Design & Analysis of H-Shape Microstrip Patch Antenna

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***Abstract*- In this paper, the characteristics of a small antenna using an H-shaped microstrip patch antenna are analyzed. Operating frequency of H-shaped microsrip antenna is 2 GHz. The theoretical results are compared with experimental result using cavity model. Comparison with other reported results justify the veracity of the proposed method. Significant reduction of antenna size can be realized when the H-shaped patch is used instead of the conventional rectangular microstrip patch antenna. The designed antenna is simulated by using IE3D software. A comparison between the simulation and MATLAB result is shown. Good agreement with the experimental results is demonstrated.**

Keywords- Microstrip antenna, H-shape patch, Cavity model, IE3D software.

I. Introduction

Microstrip antennas [1] are mostly used for aerospace applications because of their low weight, low volume and conformal nature. The most commonly used microstrip antennas are rectangular and circular disc antennas. However, other microstrip antennas are also being considered, depending on the application. Here we report two alternatives to the rectangular patch antenna.

The H-shaped patch antenna [2] reported here has a size about half that of the rectangular patch, with larger beam-width but smaller bandwidth. On the other hand, the rectangular ring antenna has smaller size, larger bandwidth and narrow beam-width. The H-shaped microstrip patch antenna, because of its considerably smaller size, could replace the rectangular patch at UHF frequencies. When they are applied in the frequency range below 2 GHz, the sizes of conventional rectangular microstrip patches seem to be too large.

II. Design of H-Shape Microstrip Patch Antenna

The H-shaped microstrip antenna [7] consists of an H shaped patch; supported on a grounded dielectric sheet of thickness h and dielectric constant εr the physical dimensions of the H-shaped microstrip patch antenna are shown in Fig.1.The and two identical conductor strips with length L4 and width on both sides. The feed point is located at the point (L_1, W_1).

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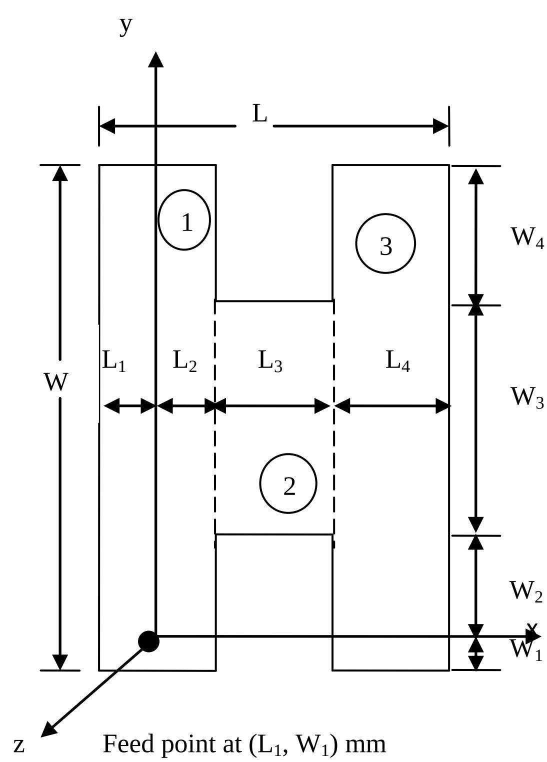

Fig.1. H-shaped Patch Antenna with Parameters L=36.26 mm, W=46.51mm, L_3=16.26 mm, L_4=10 mm, W_3=26.51 mm, Frequency f=2 GHz, ε_r =4.2, h=1.6mm

III. Method of Analysis

Transmission line model [11] represents the microstrip antenna by two slots, separated by a low impedance Z_c transmission line of length L. This method includes the dielectric constant of the substrate (ε_r), resonant frequency (f_r) and the height of substrate h. For low frequencies the effective dielectric constant is essentially constant. It is given by

$$W/h \geq 1 \quad (1)$$

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

Actual length L of the patch can be determined by the following formula

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L \quad (3)$$

For an efficient radiator, a practical width that leads to good radiation efficiencies is

