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Miniaturized Patch Antenna Configuration for Wireless Communication Applications

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ABSTRACT
In, modern world technology the communication systems arethe most widely researched area for wireless technology and the study of this communication system is incomplete without understanding the operation of the microstrip patch antennas.This technological trend has focused much effort into the design of a Micro strip patch array antenna mainly used in defense etc. The design and simulation of patch antennas is widely used in mobile cellular phones today as the antennas are easily fitted in the mobile housing, and our emphasis in this work is on optimization of a 10GHz microstrip patch antenna.In order to showcase and physically realize the model, for the same design's mathematical analysis, numerical and iterative simulations are carried out at 10GHz. Simulation is carried out in CST and the same.
KEYWORDS:*Patch Antennas, Wireless Communication, Directivity, Return loss, Gain, Bandwidth.*

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I. INTRODUCTION

The size, cost, installation, aerodynamic profile and constraints, low profile antenna etc. are the prime requirement for different applications utilized in satellite communication, missile technology, space technology and in various aircrafts. Now-a-days there are many of the appliances in commercial and government sectors, such as mobile radio and wireless communications, which have similar specifications. Microstrip patch antenna can be used for the designing of various antenna based on the necessary requirements. This type of antennasis comfortable for both the planar and non-planar structures, also simple and very low cost to design and manufacture an antenna using a new printed-circuit technology [1][2]. Microstrip patch antennas consist of a metallic patch which is arranged on grounded substrate and dielectric material. The dielectric material utilized in this paper is FR4. The advantage of these antennas is there low profile and have low fabrication cost, are very much suitable for aerospace appliances and mobile housing applications [3][4]. Due to their low-power handling capacity, these antennas are used for low power transmission and reception applications.
Wireless communication technology is a modern technology in the present and future generation aspects, used for communication of people to any device from any location[5][6]. Wireless communications are the fastest growing segment of the communications industry. Because of this technological development, it has captured many attentions such as the imagination of the public [7]. Modern wireless technology systems are completely based on light weight of antenna, low profile of antenna, high gain and simple structure antennas to assure reliability, mobility and high efficiency [8]. The parameters such as dielectric substrate and dielectric constant, height of the material, width of the material, loss tangent etc. are the main parameter for designing any microstrip patch antenna [9].

II. DESIGN OF PATCH ARRAY ANTENNA

The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth [10]. The resonant frequency of microstrip antenna and the size of the radiation patch can be similar to the following formulas while the high dielectric constant of the substrate results in smaller size of antenna [11]. Figure 1 shows the geometry of the design in which the Length of ground plane of Antenna is 38.4 mm and Width is 46.8 mm, L & W of the patch is 28.8 mm & 37.2 mm.Thepatch width, effective dielectric constant, the length extension and also patch length [12] are given by

$$Width = \frac{c}{2f_o\sqrt{\frac{\varepsilon_R+1}{2}}}; \quad \varepsilon_{eff} = \frac{\varepsilon_R+1}{2} + \frac{\varepsilon_R-1}{2}\left[\frac{1}{\sqrt{1+12\left(\frac{h}{W}\right)}}\right]$$

$$Length = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 0.824h\left(\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}\right)$$

where c is the velocity of light,

The dimensions of the patch along its length have now been extended on each end by a distance 'ΔL', which is given empirically by as

$\Delta L = 0.412h\,(\varepsilon_{reff} + 0.3)\,(W/h + 0.264) / ((\varepsilon_{reff} - 0.258)\,(W/h + 0.8))$.

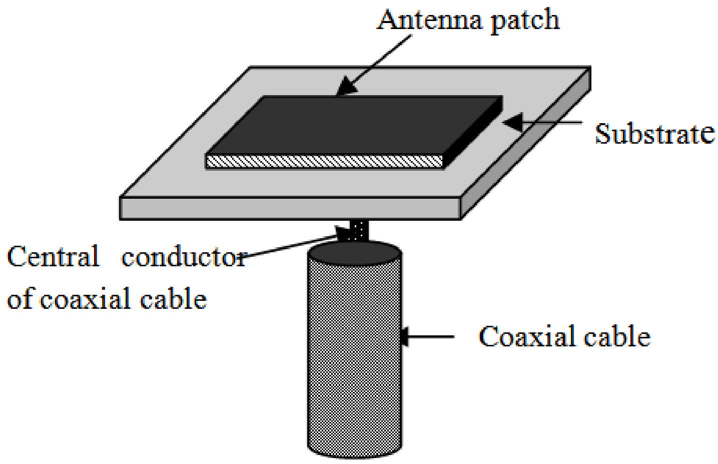

Figure 1 Co-axial Feed Technique [13]

