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Multiple Rectangular Patch Based Antenna Design Using FEM

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ABSTRACT: Research work is carried out to design and simulate microstrip patch antenna. Finite Element Method (FEM) based software is used to model the antenna. PCB is used as the substrate and perfect electric conductor (PEC) as the radiation material. Antenna is simulated for frequency range of 1.4 GHz to 2.5 GHz. Minimum return loss i.e. S_{11} of -10 dB is obtained for the frequency of 1.9 GHz.

Keywords: Microstrip, PEC, FEM, antenna.

I. INTRODUCTION

Microstrip patch antennas are widely used in communication system due to their light weight, reliability, and low cost. Communication plays an important role in the world and almost all the communication system are changing rapidly from wired to wireless. Microstrip patch antenna can be integrated with strip line feed network and active devices. The application of microstrip antennas started in early 1970's for missiles guidance. Varieties of array configuration of rectangular and circular microstrip resonant patches have been used extensively. Current revolution in electronic circuit miniaturization brought about by developments in large scale integration is the major contribution factor for advancement of microstrip antennas [1-8]. These antennas are very popular for microwave and mm wave applications because they offer several distinct advantages over conventional microwave antennas. Some of the advantages are small size, easy to fabricate, light weight, and conformability with the hosting surfaces of vehicles, aircraft, missiles, and direct integration with the deriving electronics. The schematic of microstrip patch antennas consists of radiating conducting patch, a conducting ground plane, a dielectric substrate sandwiched between the two, and a feed connected to the patch through the substrate as shown in Fig. 1.

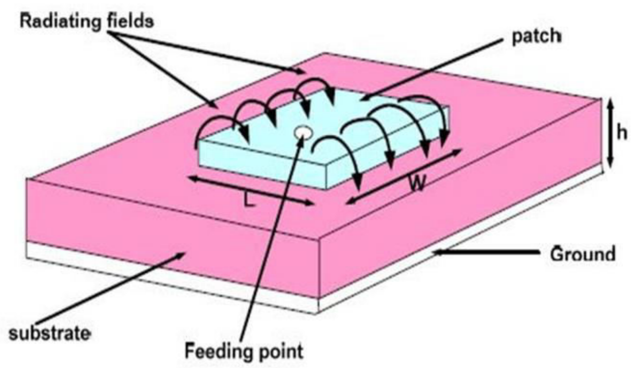

Fig. 1 Schematic of rectangular microstrip patch antenna.

II. GEOMETRICAL PARAMETER OF ANTENNA

The antenna parameters of this antenna can be calculated by the transmission line method. Width of the Patch can be determined by the equation given as [9]

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$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Length of the patch is give as [10]

$$L = \frac{\lambda_0}{2} - 2\Delta L$$

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

where

ε_{reff} is the effective dielectric constant, ε_r is Dielectric constant of substrate, h the height of dielectric substrate, and W is the width of the patch.

The position of the feed location can be obtained by using

$$X_f = \frac{L}{\sqrt[2]{\varepsilon_{reff}}}$$

where X_f is the desire input impedance to match the coaxial cable and ε_{reff} is the effective dielectric constant.

Finite ground plane is essential, if the size of the ground plane is greater than the patch dimensions by nearly six times the substrate thickness. Ground plane dimensions is given as [12]

$$L_g = 6h + L$$

$$W_g = 6h + W$$

III. Design Procedure

Finite Element Method (FEM) based approach is taken to carry out the simulation. Table 1 shows the dimensional and material parameters of the designed patch antenna. Geometry of the design antenna is shown in Fig. 2.