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{4}$$

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \tag{5}$$

$$f_r = \frac{1}{2L\sqrt{\varepsilon_r}\sqrt{\mu_0\varepsilon_0}} \tag{6}$$

Boundary condition for region-1

$$-L_1 \le x \le L_2 \tag{7}$$

$$-W_1 \le y \le W - W_1 \tag{8}$$

$$0 \le z \le h \tag{9}$$

Boundary condition for region-2

$$L_2 \le x \le L_2 + L_3 \tag{10}$$

$$W_2 \le y \le W_2 + W_3 \tag{11}$$

$$0 \le z \le h \tag{12}$$

Boundary condition for region-3

$$L_2 + L_3 \le x \le L - L_1 \tag{13}$$

$$-W_1 \le y \le W - W_1 \tag{14}$$

$$0 \le z \le h \tag{15}$$

Electric field equations for H- shape microstrip antenna

$$E_x = -j\frac{1}{\varpi\mu\varepsilon}k^2\cos\left(\frac{\pi}{h}z'\right) \tag{16}$$

$$E_y = -j\frac{1}{\varpi\mu\varepsilon}k^2\cos\left(\frac{2\pi}{h}z'\right) \tag{17}$$

$$E_z = 0 \tag{18}$$

Magnetic field equations for H- shape microstrip antenna

$$H_x = -\frac{4\pi}{\mu h}k^2\sin\left(\frac{2\pi}{h}z'\right) \tag{19}$$

$$H_y = -\frac{\pi}{\mu h}k^2\sin\left(\frac{\pi}{h}z'\right) \tag{20}$$

$$H_z = 0 \tag{21}$$

IV. EXPERIMENTAL SETUP

Fig.2.Shows that the experimental setup for the determination of the return loss of the proposed antenna. In this experiment the designed antenna is connected to the SWR bridge (50Ω, 5-3000 MHz) and this is attached to the analyzer of range 0-3 GHz .This analyzer determined the return loss of the designed H-shaped microstrip patch antenna and demonstrates the return loss versus frequency

Fig. 2. Experimental setup

V. DISCUSSION & RESULTS

We have designed the H-shaped Microstrip Patch Antenna at frequency 2 GHz. The resonant frequency of the antenna is 1.99 GHz. A comparison between the simulation and MATLAB result is shown in Fig. 3 & 4. This Patch Antenna is simulated by IE3D software, version 12.6. We have observed that from following Fig. 3. Shows that return loss with frequency of antenna is found to be -30.33 dB at resonant frequency 1.99 GHz. Fig. 4. Shows that return loss -10.5 dB of the proposed antenna using the Matlab.

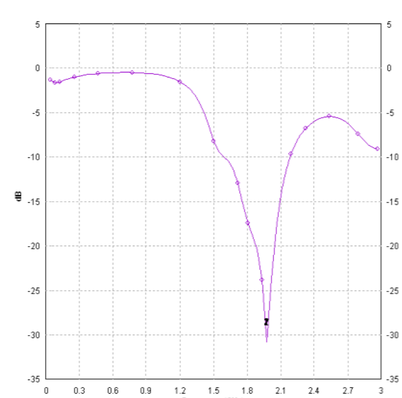

Fig.3. Return loss of proposed antenna at f 1.99 GHz

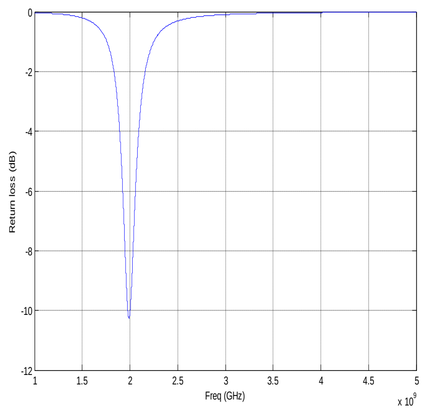

Fig.4. Return loss of proposed antenna using MATLAB at f=1.99GHz

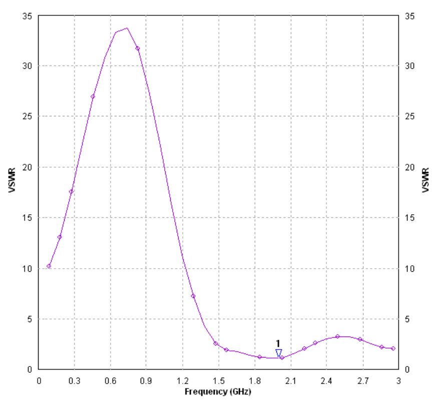

Fig.5. VSWR with frequency of antenna

Designed antenna is resonant at frequency 1.99 GHz gives the total field properties as Gain: 11.3677 dBi, Directivity: 7.28714 dBi, 3dB Beam Width: 74.1333, 114.927 deg, Incident Power: 0.01 W, Input Power: 0.00999073 W, Radiated Power: 0.000136305 W, Radiation efficiency: 1.36431%.

