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Study on the Performance of Micro Strip Patch Antenna for Different Substrate Material

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Abstract— In this paper, inset feed rectangular microstrip patch antenna is being proposed. For designing of microstrip antenna the selection of suitable substrate material is important. The substrate properties such as its dielectric constant, loss tangent have a good effect on the antenna characteristics. This paper represents that how antenna performance changes when we vary substrate material. The designed inset feed rectangular microstrip patch antenna operates at 0.92GHz. The design is being simulated using HFSS (High Frequency Structure Simulator) software

Index Terms—*Inset-Feed Line, Rectangular Microstrip Antenna, VSWR, Return loss, HFSS.*

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I. Introduction

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. The patch is generally made of conducting material such as copper or gold and can take any possible shape like circular, square, rectangle etc. The microstrip patch antennas are well known for their performance and their robust design, fabrication and their extent usage. The inherently narrow impedance bandwidth is the major weakness of a microstrip antenna.

In this paper, we study the effect of different substrate on characteristics of inset fed microstrip patch antenna. A dielectric substrate is a insulator which is a main constituent of the microstrip structure. Here bandwidth is direct proportional to thickness of substrate whereas dielectric constant is inversely proportional to bandwidth. Another factor that impact directly is loss tangent it shows inverse relation with efficiency. The material which has the dielectric constant in the range of $2.2 \leq \varepsilon r \leq 12$ can be used as substrate. There are two different i.e. Rogers TMM4 (tm) and Rogers Ultralam 1250 (tm) substrate materials are used, with relative permittivity (Ɛr) of 4.5 and 2.5.

A set of simulation and measurements of inset fed rectangular patch antenna on different substrate material (Rogers TMM4 ™ and Rogers Ultralam 1250 ™) is presented in this research paper. The design, simulation and measurements are performed by using HFSS (High Frequency Structure Simulator) software.

II. Theoretical Evaluation and Effect of Substrate Permittivity on Antenna Design

Effect of Substrate Permittivity on dimensions of the antenna is calculated based on equations (1)-(5). The length is given by

$$L = 0.49\frac{\lambda}{\sqrt{\varepsilon_r}} \quad (1)$$

The width is given by

$$W = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \quad (2)$$

Where, f_r is the resonant frequency of the patch antenna, C is the free space velocity of light. The effective dielectric constant for the space of $(W/h) > 1)$ [12] is given by

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12h/W]^{-1/2} \quad (3)$$

The extension of patch length due to fringing effect can be determined by

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.26)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

The effective length of patch after taking into fringing effect can be calculated by

$$L = \frac{C}{2f_o\sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (5)$$

III. Geometry of Proposed Antenna

The geometry of finest feed rectangular shaped microstrip patch antenna is shown in figure. The length (L) of patch antenna is 77 mm and its width (W) is 98m, the thickness of the substrate is 2.25mm. The antenna uses the microstrip line feeding technique.

Figure 1 shows the proposed inset feed rectangular microstrip patch antenna constructed on substrate layer of material (Rogers TMM4 ™ and Rogers Ultralam 1250 ™) having relative permittivity (ε_r) of 4.5 and 2.5 thickness (h) of 2.25mm with Tangent (tanδ) of 0.002 and 0.0015.

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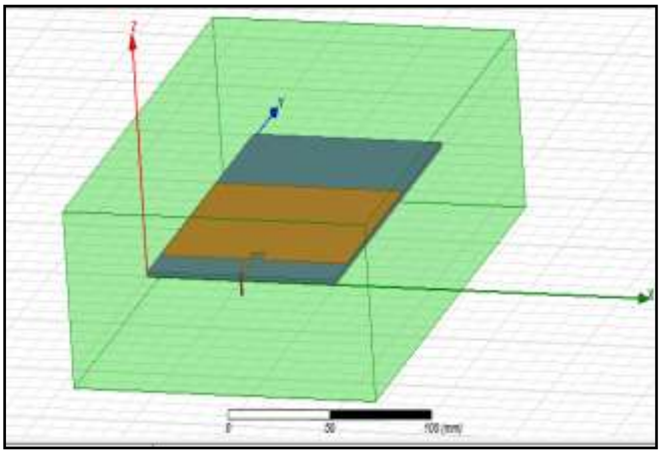

