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# DESIGN & SIMULATION AND FABRICATION OF CIRCULAR MICROSTRIP ANTENNA FOR WIRELESS COMMUNICATION

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**ABSTRACT**

*In this paper we have designed a Circular microstrip patch antenna operating at 2.4GHz using EM simulator software – Ansoft's HFSS. The aim is to Design and fabricate an rectangular Microstrip Antenna at 2.4 GHz and study the effect of antenna dimensions Length (L) , Width (W) and substrate parameters relative Dielectric constant (εr) , substrate thickness on Radiation parameters of Bandwidth. Low dielectric constant substrates are generally preferred for maximum radiation. The function of radiating element was analyzed, by determining the return loss, voltage standing wave ratio (VSWR), directivity, gain and efficiency. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Since the circular microstrip patch antenna is designed at ISM band it is applicable in different wireless communication applications.*

***Keywords :*** *Circular Microstrip patch antenna, HFSS, Return loss, Antenna gain, VSWR, Bandwidth.*

## I. INTRODUCTION

Antennas play a very important role in the field of wireless communications. Some of them are Parabolic Reflectors, Patch Antennas, Slot Antennas, and Folded Dipole Antennas. Each type of antenna is good in their own properties and usage. We can say antennas are the backbone and almost everything in the wireless communication without which the world could have not reached at this age of technology.

Microstrip antennas have profound applications especially in the field of medical, military, mobile and satellite communications. Their utilization has become diverse because of their small size and light weight. Rapid and cost effective fabrication is especially important when it comes to the prototyping of antennas for their performance evaluation. As wireless applications require more and more bandwidth, the demand for wideband antennas operating at higher frequencies becomes inevitable. Inherently microstrip antennas have narrow bandwidth and low efficiency and their performance greatly depends on the substrate parameters i.e. its dielectric constant, uniformity and loss tangent [5].

The microstrip antennas are mostly a broadside radiator. The patch is designed in such a way so that its pattern is maximum normal to it. End-fire radiator can also be chosen by proper mode selection. The microstrip patch antennas is one of the most useful antennas working at microwave frequencies (f > 1 GHz). It consists of a metallic "patch" on top of the dielectric substrate and below the dielectric material it has ground plane. The position of the feed has to be changed as before to control the input impedance [7, 8]. The patch, microstrip transmission line (or input, output pin of coaxial probe), and ground plane are made of high conductive material (typically copper). The patch may be in a variety of shapes, but rectangular and circular are the most common because ease of analysis and fabrication, attractive radiation characteristics, especially low cross polarization [2].

After rectangular patch the next configuration is the circular patch (as shown in figure 1) which has varying applications as a single patch element as well as in arrays. The modes that are supported primarily by a circular microstrip patch antenna whose substrate height is small ($h << \lambda$) are TMzwhere z is taken perpendicular to the patch [4]. The circular patch has only one degree of freedom to control i.e. radius of the patch. Though this does not change the order of the modes; however, it does change the absolute value of the resonant frequency [3].

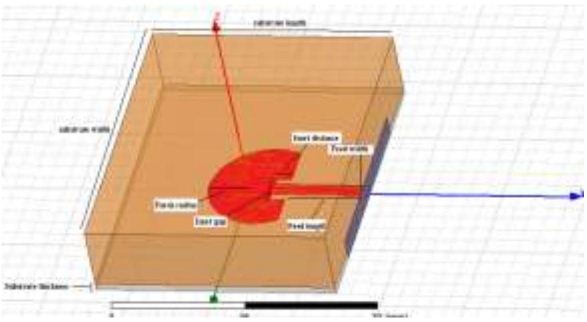

Fig. 1: A Circular microstrip patch antenna

Patch antennas play a very significant role in today's world of wireless communication systems. A Microstrip patch antenna is very simple in the construction using a conventional Microstrip fabrication technique. The most commonly used Microstrip patch antennas are rectangular and circular patch antennas. These patch antennas are used as simple and for the widest and most demanding applications.

In this paper we have designed a circular microstrip patch antenna operating at a frequency of 2.4GHz. The circular patch antenna is designed using EM (Electromagnetic) simulator software Ansoft's HFSS(High Frequency Structure Simulator).

