SINGLE LAYER MONOPOLE HEXAGONAL MICROSTRIP PATCH ANTENNA FOR SATELLITE TELEVISION

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ABSTRACT

A single layer monopole hexagonal patch antenna is thoroughly simulated in this paper. Resonant frequency has been reduced drastically by cutting three unequal slots which are the combinations of one circle and two irregular rectangular slots from the conventional microstrip patch antenna. It is shown that the simulated results are in acceptable agreement. More importantly, it is also shown that the differentially-driven microstrip antenna has higher gain of simulated 3.36 dBi at 9.61GHz and -0.43 dBi at 13.57GHz and beam width of simulated 162.08[0] at 9.61GHz and 53.45[0] at 13.57GHz of the single-ended microstrip antenna. Compared to a conventional microstrip patch antenna, simulated antenna size has been reduced by 50.80% with an increased frequency ratio.

KEYWORDS

Compact, Patch, Slot, Resonant frequency, Bandwidth.

1. INTRODUCTION

In recent years, demand for small antennas on wireless communication has increased the interest of research work on compact microstrip antenna design among microwave and wireless engineers [1-6]. 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. In recent years much research and testing has been done to increase both the bandwidth and radiation efficiency of microstrip antennas.

Due to the recent interest in broadband antennas 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 $\varepsilon_r = 4.4$) has a gain of 3.19 dBi and presents a size reduction of 54.55% when compared to a conventional microstrip patch (10mm X 6mm). The simulation has been carried out by IE3D [14] 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 [7-10]microwave communication and Ku-Band RADAR communication & satellite 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. The X band is used for short range tracking, missile guidance, marine, radar and air bone intercept. Especially it is used for radar communication ranges roughly from 8.29 GHz to 11.4 GHz. The Ku band is used for high resolution mapping and satellite altimetry. Especially, Ku Band is used for tracking the satellite within the ranges roughly from 12.87 GHz to 14.43 GHz. In this paper the micro strip patch antenna is designed for use in a satellite TV at 13.5773 GHz. The results obtained provide a workable antenna design for incorporation in a satellite TV. Recently the Direct broadcast satellite (DBS) system uses the upper portion of the Ku band.

2. ANTENNA DESIGN

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 $\varepsilon_r = 4.4$. 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 [6],

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

Where, c = velocity of light in free space. Using the following equation [9] we determined the practical length L (=6mm).

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

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

Where, L_{eff} = Effective length of the patch, $\Delta L/h$ =Normalized extension of the patch length, ε_{reff} = Effective dielectric constant.
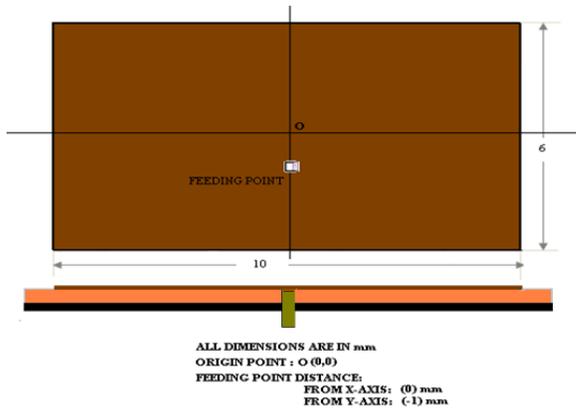
Figure 1: Conventional Antenna configuration
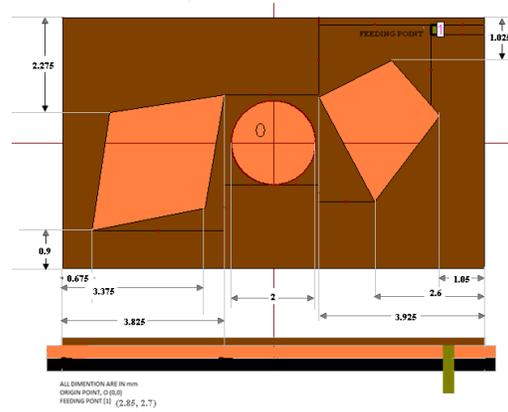
Figure 2: Simulated Antenna configuration

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 [10]) 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.
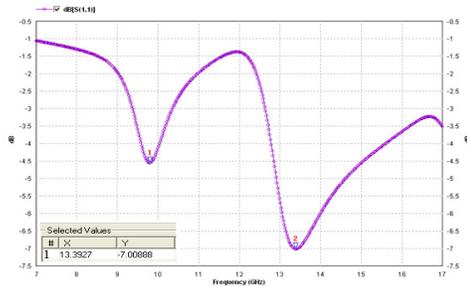

Figure 3: Return Loss vs. Frequency (Conventional Antenna)
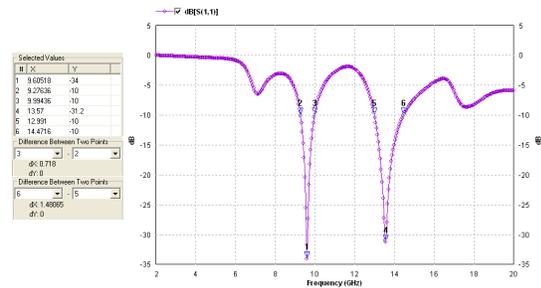
Figure 4: Return Loss vs. Frequency (Slotted Antenna)

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 9.61 GHz with a return loss of around -6 dB. For the simulated antenna there is a resonant frequency at around 9.61 GHz where the return loss is as high as -34 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= 9.61 GHz with return loss of about -34 dB and at f_2 = 13.57 GHz with return losses -31.2 dB respectively.

