WAVEGUIDES & ANTENNA

ECL 307

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TOPIC :- DUAL PATCH ANTENNA SIMULATION AND FARICATION

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INTRODUCTION

The wireless local area network (WLAN) is commonly used in home networks and in commercial complexes offering wireless access to their customers. Most modern WLANs are based on IEEE 802.11 standards. The frequency bandwidths of IEEE 802.11a and 802.11b/g are 5.15-5.825 GHz and 2.400–2.4845 GHz, respectively. The frequency ranges of IEEE 802.11a are 5.15–5.35 and 5.725–5.825 GHz in the US and 5.15–5.35 and 5.470– 5.725 GHz in Europe are used for wireless local area network (WLAN) that offers data rate up to 54 Mb/s. The present scenario in the wireless communication systems indicates a shift of operating frequency from 2.4GHz band to the 5.2/5.8GHz band for various reasons. There is a need for a dual-band with high gain and broad bandwidth for higher data rates as this will permit a greater number of devices to share the available space with good signal strength [1, 2]. This dual-band patch antenna is very attractive because of its cost-effective solution for reducing the number of antenna units and minimizing the installation area for WLAN access points [3].

A dual-band dipole antenna has been investigated owing to its low profile, low cost and omnidirectional pattern; however, this type of antenna has a relatively low gain in where superior RF coverage is required [4]. Xiao Lei Sun, Li Liu designed a dual band planar antenna with overall antenna size of 40×30×0.8mm3 for 2.4/5.2/5.8GHz WLAN application. The measured bandwidths were from 2.39 to 2.51 GHz and from 5 to 6.1 GHz for lower and higher band respectively. Gain for the both bands was less than 2dBi [5]. Various dual band monopole antennas operating in 2.182/ 5.548 GHz band have been designed for WLAN application such as F-shape, L-shaped , triangular monopole and a U-shaped monopole, assembled ,split ring monopole in which The peak gain varies from 2.2-4.5dBi for 2.182GHz band and with 3.9 -6dBi for 5.548 GHz band. The impedance bandwidth varies from 7.5%-15.6% and from 12.6%-25% for lower and higher band respectively [6- 10].planar inverted F antenna have also been investigated for dual band WLAN application, in which peak gain ranges from 1.6-2.4 dBi and impedance bandwidth ranges from 130 MHz- 146 MHz and 200MHz- 834MHz for lower band and higher band respectively.[11-14]. All the above antenna have lower peak gain and not suitable for superior WLAN coverage. slot antennas having peak ain from 4.95-6dBi and4.42-8dBi, but these have very large volume with multilayer structure.[15-19].several patch antenna of various shapes and size have also been designed [20-23]. Rectangular patch antenna operating at 2.4GHz frequency as 7dBi simulated ain and 38 dB return loss [24]. In this paper, dual-band edge-fed slotted rectangular patch antenna with partial groundfor WLAN applications is presented. It can be easily designed, fabricated, and integrated with WLAN access points and other RF frontend circuits in a PCB.

ANTENNA DESIGN

Designing For designing of a microstrip patch antenna, we have to select the resonant frequency and a dielectric medium for which antenna is to be designed. The parameters to be calculated are as under. Width (W): The width of the patch is calculated using the following equation.

$$W=\frac{C0}{2fr}\sqrt{\frac{2}{\varepsilon r+1}} \quad \dots\dots\dots\dots\dots\dots \quad (1)$$

Where, W = Width of the patch, f r = Frequency of operation, $C0$= Speed of light, εr = Dielectric constant of substrate

Effective dielectric constant (εeff): The effective dielectric constant value of a patch is an important parameter in the designing procedure of a microstrip patch antenna. The radiations travelling from the patch towards the ground pass through air and some through the substrate (called as fringing). Both the air and the substrates have different dielectric values, therefore in order to account this we find the value of effective dielectric constant. The value of the effective dielectric constant (εeff) is calculated using the following equation

$$\varepsilon eff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-0.5} \dots\dots\dots \quad (2)$$

Length: Due to fringing, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation.

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon eff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon eff-0.258)\left(\frac{W}{h}+0.8\right)} \dots\dots\dots\dots \quad (3)$$

Where ‘h’= height of the substrate The length (L) of the patch is now to be calculated using the below mentioned equation.

$$L=\frac{1}{2fr\sqrt{\varepsilon eff\ \mu_0\varepsilon_0}}-2\Delta L \dots\dots\dots\dots\dots\dots \quad (4)$$

Length (Lg) and width (Wg) of ground plane: Now the dimensions of a patch are known. The length and width of a substrate is equal to that of the ground plane. The length of a ground plane (Lg) and the width of a ground plane (Wg) are calculated using the following equations.

