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Design of Modified Aperture Coupled Microstrip Antenna under Dual Resonance Gain Enhance

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ABSTRACT: A low-profile aperture-coupled micro strip patch antenna using resonant to enhance the gain is designed. Based on cavity model for a square micro strip patch antenna a rectangular radiating patch with an aperture coupler feeder is employed. By loading shorting pins underneath patch different resonant modes are turn up resulting in wide gain with a stable radiation pattern. An antenna has to be fabricated and simulated using CST software which is having a low profile property in an operating band of about 2.32-2.90Ghz and stable gain ranging from 3 to 8.0 dB in whole operating band and a bandwidth of nearly 40Mhz which is used for wide range applications like 4G technologies.

I.INTRODUCTION

Exploring the unexplored had become the destination of researchers in any field of advancements in propelling technologies these days. In order to match with rapid growth and demand of small scale electronic systems like VLSI, advancement of antennas also demands small and low cost antennas. Patch antennas are the most flexible ones for their compatibility with microwave integrated circuits and RF systems. Due to their low fabrication cost and compact size planar antenna structures have become some integral part of some communication systems for various standards including 1G, 2G, 3G, 3.5G, WIMAX and 4G technologies. There has been a growing interest in smart antenna systems with high data rate transmission capability. Antenna is a device used for radiating and receiving an electromagnetic wave in free space. The antenna works as an interface between transmission lines and free space. Antenna is designed for certain frequency band. Beyond the operating band, the antenna rejects the signal. Therefore, we might look at the antenna as a band pass filter and a transducer. There are many types of antenna. The isotropic point source radiator is one of the basic theoretical antennas which is considered as a radiation reference for other antennas. In reality such antennas cannot exist. The isotropic point source radiator radiates equally in all direction in free space. Antennas gains are measured with respect to an isotropic radiator (dB).

Generally, it is possible to produce high gain patch antennas if and only if the thickness of substrate is large, that is in order to improve gain the substrate thickness should be large which is not reliable due to it's incompatible size. A solution to this is to design an aperture coupled antenna. A high gain antenna can be designed with this technique by using shorting pins with a reliable thickness and compatible size. The resulted antenna can be used at different applications like mobiles, satellite communications and many others.

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II. RELATED WORK

A microstrip antenna is a printed antenna that consists of metallic patch above ground plane. The shape and size of patch determine frequency of operation i.e., its frequency is inversely proportional to size of antenna. Microstrip antenna can be fabricated using photolithographic method. Photolithographic method is a chemical process which removes unwanted metal regions of metallic layer. The concept of microstrip radiators was introduced first by 'DESCHAMPS' in 1953, the practical antennas were developed by 'HOWELL' and 'MUNSON' in early 1970's. Presently, there are many applications for commercial and government purposes like mobile, wireless communications. The substrate dimensions effect bandwidth, its thickness is about 0.05λ (operating wavelength). Its operation depends upon fringing fields that are tangential components which are in phase and combine to give broad side radiation. Different feeding techniques of microstrip antenna are 1) microstrip line, 2) co axial probe, 3) aperture coupling, 4) proximity coupling. These feeding techniques include both advantages and disadvantages like efficiency, low profile, but involves complexity. Various characteristics of antenna includes bandwidth, directivity, gain, radiation efficiency, reflection coefficient, resonant frequency, radian and steradian, far field radiation pattern which is independent of distance of antenna, polarization, radiation resistance, input impedance.

III. SIMULATION STEPS

After starting CST DESIGN ENVIRONMENT, a new CST MICROWAVE STUDIO project is chosen to be created. A template for a structure which is close to the device of interest is selected; project can be started by scratch opening an easy project. The following steps are performed for successful simulation: For modelling the antenna structure, a number of different geometrical design tools for typical geometrics such as plates, cylinders, spheres etc... are provided in the CAD section of CST MICROWAVE STUDIO. These shapes are added or added or interested using Boolean operators for building up more complex shapes.