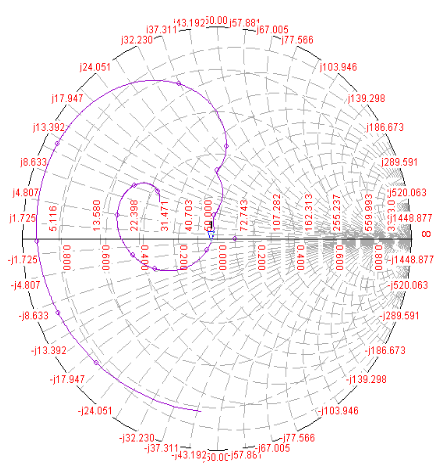

Fig.6. Smith chart of the proposed antenna

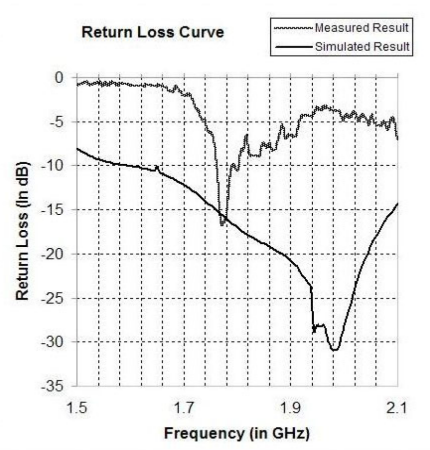

Fig.7. Comparison of Simulated & Measured result

At all centre frequencies value of VSWR 1.078 at 1.99 GHz which is less than 2 is shown in Fig. 5. Smith chart which is a polar plot of the of the complex reflection coefficient determine the input impedance of the designed antenna in our simulated result it is closed to 50 ohms is shown in Fig. 6.Fig.7.Shows that the comparison of simulated and measured result in simulated result return loss is found to be

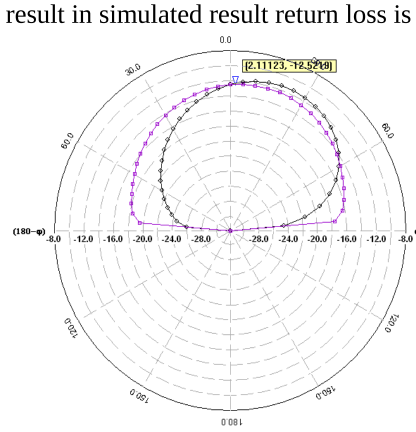

Fig.8. Simulated 2-D radiation pattern at f=1.99 GHz

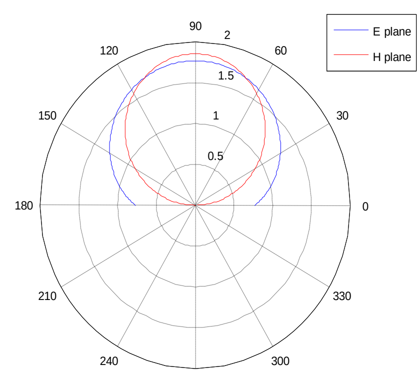

Fig.9. Radiation pattern using MATLAB

-30.33dB at resonant frequency 1.99 GHz while in measured result return loss is obtained -16.6dB at f_r =1.77 GHz. Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for $\varphi=0^0$ and $\varphi=90^0$ would be important this is shown in Fig. 8 & 9.

VI. Conclusion

We have concluded that the characteristics of a small antenna using an H-shaped microstrip patch antenna are analyzed. Based on the cavity model resonant frequencies with respect to different antenna parameters are studied. This antenna is alternative to the rectangular microstrip antennas. The Simulation has been performed using the IE3D software to determine the various parameters of antenna. Good agreement between the simulations and measurements has been achieved on proposed antenna.

VII. References

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