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Dual-Band Size Deducted Un-Equal Arm Y-Shaped Printed Antenna for Satellite Communication

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Abstract:- A dual-band deducted un-equal arm Y-shaped printed antenna is thoroughly simulated in this paper. Resonant frequency has been reduced drastically consists of Y-shaped slot in middle point located 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 4.69 dBi at 6.23GHz and 4.18 dBi at 9.56GHz and beam width of simulated 170.38^0 at 6.23GHz and 166.131^0at 9.56GHz of the printed antenna. Compared to a conventional microstrip patch antenna, simulated antenna size has been reduced by 52.02% with an increased frequency ratio.

Keywords:- Compact, Patch, Slot, Resonant frequency, Bandwidth.

I. 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 [7-8].

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 ε_r = 4.4) has a gain of 4.18 dBi and presents a size reduction of 52.02% 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 C-Band of satellite communication and X-Band for microwave communication

The C-band and X-Band defined by an IEEE standard for radio waves and radar engineering with frequencies that ranges from 4.0 to 8.0GHz and 8.0 to 12.0GHz[10] respectively. The C band is used for microwave relay. The X [11-13] 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 8.29GHz to 11.4GHz .In this paper the microstrip patch antenna is designed for use in military communication satellites at 9.56GHz and satellite communication at 6.23 GHz. The results obtained provide a workable antenna design for incorporation in a satellite alliance.

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

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

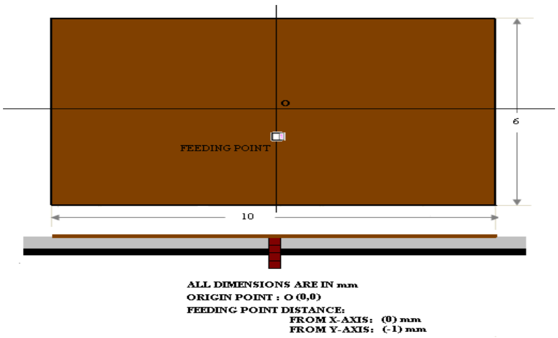

Figure 1: Conventional Antenna configuration

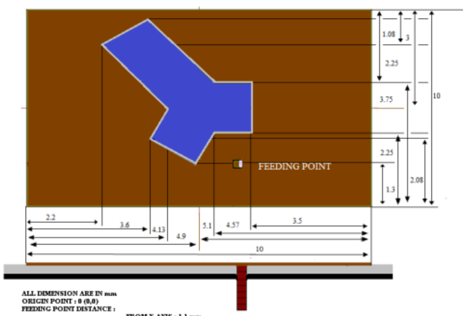

Figure 2: Simulated Antenna configuration

Figure 2 shows the configuration of simulated printed antenna designed with similar PTFE substrate. The middle point Y-shaped the location of coaxial probe-feed (radius=0.5 mm) are shown in the figure 2.

III. 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.

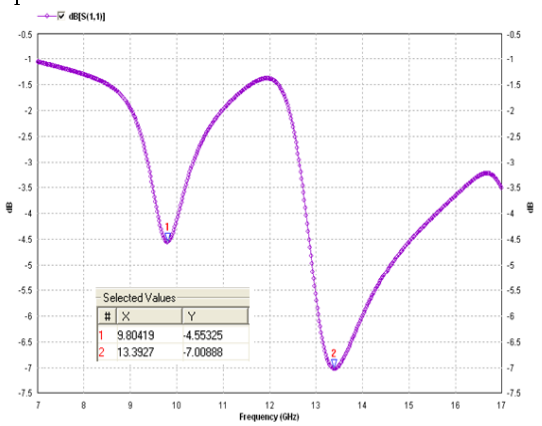

Figure 3: Return Loss vs. Frequency (Conventional Antenna)

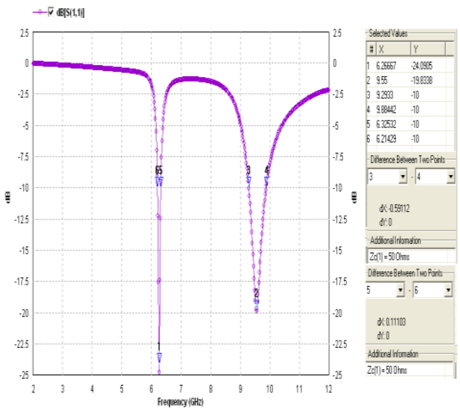

Figure 4: Return Loss vs. Frequency (Slotted Antenna)

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 6.23GHz with a return loss of around -6 dB. For the simulated antenna there is a resonant frequency at around 6.23GHz, where the return loss is as high as -24.725.