## II. THEORY OF RECTANGULAR PATCH ANTENNAS

Microstrip antennas are attractive due to their light weight, conformability and low cost. These antennas can be integrated with printed strip-line feed networks and active devices. This is a relatively new area of antenna engineering. The radiation properties of micro strip structures have been known since the mid 1950's. The application of this type of antennas started in early 1970's when conformal antennas were required for missiles. Rectangular and circular micro strip resonant patches have been used extensively in a variety of array configurations. A major contributing factor for recent advances of microstrip antennas is the current revolution in electronic circuit miniaturization brought about by developments in large scale integration.

As conventional antennas are often bulky and costly part of an electronic system, micro strip antennas based on photolithographic technology are seen as an engineering breakthrough.In its most fundamental form, a Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure No 2 The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

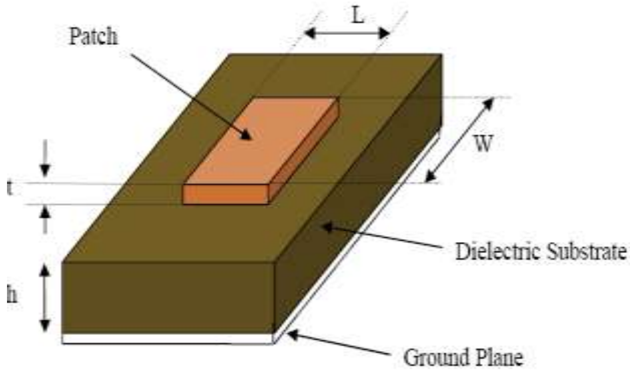


Figure 2: Structure of a Microstrip Patch Antenna

Hence, as seen from Figure No 2, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electromagnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant (ε*reff*) must be obtained in order to account for the fringing and the wave propagation in the line. The value of ε*reff* is slightly less then ε*r* because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure 3.8 above. The expression for ε*reff* is given by Balanis as:

$$E_{reff} = \frac{E_r+1}{2} + \frac{Er-1}{2}\left[\sqrt{1+12\frac{h}{W}}\right] \qquad (1)$$

Where E*reff* = Effective dielectric constant

E*r* = Dielectric constant of substrate

*h* = Height of dielectric substrate

*W* = Width of the patch

Consider Figure 3 below, which shows a rectangular microstrip patch antenna of length *L*, width *W* resting on a substrate of height *h*.

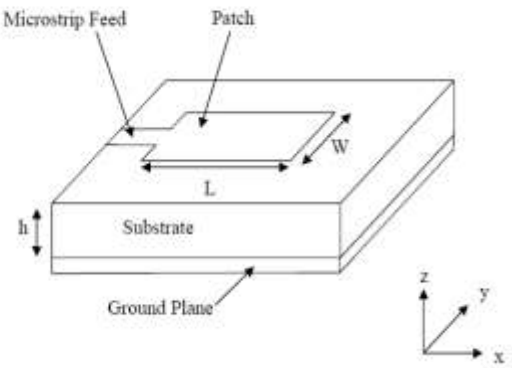


Figure 3: Microstrip Patch antenna

The co-ordinate axis is selected such that the length is along the x direction, width is along the *y* direction and the height is along the *z* direction. In order to operate in the fundamental *TM*10 mode, the length of the patch must be slightly less than λ/2 where λ is the wavelength in the dielectric medium and is equal to $\lambda o/\sqrt{\varepsilon reff}$ where λ*o* is the free space wavelength. The *TM*10 mode implies that the field varies one λ/2 cycle along the length, and there is no variation along the width of the patch. In the Figure3 shown below, the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends.

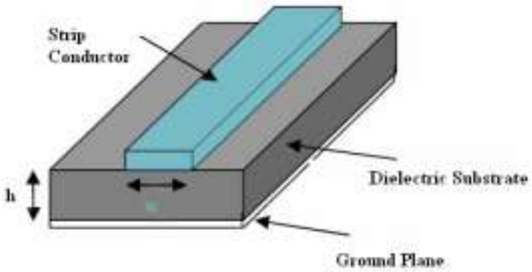


Figure 4: Transmission line model

Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.It is seen that the normal components of the electric field at the two edges along the width are in opposite directions and thus out of phase since the patch is λ/2 long and hence they cancel each other in the broadside direction. The tangential components (seen in Figure), which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure.

