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Rectangular Microstrip Patch Antenna for 2.4 GHz Frequency of ISM Band

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Abstract

A Microstrip patch antenna along with its array is expected to be designed for the next generation mobile communication and computing systems. Now a days the antennas play an important role in all the electronic devices due to wireless world. This research aims to design the antenna in such a way that the all the advancements in the antenna design can be covered in the design proposed .In this research we are planning to design the antenna along with the array so that the features are also enhanced by improving the directivity of this design . This can be done mostly using different ways of fabrication or deciding the material of substrate or mathematical model. This may help to improve the quality of the signal to be transmitted and received. Also, by making the antenna steerable towards the user, power saving issue could be resolved.

Keywords *— Microstrip Antenna, Patch Antenna, Single Band Antenna, ISM Band, Radiation pattern of Antenna.*

I. INTRODUCTION

For last 10 year, the wireless communication devices have started playing a very important role in our daily life .Therefore, the antennas designed for wireless applications have been in focus of research and have attracted maximum of attention from researchers all over the world.

What is an Antenna? The Antenna can be defined as an electrical device that converts electric power into electromagnetic waves (or simply radio waves) and vice-versa. An antenna is an array of conductors electrically connected to transmitter or receiver .We use many electronic devices daily which consists of antennas like mobile phones, remote controls and so on .The working principle of an antenna is that it converts electrical currents (carried along by metallic conductors) into EM radiation in free space and vice versa. Therefore, an antenna is used both to transmit and receive EM waves. So there is advancement in this field of research on daily basis.There are different types of antennas like wired antenna, log periodic antenna, aperture antenna, microstrip antenna, reflector antenna etc. We would be using the microstrip antenna for our research. A Microstrip Patch antenna is an antenna which is fabricated using different fabrication techniques. It has attracted focus of all the researchers around the globe due to its many advantages like low weight, low cost , easy to fabricate , conformal to surface and they also can be can be easily embedded into PCB .The microstrip patch antenna contains dielectric substrate placing a patch on one side and ground plane on other side .[1]Taking the view of conventional antennas, they do not handle high data rates, high traffic rates and high interference. The cost of power is also high .The above mentioned all three search issues are solved by microstrip patch Antenna.

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Hence , designing and modeling of Microstrip Antenna and its array in recent times have seen a huge surge of professional work due to its use in next generation mobile communication and computing systems.

II. LITERATURE SURVEY

There are many researches in antenna comparing the different parameters of microstrip patch antenna. The antenna is of shape meander and using FR-4 epoxy substrate. The meander shape antenna has formed a inverted S shape antenna. The resonating frequency is 2.4 GHz and gain obtained is 1.347 dB[2].The antenna achieved - 40dB return loss using FR4 epoxy substrate and bandwidth obtained is 160 MHz. It has inset type of feeding .The main research of this paper is low return loss and high bandwidth. The shape of the antenna is rectangular with two slots on either side and is designed at 2.4GHz[3].

III. DESIGN SPECIFICATIONS

Firstly, to start with, there are different band in ISM range which are freely usable in India. These bands are as follows: 2.4 GHz to 2.4835 GHz, 5.15GHz to 5.35 GHz, 5.470 GHz to 5.725 GHz, 5.725 GHz to 5.850 GHz[4]. In this research paper, frequency of 2.4 GHz is selected and simulation results are also shown. Fig. 1 shows the microstrip patch antenna top view.

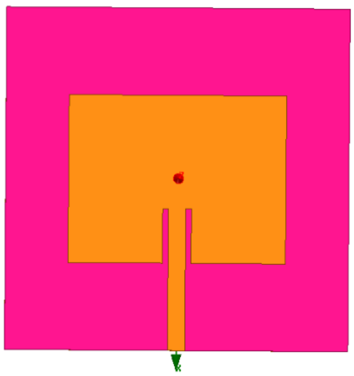

Fig. 1Microstrip Patch antenna Top View

A. *Calculation of Width of the Patch*

The width of the patch is calculated by using the below formula [5].

$$W = \frac{C_o}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \quad (1)$$

where,
W= Width of the patch
C_0= Speed of Light =3 * 10^8 m/s
f_r= Frequency of operation = 2.4GHz
$\mathcal{E}_r$ = Dielectric of the substance = 4.4

$$W = \frac{3 * 10^8}{2 * 2.4 * 10^6}\sqrt{\frac{2}{4.4+1}}$$

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W= 38 mm

B. *Calculation of Effective Dielectric Constant*

The Effective Dielectric constant is calculated by using the formula given[6].