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= 6.23GHz with return loss of about -24.725dB and at f_2 = 9.56GHz with return losses -19.8438 dB respectively.

Corresponding 10dB band width obtained for Antenna 2 at f1, f2 are 111.0 MHz and 591.1MHz respectively. The simulated E plane and H-plane radiation patterns are shown in Figure 5-8. The simulated E plane radiation pattern of simulated antenna for 6.23GHz is shown in figure 5.

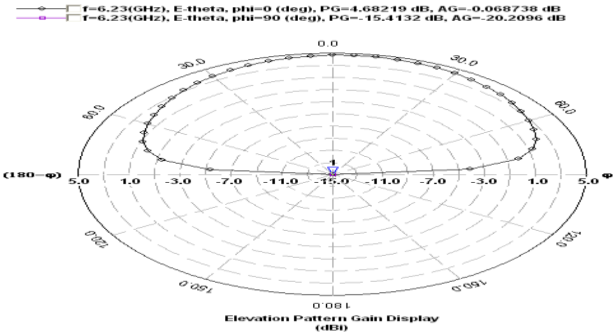

Figure 5: E-Plane Radiation Pattern for Slotted Antenna at 6.23 GHz

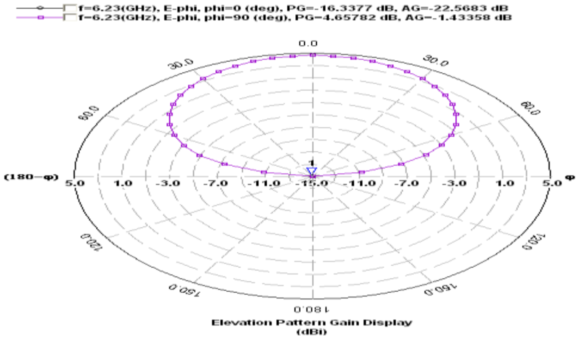

Figure 6: H-Plane Radiation Pattern for slotted Antenna at 6.23 GHz

The simulated H plane radiation pattern of simulated antenna for 6.23 GHz is shown in figure 6.The simulated E plane radiation pattern of slotted antenna for 9.56 GHz is shown in figure 7. The simulated H plane radiation pattern of slotted antenna for 9.56 GHz is shown in figure 8.

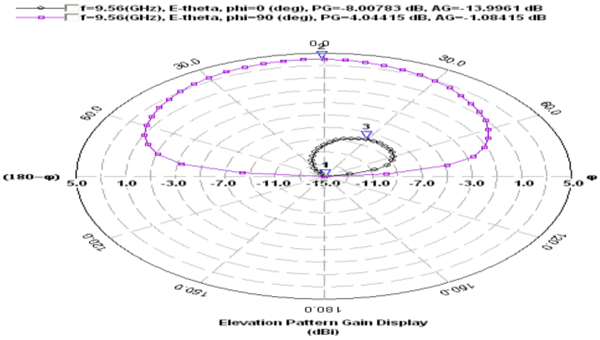

Figure7: E-Plane Radiation Pattern for slotted antenna at 9.56 GHz

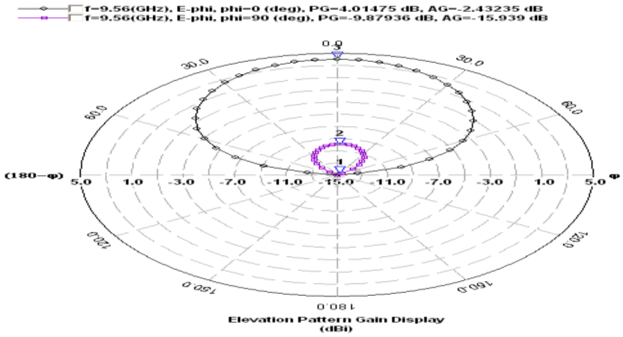

Figure 8: H-Plane Radiation Pattern for slotted antenna at 9.56 GHz

The simulated E plane & H-plane radiation pattern (3D) of simulated antenna for 6.23 GHz is shown in figure 9 & figure 10.