Hence the edges along the width can be represented as two radiating slots, which are λ/2 apart and excited in phase and radiating in the half space above the ground plane. The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical

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dimensions. The dimensions of the patch along its length have now been extended on each end by a distance $\Delta L$, which is given empirically by Hammerstad as:

$$\Delta L = 0.412h \frac{(E_{reff}+0.3)(\frac{W}{h}+0.264)}{(E_{reff}-0.258)(\frac{W}{h}+0.8)} \qquad (2)$$

The effective length of the patch $L_{eff}$ now becomes;

$$L_{eff} = L+2\,\Delta L \qquad (3)$$

For a given resonance frequency $f_0$ , the effective length is given by:

$$L_{eff} = \frac{c}{2f_0\sqrt{E_{eff}}} \qquad (4)$$

The resonsnt frequency is given by:

$$f_0 = \frac{c}{2\sqrt{E_{eff}}}\sqrt{[(\frac{m}{L})^2 + (\frac{n}{W})^2]} \qquad (5)$$

Where m and n are modes along L and W respectively.
For efficient radiation the width W is given by Bahl and Bhartia as:

$$w = \frac{c}{2f_0\sqrt{(\frac{E_r+1}{2})}} \qquad (6)$$

## III. DESIGN METHODOLOGY

A circular microstrip patch antenna designing is easier than other patch configuration as we only need one design parameter i.e. radius of the patch. A schematic of circular patch antenna is shown in figure 2. Based on the cavity model formulation, a design procedure is outlined which leads to practical designs of circular microstrip antennas for the dominant TM110 mode [1].

Fig. 5: Schematic of a Circular microstrip patch antenna

The procedure assumes that the specified information includes the dielectric constant of the substrate (εr), the operating frequency (fr) and the height of the substrate (h).To find the actual radius 'a' of the patch we have [7]:

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

$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}} \quad (7)$$

In the above equations we should remember that the operating frequency fr should be taken in Hertz (Hz) and the height of the substrate h should be taken in Centimeters (cm).

## IV.Electromagnetic Simulation

The circular microstrip patch antenna is designed on a FR4 substrate having a dielectric constant, εr = 4.4 and height of the substrate h = 1.6mm at an operating frequency of 5GHz. For designing patch and ground copper conductor is used with bulk conductivity equal to 5.8×107siemens/m. The circular patch antenna is designed using EM simulator software Ansoft's HFSS v13, which works on the principle of Finite Element Method (FEM). Using equation (1) and (2), and the given specified data the radius of the circular patch a = 8.56mm. A FR4 substrate of dimensions 30mm×30mm is taken. The depth (L) and width (W) of the inset are taken as 7.4mm and 3.6mm respectively. A 50Ω impedance microstrip line is used to feed the circular patch. The length of the feed line is 15.53mm and the width of the line taken is 3mm. For exciting the circular patch a wave port is used. The circular microstrip patch antenna model designed in HFSS software is shown in figure 6.

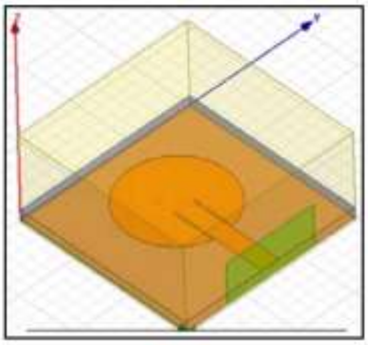

Fig. 6: HFSS model of Circular Microstrip Patch Antenna

## V.SIMULATION RESULTS

The HFSS designed model of circular microstrip patch antenna is simulated and a various antenna characteristics are obtained. Figure 4 shows the return loss plot of the designed circular patch antenna. The circular patch antenna shows a resonance peak at 5.026GHz and gives return loss value equal to -38.09dB. This shows that almost a perfect feed configuration is achieved, i.e. patch and feed line are in perfect impedance matching state. Also, the 10dB frequency bandwidth equal to 190.5MHz is observed.

