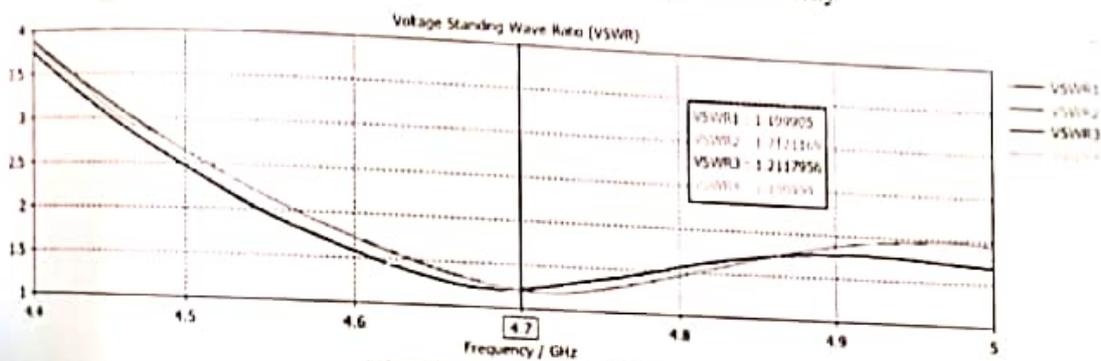


Fig (23) VSWR of 4.7 GHz array

CHAPTER 5: RESULTS OF 3.45 & 4.7 GHz

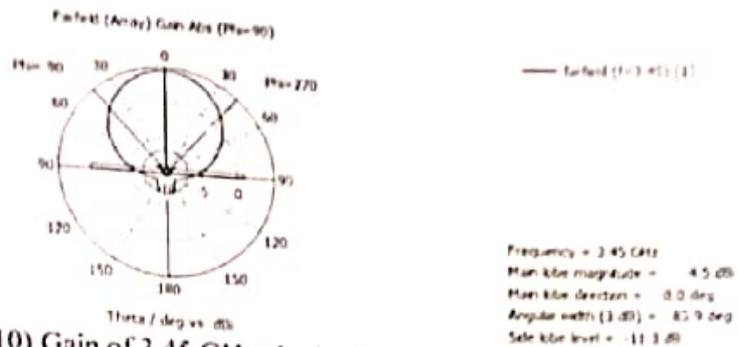


Fig (10) Gain of 3.45 GHz single element

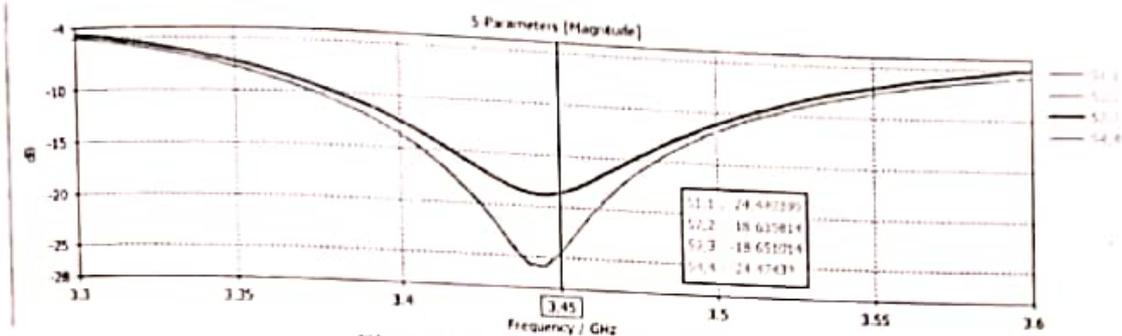


Fig (11) S-parameter of 3.45 GHz array

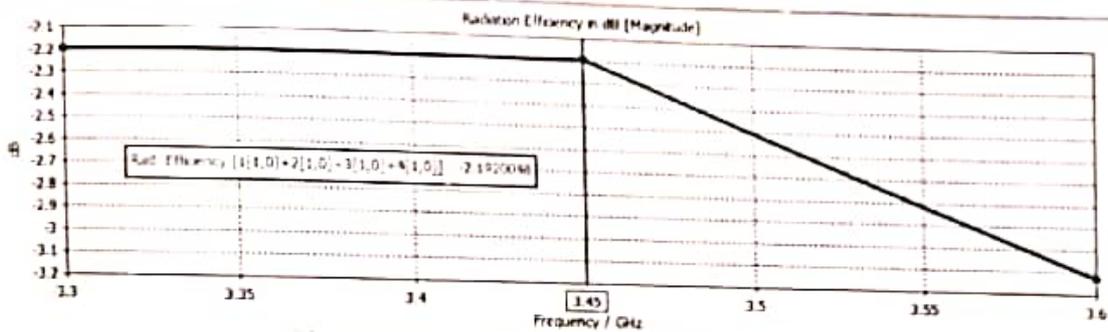


Fig (12) Radiation Efficiency of 3.45 GHz array

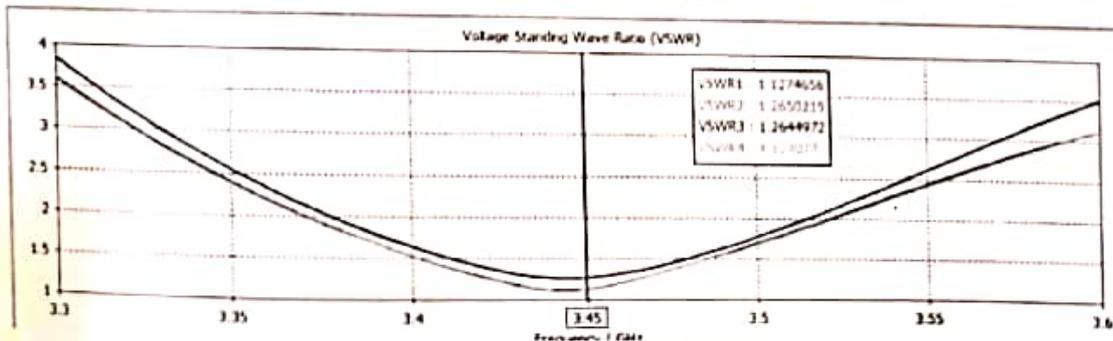


Fig (13) VSWR of 3.45 GHz of array

CHAPTER 5: WORKING OF 3.45 & 4.7 GHz

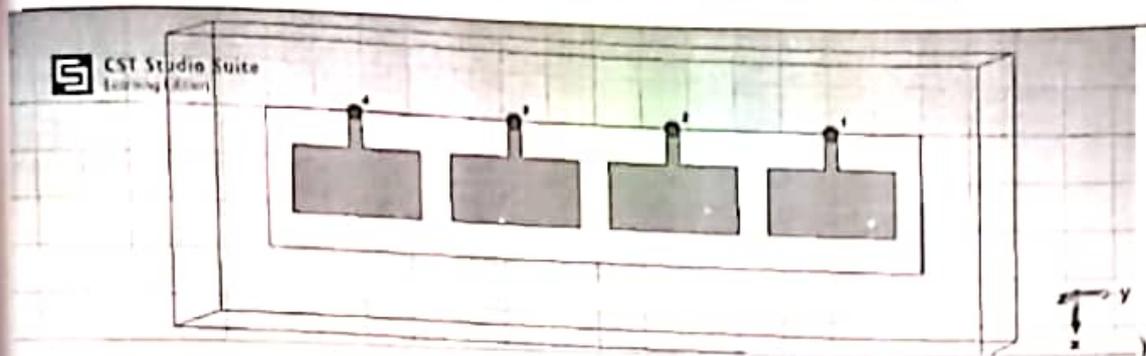


Fig (5) Structure of four element antenna for 4.7 GHz

CHAPTER 3:WORKING OF 3.45 & 4.7 GHZ

The MPA works with a very basic structure, when we put a dielectric material in between Two conducting plates. And combine the patch with the ground via a port. Then it'll start conducting and radiates a certain frequency. In this work, we have taken a dielectric material of type FR-4 which has a dielectric constant of 4.3 and this substrate is sandwich between two plates of PEC. Bottom one is called ground and other the top one is known as patch of the given antenna.

Normally; the area (length and width) of ground and substrate are same for a given MPA, difference been the thickness of the 2 layers. Here, the ground has a thickness of 0.035 mm whereas the patch is taken to be of 1.6 mm thick. The patch is also of thickness 0.035mm. Some times in order to get better results, the proposed design can be defected by removing some of the portion from ground or from the patch, which when do in optimal way will help in increasing the overall results parameters such as Gain, Directivity, Return losses and radiation efficiency.

In designing of the micro-strip patch antenna, the main part is to calculate the dimensions of the patch. These dimensions are calculated by the mathematical formulas and then, iterations are done by increasing or decreasing the length and width of the patch to get the maximum gain from the antenna at the target frequency below -10dB of reflection coefficient.