TABLE I
FONT SIZES FOR PAPERS

Antenna Dimension		
Parameter	**Length (mm)**	**Width (mm)**
Substrate	90	90
Patch	60	50
Stub		
Array of patches	10	5
Substrate Material Property		
Relative Permittivity	3.38	
Relative Permeability	1	
Electrical Conductivity	0	

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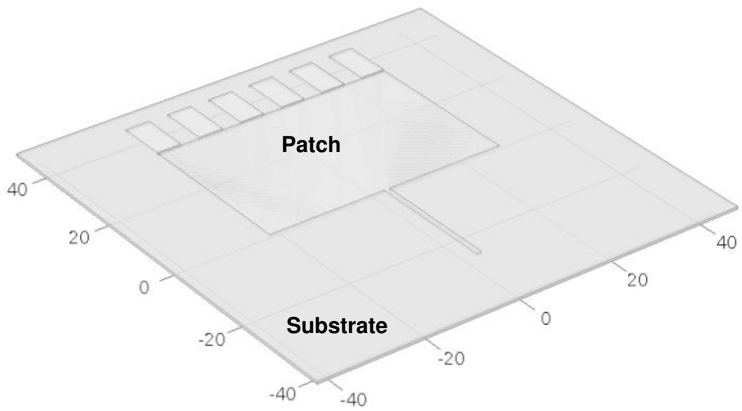

Fig. 2. Geometry of designed microstrip patch antenna.

After designing the geometry of the antenna, it is subjected to FEM analysis with maximum element size of 22.8 mm and the stub of the antenna is having maximum element size of 0.5mm. Figure 3 shows the mesh formation of the modelled design.

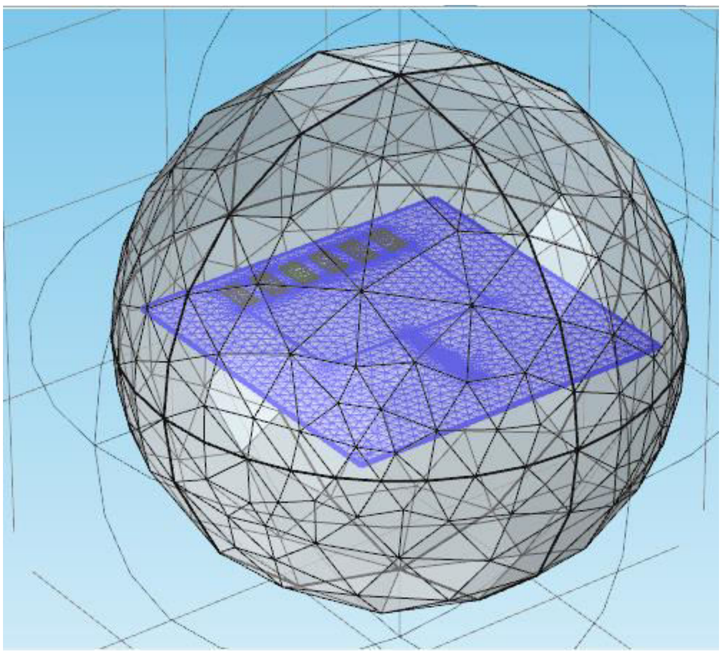

Fig. 2. Mesh formation for the designed microstrip patch antenna.

IV. RESULTS AND DISCUSSION

The antenna was simulated with final patch. Figure 4 shows the S parameter plot for the simulated antenna for frequency range from 1.4 GHz to 2.5 GHz. The return loss of the antenna obtained is -10 dB at the center frequency of 1.9 GHz. 3D view of the far filed graph obtained for the designed antenna is shown in Fig. 5. The maximum value of

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the field radiation is 0.0662 V/m. Line graph of the far filed is shown in Fig. 6. Radiation of the em wave is along the 90^{o} to the antenna plane.

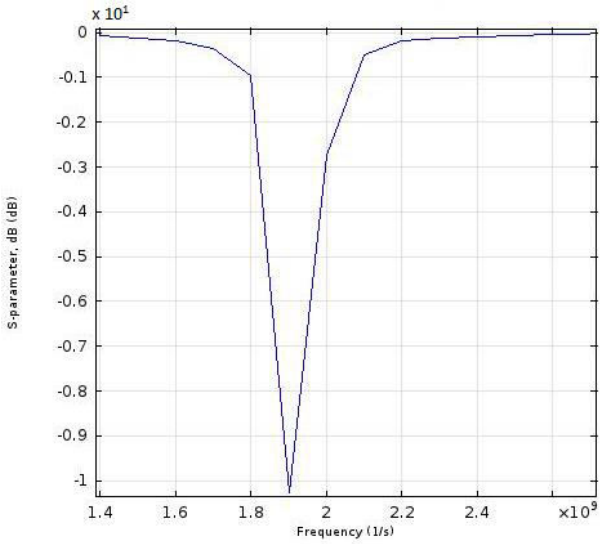

Fig. 4 Return loss vs frequency graph.