Lg = 6h + L...............................(5)

Wg = 6h + W............................. (6)

Proposed antenna geometry

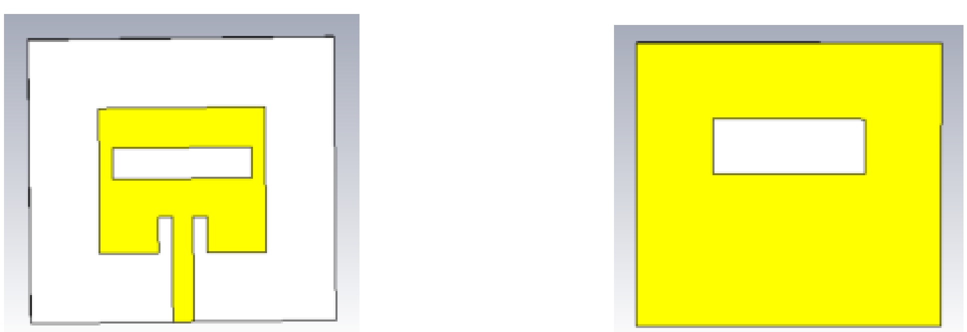
The proposed slotted rectangular patch antenna with partial ground plane is fabricated on FR4 substrate (εr=4.4 and tangent loss=0.02) of the size of (L×W×H),were L,W and H is length ,width and height of substrate respectively, the overall dimension of antenna is 50mm×50mm×1.6mm. Rectangular patch of size (L1×W1) were L1= 24mm and W1= 21mm, has been etched on the top layer of the substrate. For dual band operation a rectangular slot of size (L2×W2) were L2= 32.5mm and W2=10mm has been cut over the rectangular patch. The dimension of L3, L4, L5,W3 and W4 are .75mm, 16mm, 8 mm, 5mm and 5mm respectively. The patch is fed with 50-Ω microstrip line of feed length FL= 9mm and feed width FW=2mm. Partial ground plane of size (LG × WG) where LG=50mm and WG =8mm is etched on bottom layer of substrate. Fig1a, b show the proposed antenna geometry.

<u>Parameter list</u>

Name	Expression	Value	Description
ws	44	44	
ls	41	41	
hs	1.6	1.6	
hg	0.00035	0.00035	
wp	24	24	
lp	21	21	
wc	6.96	6.96	
yo	5.2	5.2	
wf	2.96	2.96	
b	13	13	
w1	20	20	
l1	4.5	4.5	
m	26	26	
w2	22	22	
l2	8	8	

<u>SIMULATION AND RESULTS</u>

The proposed antenna has been designed and simulated with CST software. The figure below shows 2D view of design of proposed antenna on simulation software



<u>CST Simulation</u>

Fabricated Patch

Design Analysis :-

Every successful story has many failed attempts. These are few of our attempts. Unfortunately we didn’t kept screenshots previous calculation, E H field graphs. All we have is S-parameters graph screenshot because we were more concerned about that so we took screenshots.

We’ve incorporated many changes both in the dimensions of patch as well as in that of slots cut corresponding, to which different frequency and bandwidth is observed in the S- Parameter, which have been listed as follows:-

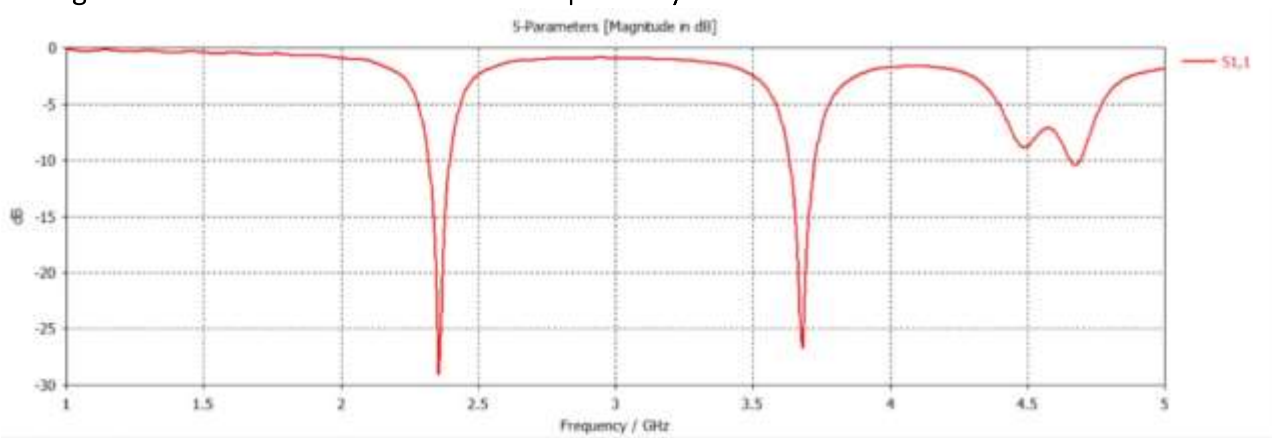
Analysis-1

We’ve kept the length and width of substrate to be 60 mm and some other changes which have been listed in the parameter list as follows:-

