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RESEARCH ARTICLE

DESIGN OF CONVENTIONAL ANTENNA FOR C-BAND AND X-BAND APPLICATIONS

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ABSTRACT

In this paper, the design and development of so called conventional type of microstrip patch antenna. The enhancing bandwidth and size reduction mechanism that improves the performance of a conventional microstrip patch antenna on a relatively dielectric thin substrate, is presented. The proposed conventional antenna is operated in the C-band and X-band with three resonant frequencies. The antenna has two resonances in the X-band used in weather mapping and detecting, long –range tracking radar and missile application and other in the C-band used in satellite communication, microwave relay. IE3D software used to simulate the antennas. Without any slot the simulated conventional microstrip patch antenna size has been reduced by 100% with an increased frequency ratio.

INTRODUCTION

Conventional microstrip patch antennas, in general, have a conducting patch printed on a grounded microwave substrate. They have attractive features of low profile, light weight, conformal shaping, and low cost, high efficiency, simplicity of manufacture, easy fabrication and integration to circuits. However they inherently have a narrow bandwidth (Garg *et al.,* 2001; Wong, 2002; Singhal *et al.,* 2003). Moreover the impedance bandwidth of a patch antenna is proportional to the antenna dimensions measured in wavelengths. Therefore the size reduction and bandwidth enhancement are becoming major design consideration and usually demanded for different practical applications (Chatterjee *et al.,* 2010). The most commonly used microstrip patch antennas are rectangular and circular patch antennas. These patch antennas are used as simple and for the widest and most demanding applications. Dual characteristics, circular polarizations, dual frequency operation, frequency agility, broad band width, feed line flexibility, beam scanning can be easily obtained from these patch antennas. Intensive research has been done in recent years to develop bandwidth enhancement techniques. This technique includes the utilization of thick substrates with low dielectric constant. The IEEE C-band is a portion of the electromagnetic spectrum in the microwave range of frequencies ranging from 4.0 to 8.0 GHz, which is followed by radar manufacturers, microwave relay and users.

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The C band is a name given to certain portions of the electromagnetic spectrum, including wavelengths of microwaves that are used for long-distance radio telecommunications (Supriya Jana *et al.,* 2012; Supriya Jana *et al.,* 2013; Bipadtaran Sinhamahapatra *et al.,* 2013). The C-band and its slight variations contain frequency ranges that are used for many satellite communication transmissions, some Wi-Fi devices, cordless telephones, and weather radar systems (Wu *et al.,* 2004; Chakraborty *et al.,* 2011; Jan and Tseng, 2004; Samiran Chatterjee *et al.,* 2011). The X -band defined by an IEEE standard for radio waves and radar engineering with frequencies that ranges from 8.0 to 12.0 GHz respectively. The X band is used for short range tracking, missile guidance, marine, radar and air bone intercept (Supriya Jana and Moumita Mukherjee, 2012). Especially it is used for radar communication ranges roughly from 8.29 GHz to 11.4 GHz. The proposed antenna (substrate with ε_r = 4.4) has a gain of 8.46 dBi and presents a size reduction of 100% without any slot of conventional microstrip patch (10mm X 6mm) antenna. The simulation has been carried out by Zeland IE3D software (http://www.zeland.com/) which uses the method of moment (MoM) method.

The configuration of the conventional printed antenna is shown in Figure 1 with L=6 mm, W=10 mm, substrate (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 (Balanis, 1989),

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

Where, c = velocity of light in free space. Using the following equation (Balanis, 1989) we determined the practical lengthL (=6mm) andW (=10mm).

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

And

$$w = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

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

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

and

$$L_{eff} = \left[\frac{c}{2 \times f_r \times \sqrt{\epsilon_{eff}}}\right]$$

Where, L_{eff} = Effective length of the patch, ΔL/h =Normalized extension of the patch length,

ε_{reff} = Effective dielectric constant.

The configuration of simulated antenna designed with similar PTFE substrate. Without slot the location of coaxial probe-feed (radius=0.5 mm) are shown in the Figure 1.