1. MODELLING THE STRUCTURE:

Now the actual antenna structure is being built the definition of your device even further. After the component has been modelled, a fully automatic meshing procedure is applied before a simulation engine is started. It is specialized tool for the fast accurate simulation of high frequency problems. The shape creation is the one of the most flexible operations. Many different options exist to create the desired models. The following sections provide a basic overview of the available tools.

2. DEFINING PORTS:

In order to calculate reflection parameters, port is defined for patch antenna. In the measurement setups, the waveguide port is selected by selecting a face or edge or vertex.

3. FIELD MONITORS:

This dialog box in design tool gives the opportunity to define field monitors that might be needed to obtain on electromagnetic field distribution structure information.

4. TRANSIENT ANALYSIS:

This is very flexible time domain simulation module that is capable of solving any kind of S-Parameter. It will simulate structure previously defined port using a broadband signal. Broad band simulation enables to receive S-Parameters on entire frequency range. The time domain solver calculate development of fields through time discrete location. The accuracy of settings are selected as -30dB and standard characteristic impedance of about 50 Ohms.

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IV. DESIGN OF APERTURE-COUPLED ANTENNA

In designing an antenna that meet our desired requirements, the main target is to design the low profile 3-D geometry of an aperture-coupled MPA loaded with six shorting pins. It consists of a rectangular radiating patch on the top of the substrate1 ($\epsilon_{r1} = 1.96$ and $H1=1.27\text{mm}$), a ground plane with a narrow slot on the top of substrate2 ($\epsilon_{r2} = 3.38$ and $H2=0.813\text{ mm}$), and a 50- Ω microstrip feeding line on the bottom of substrate2. Beside, an array of shorting pins with radius of R are installed between the radiating patch and ground plane, aiming to achieve a wide impedance bandwidth for the proposed MPA. Under the 50- Ω microstrip feeding line on the bottom of substrate2, the electric fields on the slot are excited from one side to another. By using CST computer Simulated Technology entire antenna must be simulated and characterized to derive its various parameters and radiation pattern. The gain of antenna can be increased by increasing substrate thickness, but by using this technique without increasing thickness gain can be improved which is more reliable. This can be done by decreasing width (W) of the patch less than 0.707 times of length (L) of patch. To validate the working principle and the predicted results of the proposed aperture-coupled MPA with enhanced bandwidth under dual resonance, the antenna loaded with an array of shorting pins with dimensions as denoted in Table1 will be designed, fabricated. Finally, the band width ($|S_{11}| \leq -10\text{ dB}$) of about 40Mhz in the operating range from 2.3 to 2.80 GHz, while keeping a low profile property with the height of 0.0032 free-space wavelength will be measured. As a result, the radiation pattern of the MPA at 2.4 Ghz will produce the nulls, and the stable radiation near the broadside direction.

The simulated and measured gains as the function of the frequency that are obtained finally. In addition to this, a stable gain varied from 3 to 6.8dB in the operating band is achieved at the broadside direction. The results produced depends upon ratio of length of slot and width of the patch. The no. of shorting pins also depends on proximity of two radiation peaks.

The designed can be used at two different frequency bands which is dual resonance obtained by eliminating all even order modes like TM_{12} as their broad side radiation is null.

The design of antenna is shown with help of pictures shown below.

STEP1:

Opening of CST for usage of antenna design as it can be used for many applications. The below figure shows that CST can be used in many ways like MW and RF optical, radar cross section, biomedical, circuits and components, antennas, etc. It can be used at both higher and lower frequencies. On selecting antennas from various categories we select a planar type among various types .