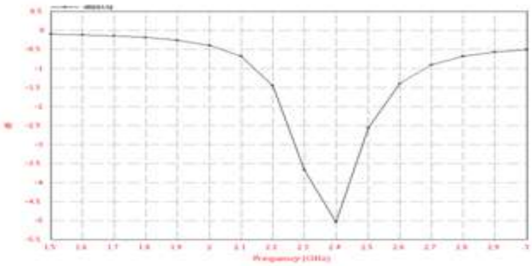

Fig. 7: Return loss plot of Circular Microstrip Patch Antenna

Figure 8 and 9 shows that 2D and 3D plot of radiation pattern of the designed circular patch antenna. From these plot we can observe that an end-fire radiation plot is achieved and no radiation is observed below the ground, which means perfect ground condition is achieved. From the radiation plot we have also obtained the directivity and antenna gain of the designed circular patch antenna which are 4.5dBi and 2.66dBi respectively. Also one more antenna characteristics known as radiation efficiency equal to 59.1% is achieved.

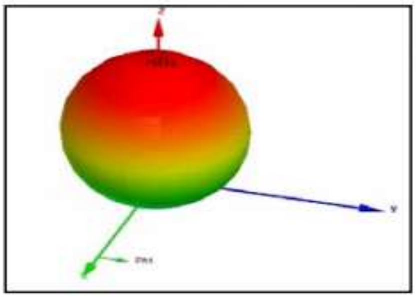

Fig 8:3D radiation plot

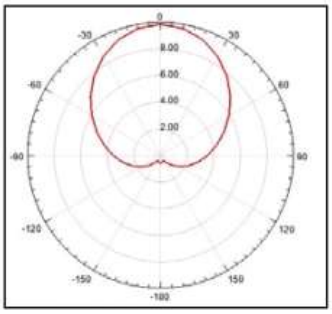


fig 9:2D radiation pattern

## VI.PARAMETERS OF ANTENNA:

| | |
|---|---|
| Operating Frequency | 2.4GHz |
| Substrate | FR4_Epoxy |
| Dielectric Constant | 4.4 |
| Loss Tangent | 0.02 |
| Substrate Height | 1.6mm |
| Width of Patch | 38.036mm |
| Effective dielectric constant | 4.785 |
| Effective length | 0.0285mm |
| Actual length of patch | 27.122mm |

Table no.1

## VII. RESULT ANALYSIS:

| | |
|---|---|
| Return loss | -18db |
| Gain | 2 db |
| VSWR | 1 |
| Input Impedance | 50 Ω |
| Efficiency | 59.1 % |
| Directivity | 4.2 db |

Table no.2

## VIII. CONCLUSION

The study of the performances of microstrip antennas supposes the development of the conception and the simulation, which provokes a variation on the structure of this type of antenna.

In this paper, we have presented the design and simulation of a Circular Microstrip patch Antenna at ISM band frequency region. The high return loss value gives perfect impedance matching between patch and feed. Also, designed circular patch antenna gives radiation efficiency equal to 59.1%. However, we can also improve the antenna characteristics using different known technologies to increase the applicability of this patch antenna.

## REFERENCES

[1] Constantine A. Balanis, "Antenna Theory, Analysis and Design", Third Edition, John Wiley & Sons, Inc.

[2] Ramesh garg, PrakashBhartia, InderBahl and ApisakIttipiboon, "Microtrip Design Antenna Handbook", Artech House, Boston London.

[3] Kin-Lu Wong, "Compact and Broadband Microstrip Antennas", John Wiley & Sons, Inc

[4] A.Al-Zoubi, F. Yang, and A. Kishk, "A broadband center-fed circular patch-ring antenna with a monopole like radiation pattern," IEEE Transaction Antennas Propagation, vol. 57, pp. 789–792, 2009.

[5] Prasanna L. Zade,SachinS.Khade, Dr. N. K. Choudhary, "Modeling and Designing of Circular Microstrip Antenna For wireless communication", International Conference on Emerging Trends in Engineering and Technology, ICETET2009.

[6] Arun Singh Kirar, Veerendra Singh Jadaun, Pavan Kumar Sharma, "Design a Circular Microstrip Patch Antenna for Dual Band", International Journal of Electronics Communication and Computer Technology (IJECCT) Volume 3 Issue 2 March 2013.