Name	Expression	Value	Description
Freq	2.4*10^9	2400000000	
epsion	4.3	4.3	
ws	60	60	
ls	60	60	
hs	1.6	1.6	
hc	0.035	0.035	
w	38.3	38.3	
l	29.77	29.77	
wf	3	3	
w1	0.6	0.6	
l1	21	21	

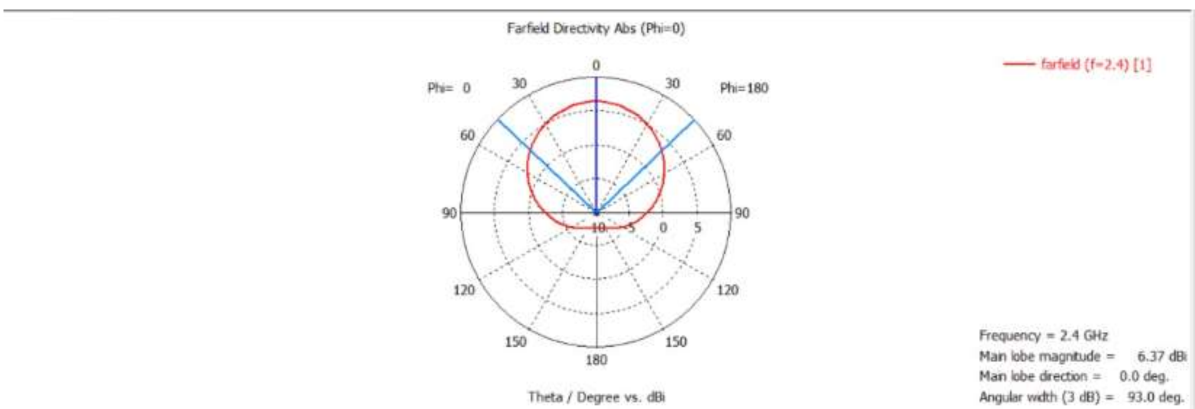
S-Parameter

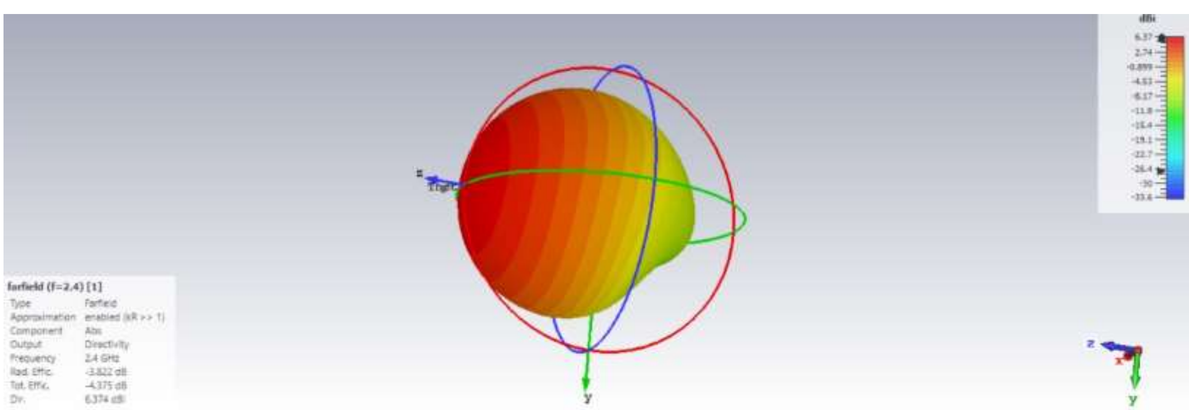
Two resonant frequencies, one at 2.4 GHz and other at 3.6 GHz are observed in the S-Parameter having return loss -29.8 dB and -27.2 dB respectively.



Farfield

The following screenshots reveals the 2-D AND 3-D farfield visualization at the resonating frequency of 2.4 GHz having the directivity 6.374 and gain 2.552 respectively, but these aren't suitable for Wi-Fi and Bluetooth application.





