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Research Article

Suitable Design of Single Layer Hexagonal Microstrip Patch Antenna for Terrestrial Communication & Networking

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Abstract

A suitable single layer hexagonal microstrip patch antenna is thoroughly simulated in this paper. First we have designed a rectangular microstrip patch antenna. After that resonant frequency has been reduced drastically by cutting two equal slots which are the combinations of two triangular and one rectangular slot at the upper right and lower left corner located from the conventional microstrip patch antenna. Compared to a conventional microstrip patch antenna, simulated antenna size has been reduced by 52.64% with an increased frequency ratio. The antenna designs and performances are analyzed using Zealand IE3D software. The antenna can be used for many future communication systems.

Keywords: *Compact, Gain, Patch, Slot, Resonant frequency, Bandwidth.*

1. Introduction

Microstrip patch antennas have drawn the attention of research scholar's work over the past years. Recent years, demand for small antennas on communication and networking has increased the interest on compact microstrip antenna design among microwave and wireless engineers (I.Sarkar e*t al*, 2009; S. Chatterjee *et al*; J.-W. Wu *et al*, 2004; U. Chakraborty et al,2011; Rohit K. Raj *et al*,2006; Zhijun Zhang *et al*,2005). Because of their simplicity and compatibility with printed-circuit technology microstrip antennas are widely used in the microwave frequency spectrum. Simply a microstrip antenna is a rectangular or other shape, patch of metal on top of a grounded dielectric substrate. Microstrip patch antennas are attractive in antenna applications for many reasons. They are easy and cheap to manufacture, lightweight, and planar to list just a few advantages. Also they can be manufactured either as a stand-alone element or as part of an array. However, these advantages are offset by low efficiency and limited bandwidth. Throughout the years, authors have dedicated their investigations to creating new designs or variations to the original antenna that, to some extent, produce wider bandwidth and radiation efficiency of microstrip antennas.

The recent interest in broadband antennas as a microstrip patch antenna was developed to meet the need for a cheap, low profile, broadband antenna. This antenna could be used in a wide range of applications such as in the communications industry for cell phones or satellite communication. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with ε_r = 4.4) has a gain of 3.19 dBi and presents a size reduction of 52.64% when compared to a conventional microstrip patch antenna (10mm X 6mm). The simulation has been carried out by Zeland IE3D (Zeland Software Inc) software which uses the MoM method. Due to the small size, low cost and low weight this antenna is a good entrant for the application of X-Band microwave communication. The X band and Ku-Band defined by an IEEE standard for radio waves and radar engineering with frequencies that ranges from 8.0 to 12.0 GHz and 12.0 to 18.0 GHz respectively.

World's most of the country particularly Ireland, Libya, Saudi Arabia and Canada, the X band is used for terrestrial broadband. Alvarion, Cambridge, and Ogier make systems for this, though these are all incompatible. The Ogier system is a full duplex Transverter used for DOCSIS over microwave (J. Y. Jan *et al*,2004; Samiran Chatterjee *et al*,2011; C. A. Balanis,1989). The home, business CPE has a single coaxial cable with a power adapter connecting to an ordinary cable modem. The local oscillator is usually 9.750 GHz, the same as for K_u band satellite TV LNB. The two way applications such as broadband typically use in X-band. Our paper aim this 9.50 GHz frequency has been used in terrestrial communication & networking.

2. Antenna Design

The configuration of the conventional printed antenna is shown in Figure 1 with L=6 mm, W=10 mm, substrate

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(PTFE) thickness h = 1.6 mm, dielectric constant ε_r = 4.4. Coaxial probe-feed (radius=0.5mm) is located at W/2 and L/3. Assuming practical patch width W= 10 mm for efficient radiation and using the equation,

$$f_r = \frac{c}{2W} \times \sqrt{\frac{2}{(1+\varepsilon_r)}}$$

Where, c = velocity of light in free space. Using the following equation we determined the practical length L(=6mm).

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

$$\text{Where, } \frac{\Delta L}{h} = \left[0.412 \times \frac{(\varepsilon_{reff}+0.3)\times(W/h+0.264)}{(\varepsilon_{reff}-0.258)\times(W/h+0.8)}\right]$$

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

$$\text{and} \quad L_{eff} = \left[\frac{c}{2\times f_r \times \sqrt{\varepsilon_{eff}}}\right]$$

Where, L_{eff} = Effective length of the patch, ΔL/h =Normalized extension of the patch length, ε_{reff} = Effective dielectric constant.