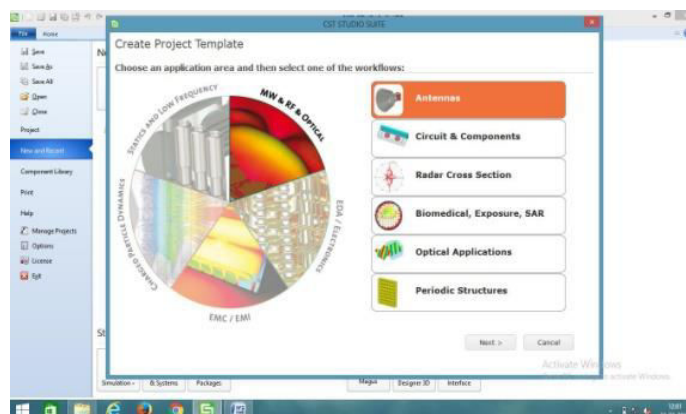


Figure 1: STEP1

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STEP2:

Next select in which domain the simulation should carry on whether it is in time or in frequency domain. Here, the time domain is selected for simulating using transient solver.

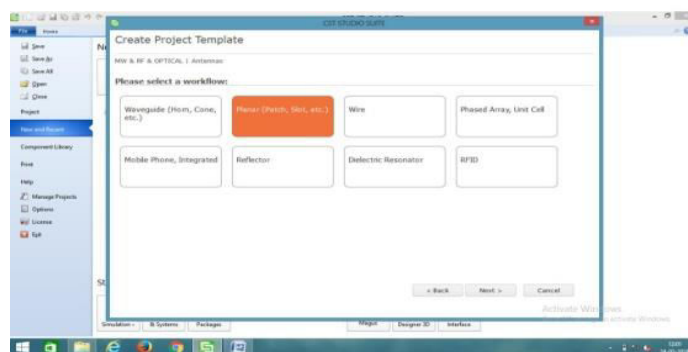


Figure2: STEP2

STEP3:

Following, all the parameters we need to calculate or defined for designing should be defined with their respective units. All the dimensions like length, width, height are taken in mm, frequency in Ghz, time in ns and many others. These are based on our requirement of designing.

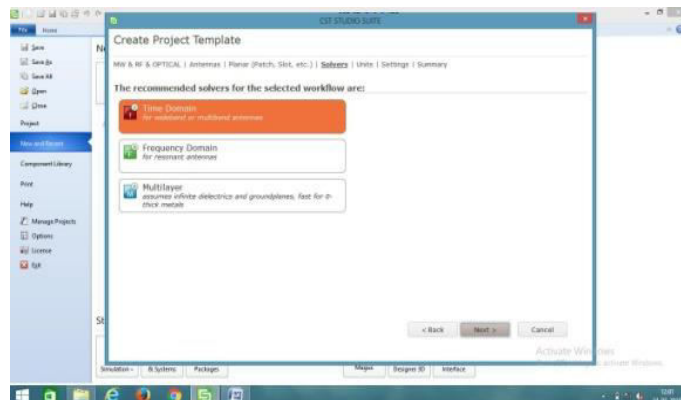


Figure3: STEP3

STEP4:

By selecting all required parameters a window as shown below is opened. It consists of home to design, simulation part, results to observe the results, type of view, etc.

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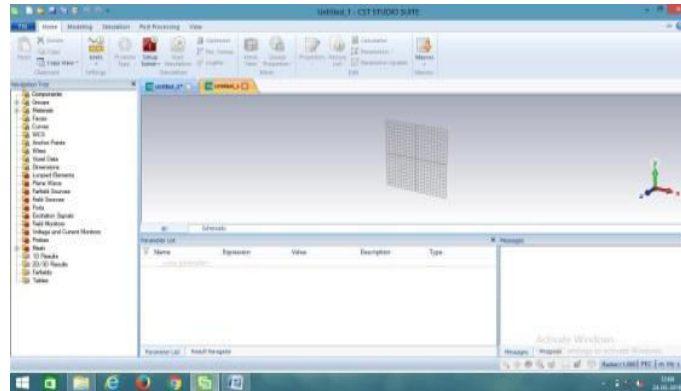


Figure4: STEP4

STEP5:

Then to design a substrate select the required shape of component like sphere, rectangle, cylinder, triangular, etc. Select on the shape then click on the ESC button to give the dimensions in all x, y, z directions of required shape. The material can be chosen from list having various epsilon values.

