Design of double rectangular slotted Microstrip Patch Antenna for Wireless Communication

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***Abstract-* To improve performance over the broad range of frequencies, advanced wireless communication systems low return loss, high gains, and small antennas. This paper shows how the double rectangular slotted microstrip patch antenna for 2.4 GHz is designed. The antenna presented is designed over the substrate FR-4 epoxy with dielectric constant 4.4 and is fed with a standard of 50 ohms. With HFSS (High-Frequency Structure Simulator) software, the characteristics of the designed antenna were studied. HFSS is an Electromagnetic Field Simulator (EM) with Elevated full-wave and uses the method of Finite Elements (FEM). The etched double rectangular slotted circular antenna gives a better return loss and gain. The antenna is fed with a Microstrip line. The antenna is subjected to the studied parameters such as gain, return loss, and VSWR using HFSS v-15 Simulation software. This paper is aimed at the betterment of antenna performance by enhancing the return loss, gain, and VSWR. The proposed antenna is resonating at a frequency of 2.4 GHz with return loss and gain of -22 dB and 4.3 dB respectively.**

Keywords- Double rectangular slotted circular patch, Ansys HFSS v-15, Finite Elements Method (FEM).

I. INTRODUCTION

The broadly defined communication system is information transfer from one point to another [1]. The antennas are used most frequently to radiate the Electromagnetic wave for communications. The antenna includes 4 parts they are feed, patch, substrate, and ground. The microstrip patch antennas can be of different forms such as square, circle, rectangular and ellipses are the most common shapes that include ground on one side and dielectric constant on another side [2],[3]. These are the most common form of printed antennas.[4]. In general, all antennas are uses in the domains of Automotive Communications, Satellite Communications, Microwave global positioning systems [5][6]. Fig.1 shows a circular double-slotted microstrip patch antenna over the substrate with an effective dielectric constant (εr) of 4.4(FR4) [7],[8]In the Microstrip patch antenna the Electromagnetic wave propagation mechanism is a quasi TEM approximation [10]. The simulated antenna presented in this paper is resonating at a frequency of 2.4 GHz which is designed to work mainly in the wireless communications field such as Bluetooth and WLAN applications with double rectangular slotted microstrip patch and the proposed antenna is analyzed with parameters such as return loss, VSWR, and gain using HFSS-15 simulation software.

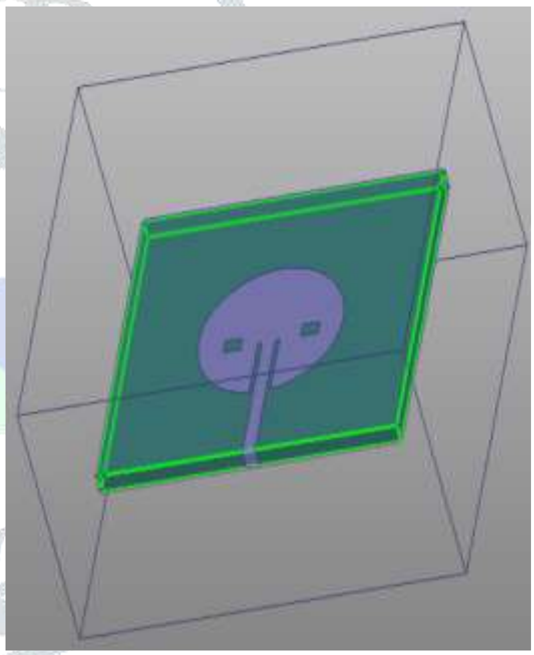

Fig.1-Microstrip patch antenna

The Fig.1 gives the Layout designed slotted double rectangular Microstrip patch antenna using FR-4 epoxy as substrate with dielectric constant 4.4.

II. GEOMETRY OF PROPOSED DESIGN ANTENNA

The geometry of the microstrip antenna is shown in Fig.2 The slotted antenna has a double rectangular slotted circular patch radius of r. A method of feeding the microstrip line used is inset line feeding with lumped port. The choice of substrate materials for the microstrip patch antenna is a major consideration in the design. To get the better return loss, VSWR, gain, plays a vital role in choosing the thickness and relative permittivity. We used FR-4 epoxy as a substrate, with a relative permittivity of 4.4 in this proposed prototype patch antenna design.