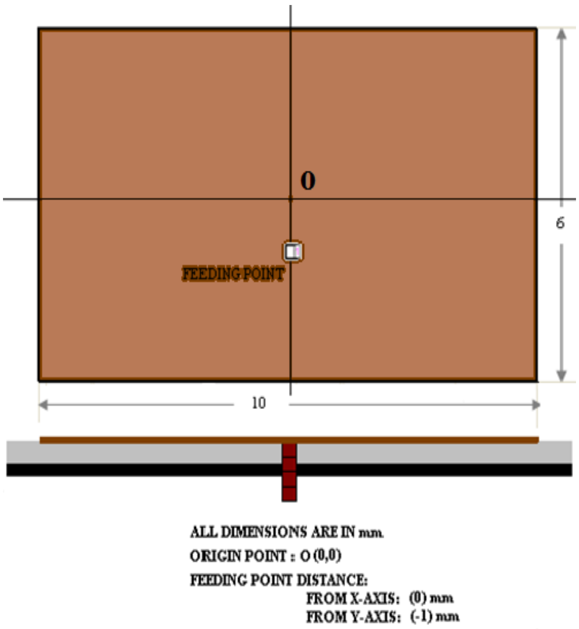

Figure 1: Conventional Antenna configuration

Figure 2 shows the configuration of simulated printed antenna designed with similar PTFE substrate. Two equal slots which are the combinations of two triangular and a rectangular slot at the upper right and lower left corner and the location of coaxial probe-feed (radius=0.5 mm) are shown in the figure 2.

3. Results and Discussion

Simulated (using IE3D) results of return loss in conventional and simulated antenna structures are shown in Figure 3-4. A significant improvement of frequency reduction is achieved in simulated antenna with respect to the conventional antenna structure.

In the conventional antenna return loss of about -7.01 dB is obtained at 13.39 GHz. Comparing fig.3 and fig.4 it may be observed that for the conventional antenna (fig.3), there is practically no resonant frequency at around 9.50 GHz with a return loss of around -6 dB. For the simulated antenna there is a resonant frequency at around 9.50169 GHz where the return loss is as high as -19.525 dB.

Due to the presence of slots in simulated antenna resonant frequency operation is obtained with large values of frequency ratio. The first and second resonant frequency is obtained at f_1= 9.50169 GHz with return loss of about -19.525 dB and at f_2 = 13.0013 GHz with return losses -35.275 dB respectively.

Corresponding 10dB band width obtained for Antenna 2 at f1, f2 are 423.259 MHz and 0.4331 GHz respectively. The simulated E plane and H-plane radiation patterns are shown in Figure 5-14. The simulated E plane radiation pattern of simulated antenna for 9.50169 GHz is shown in figure 5.

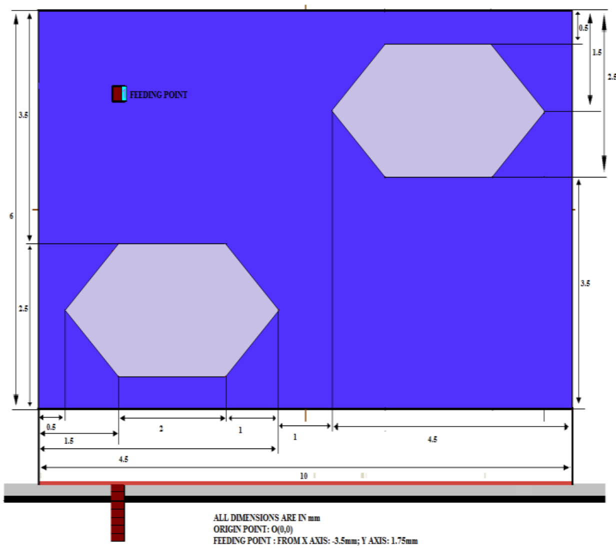

Figure 2: Simulated Antenna configuration

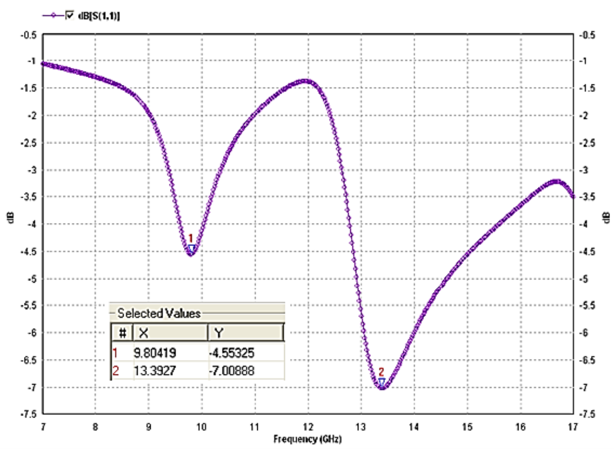

Figure 3: Return Loss vs. Frequency (Conventional Antenna)