Basically, a microstrip patch antenna consists of two different materials i.e. dielectric substrate and perfect electric conductor (PEC). To design an miniatured patch array antenna boundary conditions and dimensions (i.e. dimensions must be in mm) for the patch antenna are specified [14]. For an antenna design, the most preferences is given to co-axial feed technique compared to other three techniques because the advantage of co-axial feed is easy to fabricate. For, designed microstrip patch array antenna at X-band frequency the electromagnetic parameter results observed. The results include, S_{11} parameter (return loss), gain, reference impedance and directivity [15].

III. SIMULATION OF DESIGNED PATCH ARRAY ANTENNA

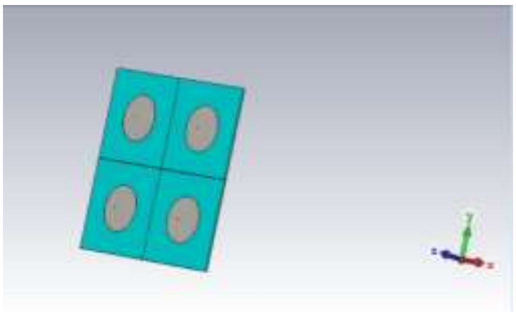

Figure2 Patch Array Antenna Design at X- band.

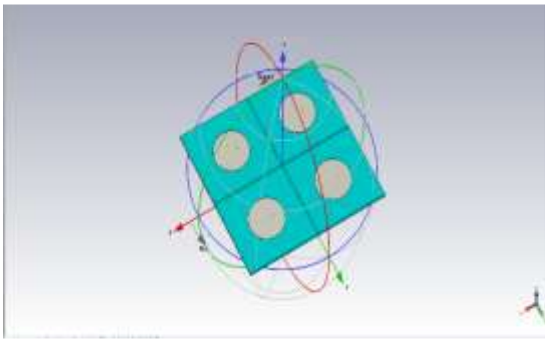

Figure3 Electric and Magnetic Field Pattern of Patch Array Antenna.

The scattering parameter S_{11} for designed microstrip patch array antenna at 9.95 GHz frequency is -42.92dB as shown in below figure 4. S_{11} is the return loss achieved at the center frequency 10 GHz.