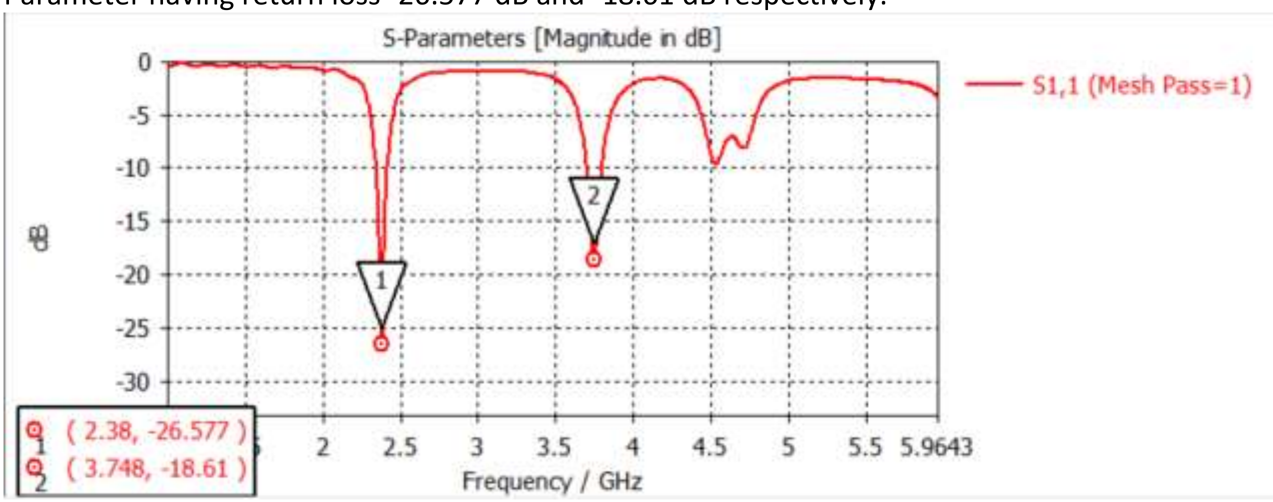
Analysis-2

We've kept the length and width of substrate to be 59 mm and 76 mm respectively and some other changes which have been listed in the parameter list as follows :-

Name	Expression	Value	Description
Sl	59	59	
Sw	76	76	
Sh	1.5	1.5	
Mt	0.035	0.035	
Pl	29.5	29.5	
Pw	38	38	
Ml	Sl/2 -Pl/2	14.75	
Mw	2.86	2.86	
InL	9	9	
InW	0.7	0.7	
k	5.62	5.62	
Al	5	5	
Am	10	10	
Nl	4.5	4.5	
Nm	8	8	

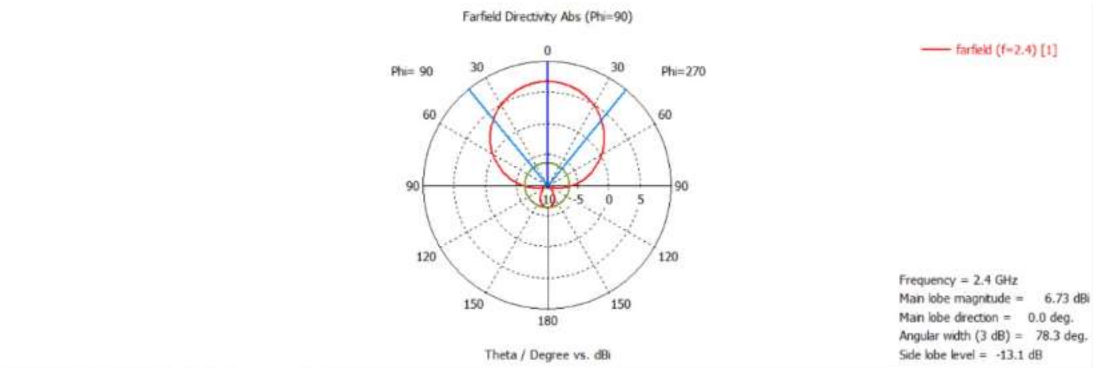
S-Parameter

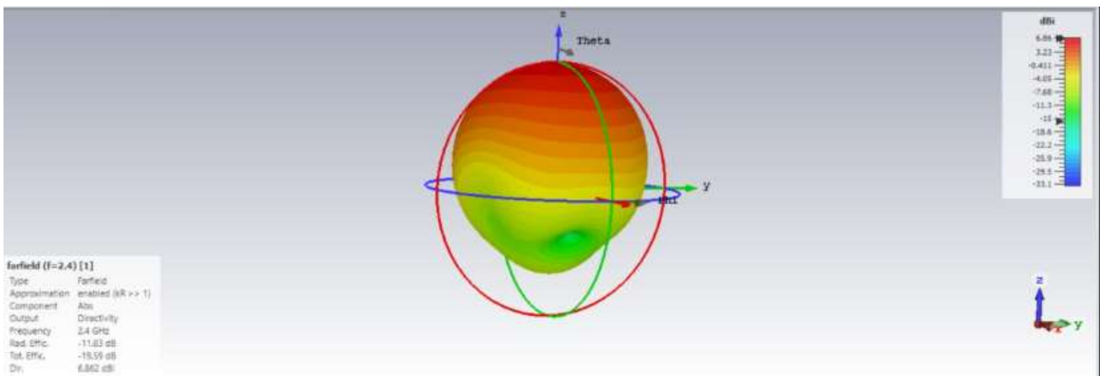
Two resonant frequencies, one at 2.38 GHz and other at 3.748 GHz are observed in the S-Parameter having return loss -26.577 dB and -18.61 dB respectively.