RESULTS AND DISCUSSION

Simulated (using IE3D (Supriya Jana and Moumita Mukherjee, 2012)) results of return loss in conventional antenna structures are shown in Figure 2. A significant improvement of frequency reduction is achieved in simulated antenna with respect to the conventional antenna structure.

Due to the presence of without slots in simulated conventional antenna resonant frequency operation is obtained with large values of frequency ratio. The first and second resonant frequency is obtained at f_1= 6.949 GHz with return loss of about -33.7 dB and at f_2 = 7.470 GHz with return losses -17.8 dB respectively. Respectively f_3= 8.513 GHz with return loss -18.6 dB.

Corresponding 10dB band width obtained for conventional microstrip patch antenna at f1 is 0.04001 GHz respectively. The simulated E plane and H-plane radiation patterns are shown in Figure 3-10. The simulated E plane radiation pattern of simulated antenna for 6.949GHz is shown in Figure 3. The simulated H plane radiation pattern of simulated antenna for 6.949 GHz is shown in Figure 4.

The simulated Conventional Antenna Cartesian E -plane & H-plane radiation pattern (2D) of simulated antenna for 6.949 GHz is shown in Figure 5 & Figure 6

The simulated E -plane and H-plane radiation pattern (3D) of simulated antenna for 6.949 GHz is shown in Figure 7 & Figure 8

The simulated smith chart and VSWR of simulated antenna shown in Figure 9 & Figure 10.

All the simulated results are summarized in the following Table1 and Table 2.