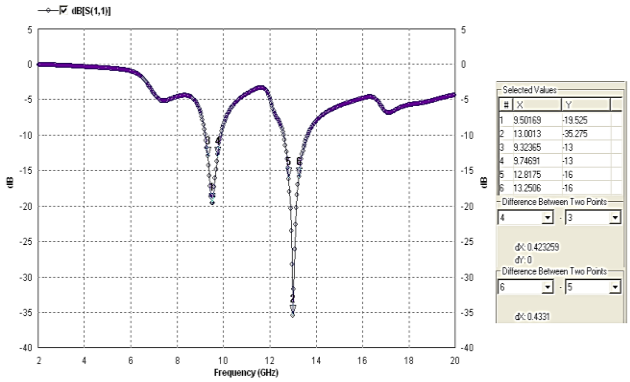

Figure 4: Return Loss vs. Frequency (Slotted Antenna)

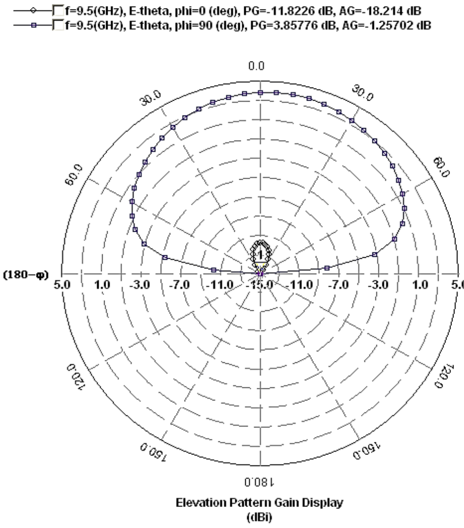

Figure 5: E-Plane Radiation Pattern for Slotted Antenna at 9.50 GHz

The simulated H plane radiation pattern of simulated antenna for 9.50169 GHz is shown in figure 6.

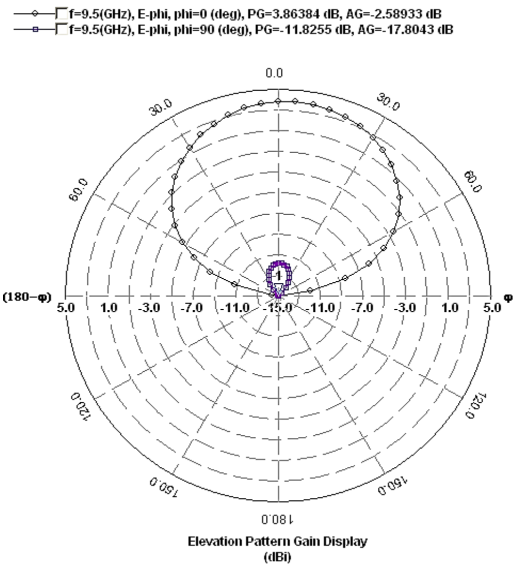

Figure 6: H-Plane Radiation Pattern for slotted Antenna at 9.50 GHz

The simulated E plane radiation pattern of slotted antenna for 13.0013 GHz is shown in figure 7. The simulated H plane radiation pattern of slotted antenna for 13.0013 GHz is shown in figure 8.

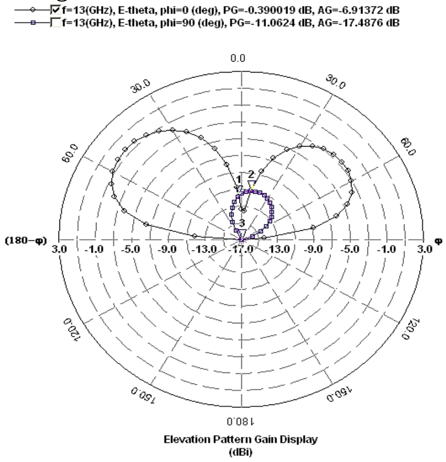

Figure7: E-Plane Radiation Pattern for slotted antenna at 13 GHz

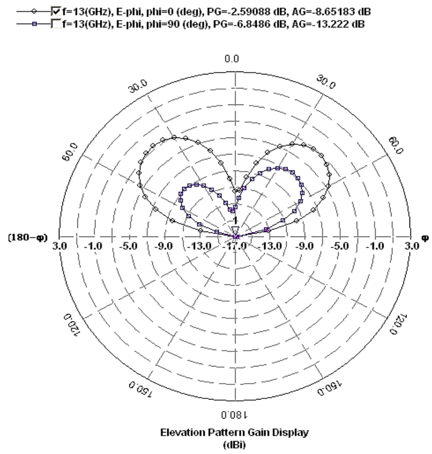

Figure 8: H-Plane Radiation Pattern for slotted antenna at 13 GHz

The simulated Cartesian E -plane & H-plane radiation pattern (2D) of simulated antenna for 9.50169 GHz is shown in figure 9 & figure 10.

