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RADIATION PATTERN AND PERFORMANCE ANALYSIS OF RECTANGULAR MICROSTRIP FEEDPATCH ANTENNA

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ABSTRACT

The technological trend has focus and much effort into the design of a Microstrip patch antenna. In this paper a design have been considered, results of this design have been compared with each other by using IE3D an electromagnetic simulation package by Zeland Software Inc. presently by Mentor Graphics Inc. and design parameters are calculated using MATLAB software. We have compared the results of the design in the frequency band 2GHz to 3.5GHz and the best configuration of antenna with suitable Return Loss(RL),VSWR, Bandwidth, Gain, 2D and 3D Radiation Pattern has been suggested that can be used in practice for communication purpose especially for mobile communication.

Keywords: *Microstrip patch antenna, Transmission line model, IE3D Electromagnetic Simulation Package, MATLAB.*

I INTRODUCTION

The purpose of this work is to design a microstrip patch antenna using commercial simulationsoftware like IE3D[1]. The IE3D previously by Zeland Software Inc. Presently by Mentor Graphics Inc. has been recently considered as the benchmark for electromagnetic simulation packages. It is a full wave, method of moment (MOM) simulates or solving the distribution on 3D and multilayered structures of general shape. The primary formulation of the IE3D is an integral equation obtained through the use of Green's functions. In the IE3D, it is possible to model both the electric current on a metallic structure and a magnetic current representing the field distribution on a metallic aperture.

II THEORY

The rectangular microstrip antenna is a basic antenna element being a rectangular strip conductor on a thin dielectric substrate backed by a ground plane (Figure1). Considering the patch asa perfect conductor, the electric field on the surface of the conductor is considered as zero. Though the patch is actually open circuited at the edges, due to the small thickness of the substrate compared to the wave length at the operating frequency, the fringing fields will appear at the edges. Here, the "Transmission Line Model" [2-4] has been used to predict the radiation characteristics of the patch. In this model, the patch antenna is treated as two parallel radiating slot sanda transmission line inter connecting them (Figure2). The electric and magnetic fields are calculated separately for each slot and the resultant field pattern is a combination of the two slots. The E-plane radiation pattern of the patch given by this model is expressed as follows [2]-

$$E_\phi = \frac{-j2V_0Wk_0e^{-jk_0r}}{4\pi r} F(\theta,\phi) \tag{1}$$

$$E_\theta = 0 \tag{2}$$

$$\text{Here } F(\phi) = \frac{\sin\left(\frac{k_0 h\cos\phi}{2}\right)}{\left(\frac{k_0 h\cos\phi}{2}\right)} * \cos\left(\frac{k_0 h\cos\phi}{2}\right) \tag{3}$$

The radiated power is expressed as follows-

$$P_r = \frac{V^2{}_0 I_1}{240\pi^2} \tag{4}$$

Where
$$I_1 = \int_0^\pi \sin^2\left(\frac{k_0 W\cos\theta}{2}\right)\tan^2\theta\sin\theta d\theta$$

