Design and Simulation of H and E-Shaped Microstrip Patch Antenna for S-band Communication

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Abstract: The paper presents a broadband microstrip patch antenna for S-band communication. H and E shaped patch antenna for S-band communication is proposed in this paper. The antenna is fed by microstrip transmission line. FR-4 dielectric substrate material is used to design these antennae The FR-4 substrate with Dielectric constant ε_r=4.4 and loss tangent tanδ=0.02 is used for proposed design at resonant frequency of 3.2GHz. A simulation tool, Sonnet Suites, a planar 3D electromagnetic simulator is used in this work.

Keywords- H-shaped Patch antenna, Dielectric Thickness, E-shaped Patch antenna, Return Loss Curve, S-Band.

I. INTRODUCTION

The rapid growing development in the area of wireless communication leads to the miniaturization of the device size along without compromising good operational capabilities. The antenna is one of the basic needs for any wireless communication. To use antenna in the reduced sized communication device, the antenna structure should also be trimmed without affecting its quality of performance. In this regard, Patch antenna plays a vital role because of its low profile, light weight, low volume, conformability, low cost and easy to integrate with microwave integrated circuits [1].

In its most basic form, 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. The microstrip patch antenna offers a number of advantages such as planar, small in size, simple structure, low cost and easy to fabricate. The applications of patch antennas are many and they are Global Positioning System application, WiMAX, mobile and satellite communication application, Radar applications etc. [2].

The S-band is part of the microwave band of the electromagnetic spectrum. It is defined by an IEEE standard for radio waves with frequencies that range from 2 to 4 GHz, crossing the conventional boundary between UHF and SHF at 3.0 GHz.

In this paper, H and E-Shaped microstrip patch antenna has been designed for S-band communication. It is a single band antenna which is studied for response and radiation properties with resonance at 3.2 GHz. Simulations were carried out on commercially available Sonnet Software® [3].

II. DESIGNING THE ANTENNA

Dimensions, substrate selection and feed techniques are the important parameters that affect the antenna response. Below mentioned properties have been kept in mind while designing the antenna [4], [5]:

1) Frequency of operation (f_r): This is the resonant frequency selected according to the application. In the current simulation we have selected this frequency 3.2 GHz which is used for S-band communication.
2) Dielectric Constant of the Substrate (ε_r): A high dielectric constant reduces the dimensions of the antenna which helps in achieving compactness. For optimum performance, microwave substrates should have low loss tangent to reduce dielectric loss and a uniform, isotropic dielectric constant to minimize circuit impedance changes. FR-4 (ε_r =4.4) is used in designing the antenna here.
3) Height of the dielectric substrate (h): A very important aspect of an antenna is the height of the substrate. This is a key parameter as it affects the spatial geometry, which depends upon the ratio w/h where 'h' is the height of the substrate and 'W' is its width. We have designed the antenna with 5 mm height.

FORMULATION

1. FOR THE DESIGNING OF THE ANTENNA, THE WIDTH (W) IS CALCULATED BY [6]

$$w = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Where,
c is the speed of light
f_r = resonant frequency
ε_r = dielectric constant of the substrate

2. The effective dielectric constant (ε_{eff}) is an important parameter which arises because part of the fields from the microstrip conductor, exist in air. It is calculated as

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

Where, h is the height of the dielectric substrate.

3. The effective length (L_{eff}) of the antenna is given as

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$$

4. The length extension (ΔL) is calculated by the equation

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

5. Calculation of the actual length of the patch (L):

$$L = L_{eff} - 2\Delta L$$

6. Calculation of the ground plane L_g and W_g: Usually the size of the ground plane is greater than the patch dimension by approximately six times the substrate thickness all around the periphery.

Hence,

$$L_g = 6h + L$$

and $$W_g = 6h + W$$

III. GEOMETRY OF PATCH ANTENNAS

A. GEOMETRY OF THE E -SHAPED PATCH: The E-shaped microstrip patch antenna is simpler in construction. The design geometry of the antenna is shown in the Fig. 1. With box wall port which is the most common types of port. A microstrip feed line is to be used in this design.