Farfield

The following screenshots reveals the 2-D AND 3-D farfield visualization at the resonating frequency of 2.4 GHz having the directivity 6.862 and gain -4.968 respectively, but these aren't suitable for Wi-Fi and Bluetooth application.





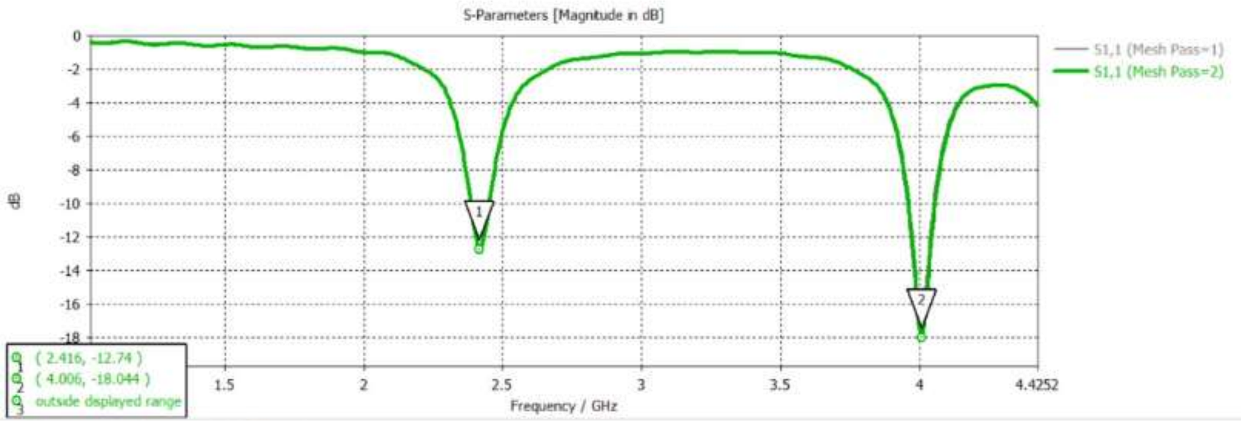
Analysis-3

We’ve kept the length and width of substrate to be 59 mm and 76 mm respectively and some other changes which have been listed in the parameter list as follows :-

Name	Expression	Value	Description
Sl	59	59	
Sw	76	76	
Sh	1.5	1.5	
Mt	0.035	0.035	
Pl	25	25	
Pw	38	38	
Ml	Sl/2 -Pl/2	17	
Mw	2.86	2.86	
InL	9	9	
InW	0.7	0.7	
k	5.62	5.62	
Al	3	3	
Am	8	8	
Nl	4.5	4.5	
Nm	7	7	