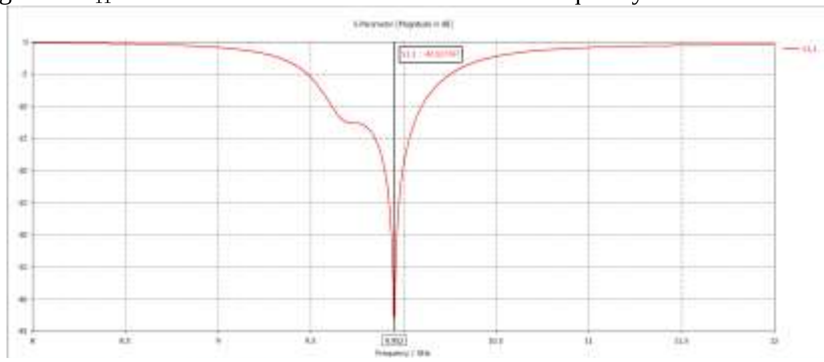

Figure 4. S_{11} Parameter

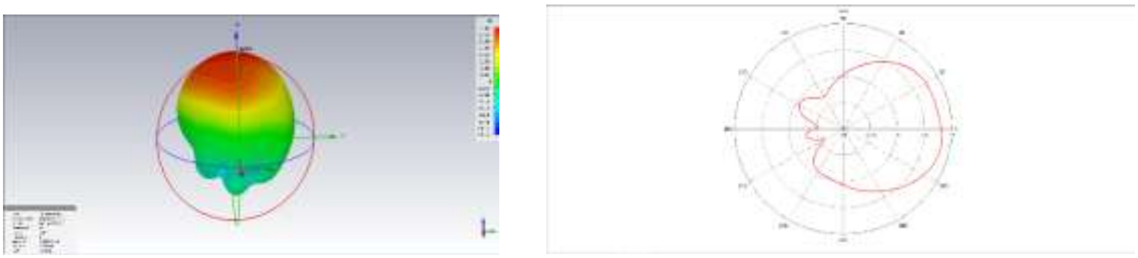

Figure 5 Gain and Radiation Pattern of Patch Array Antenna at 9 GHz.

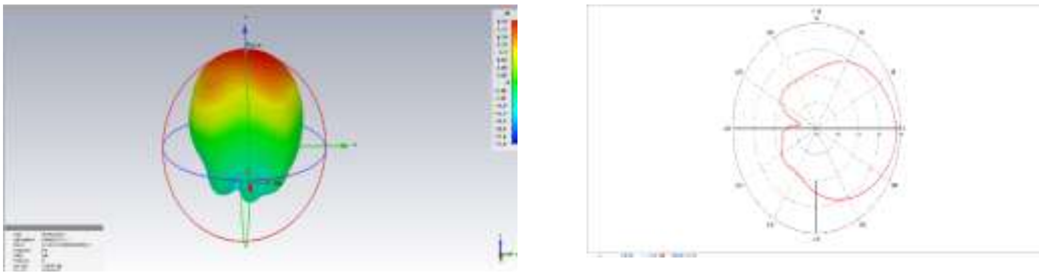

Figure 6 Gain and Radiation Pattern of Patch Array Antenna at10 GHz.

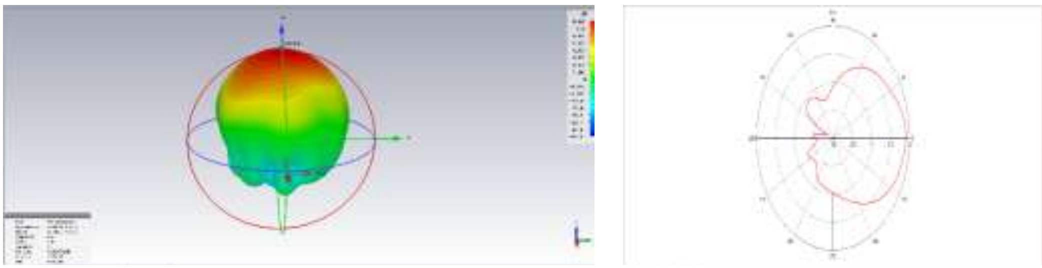

Figure 7 Gain and Radiation Pattern of Patch Array Antenna at 11 GHz.

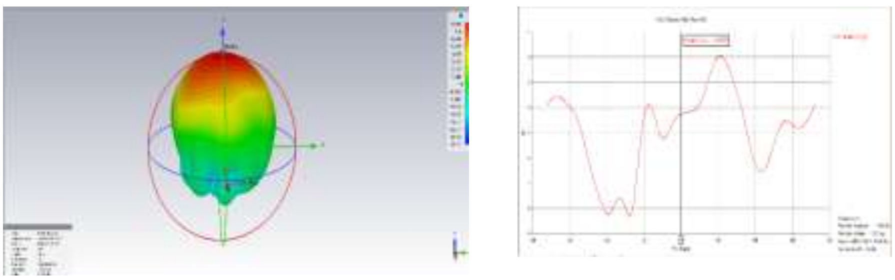

Figure 8 Directivity and Cartesian Pattern of Patch Array Antenna at9 GHz.