Circular Micro Strip Patch Antenna Design Formulas and Calculation

- The design parameters of the proposed CMSPA are Operating frequency, fr = 2.4GHz

- Generally, FR4 value varies from 4.3 to 4.7, here the dielectric constant of FR4 substrate, $\varepsilon r = 4.4$

- Height of dielectric substrate, h or $H_s = 3.6\text{mm}$,

- The wavelength, $\lambda = \lambda_0 = \frac{c}{f \text{ or } f_r \text{ or } f_0}$

The circular patch antenna radius is determined from the below expression which is the theoretical calculation equation:

Step 1.

Radius of the patch is given by,

$$a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}} \quad (1)$$

$$\text{Where, } F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}}$$

Step 2.

The effective radius of patch is given by

$$a_e = a\left\{1 + \frac{2h}{\pi\varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{\frac{1}{2}} \quad (2)$$

Step 3.

The resonant frequency for the dominant TM_{110} is given by

$$(f_r)_{110} = \frac{1.8412\times v_0}{2\pi a_e\sqrt{\varepsilon_r}} \quad (3)$$

Where v_0 = free space speed of light.

By using (1), (2), (3) we calculate radius of the patch to be fabricate.

Radius of the patch,

$$a = \frac{F}{D} = \frac{1.746227}{1.0000611} = 1.6871603\text{cm} = 16.87\text{mm}$$

Table I. Geometry of the proposed antenna

Parameter	Dimension in mm
Radius of the patch	16.87 mm
Radius of the patch	16.87 mm
Length and Width of Substrate (L,W) in mm	(70,70)
Length and Width of ground (L,W) in mm	(70,70)
Substrate material used	FR-4 epoxy
Dielectric constant εr	4.4
Resonating frequency	2.4GHz
Height of the substrate	3.6 mm

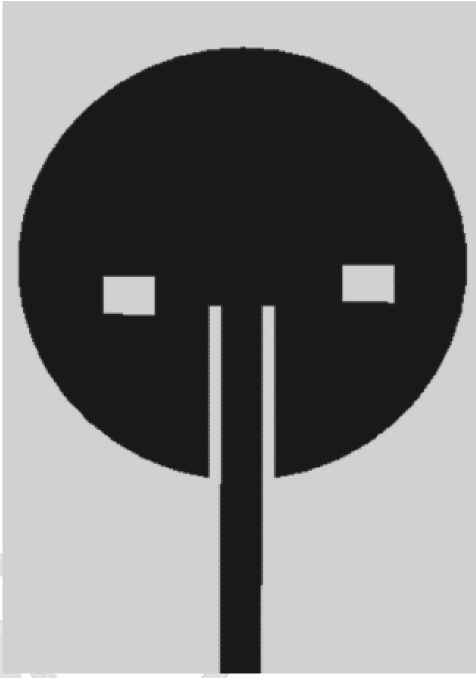

Fig.2 Double rectangular slotted circular microstrip patch

III. RESULTS AND DISCUSSION

The antenna of the proposed patch design shown is of radius 16.87 mm, with 2.4 GHz in the general size. In Fig.3, the deviation in return loss with and without slots is represented by the XY plane.

A. RETURN LOSS

The design proposes a microstrip patch with double-slotted rectangular antenna that Return loss shown in figure 3. The return loss is -22,8 dB at 2.44 GHz, which is a vital radiation antenna value.