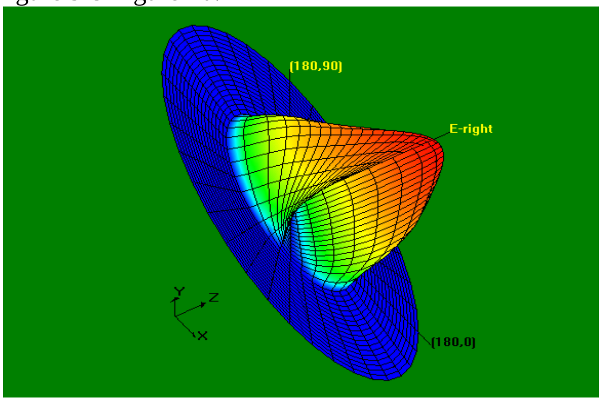

Figure 9: E-Plane Radiation Pattern (3D) for slotted antenna at 6.23 GHz

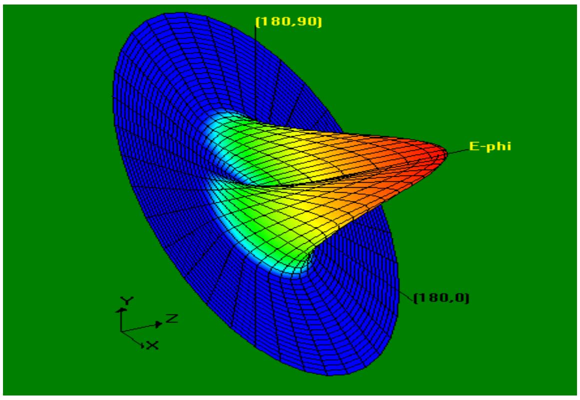

Figure 10: E-Plane Radiation Pattern (3D) for slotted antenna at 6.23 GHz

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The simulated E -plane & H-plane radiation pattern (3D) of simulated antenna for 9.56 GHz is shown in figure 11 & figure 12.

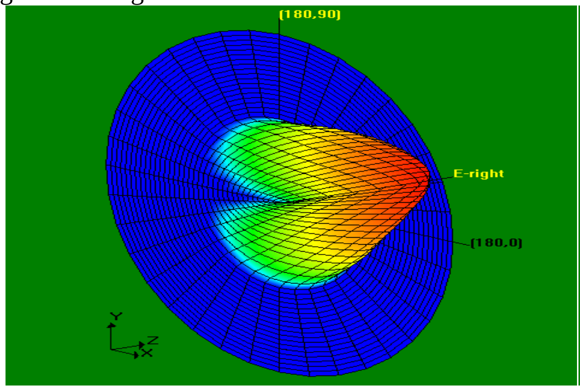

Figure 11: E-Plane Radiation Pattern (3D) for slotted antenna at 9.12 GHz

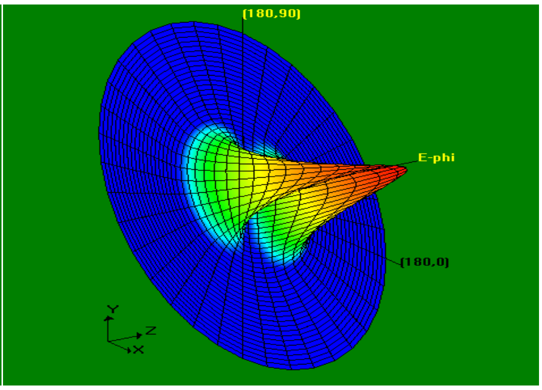

Figure 12: E-Plane Radiation Pattern (3D) for slotted antenna at 9.12 GHz

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= 9.80	-4.55	NA
	f_2= 13.39	-7.00	NA
Slotted	f_1= 6.23	-24.725	0.1110
	f_2 = 9.56	-19.8438	0.5911

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= 6.23	170.38	4.6974
	f_2 =9.56	166.131	4.1869
Frequency Ratio for Conventional Antenna			f_2 / f_1 = 1.366
Frequency Ratio for Slotted Antenna			f_2 / f_1 = 1.535

IV. 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 52.02% has been achieved. The 3dB beam-width of the radiation patterns are 170.38° (for f_1), 166.131° (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 (1.1mm, -1.7mm) 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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REFERENCES

[1]. I.Sarkar, P.P.Sarkar, S.K.Chowdhury "A New Compact Printed Antenna for Mobile Communication", 2009 *Loughborough Antennas& Propagation Conference*, 16-17 November 2009, pp 109-112.