The radiation resistance is defined as follows-

$$R_r = \frac{V_0{}^2}{2P_r} = \frac{120\pi^2}{I_1} \tag{5}$$

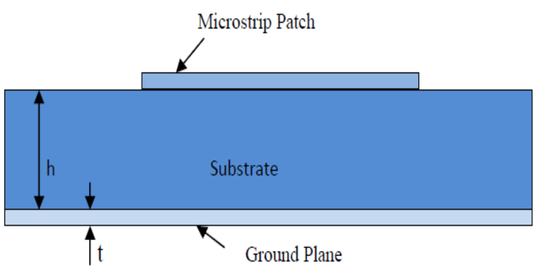


Fig. 1: Microstrip Patch Antenna

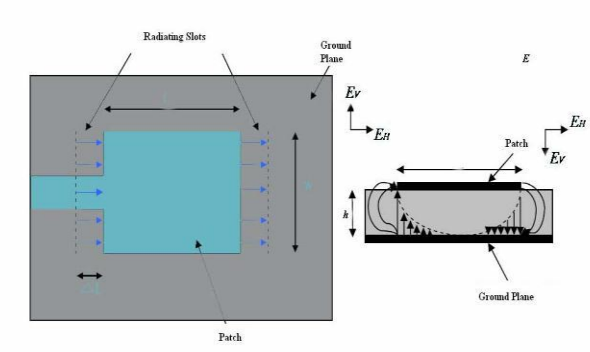


Fig. 2: Transmission line Model of Microstrip Patch Antenna

III DESIGN PROCEDURE

A microstrip antenna can be designed using either the transmission line model or the cavity model (more complex models also exist that suit a particular design). We have used the transmission line model since it is fairly simple to implement and results in antenna designs with reasonably good performance in terms of return loss and efficiency. It is also quite well suited to the rectangular designs that we have considered (other popular designs include circular, elliptical and disc like). The design starts with selecting the operating frequency fr, selecting a substrate with the required permittivity εr and defining the width of the substrates (Figure1). Thick substrates with low permittivity result in antenna designs with high efficiency and large band widths. Thin substrates with high permittivity lead to a smaller antenna size but with a lower band width and a high radiation loss[5]. The tradeoffs between substrate thickness and permittivity and antenna band width and efficiency have been discussed in [2].According to the transmission line model, the length L and width W of the patch are calculated as[6]-

$$W = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}},$$

$$L = \frac{v_o}{2f_r\sqrt{\varepsilon_{\text{reff}}}} - 2\Delta L,$$

Where v_O is the speed of light in free space, εreff is th eeffective permittivity and $2\Delta L$ is the extension in length due to fringing effects-

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

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

Although the design of the patch is quite simple, the design of the feeding mechanism is not that straight forward. There are four possible methods that can be used- Microstrip-linefeed, Probefeed, Aperture-coupled feed, Proximity-coupled feed.We have used a microstrip line feed since it is relatively easy to model, match and fabricate. It results in low-antenna bandwidths (2–5%); however, this should be sufficient for our application.

IV SIMULATION RESULTS

The designed patch antenna is then simulated in IE3D, which is EM software which is extensively used for the Design and the Simulation of the Patch Antenna at a frequency of 2.65 GHz.The structures of the designed antenna are shown below in the figures with the Microstrip feed line.

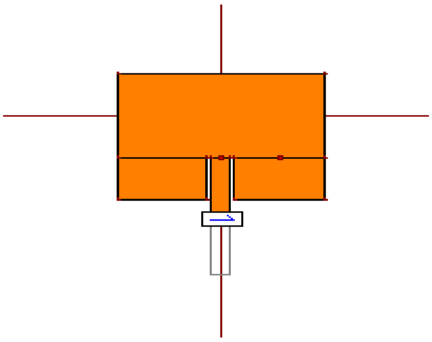


Fig.3

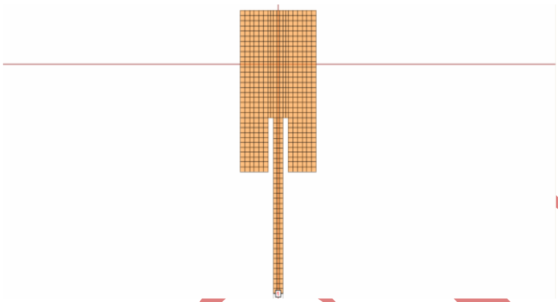


Fig.4

Fig.3: Rectangular Patch Antenna with Microstrip feed & portas signed for excitation

Fig.4: A meshed Rectangular Patch Antenna

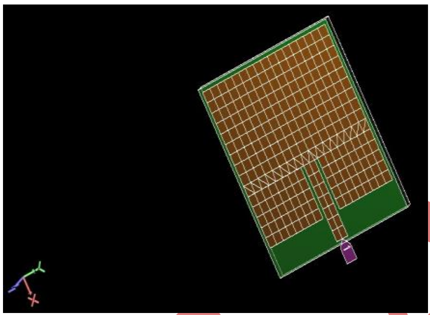


Fig.5: 3D Structure of the meshed Rectangular Patch Antenna with Simple Microstrip Feed Line

V RESULTS OF THE DESIGN

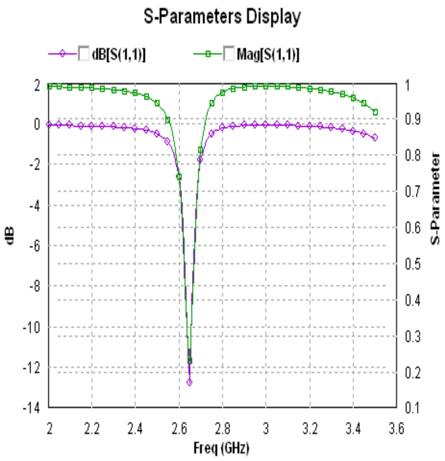


Fig.6: Return loss Vs Frequency(GHz)