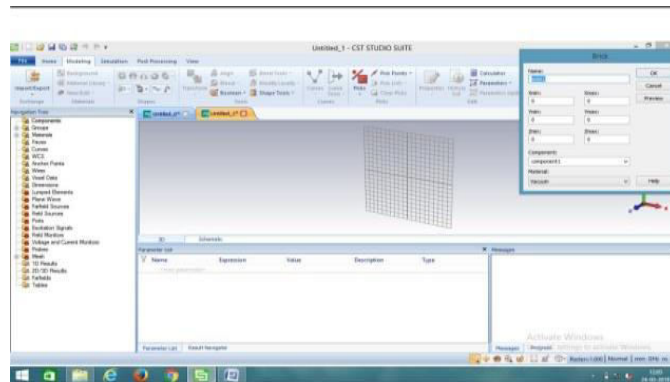


Figure5: STEP5

STEP6:

After selecting and giving required dimensions, first observe the preview and then confirm it. In the design it is necessary to add or subtract more than one components. Here, we used two substrates, a ground plane, patch, shorting pins, slot, feed. These are designed using BOOLEAN add or subtract.

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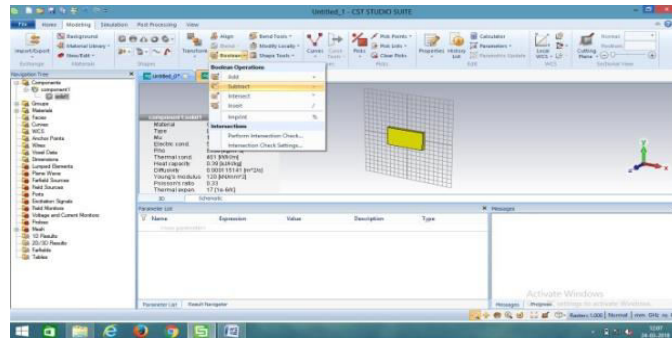


Figure6: STEP6

STEP7:

This is an overview of our design which consists of two substrates made of different materials and dimensions. It includes substrates, ground plane, patch, feed, slot. All these dimensions are given with help of local coordinate system placing at center of design so that the directions are easily recognized.

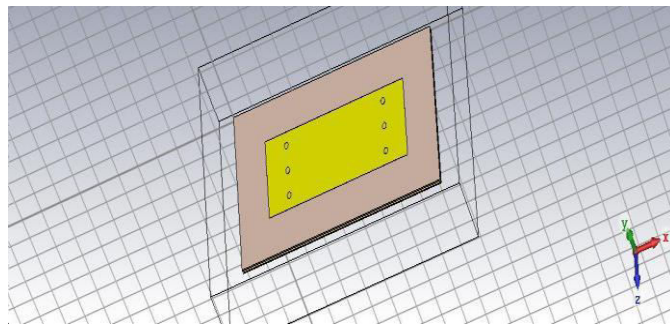


Figure7: STEP7

STEP8:

The below is shown bottom substrate which is made of material having epsilon value 3.32. The length, width, height are mentioned in the table given below. The feed will be given to this bottom substrate. The dielectric constant effects radiation.

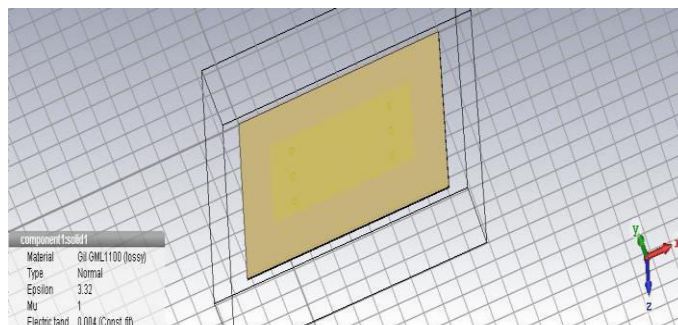


Figure8: STEP8

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STEP9:

This is ground plane made of copper by default having unity epsilon value. The copper should be of annealed one which is generally used for practical applications. A slot is made on ground plane with required dimensions that is used for coupling between bottom and top substrate.