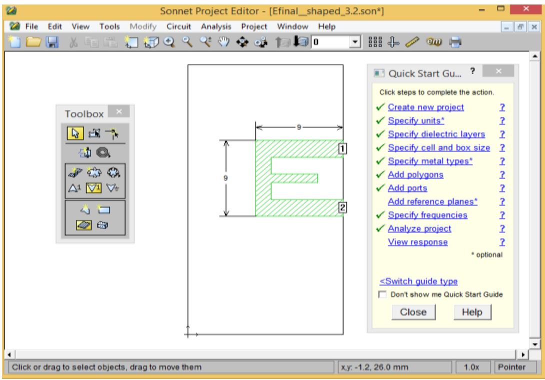

Figure.1. E-shaped Patch antenna

TABLE I: Design Parameters of the E-shape Patch Antenna

Antenna Design Parameter	Material/value
Dielectric material	FR4
Dielectric Constant(ε_r)	4.4
Loss Tangent(tanδ)	0.02
Height of Substrate (Thickness) (h) (mm)	5
Width of the Patch (W) (mm)	9
Length of the Patch (L) (mm)	9
Frequency of operation (GHz)	3.2

B. *GEOMETRY OF THE H-SHAPED PATCH ANTENNA:* The H-shaped microstrip patch antenna is also simpler in construction. The geometry is shown in Fig. 2. Patch is also designed and simulated over Sonnet Software.

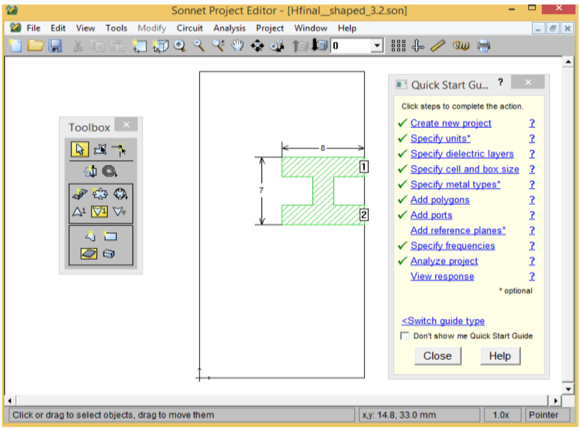

Figure 2.H-shaped Patch antenna

TABLE II: Design Parameters of the Proposed H-shape Patch Antenna

Antenna Design Parameter	Material/value
Dielectric material	FR4
Dielectric Constant(ε_r)	4.4
Loss Tangent(tanδ)	0.02
Height of Substrate (Thickness) (h) (mm)	5
Width of the Patch (W) (mm)	8
Length of the Patch (L) (mm)	7
Frequency of operation (GHz)	3.2

IV. RESULTS AND DISCUSSION

In this research work, two broad band techniques the H-shaped patch and the E-shaped patch are presented. The simulation results are representing below. Finally, the results are discussed.

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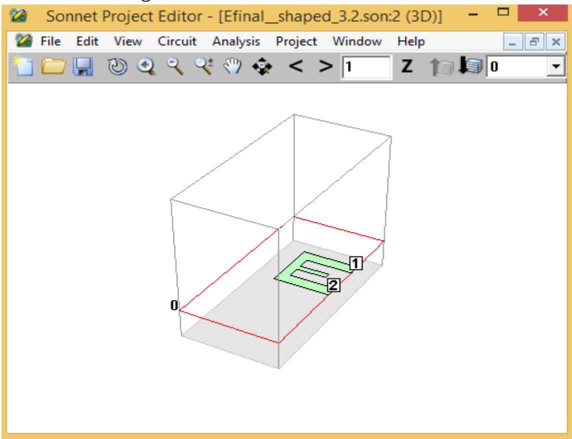
A. Proposed E-shape Patch Antenna: The results are explained in terms of three dimensional, the return loss, input impedance. The current density on the antenna is also showed.

Fig.1 shows the front view geometry and Fig.3 shows the three dimensional structure designed on Sonnet software of the proposed microstrip line fed patch antenna with single band operation for S-band application. Fig.4 shows the return loss [S11], and Fig.6 shows the VSWR of the E-Shaped microstrip patch antenna of Fig.1. It is clear from the above figure that at the resonant frequency the return loss is -34.63dB.