Corresponding 10dB band width obtained for Antenna 2 at f1, f2 are 718 MHz and 1.48 GHz respectively. The simulated E plane and H-plane radiation patterns are shown in Figure 5-12. The simulated E plane radiation pattern of simulated antenna for 9.61GHz is shown in figure 5.
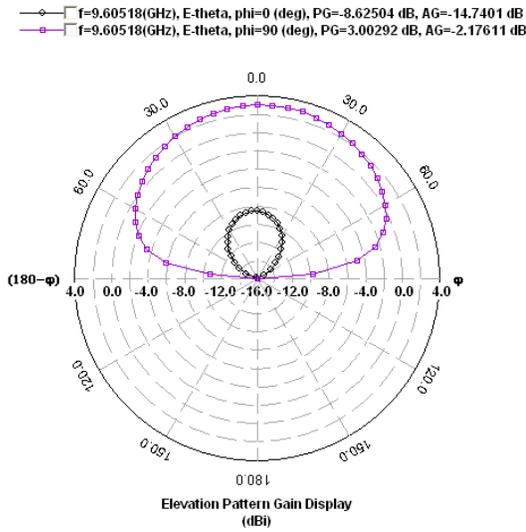

Figure 5: E-Plane Radiation Pattern for Slotted Antenna at 9.61 GHz
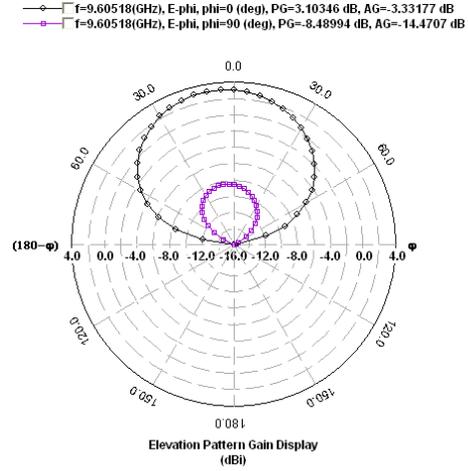
Figure 6: H-Plane Radiation Pattern for slotted Antenna at 9.61GHz

The simulated H plane radiation pattern of simulated antenna for 9.61 GHz is shown in figure 6.
The simulated E -plane & H-plane radiation pattern (3D) of simulated antenna for 9.61 GHz is shown in figure 7 & figure 8.
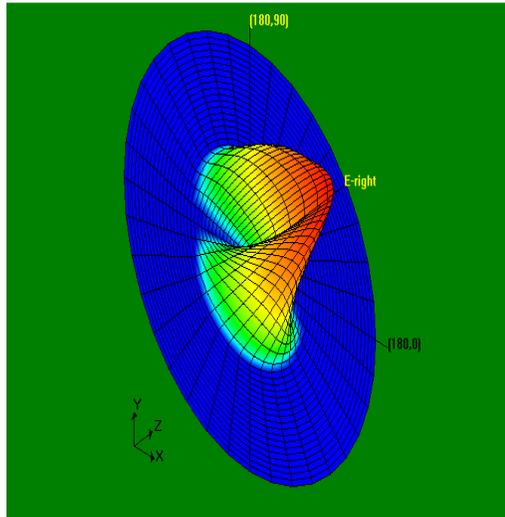

Figure 7: E-Plane Radiation Pattern (3D) for slotted antenna at 9.61 GHz
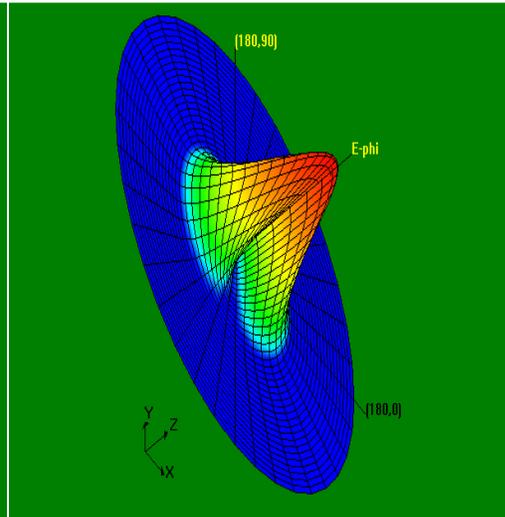
Figure 8: E-Plane Radiation Pattern (3D) for slotted antenna at 9.61 GHz