[2]. S. Chatterjee, U. Chakraborty, I.Sarkar, S. K. Chowdhury, and P.P.Sarkar, "A Compact Microstrip Antenna for Mobile Communication", IEEE annual conference. Paper ID: 510

[3]. J.-W. Wu, H.-M. Hsiao, J.-H. Lu and S.-H. Chang, "Dual broadband design of rectangular slot antenna for 2.4 and 5 GHz wireless communication", *IEE Electron. Lett.* Vol. 40 No. 23, 11th November 2004.

[4]. U. Chakraborty, S. Chatterjee, S. K. Chowdhury, and P. P. Sarkar, "A comact microstrip patch antenna for wireless communication," *Progress In Electromagnetics Research C*, Vol. 18, 211-220, 2011 http://www.jpier.org/pierc/pier.php?paper=10101205

[5]. Rohit K. Raj, Monoj Joseph, C.K. Anandan, K. Vasudevan, P. Mohanan, " A New Compact Microstrip-Fed Dual-Band Coplaner Antenna for WLAN Applications", *IEEE Trans. Antennas Propag.*, Vol. 54, No. 12, December 2006, pp 3755-3762.

[6]. Zhijun Zhang, Magdy F. Iskander, Jean-Christophe Langer, and Jim Mathews, "Dual-Band WLAN Dipole Antenna Using an Internal Matching Circuit", *IEEE Trans. Antennas and Propag.*,VOL. 53, NO. 5, May 2005, pp 1813-1818.

[7]. J. -Y. Jan and L. -C. Tseng, " Small planar monopole Antenna with a shorted parasitic inverted-L wire for Wireless communications in the 2.4, 5.2 and 5.8 GHz. bands" , *IEEE Trans. Antennas and Propag.*, VOL. 52, NO. 7, July 2004, pp -1903-1905.

[8]. Samiran Chatterjee, Joydeep Paul, Kalyanbrata Ghosh, P. P. Sarkar and S. K. Chowdhury "A Printed Patch Antenna for Mobile Communication", Convergence of Optics and Electronics conference, 2011, Paper ID: 15, pp 102-107.

[9]. *C. A. Balanis, "Advanced Engineering Electromagnetics", John Wiley & Sons., New York, 1989.*

[10]. Bipa Datta, Arnab Das, Samiran Chatterjee, Bipadtaran Sinhamahapatra, Supriya Jana, Moumita Mukherjee, Santosh Kumar Chowdhury, "Design of Compact Patch Antenna for Multi-Band Microwave Communication", National Conference on Sustainable Development through Innovative Research in Science and Technology (Extended Abstracts), Paper ID: 115, pp 155, 2012.

[11]. Arnab Das, Bipa Datta, Samiran Chatterjee, Bipadtaran Sinhamahapatra, Supriya Jana, Moumita Mukherjee, Santosh Kumar Chowdhury, "Multi-Band Microstrip Slotted Patch Antenna for Application in Microwave Communication," *International Journal of Science and Advanced Technology, (ISSN 2221-8386), Vol. 2, Issue-9, 91-95, September 2012.*

[12]. Bipa Datta, Arnab Das, S.Chatterjee, B. Sinhamahapatra, S. Jana, M. Mukherjee, S. Kr. Chowdhury "Monopole Slotted Patch Antenna for Microwave Communication,*" International Journal of Scientific and Research Publications (IJSRP), ISSN 2250-3153, Volume 2, Issue 11, November 2012.*

[13]. Bipa Datta, Arnab Das, S.Chatterjee, M. Mukherjee, S. Kr. Chowdhury"A Monopole Printed Antenna for Tracking the Satellite," *International Journal on Electronics & Communication Technology (IJECT), ISSN: 2230-7109 (Online) | ISSN: 2230-9543 (Print), IJECT Vol. 3, Issue 4, Oct - Dec 2012, PP 57-63.*

[14]. Zeland Software Inc. IE3D: MoM-Based EM Simulator. Web: http://www.zeland.com/.