Fig.3. Three dimensional view of the antenna



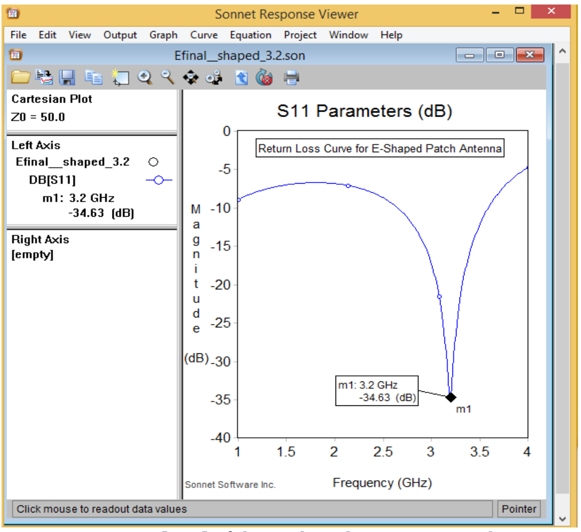


Fig.4. Return Loss[S11] of the E-Shaped Microstrip Patch Antenna

Fig.5 shows the current density. The physical meaning of current density distribution is that it is a measure of how the antenna is producing a beam. Fig.6 shows the VSWR, the vswr circle is indicated by red circle where VSWR =3.7. The input impedance curve tells us the magnitude, phase angle and VSWR of the input impedance of the antenna at the respective frequencies and Resonant frequencies are found at VSWR = 1.03.

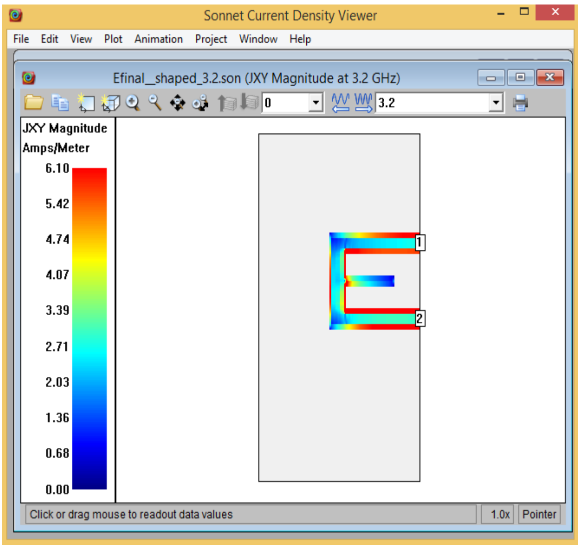


Fig.5. Current Density of the E-Shaped patch antenna at resonant

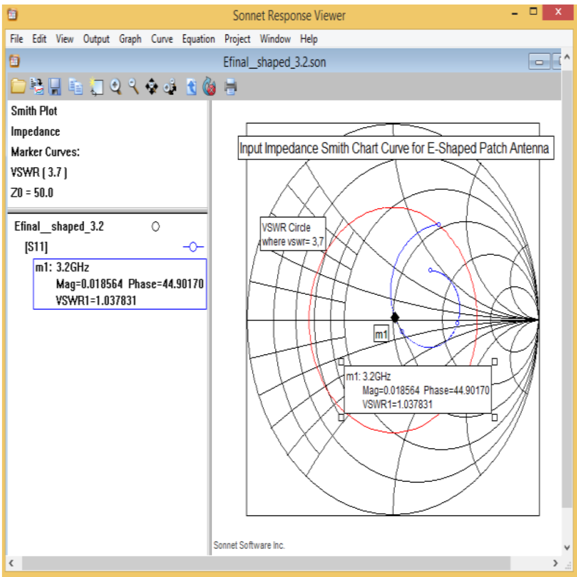


Fig.6. VSWR of the E-Shaped patch antenna at resonant frequency (3.2GHz)

B. *Proposed H-shape Patch Antenna:* The results are explained in terms of three dimensional, the return loss, input impedance. The current density on the antenna is also showed.

