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CIRCULAR MICROSTRIP PATCH ANTENNA

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***Abstract*— In this paper we have designed a Circular microstrip patch antenna operating at 5GHz using FEM based EM simulator software - Ansys HFSS v15.0 The circular patch antenna is designed on a FR4 substrate with di electric constant & 4.4 and height of the substrate is 1.6mm. Several antenna characteristics such as return loss, radiation pattern, percentage bandwidth, directivity, antenna gain, radiation efficiency etc. are studied. The designed circular patch antenna shows return loss value well below -30dB and a percentage bandwidth equal to 3.79% is achieved. Also, a good directivity value of 3.59dBi and antenna gain equal to 1.78dBi is ob served. Since the circular microstrip patch antenna is designed at C band it is applicable in different satellite communication applications such as transponder etc.**

Key Words: Circular Microstrip patch antenna, Percentage Bandwidth, Directivity, Antenna Gain, HFSS

1. INTRODUCTION

Microstrip antennas have profound applications especially in the field of medical, military, mobile and satellite communications. 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

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 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 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 The modes that are supported primarily by a circular microstrip patch antenna whose substrate height is small .

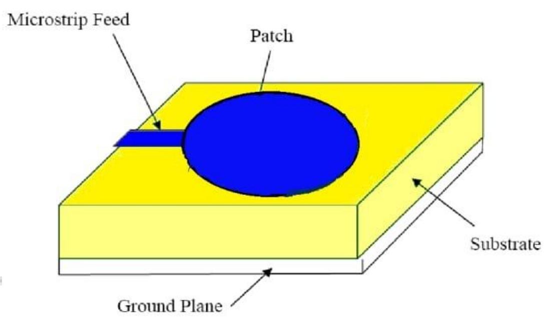

Fig. 1: Circular microstrip patch antenna

In this paper we have designed a circular microstrip patch antenna operating at a frequency of 5GHz. The patch antenna is designed on a FR4 (Flame Retardant 4) substrate having a dielectric constant, εr = 4.4 and height of the substrate h = 1.6mm. For designing patch and ground copper conductor is used with bulk conductivity equal to 5.8×107 siemens/m. The circular patch antenna is designed using EM (Electromagnetic) simulator software Ansoft's HFSS(High Frequency Structure Simulator)v13, which works on the principle of Finite Element Method (FEM).

2. DESIGN METHODOLOGY

Designing of Circular patch antenna is easy as compared to other patch antenna configuration, there only one major parameter which is radius of Circular patch.the design procedure is outlined which lead to practical design of Circular Microstrip Patch Antenna for dominant TM_{100} Mode

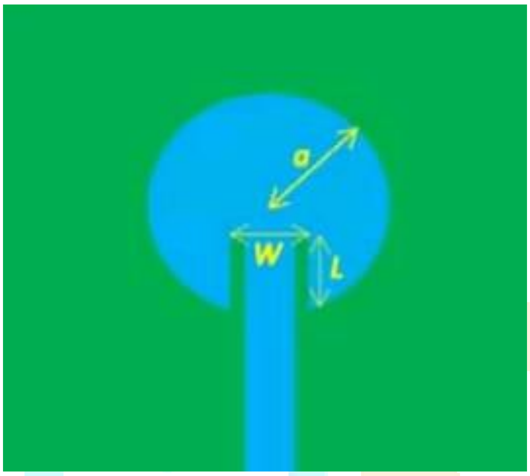

Fig. 2 Schematic of Circular Microstrip Patch Antenna

$$R_p = \frac{F}{\sqrt{1+\frac{2h}{\pi\varepsilon F}\left[\ln\left(\frac{F\pi}{2h}\right)+1.7726\right]}}$$

$$F = \frac{8.791\times10^9}{f\sqrt{\varepsilon}}$$

Rp the radius of the patch

h = the height of the substrate

f = the resonance frequency in hertz

ε = the effective dielectric constant of substrate

Microstrip antenna consists of very small conducting patch, ground plane and substrate, in which substrate is sandwiched between the ground plane and the radiating patch.

The length of the metal patch should be λ/2.

3. ELECTROMAGNETIC SIMULATION

FR4 substrate is used in design of circular Microstrip Patch Antenna which is having a dielectric constant, &,ebslonR= 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 5.8×10'siemens/m. The circular patch antenna is designed using EM simulator software Ansys HFSS v15.0, 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 30mmx30mm is taken. The depth (L) and width (W) of the inset are taken as 7.4mm and 3.6mm respectively. A Microstrip line of 50ohm impedance has been used to feed circular patch.The Length & width of 15.53mm & 3mm both respectively used.