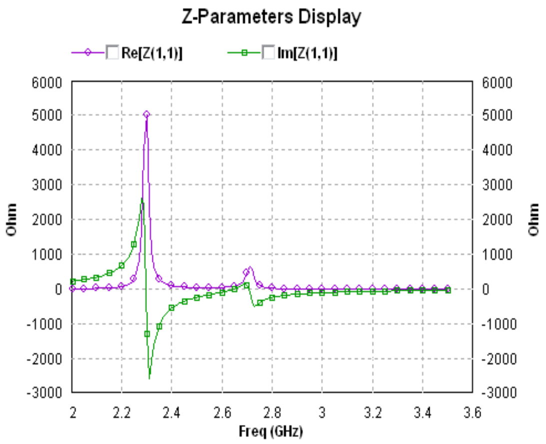


Fig.8: Z Parameter Vs Frequency

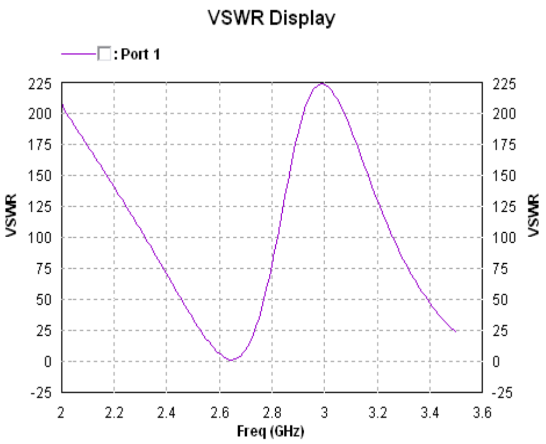


Fig.7: VSWR Vs Frequency

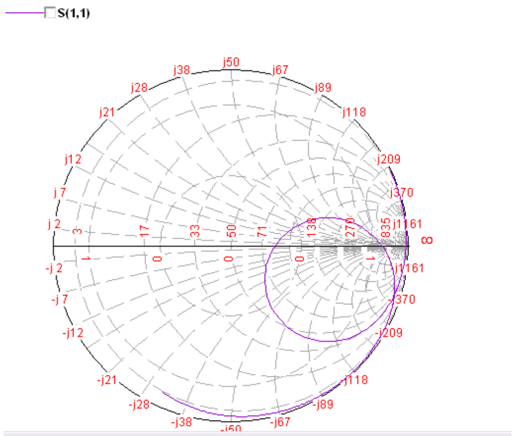


Fig.9: Smith Chart ofthe design

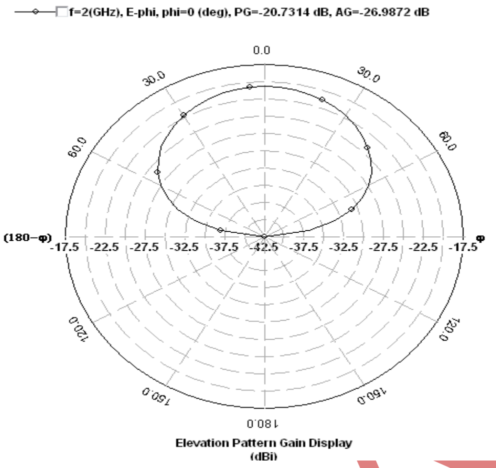


Fig.10: 2D Radiation Pattern at 2 GHz

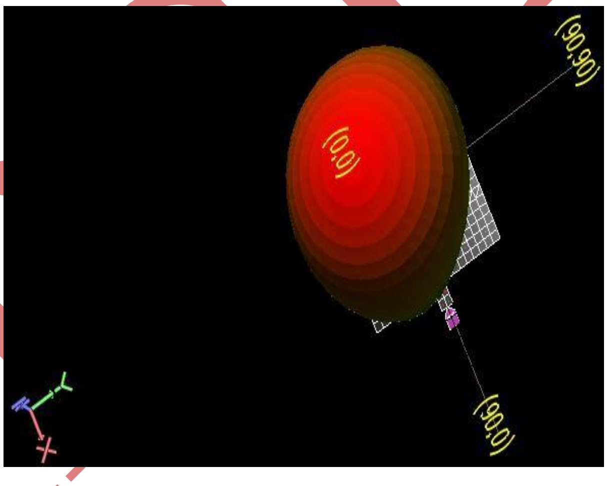


Fig. 11: 3D radiation Pattern at 2GHz

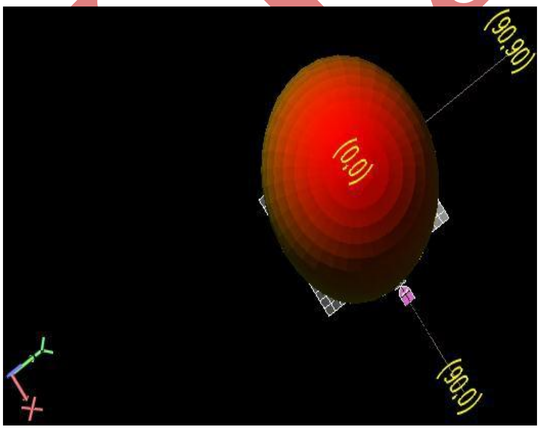


Fig.12: 3D radiation patterns at 2.65 GHz

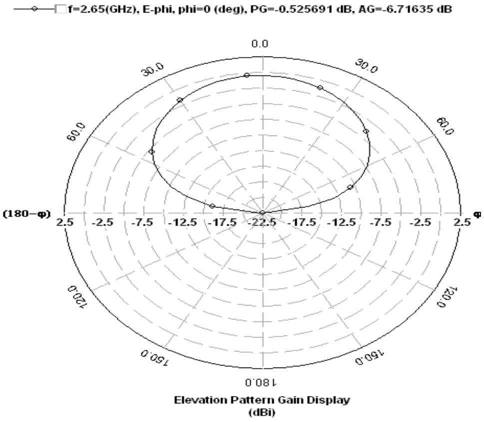
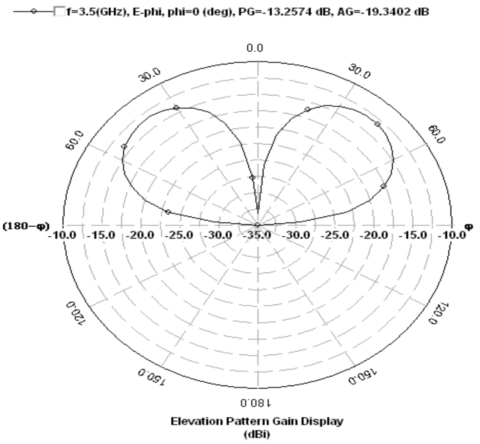


Fig.13: 2D Radiation Pattern at 2.65 GHz



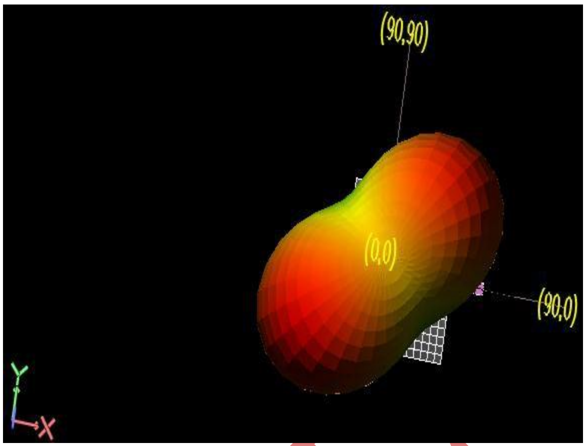


Fig.14: Radiation pattern 2D at 3.5 GHz **Fig.15: 3D radiation Pattern at 3.5 GHz**

VI CONCLUSION

The aim of this paper is to design a best and optimum Rectangular Patch Microstrip antenna in the frequency range1GHz to 3GHz which can be useful for the communication purpose. It is good to see that the return loss has a negative value which states that the losses are minimum during the transmission. In this design the RL is measured- 14 Db at resonating frequency 2.65 GHz.The *VSWR* for the design in between1to2 as we can say the level of mismatch is not so high. For this design it is measured and can be appreciated as the most desired 1.02 at the resonating frequency 2.65GHz. When the antenna efficiency is measured has the most desired efficiency of 80.1% at 2.65 GHz.

Table 1: Design Parameters -Input parameters [7-14]

Design Parametres	Values
ε_r	2.4 (RT-Duroid)
v_o	3×10^8 m/sec
f_r	2.65 GHz
h	1.58 mm
$\tan\delta_d$	0.001
W	39.6 mm
L	47.9 mm
Z_0	50 Ω
W_c	4.2 mm
Y_0	13 mm
Polarization	Linear

When the radiation patterns are considered no back lobes appears in all the cases at which simulation results are analyzed, indicating that now a stage of energy during the transmission. We can say that the energyloss is very minimum with the RL values of-14 dB for the design. By comparing all the responses and the patterns of the design it can be said as the it is optimized design with resonating frequency, suitable bandwidth, higher gain and antenna efficiencyof 80.1%. A Microstrip Line feed Rectangular Patch Antenna with the dimension parameters *h*-1.58mm (substrate thickness), *L*- 47.9 mm (length of the patch), *W*- 39.6 mm (width of the patch) with a dielectric constant of 2.4 at an operating frequency of 2.65GHz can be said the best and optimized design and can be used in practice for the communication purpose.

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