Fig.2 shows the front view geometry and Fig.7 shows the three dimensional structure designed on Sonnet software of the proposed microstrip line fed patch antenna with single band operation for S- band application

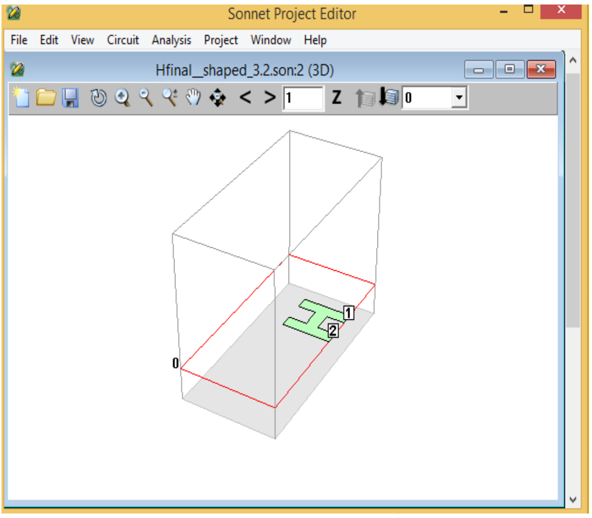


Fig.7. Three dimensional view of the antenna

Fig.8, 9 and 10 shows the return loss, the current density, and show the VSWR of the h-Shaped microstrip patch antenna of Fig.1. It is clear from the above figure that at the resonant frequency, the return loss is -37.13dB.

δ

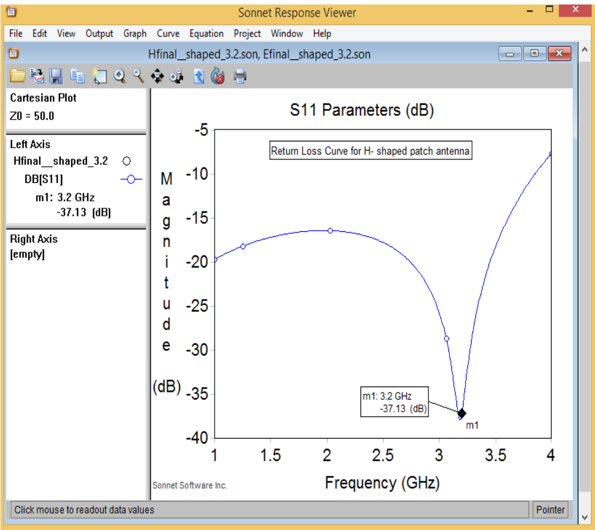


Fig.8. Return Loss [S11] of the H-Shaped Patch Antenna

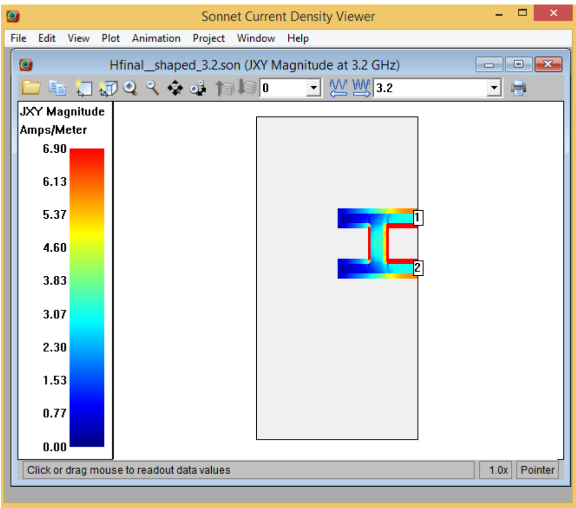


Fig.9. Current Density of the H-Shaped patch antenna at resonant Frequency (3.2 GHz).