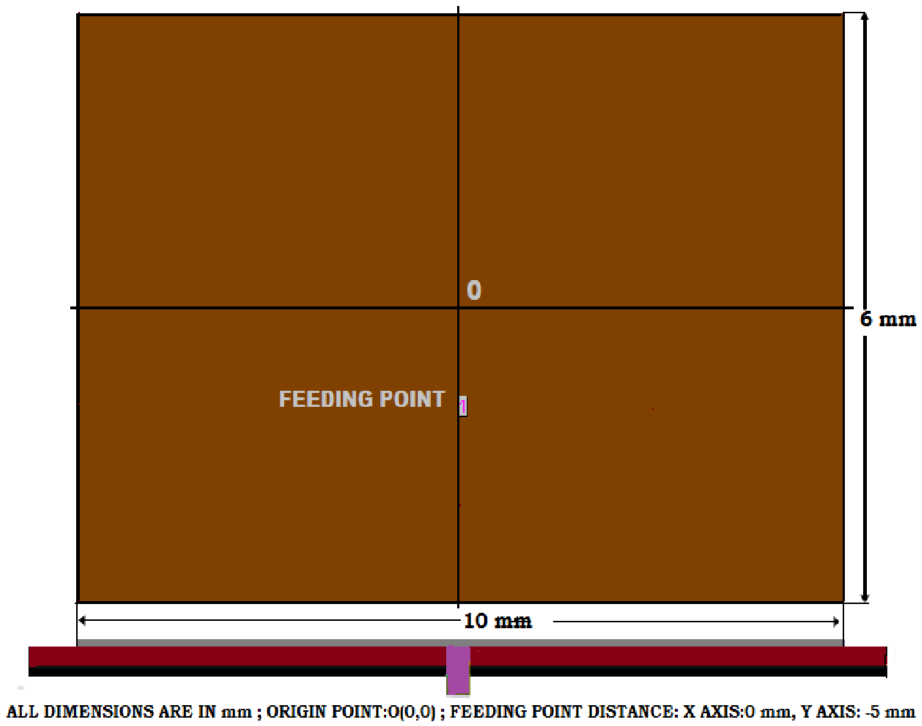


Fig. 1. Conventional Antenna configuration

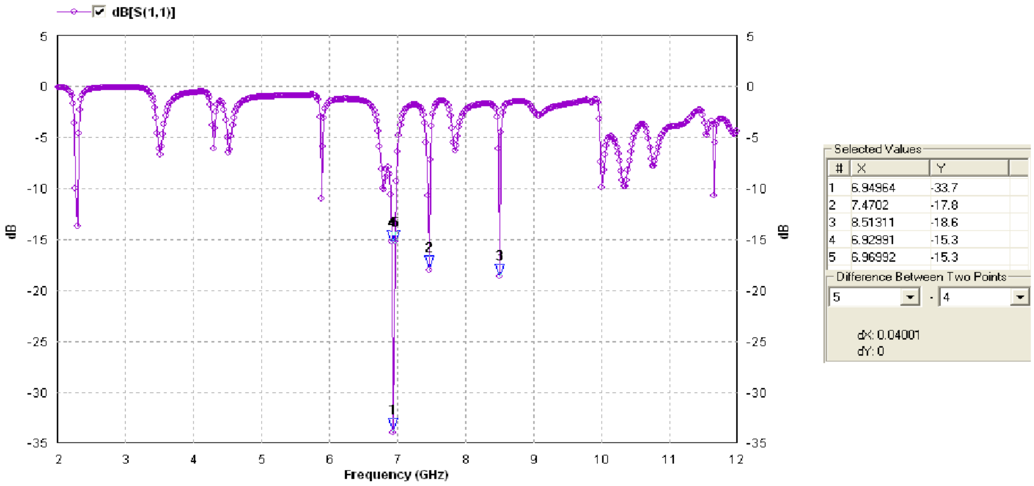
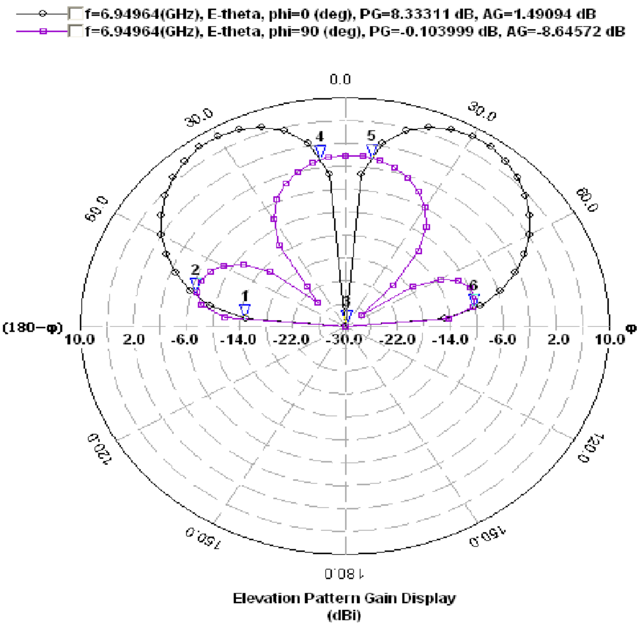


Fig. 2. Return Loss vs. Frequency (Conventional Antenna)