. Fig. 1. HFSS design model of proposed antenna

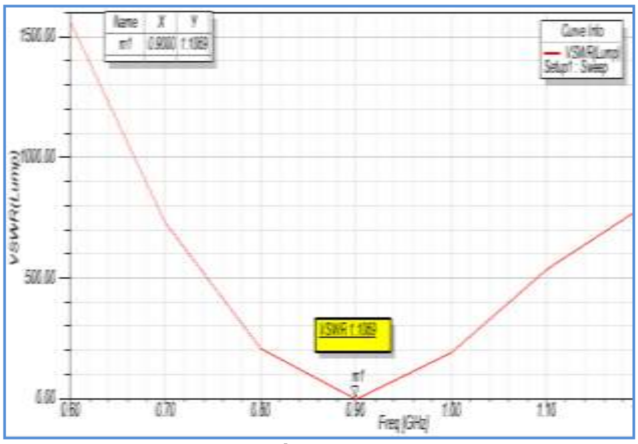

Fig. 3. Standing Wave Ratio

IV. SIMULATED RESULTS OF TWO DIFFERENT SUBSTRATE MATERIALS

The substrate used here is **Rogers TMM4 ™** having dielectric constant 4.5. The above given dimensions are used to simulate the structure. The operating frequency of this design is 0.92 GHz and the obtained return loss is -32.7347 dB. The gain obtained at this frequency is 4.42 dB which is better than conventional antennas. The simulation results are shown with the help of figure 2 and figure 3. The proposed antenna is radiating very efficiently as can be seen by the figure 5.

As by changing the dimensions of proposed patch antenna, resonant frequency can be controlled. The figure 2 shows return loss as the function of frequency. Here we see that reflection coefficient (S_{11}) is more than -32db. Which implies that antenna is well suitable with bandwidth of 2.71%.

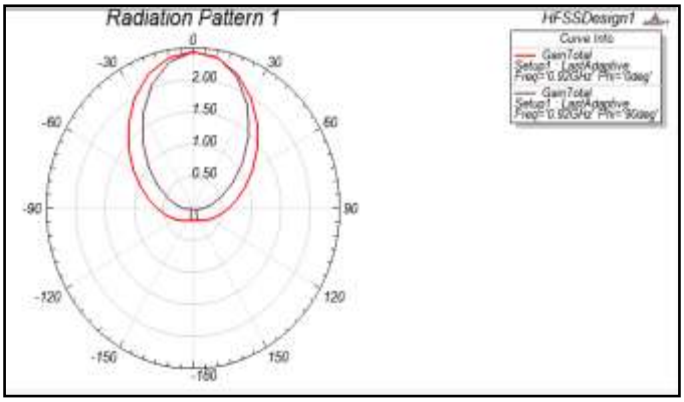

Fig. 4. Radiation pattern of proposed antenna

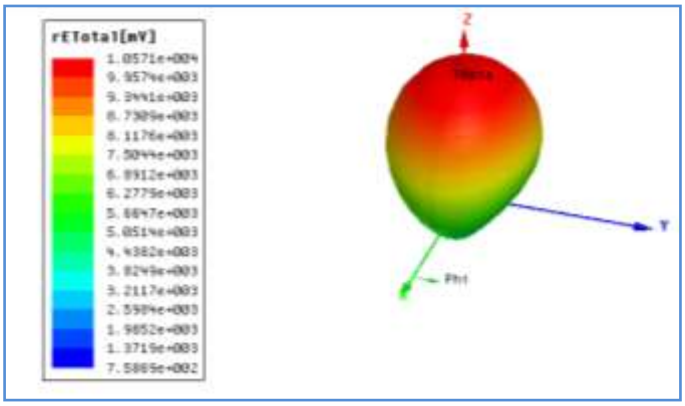

Fig. 5. 3D Polar plot of designed antenna

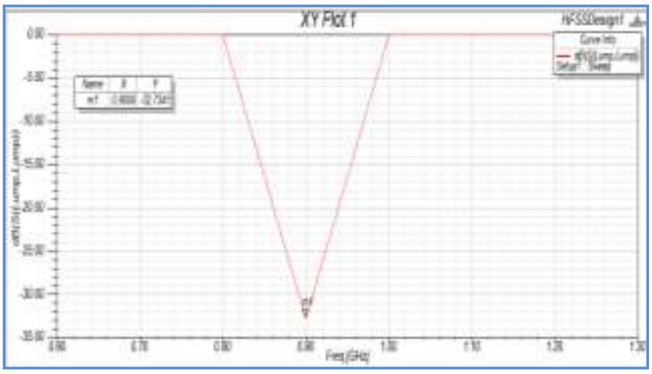

Fig. 2. Return loss

The standing wave ratio (VSWR) is shown in figure 3. The result and order of VSWR 1.1089 is shows high suitability.

Here the substrate used is Rogers Ultralam 1250 ™ having dielectric constant 2.5. The other dimensions of the design are same except the substrate. An antenna is operating at a frequency of 1.2 GHz and return loss obtained is -14.4248 dB. The gain obtained at this frequency is 2.2916 dB. The simulated results are shown in the figure 6 and figure 7. By changing the dielectric constant antenna performance varies. figure 8 shows field pattern.