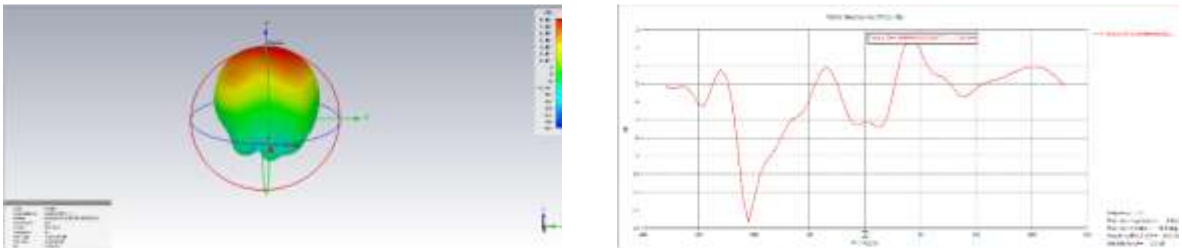

Figure 9 Directivity and Cartesian Pattern of Patch Array Antenna at 10 GHz.

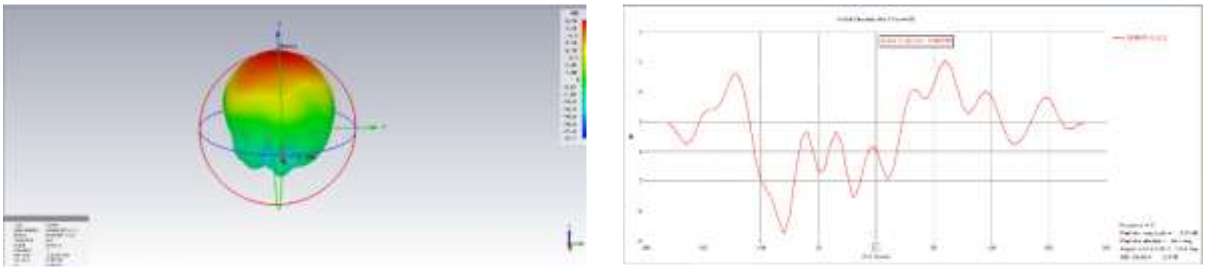

Figure 10 Directivity and Cartesian Pattern of Patch Array Antenna at 11 GHz.

The figures 4-10 represents the simulation results of the electrical performance parameters of the microstip antenna. It is observed that the radiation pattern and gain obtained at frequency 9 GHz is 7.438 dB as shown in the figure 5.The radiation pattern and gain obtained at frequency 10 GHz is 8.191 dB as shown in the figure 6.At frequency 11 GHz is the Gain is 8.456 dB as shown in the figure 7.The directivity obtained at frequency 9 GHz is 7.308 dB as shown in the figure 8.The cartesian pattern and directivity obtained at frequency 10 GHz is8.034 dB is observed as shown in the figure 9.Whereas at frequency 11 GHz is 8.260 dB as shown in the figure 10.Simulated reflection coefficient for the proposed antenna is shown in solid line in Figure 2 with co-axial feed technique, in which four are observed, while S_{11} parameter for the designed patch array antenna is shown in dotted line in which only three resonant modes are observed. The electric fields distrubution for the circular patch and the magnetic field distrubution for circular patch array antenna are shown in Figure 3.

Comparative Analysis of Electrical performance parameters of Antenna

The table 1 shows the comparative analysis of the various electrical performance parameters of the designed patch array antenna operating at different x-band frequencies. The parameter such as scattering matric S_{11}, Gain and directivity are compared at x-band frequencies (i.e. 9,10 & 11 GHz).

Table 1: Comparison of various Electrical performance parameters of the designed antenna

Parameters	**f=9GHz**	**f=10GHz**	**f=11GHz**
Return Loss (S_{11}) in dB	-40.93	-42.92	-43.96
Gain (dB)	7.438	8.191	8.456
Directivity(dBi)	7.308	8.034	8.260

IV. CONCLUSION

A micorostrip array antenna is designed which operates at different X-band frequemcies. Simulation of the antenna is carired out and the results of the electrical perfomrance parameters such as S_{11}, Gain, Directivity are presented and tabulated in the table 1. A good agreement between the electrical perfomance parameters is observed at the frequencies which is highly appreciable for the wireless communication applications at X-band frequencies. Further as a future scope various techniques of optimization can be introduced and upgradation and improvement in the electrical perfomance parameters can be analyzed.

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