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\,\frac{h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

where,
ϵ_{reff} = Effective dielectric constant
ϵ_r = Dielectric of the substance = 4.4
h = Height of substrate = 1.6 mm
W= Width of the patch

$$\epsilon_{reff} = \frac{4.4\ + 1}{2} + \frac{4.4\ - 1}{2}\left[1 + 12\,\frac{1.6}{38}\right]^{-\frac{1}{2}}$$

ϵ_{reff} = 4.802

C. *Calculation of Length extension*

The formula for length is given as below[6].

$$\frac{\Delta L}{h} = 0.412\,\frac{(\epsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (3)$$

where ,
ΔL= length extension
ϵ_r = dielectric of the substance = 4.4
h = height of substrate=1.6mm
W= width of the patch

$$\frac{\Delta L}{1.6} = 0.412\,\frac{(4.802 + 0.3)(\frac{38}{1.6} + 0.264)}{(4.802 - 0.258)(\frac{38}{1.6} + 0.8)}$$

ΔL = 0.7599 mm

D. *Calculation of Length of the Patch*

The length of patch antenna formula is stated as below[6].

$$L = \frac{C_o}{2 f_r \sqrt{\epsilon_{reff}}} - 2\Delta L \quad (4)$$

where,
L = Length of the patch
C_0= Speed of Light =3 * 10^8 m/s
f_r=frequency of operation = 2.4 GHz
ϵ_{reff} =Effective dielectric constant
ΔL= length extension

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$$L = \frac{3 * 10^8}{2 * 2.4 * 10^6\sqrt{4.802}} - 2 * 0.7599$$

L = 29.4 mm

E. Calculation of Wavelength of the Antenna

The wavelength of antenna is given by the below formula[6].

$$\lambda = \frac{c}{f_o} \qquad (5)$$

where,
λ = wavelength
C= Speed of Light =3 * 10^8 m/s
f = frequency of operation = 2.4 GHz

$$\lambda = \frac{3 * 10^8}{2.4 * 10^6}$$

λ =125 mm

Now, once the dimensions of the patch antenna are known, the antenna is been simulated in HFSS v 15 (High Frequency Structure Simulator) Software.

IV. Results and Discussion

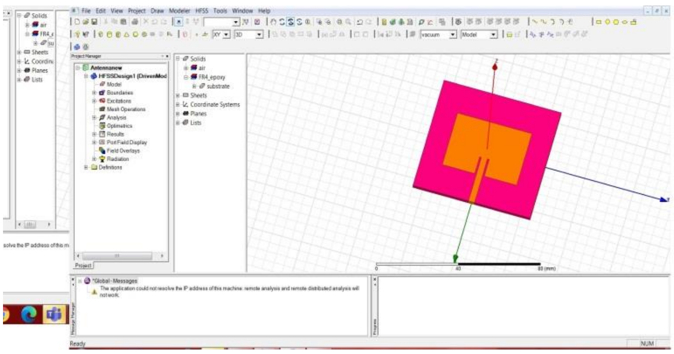

Fig. 2 Front view of antenna in HFSS (V15)

Fig. 2 shows the simulation of antenna in HFSS(V15).After simulation , the results obtained are given below.

A. *Resonant Frequency*

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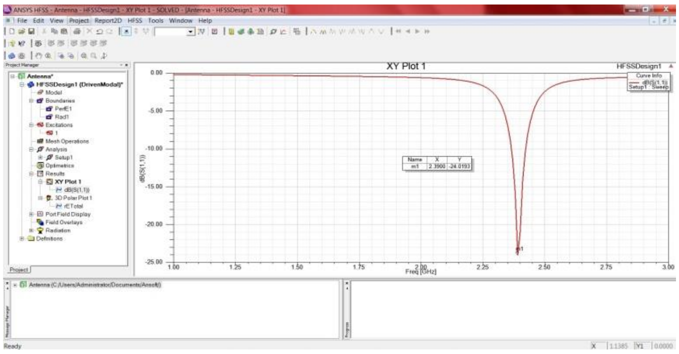

Fig. 3Resonant Frequency graph in HFSS(V15)

From Fig. 3,this antenna is resonating at 2.4 GHz.The S $_{(1,1)}$ parameter or return loss is -24.0193 dB. The Bandwidth of the antenna is 58 MHz .

B. *Radiation Pattern with Antenna*

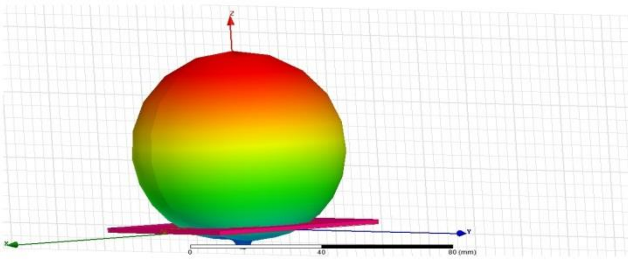

Fig. 4 Radiation pattern with Antenna in HFSS (V15)

Fig. 4 shows the radiation pattern. It is observed that the maximum radiation is in Z direction.