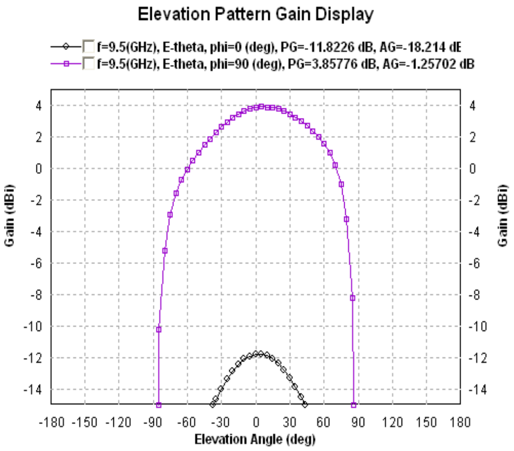

Figure 9: E-Plane Radiation Pattern (2D) for slotted antenna at 9.50 GHz

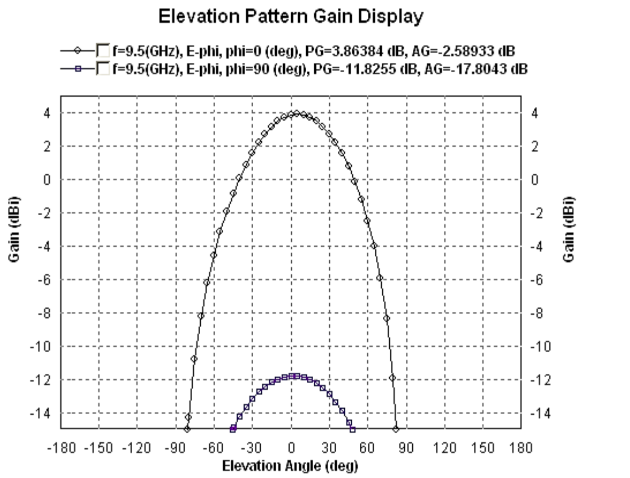

Figure 10: H-Plane Radiation Pattern (2D) for slotted antenna at 9.50 GHz

The simulated E plane & H-plane radiation pattern (3D) of simulated antenna for 9.50169 GHz is shown in figure 11 & figure 12.

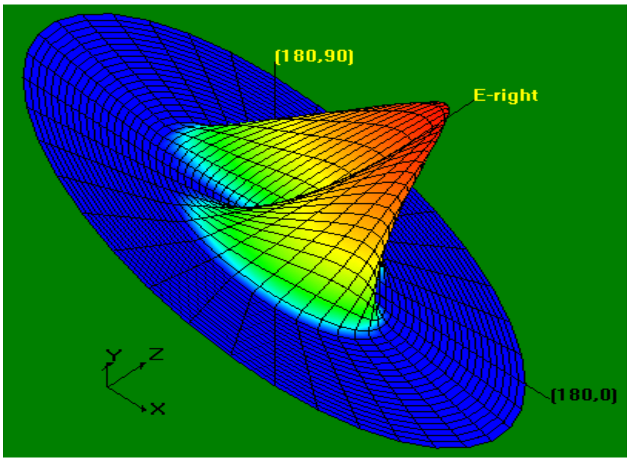

Figure 11: E-Plane Radiation Pattern (3D) for slotted antenna at 9.50 GHz

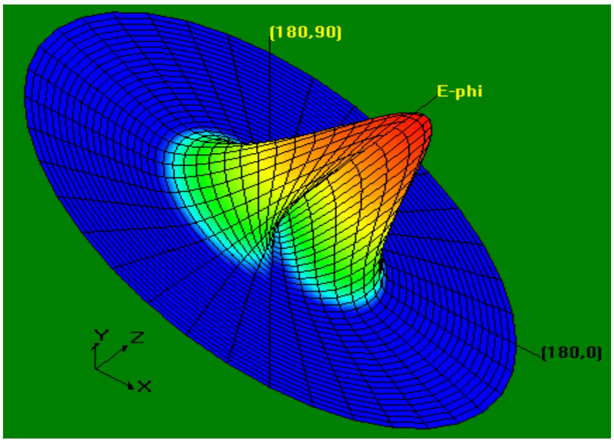

Figure 12: H-Plane Radiation Pattern (3D) for slotted antenna at 9.50 GHz

The simulated smith chart and VSWR of simulated antenna shown in figure 13 & figure 14.