For exciting the circular patch a wave port is used. The circular microstrip patch antenna model designed in HFSS software is shown in figure

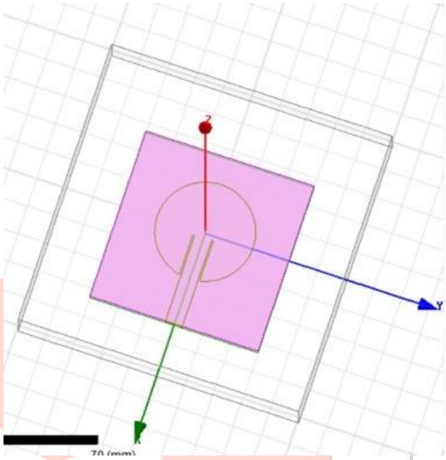

Fig. 3 HFSS Model of Circular Microstrip Patch Antenna

4. SIMULATION RESULTS AND DISCUSSIONS

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 which means a percentage bandwidth equal to 3.79% is calculated.

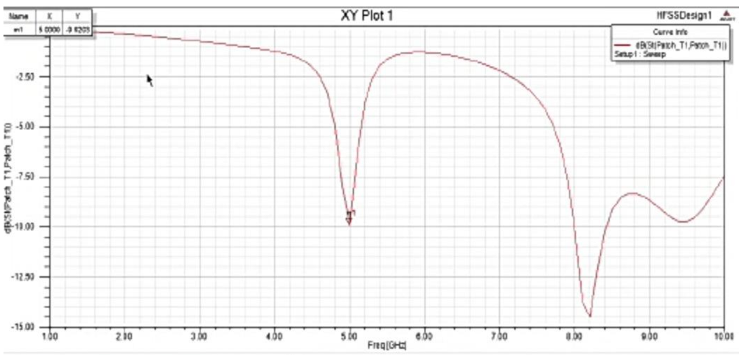

Fig. 4: Return loss plot of Circular Microstrip Patch Antenna

The frequency bandwidth and the percentage bandwidth for a circular Microstrip patch antenna are determined using [6]:

Frequency Bandwidth = fH-fl ……. (3)

And, Percentage Bandwidth = (fH-fL/fc) x 100% …… (4)

Where f, and f, are the two frequency points on the return loss curve obtained on the -10dB line and f, is the center frequency at which the resonance peak is observed.

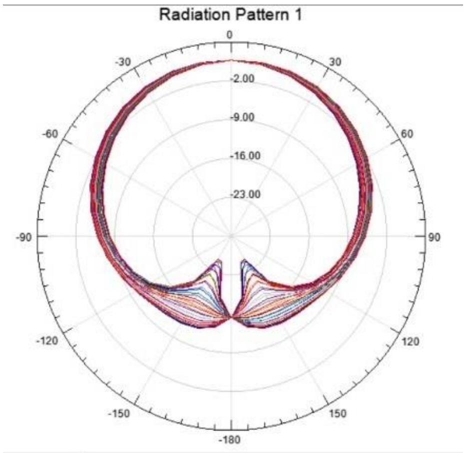

Fig. 5 2D Radiation Plot

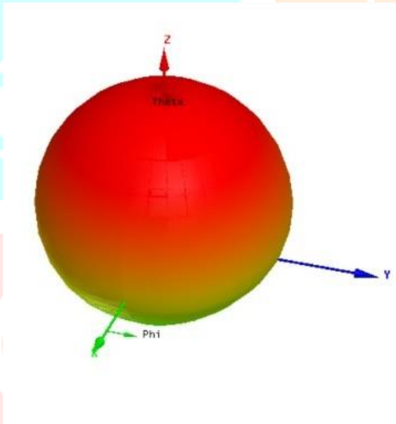

Fig. 6 3D Plot of Raditation Pattern

Figure 5 and 6 shows the 2D and 3D plot of the radiation pattern of the designed circular patch antenna. From the radiation pattern plot we can observe that an end-fire radiation plot is achieved and no radiation is observed below the ground, which means a 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 3.59dBi and 1.78dBi respectively. Also, one more antenna characteristic known as radiation efficiency equal to 59.1% is achieved.

5. CONCLUSION

In this paper, we have presented the design and simulation of a Circular Microstrip patch Antenna at E band frequency region. The simulated results of circular microstrip patch antenna shows good directivity and gain value. The directivity and gain for the circular patch antenna is 3.59dBi and 1.78dBi respectively and a percentage bandwidth achieved is 3.79%. The high return loss value gives perfect impedance matching between patch and feed. Also, designed circular patch antenna gives a 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. Although, this circular patch antenna may find applications in C-band satellite communication applications such as transponders.

6. FUTURE SCOPE

- There is definitely room for improvement, particularly if we can identify the right features.
- Include deep learning technologies and complex deep learning algorithms such as LSTM and RNN.
- Image processing can also be used to grade handwritten essays that have been graded offline.

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