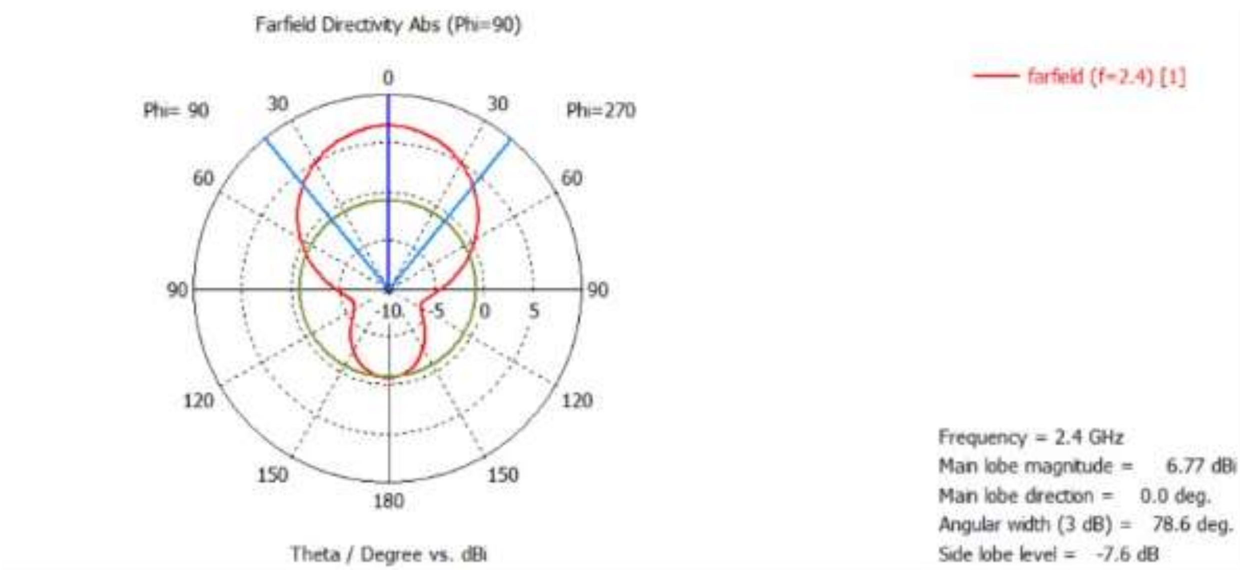
S-Parameter

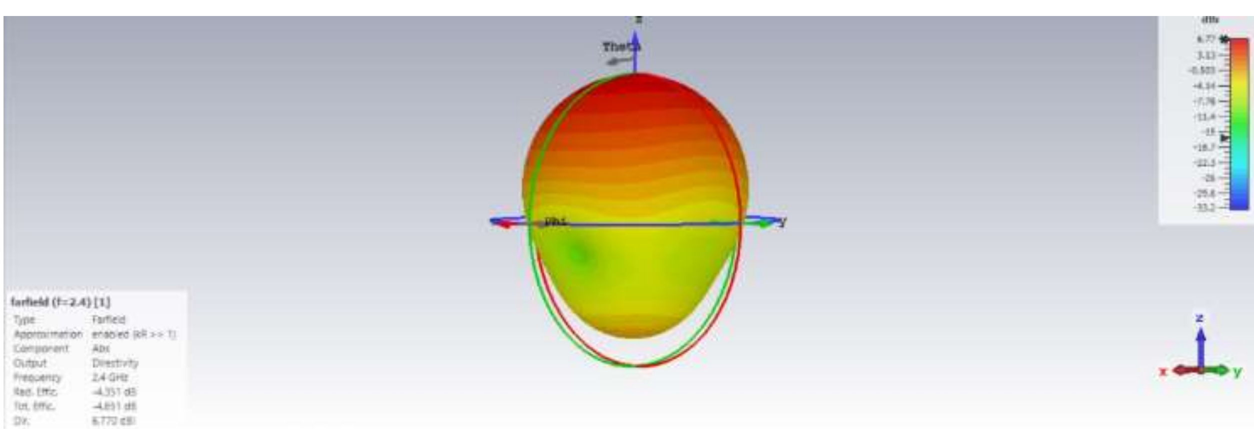
Two resonant frequencies, one at 2.416 GHz and other at 4.006 GHz are observed in the S-Parameter having return loss -12.74 dB and -18.044 dB respectively.



Farfield

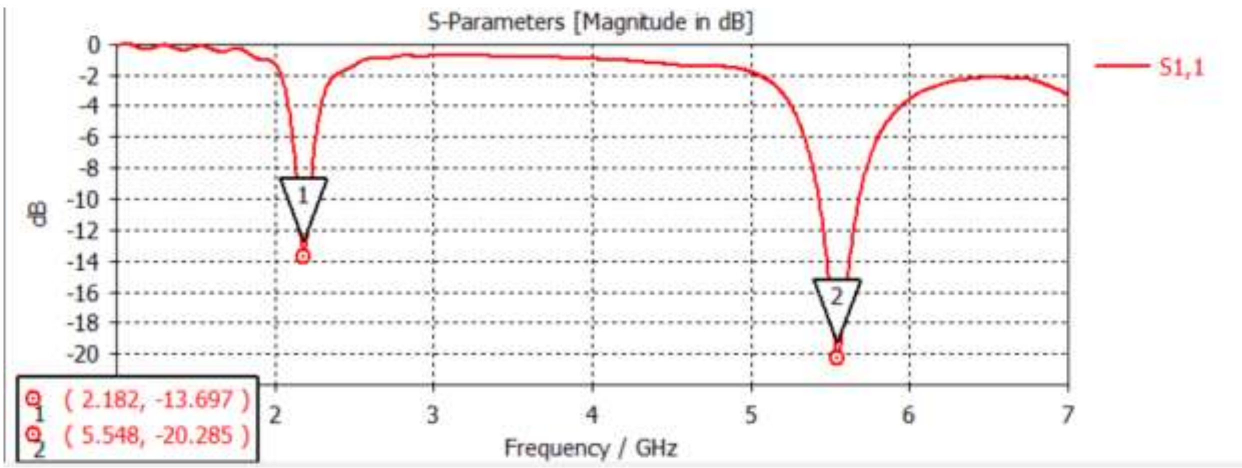
The following screenshots reveals the 2-D and 3-D farfield visualization at the resonating frequency of 2.4 GHz having the directivity 6.770 and gain 2.419 respectively, but these aren't suitable for Wi-Fi and Bluetooth application.