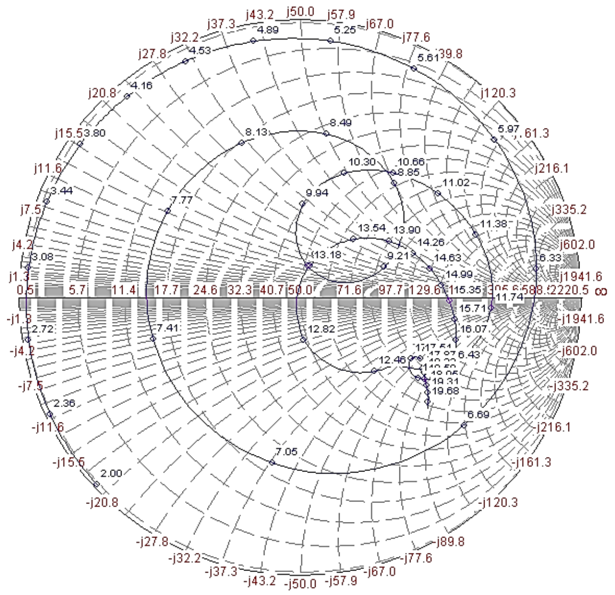

Figure13: Simulated Smith Chart for slotted antenna

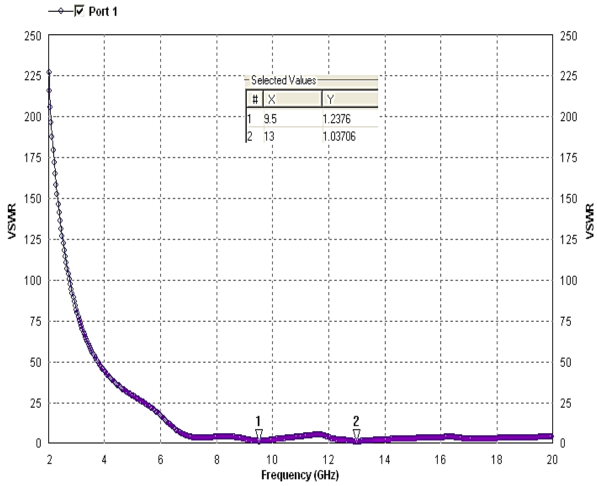

Figure 14: Simulated VSWR for slotted antenna

All the simulated results are summarized in the following Table1 and Table2.

Table I: Simulated Results for Antenna 1 And 2 W.R.T Return Loss

Antenna Structure	**Resonant Frequency (Ghz)**	**Return Loss (db)**	**10 db Bandwidth (Ghz)**
Conventional	f_1= 9.80	-4.55	NA
	f_2= 13.39	-7.01	NA
Slotted	f_1= 9.50169	-19.525	0.423259
	f_2 = 13.0013	-35.275	0.4331

Table II: Simulated Results For Antenna 1 And 2 W.R.T Radiation Pattern

Antenna Structure	**Resonant Frequency (ghz)**	**3db Beamwidth (^{0})**	**Absolute Gain *(dbi)***
Conventional	f_1= 9.80	NA	NA
	f_2= 13.39	NA	NA
Slotted	f_1= 9.50169	132.714	3.97715
	f_2 = 13.0013	152.585	1.50649
Frequency Ratio for Conventional Antenna	f_2 / f_1 = 1.366		
Frequency Ratio for Slotted Antenna	f_2 / f_1 = 1.3683		

3. Conclusion

This paper focused on the simulated design on differentially-driven microstrip antennas. Simulation studies of a single layer hexagonal microstrip patch antenna have been carried out using Method of Moment based software IE3D. Introducing slots at the edge of the patch size reduction of about 52.64% has been achieved. The 3dB beam-width of the radiation patterns are 132.714° (for f_1), 152.585° (for f_2) which is sufficiently broad beam for the applications for which it is intended.

The resonant frequency of slotted antenna, presented in the paper, designed for a particular location of feed point (-3.5mm, 1.75mm) considering the centre as the origin. Alteration of the location of the feed point results in narrower 10dB bandwidth and less sharp resonances.

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