C. *Electric Field*

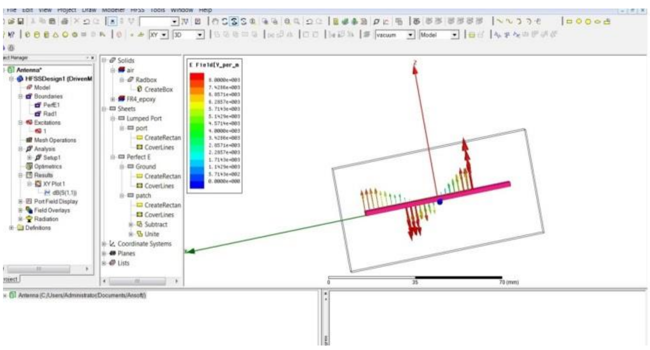

Fig. 5 Radiation pattern with Antenna in HFSS (v15)

Fig. 5 indicates the direction of E field. It is observed and it is concluded that the E plane is the XZ Plane here. Maximum direction of E field is in Z direction.

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D. *Polar plot of Gain in E Plane*

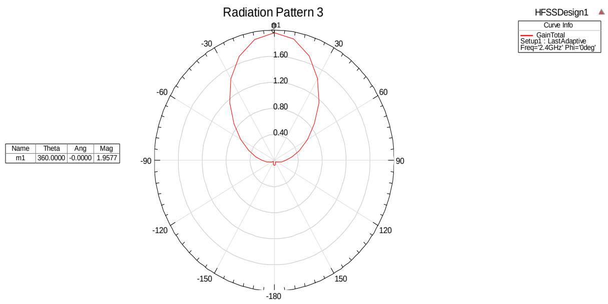

Fig. 6 Polar plot of E Plane in HFSS (V15)

From Fig. 6, The maximum gain observed is at 0 degree or 360 degree. From the marker; it is observed that the gain is 1.9577 dB in E Plane.

E. *Magnetic Field*

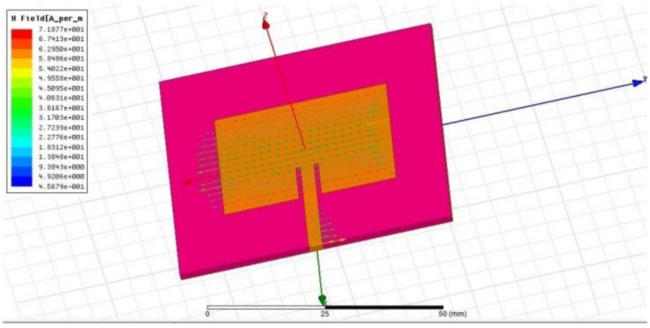

Fig. 7 Polar plot of E Plane in HFSS (V15)

Fig. 7 demonstrates the direction of H field. It is observed and it is concluded that the H plane is the in YZ Plane here. The direction of magnetic field is also seen in the figure above.

F. *Polar Plot of Gain in H Plane*

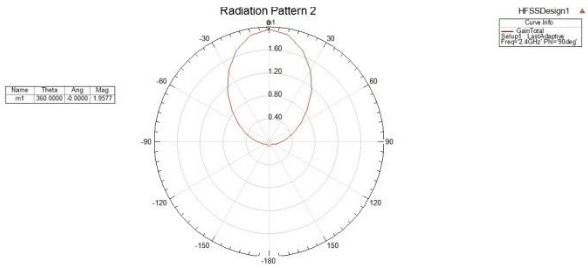

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Fig. 8 Polar plot of gain in H Plane in HFSS (V15)

Fig. 8 show the maximum gain is in 0 degree or 360 degree. From the marker, it is observed that the gain is 1.9577 dB in H Plane is the in YZ Plane here. The direction of magnetic field is also seen in the figure above.

G. *Gain Vs Frequency Plot*

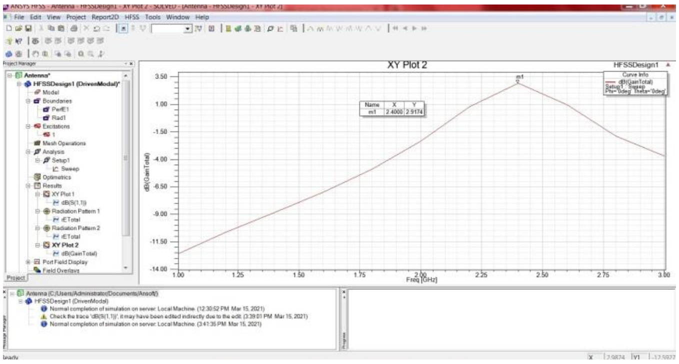

Fig. 9 Gain Vs Frequency Graph in HFSS (V15)

Fig. 9 indicates the Gain is maximum at 2.4 GHz and the value for gain is 2.9174 dB.

V. Conclusion

A successful design of 2.4 GHz frequency in ISM band is been designed and presented in this paper. Simulation using HFSS (v15) software is been done for obtaining results. From the results, the resonating frequency is 2.4 GHz and the return loss is obtained is -24.0193 dB. The Bandwidth of the antenna is 58 MHz. The electric field is in XZ plane and maximum in Z direction .The maximum gain is 1.9577dB in 0 degree or 360 degree. The magnetic field is in YZ plane .Here as well, the maximum gain is 1.9577dB in 0 degree or 360 degree. The total gain of the antenna is at frequency 2.4 GHz and value is 2.9174dB.The major application of this antenna is in WLAN like WIFI and Bluetooth and IoT [7],[8].

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