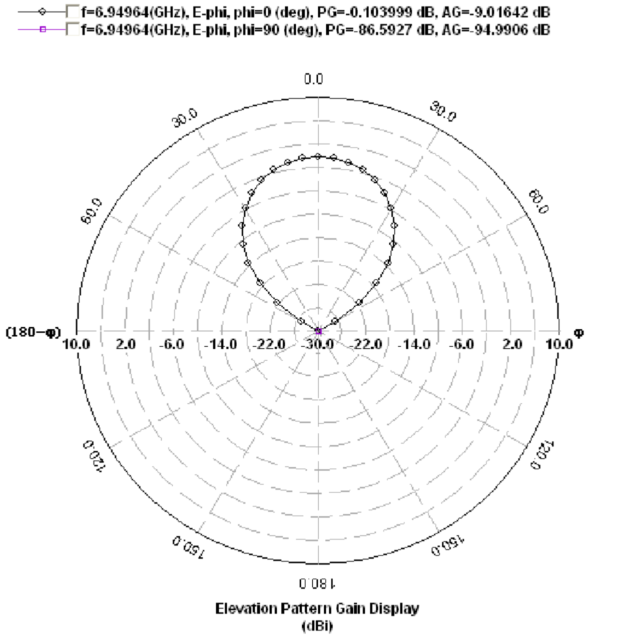


Fig. 3. E-Plane Radiation Pattern for Conventional Antenna at 6.94 GHz

Fig. 4. H-Plane Radiation Pattern for Conventional Antenna at 6.94GHz

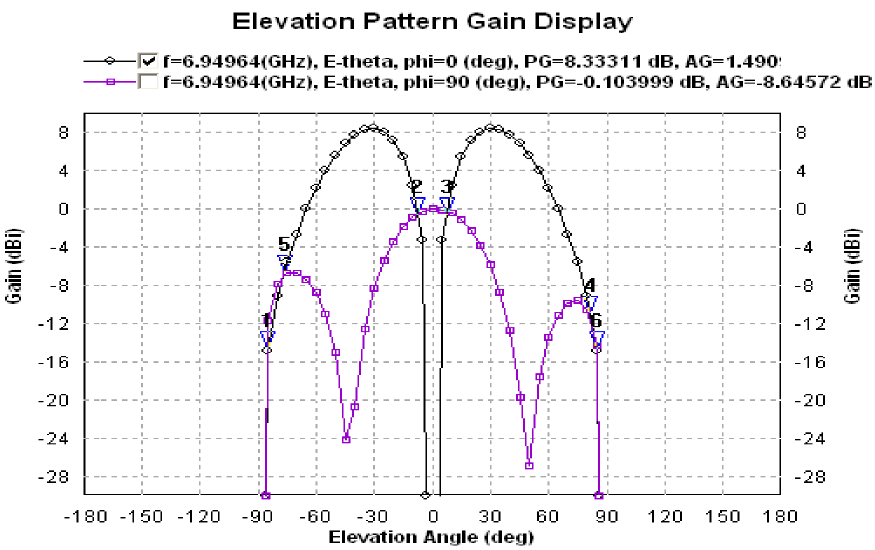


Fig. 5. E-Plane Radiation Pattern (2D) for Conventional Antenna at 6.949 GHz

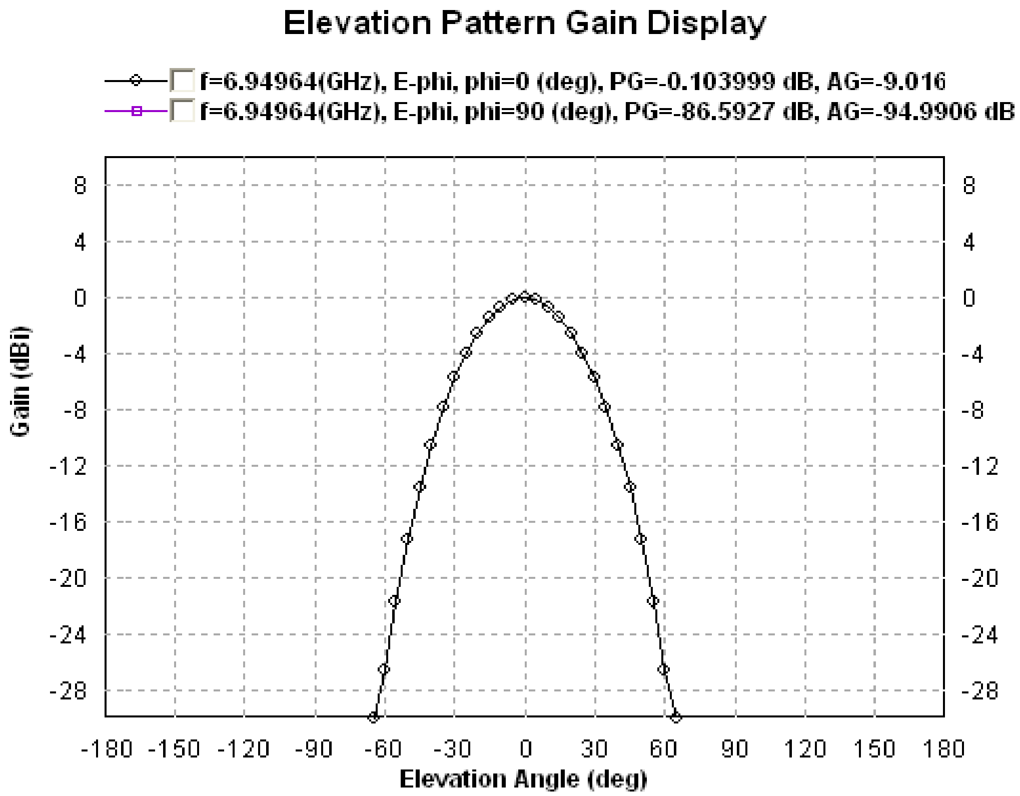
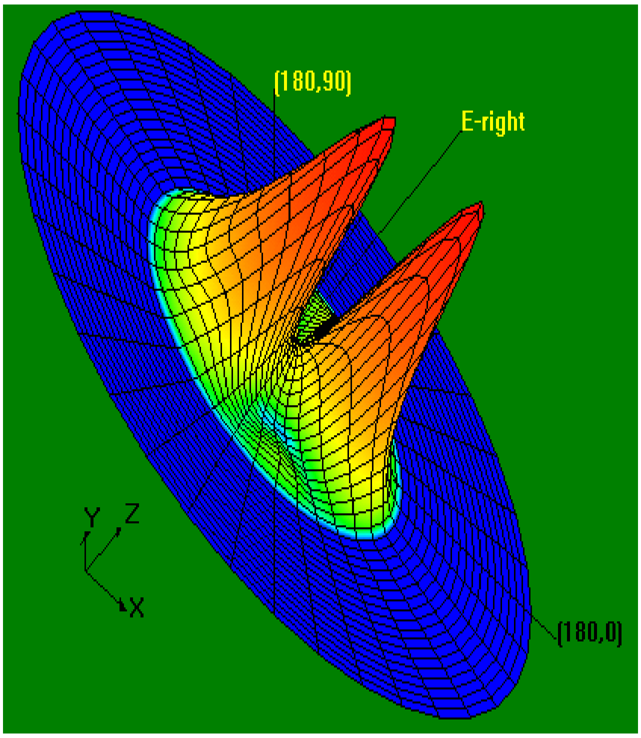