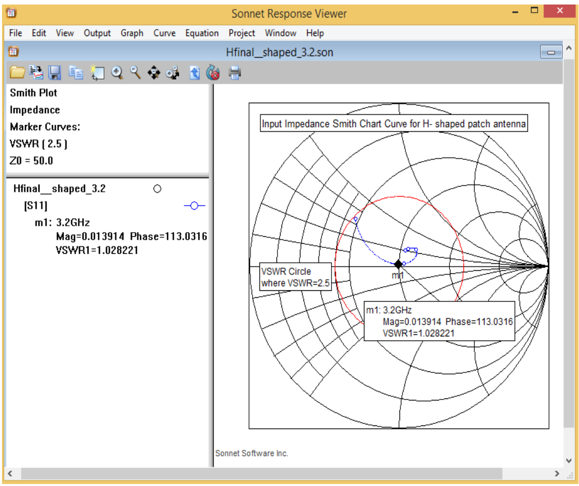


Fig.10. VSWR of the H-Shaped patch antenna at resonant frequency (3.2GHz)

Here VSWR =2.5. The input impedance curve tells us the magnitude, phase angle and vswr of the input impedance of the antenna at the respective frequencies and Resonant frequencies are found at VSWR = 1.02.

Fig. 11 and 12 shows the comparison of the return loss and VSWR in E and H-Shaped patch antenna. The return loss of H-Shaped is decreased much more than E- Shaped patch antenna (as shown in the Fig.11) and VSWR of H- Shaped is closer than E- Shaped Patch antenna to 1.

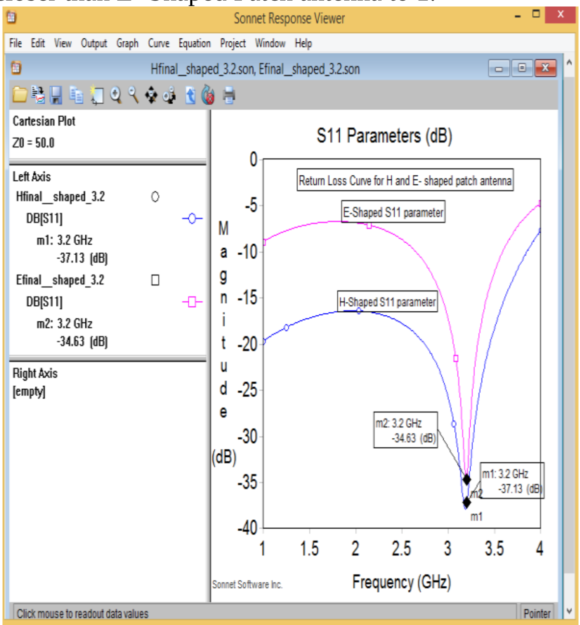


Fig. 11 Comparison of return loss of the two patch antenna

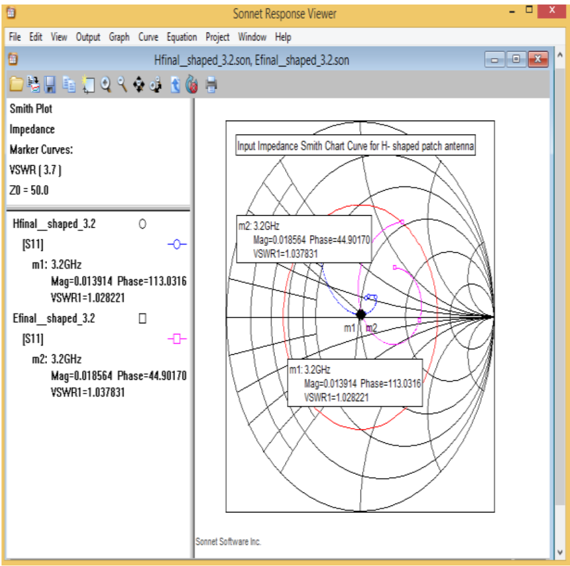


Fig. 12 Comparison of VSWR of the two patch antenna

V. CONCLUSION

Finally, two different patch antennas are presented, simulated and discussed for wireless communications especially S band communication at 3.2GHz and the simulated results compare between current density, S-parameter and VSWR [7]. Proposed H-shape patch is better than any existing E-shaped patch antenna at resonant frequency. The return loss of E-Shaped is higher than H-Shaped patch antenna and the VSWR is found to be 1.03 and 1.02 at resonant frequencies of E shape patch and of H-shape patch respectively. It was seen that current density, return loss and VSWR of H-shaped patch antenna is better than E-shaped patch antenna. The antenna characteristics are applicable for S band communication,

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