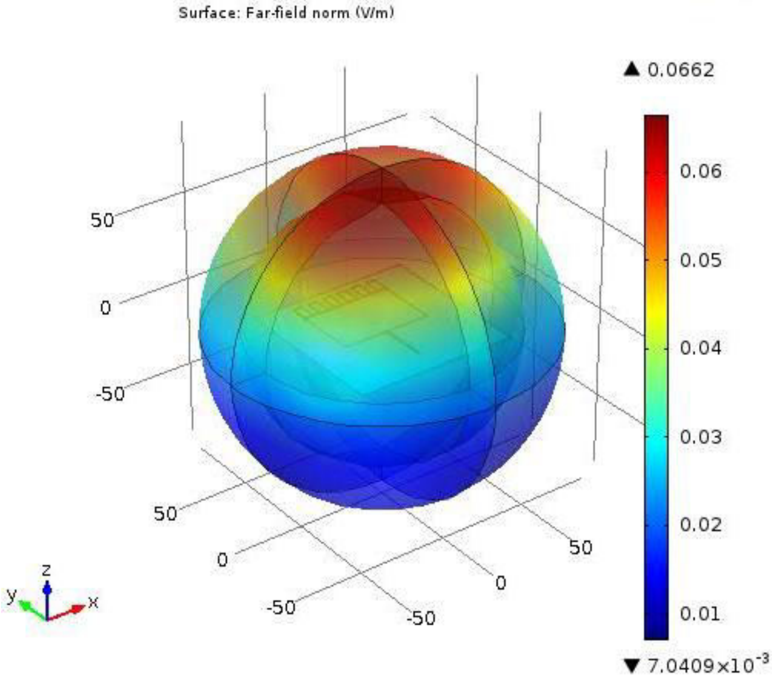

Fig. 5. 3D view of the far field radiation of the simulated antenna.

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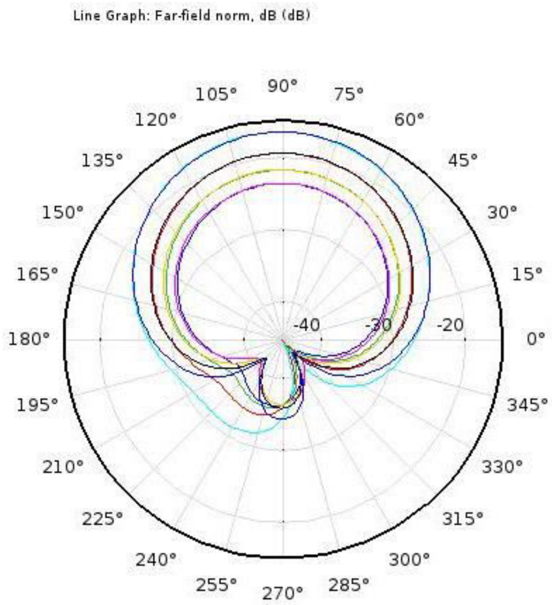

Fig. 6. Line view of the far field radiation of the simulated antenna.

V. CONCLUSION

The research work is carried out to model and simulate the rectangular microstrip patch antenna using finite element analysis. The designed antenna is simulated for frequency range from 1.4 GHz to 2.5 GHz. A dip in the S parameter of the value of -10 dB is obtained at frequency 1.9 GHz. The proposed geometry is designed using pcb as a dielectric between the ground plane and patch. These features are very useful for wireless communication equipment's used worldwide.

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