Fig. 6. E-Plane Radiation Pattern (2D) for Conventional Antenna at 6.949 GHz



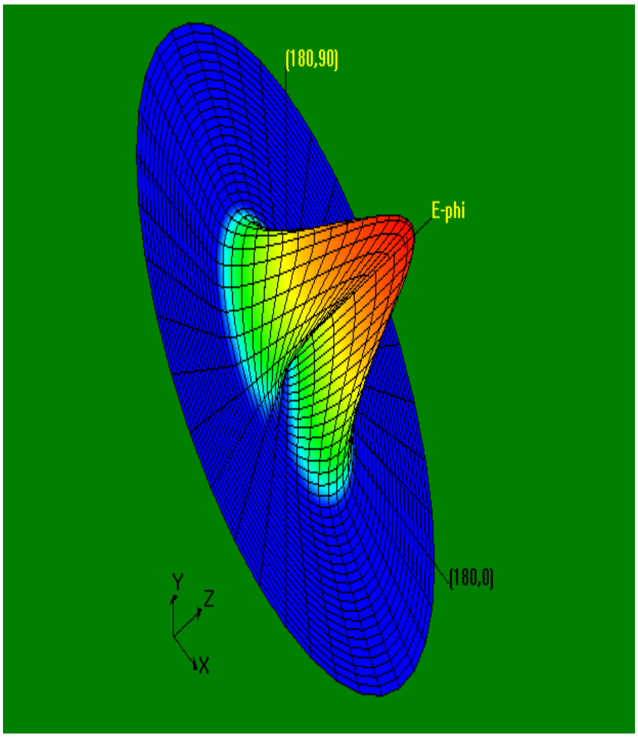


Fig. 7. E-Plane Radiation Pattern (3D) for Conventional Antenna at 6.949 GHz Fig. 8. E-Plane Radiation Pattern (3D) for Conventional Antenna at 6.949 GHz