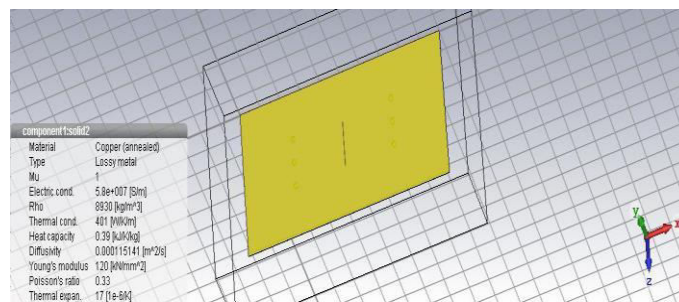


Figure9: STEP9

STEP10:

Here, is top substrate which is made of epsilon value as shown in table. Our required patch is placed on the substrate. The required dimensions of this is same as below substrate except the thickness is varied. These two substrates are separated by ground plane with specified distance between ground and top substrate.

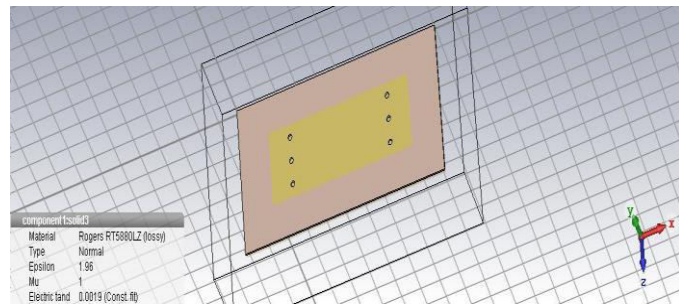


Figure10: STEP10

STEP11:

The patch which is responsible for radiation is placed in top substrate. This is of rectangular shape. The input from feed is coupled bottom substrate to top substrate and there gets cut by radiating patch. The electric field is cut and moved in all directions around edges of patch and these are known as FRINGING FIELDS. Six shorting pins are placed from patch to ground plane through top substrate.

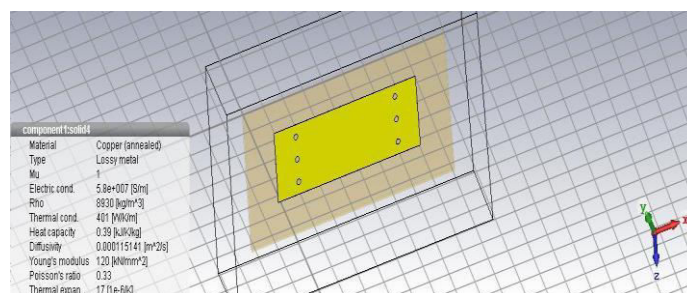


Figure11: STEP11

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STEP12:

Different types of feeds are used . Here, a micro strip feed is placed in back side of bottom substrate as shown in figure. An input power with characteristic impedance of 50 ohms is given to this feed. The waveguide port is highlighted with red colour as shown in figure.

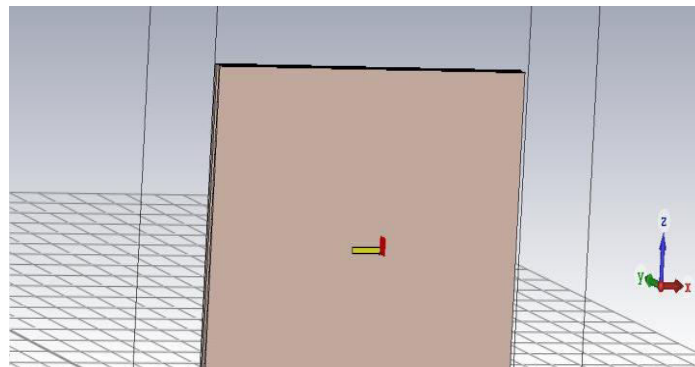


Figure12: STEP12

DESIGN PARAMETERS:

Parameters	Values(mm)
L	140
L ₁	200
L ₂	100
L _{slot}	31
L ₅	8.15
L _{feed}	9.85
W	50
W _{feed}	1.82
W _{slot}	0.30
S ₁	98
S ₂	32.50
R	2
H	1.80

Table1: DESIGN PARAMETERS

IV.RESULTS

S-PARAMETER AND BANDWIDTH CALULATION:

After, simulation with help of CST transient solver, the s-parameter graph is obtained from the 1D-results. The s-parameter value is also known as return loss value. This says the amount of power that is returned back to antenna. The s-parameters are defined as quotient of output and input spectrum signal. This is done with help of DFT(Discrete fourier Transform). The scattering matrix is calculated which quantifies how RF energy propagates through multiport network. This graph gives bandwidth by obtaining difference between upper and lower frequencies.

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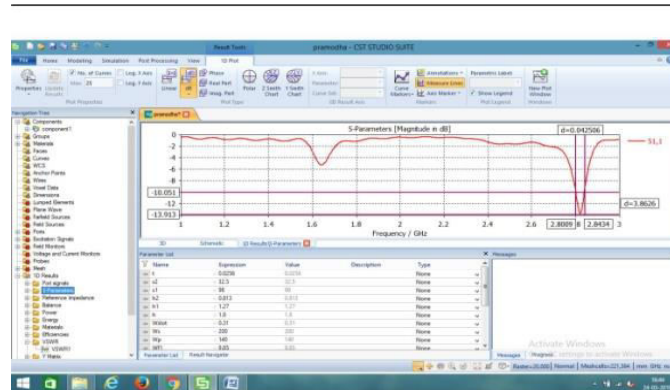


Figure13: S-PARAMETER

The sub graph of above that shows the s-parameter value is below. The graph shows operating frequency of 2.82 Ghz.

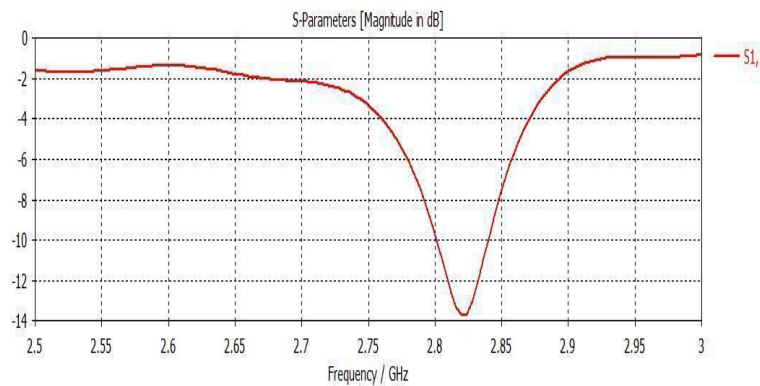


Figure14: DETAILED VIEW OF S-PARAMETER

VSWR:

This is operating band of our designed antenna i.e., antenna can be used in this frequency range. This is graph of VSWR Voltage Standing Wave Ratio. This is theoretically known as maximum voltage and minimum voltage. This is dependant on reflection coefficient factor which describes the power radiated or reflected. This value should be equal to one theoretically. But, practically it which is the reliable value. This value is shown in the figure. The figure is shown from frequency range of one to three. The value is observed at centre frequency. Input impedance is impedance presented by the antenna at it's terminals. If the antenna is not matched to inter connecting transmission line a standing wave is induced along the transmission line. Thus, VSWR is ratio of maximum voltage to minimum voltage. A standing wave is developed when power is reflected from load. It is also closely related to measure of source and load impedance. The power loss will be virtually zero when this value is 1. This is the detailed view of VSWR graph whose value is 1.5.