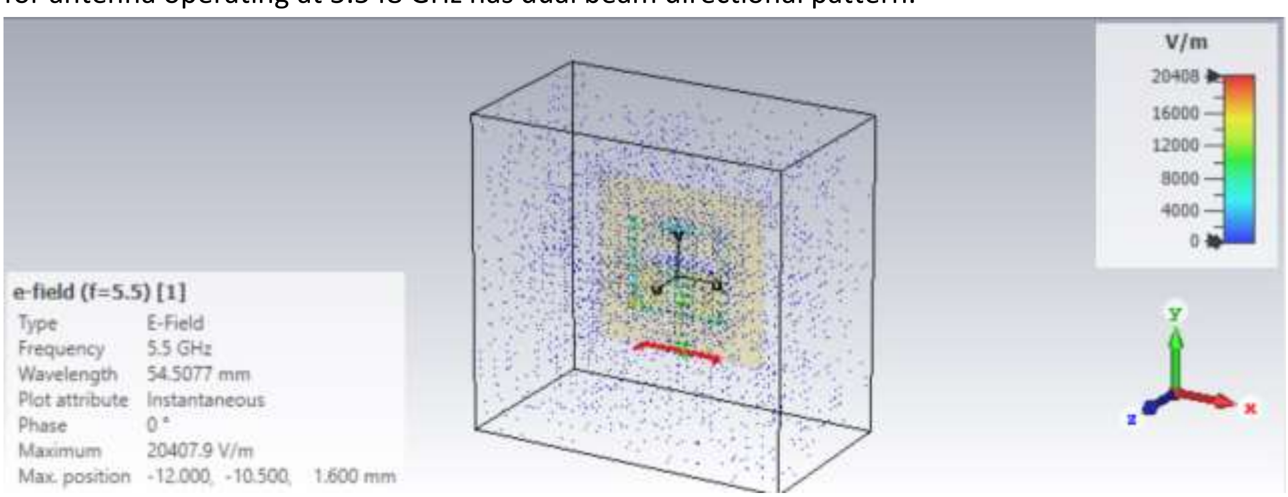
Return loss and Impedance bandwidth

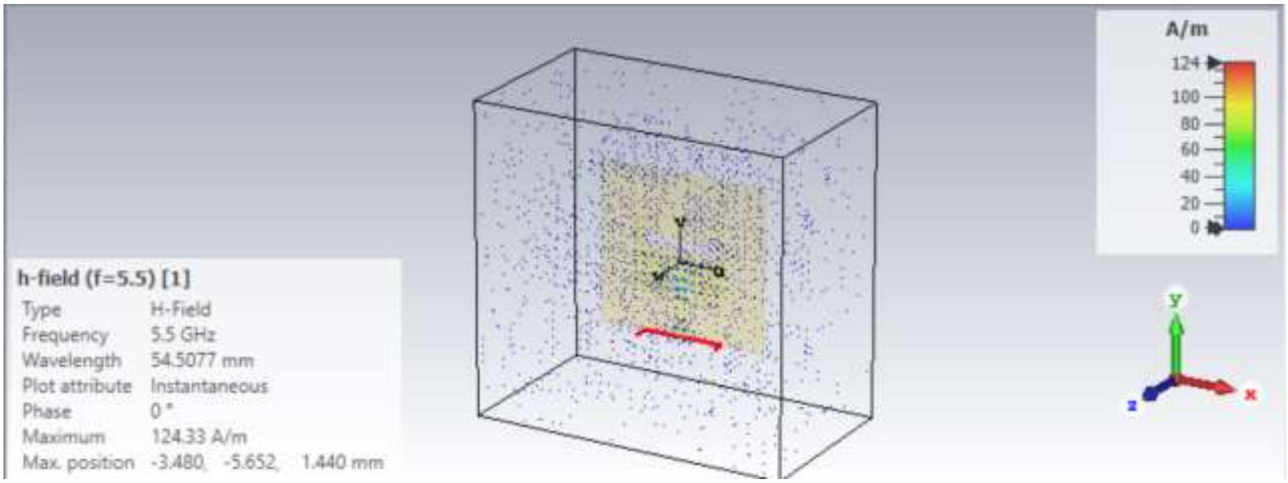
The figure below shows the simulated impedance (S11< -10dB) bandwidth and return loss of proposed antenna. From the simulated plot it is obvious that the antenna shows dual-band characteristic in the frequency band of 2.182/5.548 GHz. When the antenna operates at 2.182 GHz frequency it has impedance bandwidth of (2.018-2.318 GHz) with central frequency of 2.33 GHz and return loss -13.697 dB andwhen it operates at 5.548 GHz frequency it has impedance bandwidth of (4.99-6.00 GHz) with central frequency of 5.58 GHz and return loss -20.285 dB. Both the bands have wider impedance bandwidth.