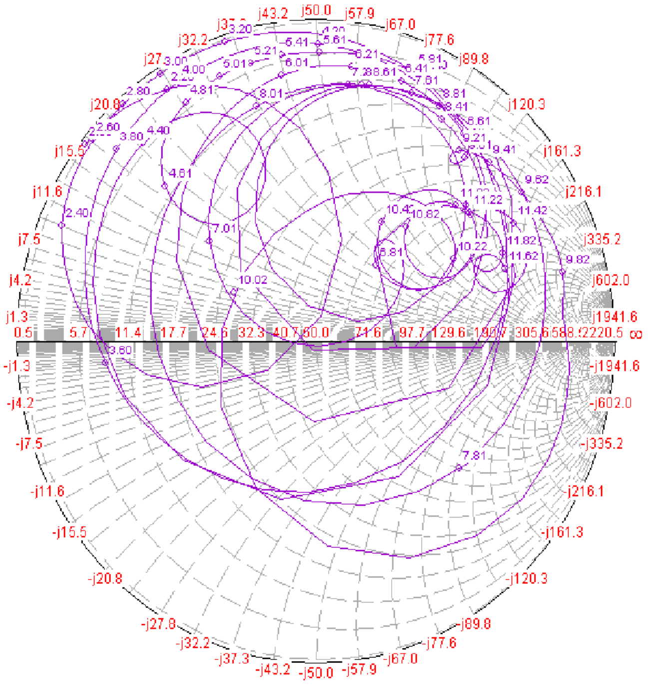


Fig.9. Simulated Smith Chart for Conventional Antenna

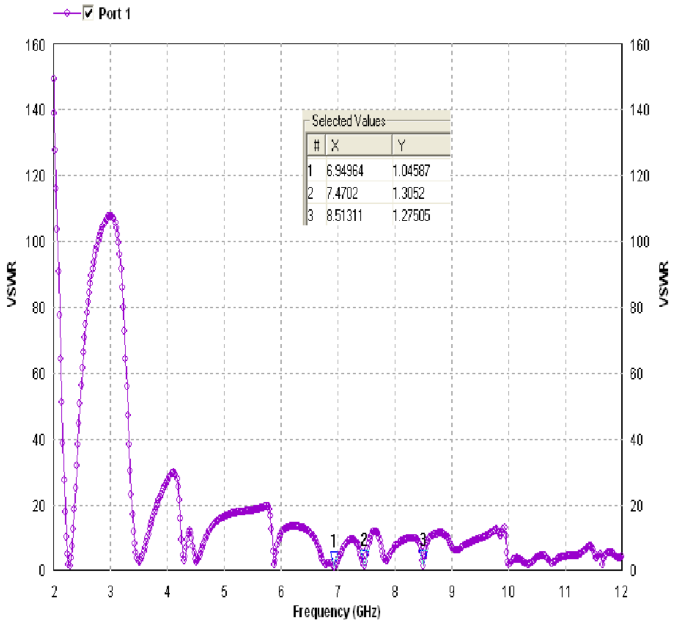


Fig. 10. Simulated VSWR Conventional Antenna

Table 1. Simulated results for antenna W.R.T return loss

Antenna Structure	Resonant Frequency (GHz)	Return Loss (dB)	10 db Bandwidth (GHz)
Conventional	F_1= 6.94964	-33.7	0.04001
	f_2= 7.4702	-17.8	-
	F_3= 8.51311	-18.6	-

2. Simulated results for antenna W.R.T radiation pattern

Antenna Structure	Resonant Frequency (GHz)	3db Beamwidth (^{0})	Absolute Gain (dBi)
Conventional	f_1= 6.94964	100.515	8.46154
	f_2= 7.4702	-	-
	f_3= 8.51311	-	-

Conclusion

The aim of this paper is to design a conventional microstrip patch antenna and to study the responses and the radiation properties. The simulated design on differentially driven microstrip antenna is operating 6-9 GHz frequency. Dimensions, selection of the substrate, feed technique and also the operating frequency can take their position in effecting the performance. A rigorous analysis of the Problem begins with the application of the equivalence principle that introduces the unknown electric and magnetic surface current densities on the dielectric surface and without slot. This paper focused on the simulated design on differential driven microstrip antennas. Simulation studies of antenna have been carried out using Method of Moment based software IE3D (http://www.zeland.com). The resonant frequency of without slotted antenna presented in the paper, designed for a particular location of feed point (0, -5mm) 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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Zeland Software Inc. IE3D v 10: MoM-Based EM Simulator. Web: http://www.zeland.com/

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