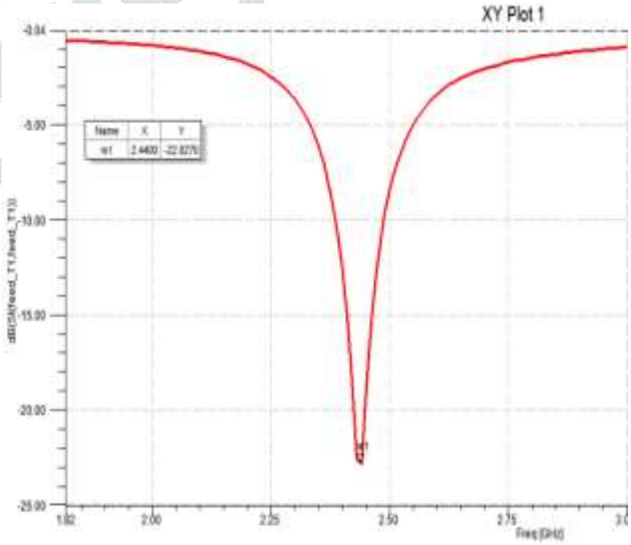

Fig.3 Simulated results of s11 for slotted patch antenna

B. VOLTAGE STANDING WAVE RATIO

The designed patch antenna achieved the VSWR of 1.25 dB for the frequency of 2.44 GHz. This reveals that the magnitude of VSWR obtained is close to 1dB which is an ideal value. This indicates very low power is reflected from the antenna. For an optimized antenna the VSWR should be less than 2, but not less than 1. The proposed patch antenna is capable to attain desired value of the Voltage Standing Wave Ratio (VSWR).

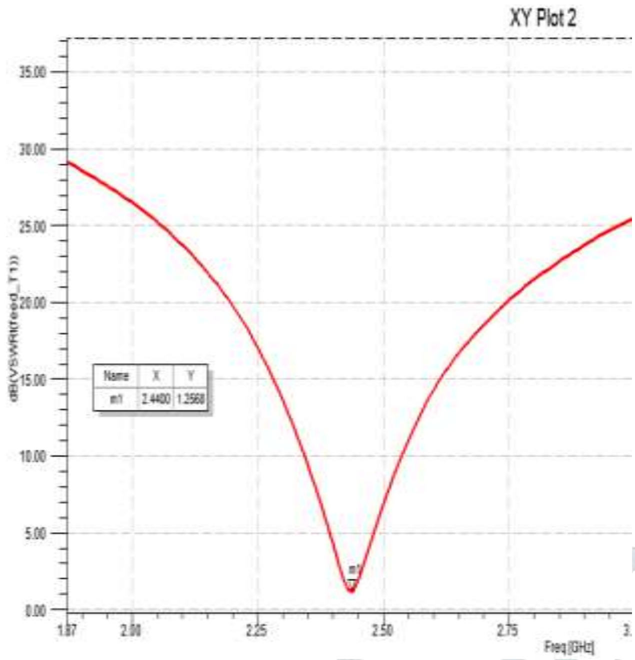

Fig .4 Simulated results of s22 for slotted patch antenna

C. FIELD DISTRIBUTION

The field distribution of the Electric Field and magnetic field is shown in Fig 5 and Fig 6 respectivelyfor and also their correspondong magnitudes are also mentioned.

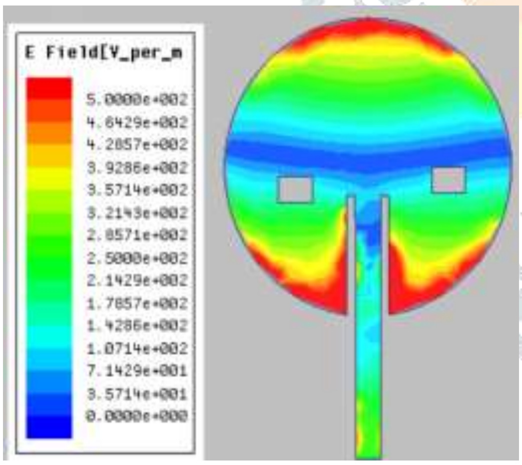

Fig.5 Electric Field Distribution of slotted microstrip antenna

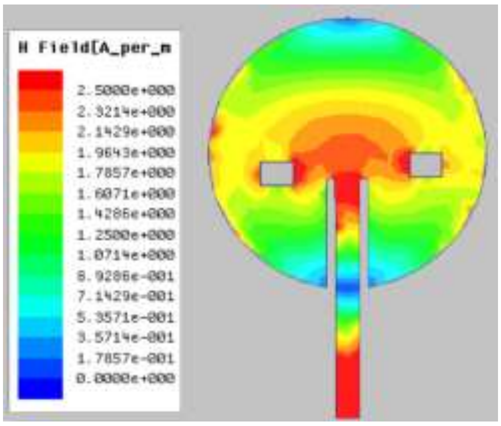

Fig.6 Electric Field Distribution of slotted microstrip antenna

D. RADIATION PATTERN

Radiation pattern in the above figure showing the main lobe of radiation. We can notice that all its power is radiating in one direction, so that we can conclude it as an optimized antenna radiation pattern that is unidirectional in nature.