Radiation pattern

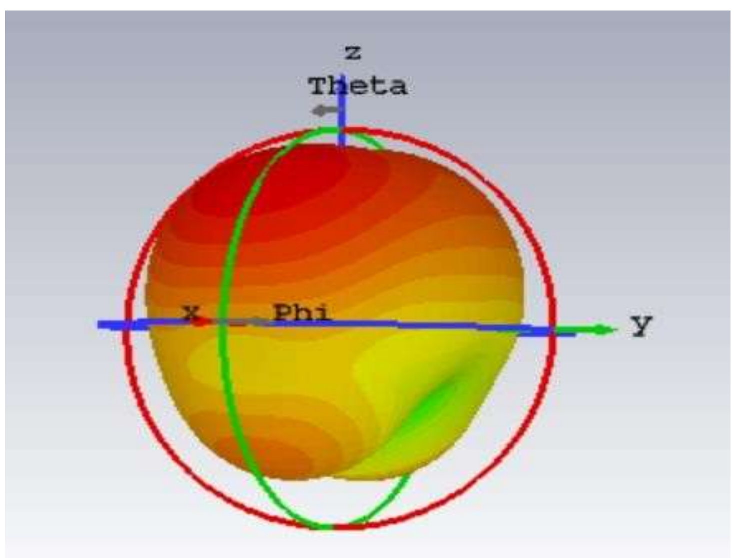
The figure below shows the 3D /2D radiation pattern of proposed antenna at 2.18 GHz and 5.548GHz frequency respectively. 3D radiation is pattern is like doughnut shaped radiation pattern and 2D radiation pattern shows omni-directional in E-plane and H-plane at 5.548GHz. for antenna operating at 5.548 GHz has dual beam directional pattern.

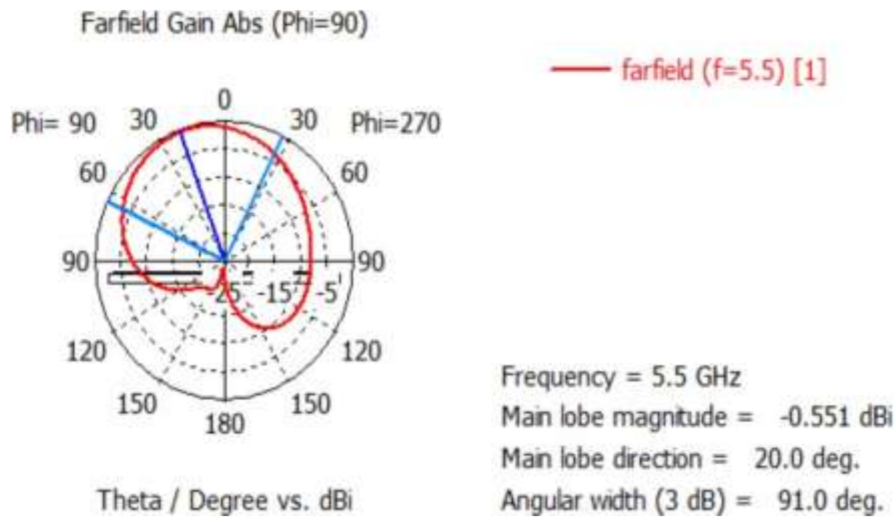




Gain

The figure below presents the proposed antenna gain operating at 2.182 and 5.548 GHz frequencies. The peakgain at this frequency is 3.01dBi, which is promising gain for indoor WLAN application, hallways and large office space etc. peak gain at 5.548 GHz is 2.869 dBi which is good for superior WLAN coverage.





CONCLUSION

The proposed antenna shows dual band characteristic in 2.18 /5.548 GHz band. it shows wide impedance (9.05% &18.12%) bandwidth and less return loss in both bands, which are -13.698 dB and -20.285 dB respectively. VSWR has favorable values in both bands. Lower band gain and directional pattern is promising for indoor WLAN application with value of 3.01dBi and omnidirectional radiation pattern, where as in higher band peak gain is 6.36 dBi with dual beam directional pattern, which can have good application for superior WLAN coverage. Over all the proposed antenna has properties of lowcost , low weight, wide dual- band ,easy fabrication and integration with RF circuit with favorable gains, these properties makes antenna a promising candidate for WLAN application.

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