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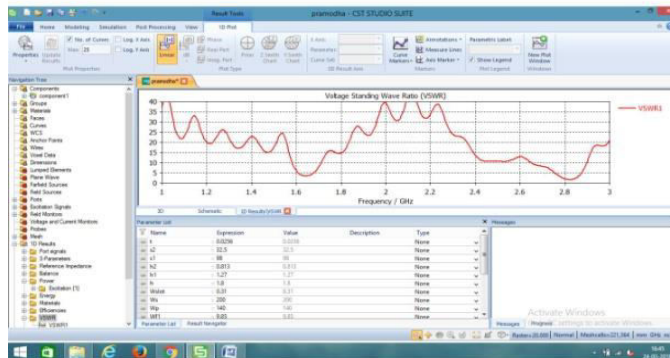


Figure15: VSWR

RADIATION PATTERN:

This is the graph obtained from far field radiation. The frequency value is placed at center frequency at 2.82GHz. Various graphs are observed at different frequencies and we found that the gain obtained is of stable with a value of 7.9dB. Thus, a stable gain is obtained at different frequencies in the operating band

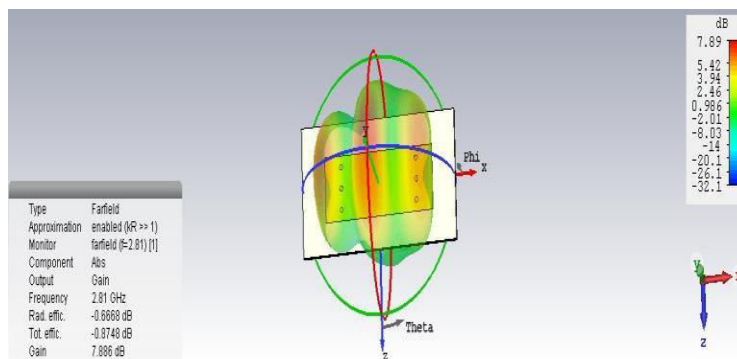


Figure16: RADIATION PATTERN ONE

This is far field radiation graph at frequency 2.81 GHz. The gain at this frequency is 7.88dB. Far field region is the region which is independent on the distance from antenna. The far field calculation deals with the field behavior far from the corresponding source of electromagnetic waves [7]. At a sufficiently great distance compared to regarded wave length, respectively dimension of finite structure, the field components of radiated or scattered field are spherical waves. This means that higher order terms of r^n can be neglected and therefore mainly transversal field components exists. These are primarily intended for simulation of various antennas as well as radar cross section of scattering problems. The three dimensional plot is shown below. This can be observed in two dimension also.

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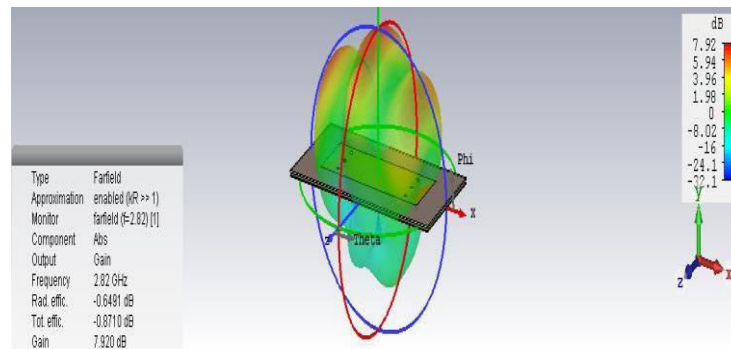


Figure17:RADIATION PATTERN TWO

V. CONCLUSION

A low profile aperture coupled antenna has been designed and simulated whose results prove the operation near the frequency of 2.85GHz. The design of a microstrip patch antenna using aperture coupled technique proved the production of high gain without any increase in thickness of substrate that is within compact size which is nothing but a low profile results in high stable gain of 7.9dB along the main lobe direction. This antenna provides a bandwidth of about 40MHz with a high stable gain which can be used in wide band applications like in mobile communications, WIMAX, LAN's (Local Area Networks), Personal Communication devices like mobile communication and in 4G technologies.

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