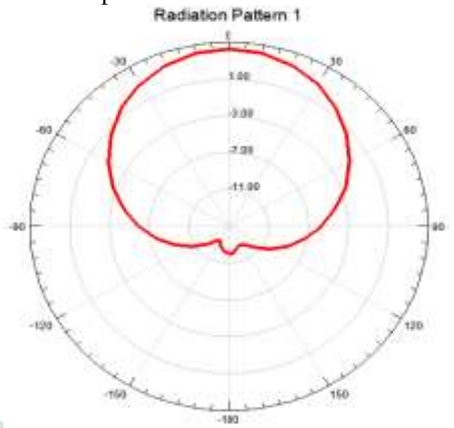

Fig.7 Radiation Pattern for proposed microstrip patch antenna

E. 3D POLAR PLOT

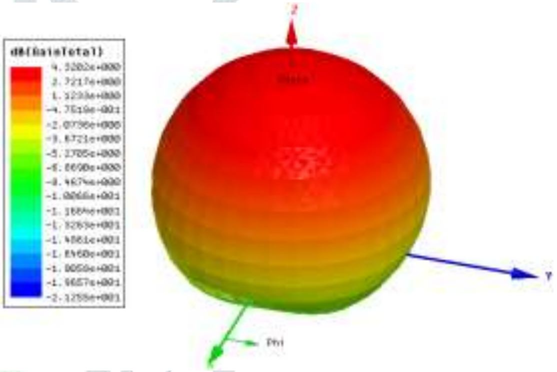

Fig.8 3D Polar Plot

3D Radiation pattern for proposed double rectangular slotted microstrip patch antenna along with theta and phi directions. In the figure, the region showing in color red is radiating more towards Z-axis.

F. GAIN OF THE ANTENNA

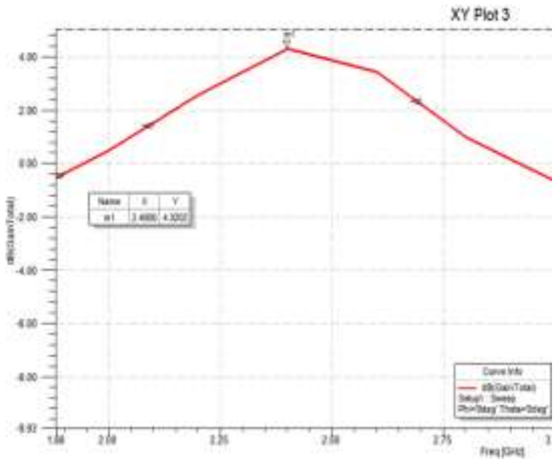

Fig.9 Gain for proposed microstrip patch antenna

The Gain of the designed double rectangular slotted microstrip patch antenna is 4.32 dB for the frequency 2.4 GHz which is shown in fig.9.

The feeding method uses in for fabrication explained in this paper is Inset Line Feeding Method, which has some advantages like, it is Easy to fabricate, simple to model and provide good impedance matching. etc

The slots etched during fabrication of the Microstrip Patch Antenna on the specific locations on patch based on the current distribution of the antenna.

IV. CONCLUSION

The design of this microstrip antenna is described and the return loss and gain of the microstrip patch antenna is obtained by etching the slots on the radiating circular patch edge of the major circular patch.

The simulation results for the proposed antenna exhibits a Return loss of -22.8 dB at the frequency of 2.44 GHz and the VSWR value is 1.25 at the frequency of 2.44 GHz whereas the gain of the antenna is observed 4.3 dB at the resonating frequency of 2.4 GHz.

The achieved results show that are emphatically effective as compared to others, very appropriate, and easy to design. Hence this slotted microstrip patch antenna is very conventional for various wireless applications such as Bluetooth and WLAN applications etc. in the modern wireless world.

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