In order to simulate the design for the micro-strip patch antenna; we'll first calculate the required length and width of the patch and then move on to consider the dimensions of the ground and substrate with the reference of the mathematically calculate parameters. And do multiple iterations until the required results are obtained.

Component name	Length (unit)	Width (unit)	Height (unit)
Ground	35mm	44mm	0.035mm
Substrate	35mm	1.6mm	1.6mm
Patch	19.744mm	37.236mm	0.035mm
Feedline	7.342mm	3mm	0.035mm

Table (1) Designing of the single Element MPA at 3.45 GHz

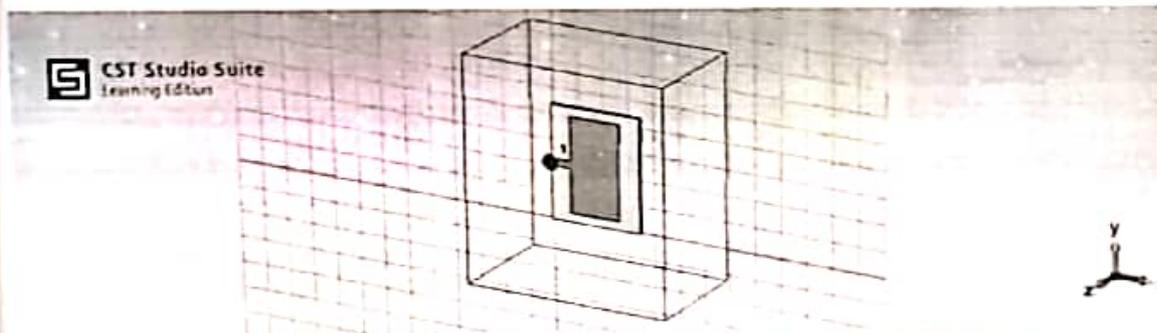


Fig (2) Structure of single element antenna for 3.45 GHz

Component name	Length (unit)	Width (unit)	Height (unit)
Ground	35mm	200mm	0.035mm
Substrate	35mm	200mm	1.6mm
Patch	19.908mm	37.436mm	0.035mm
Feedline	7.342mm	3mm	0.035mm

Table (2) Dimensions of the Four Elements MPA at 3.45 GHz

CHAPTER 1: INTRODUCTION

Microstrip Patch Antennas are one of the most explored and used types of printed antennas today, because they play an important role in wireless communications. Microstrip Antennas use microstrip technology and are very easy to design and manufacture. The microstrip patch antenna generally consists of three parts: these are the electric light on the side of the dielectric substrate (here we use FR-4 with dielectric constant 4.3) and the ground layer (copper) on the other side as can be seen in the image below.



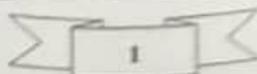
fig (1) Structure of Single element antenna example.

It can take geometric shapes such as rectangle oval triangle or other shapes on of the such examples is shown in the figure (1).

The field may also be removed in some areas. Emitted patches and feed lines are generally photoetched onto the substrate of dielectric property. The radiation of this microstrip patch antenna mainly originates from the fringe field between the edge of the patch and the ground plane. For antenna performance, a thick dielectric substrate with low dielectric constant (<6) is required as it provides better performance, larger bandwidth and better power. But such an arrangement makes the antenna larger. Therefore, we need to strike a balance between antenna size and antenna performance. Stimulation directs a source of electromagnetic energy to the patch, creating a negative charge around the feed point and a positive charge in other parts of the patch. This voltage difference creates electricity in the antenna, causing the antenna to break. The first part is emitted into space, which is the "known" radiation for the result. The second is the difference wave that bounces back into the gap between the field and the ground and helps in the actual transfer of electricity. The tip of the wave remains in the dielectric substrate due to the total reflect

Microstrip antennas can be divided into four types:

- 1 Microstrip patch antenna,
- 2 Microstrip dipole antenna,
- 3 Printed hole antenna
- 4 Microstrip strip antenna wave antenna



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DECLARATION BY THE CANDIDATE

I hereby declare that the work entitled "5G Micro-strip Patch Antenna for wireless Communication" is my work, conducted under the supervision of Deep Kishore Parsediya, Assistant Professor, during the session Jan-May 2024. The report submitted by me is a record of bonafide work carried out by me.

I further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Deepak

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0901EC201038

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