The simulated E plane radiation pattern of slotted antenna for 13.57 GHz is shown in figure 9. The simulated H plane radiation pattern of slotted antenna for 13.57 GHz is shown in figure 10.
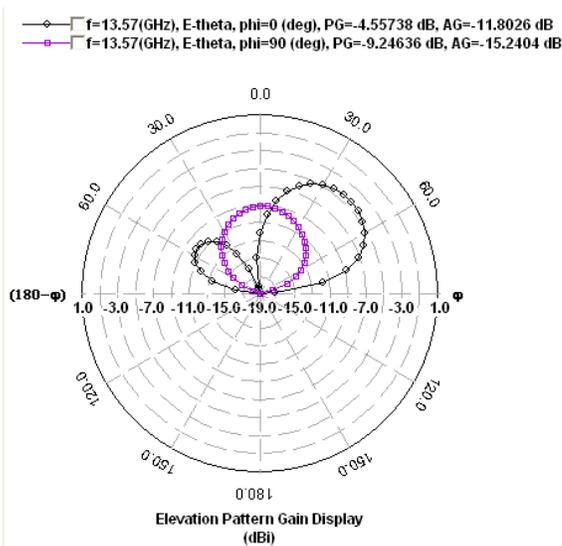
Figure9: E-Plane Radiation Pattern for slotted antenna at 13.57 GHz
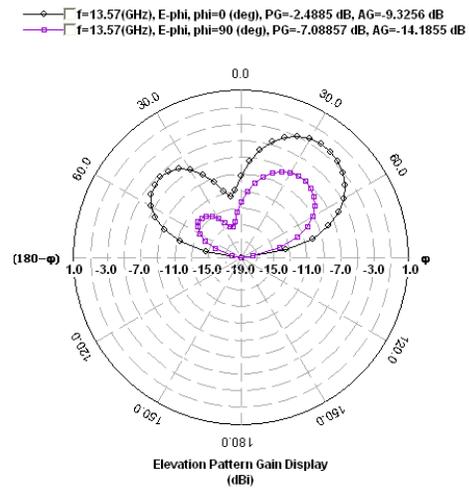
Figure 10: H-Plane Radiation Pattern for slotted antenna at 13.57 GHz

The simulated E -plane & H-plane radiation pattern (3D) of simulated antenna for 13.57 GHz is shown in figure 11 & figure 12.
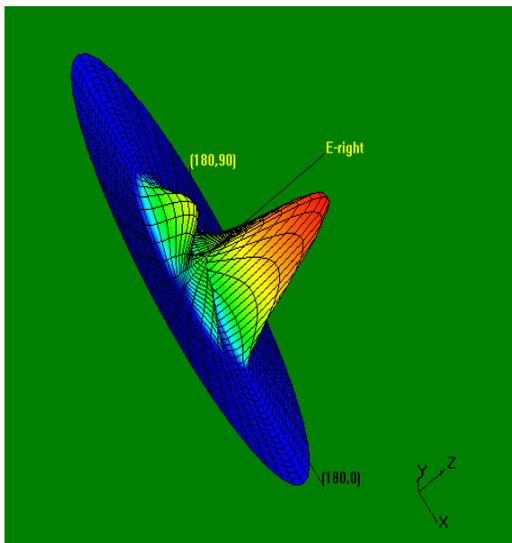

Figure11: E-Plane Radiation Pattern for slotted antenna at 13.57 GHz
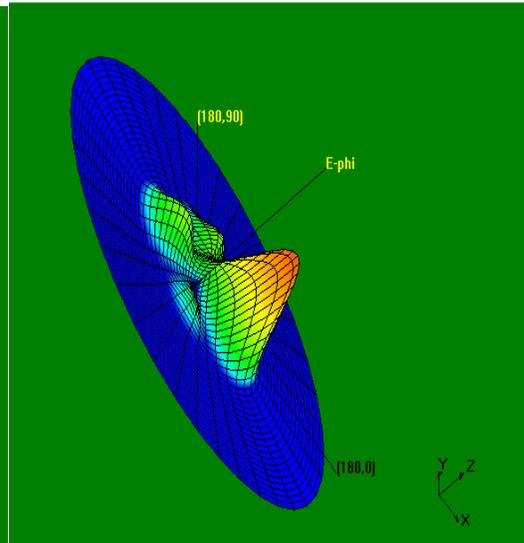
Figure 12: H-Plane Radiation Pattern for slotted antenna at 13.57 GHz

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	$f_1 = 13.39$	-7.00	NA
Slotted	$f_1 = 9.61$	-34	0.718
	$f_2 = 13.57$	-31.2	1.4806

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	$f_1 = 13.39$	NA	NA
Slotted	$f_1 = 9.61$	162.075	3.35714
	$f_2 = 13.57$	53.445	-0.428571

4. CONCLUSION

This paper focused on the simulated design on differentially-driven microstrip antennas. Simulation studies of a single layer monopole 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 54.55% has been achieved. The 3dB beam-width of the radiation patterns are 162.075° (for f_1), 53.445° (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 (2.85mm, 2.7mm) 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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