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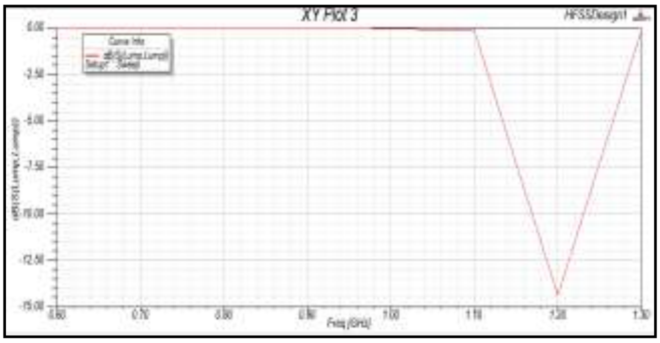

Fig. 6. Return loss

The standing wave ratio (VSWR) is shown in figure 7, which is obtained 1.4728.

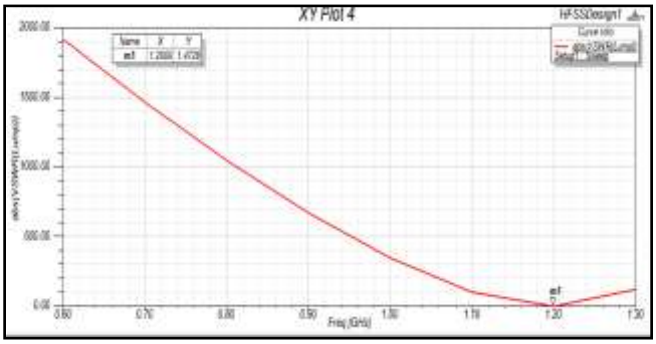

Fig. 7. Standing Wave Ratio

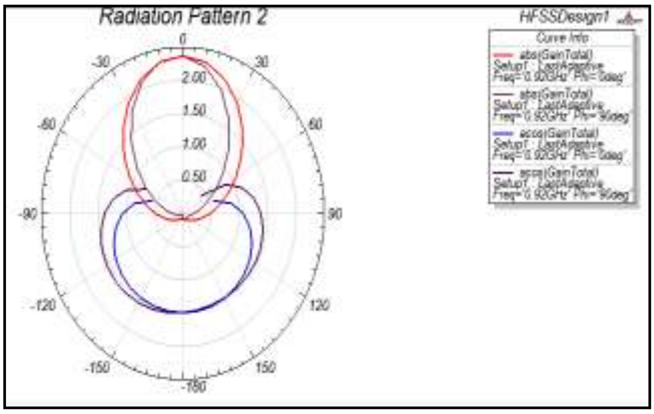

Fig. 8. Radiation pattern of proposed antenna

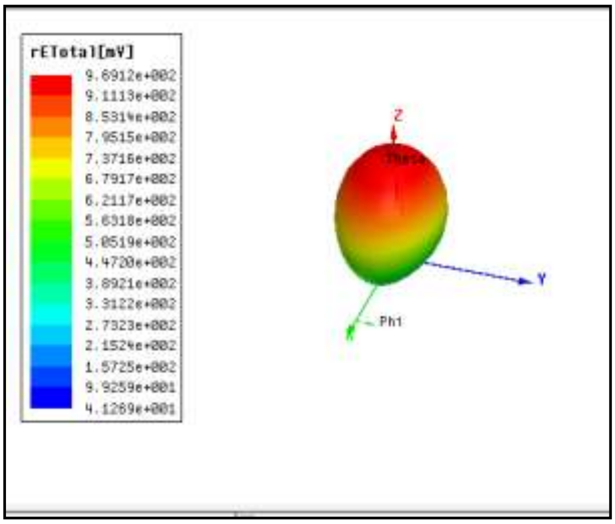

Fig. 9. 3D Polar plot of designed antenna

V. CONCLUSION

Various parameters of desired inset feed rectangular microstrip patch antenna have been studied by using two different substrates. It is found that by selecting a suitable substrate specific antenna requirement can be met.

It is being observed that when the value of dielectric constant is reduced i.e. from 4.5 to 2.5 then gain decreases. When **Rogers TMM4 ™** is being used as substrate the return loss & gain is obtained as -32.7347 dB & 4.42 dB at operating frequency of 0.92 GHz. To decrease the value of dielectric constant Rogers Ultralam 1250 ™ is being used as substrate. The return loss & gain obtained are -14.4248 dB & 2.2916 dB respectively at frequency 1.2 GHz. This shows that substrate influences the performance of antenna to a great extent. Here it is analyzed that the performance improves when the value of dielectric constant is increased. It can be concluded that **Rogers TMM4 ™** is the more efficient among the two dielectrics used and has a satisfactory value of return loss and VSWR.

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