Compact Microstrip Antenna for WLAN and H-LAN Communication

Samiran Chatterjee, Partha Pratim Sarkar, Debasree Chanda (Sarkar), Santosh Kumar Chowdhury

Abstract: ***A single layer, single feed compact rectangularantenna is proposed. Resonant frequency has been reduced drastically by cutting unequal rectangular slots at the edge of the patch & a circle in the middle. The width of the rectangular slots is different to improve the gain bandwidth performance of the antenna. The antenna size has been reduced by 41.8% when compared to a conventional rectangular microstrip patch antenna with a maximum of 24.9 MHz bandwidth at –16.3 dB return loss at 3.41 GHz. The characteristics of the designed structure are investigated by using MoM based electromagnetic solver, IE3D. There is reasonable agreement these simulated data and measured value. An extensive analysis of the return loss, radiation pattern, gain of the proposed antenna is shown in this paper. The simple configuration and low profile nature of the proposed antenna leads to easy fabrication and make it suitable for the applications in Wireless communication system.***

Keywords: ***Compact, Frequency ratio, Patch, Resonant frequency, Slot.***

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 microwaves and wireless engineers [1]. To support the high mobility necessity for a wireless telecommunication device, a small and light weight antenna is likely to be preferred. For this purpose Compact Microstrip antenna is one of the most suitable applications. The development of antenna for wireless communication also requires an antenna with more than one operating frequency.

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This is due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies. Therefore one antenna that has multiband characteristic is more desirable than having one antenna for each frequency band. To reduce the size of the antenna one of the effective techniques is cutting slot in proper position on the microstrip patch [2-4]. Compact microstrip antenna is a topic of intensive research in recent years because of increasing demand for small antennas used in various types of communications including mobile communication [5-8]. The size of the antenna may be effectively reduced by cutting rectangular slots on printed antennas. The work to be presented in this paper is also a compact printed antenna obtained by cutting rectangular slots which gave a resonant frequency much lower than the resonant frequency of the conventional printed antenna with the same patch area. The work to be presented in this paper is also a compact microstrip antenna design obtained by cutting rectangular slots on the patch to increase the return loss and gain-bandwidth performance of the antenna. To reduce the size of the antenna substrates are chosen with higher value of dielectric constant [9-14]. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with $\varepsilon r = 4.4$) presents a size reduction of 41.8% when compared to a conventional rectangular microstrip patch. The simulation has been carried out by IE3D [15] software which uses the MOM method.

II. ANTENNA DESIGN

The configuration of the conventional printed antenna is shown in Figure 1 with L=16 mm, W=20 mm, substrate (PTFE) thickness h = 1.5875 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= 20 mm for efficient radiation and using the equation [6],
$fr = [c/(2*W)]*\sqrt{(2/(1+\varepsilon_r))}$, we determined the resonant frequency fr (= 4.57 GHz). Where, c = velocity of light in free space. Using the following equation [7, 8] we determined the practical length L (=16mm). $L=L_{eff} - 2\Delta L$
where, $\Delta L/h = 0.412*[((\varepsilon_{reff}+0.3)*(W/h+0.264))/((\varepsilon_{reff} - 0.258)*(W/h+0.))]$,
$\varepsilon_{reff} = (\varepsilon_r +1)/2 + (\varepsilon_r -1)/(2*\sqrt{(1+12*h/W)})$ and $L_{eff} = [c/(2*fr * \sqrt{\varepsilon_{reff}})]$ Where, L_{eff} = Effective length of the patch, $\Delta L/h$ =Normalized extension of the patch length, ε_{reff} = Effective dielectric constant.

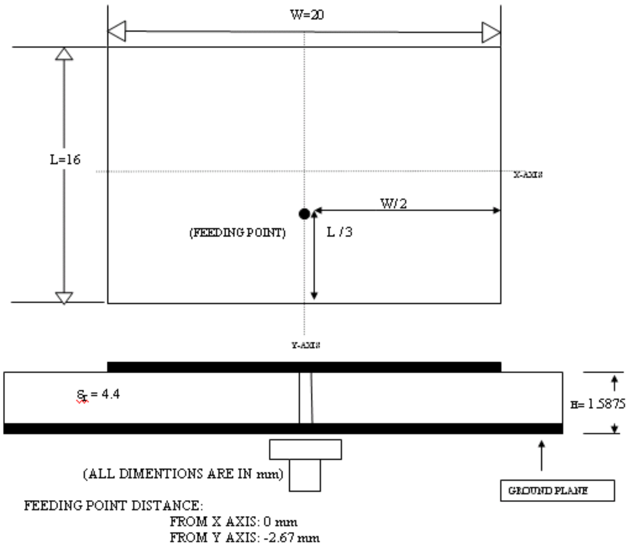

Figure 1: Antenna 1 configuration

Figure 2 shows the configuration of antenna 2 designed with similar PTFE substrate. Four unequal rectangular slots (L1, L2, L3, L4) and one circle whose dimensions and the location of coaxial probe-feed (radius=0.5 mm) are shown in the figure 2.

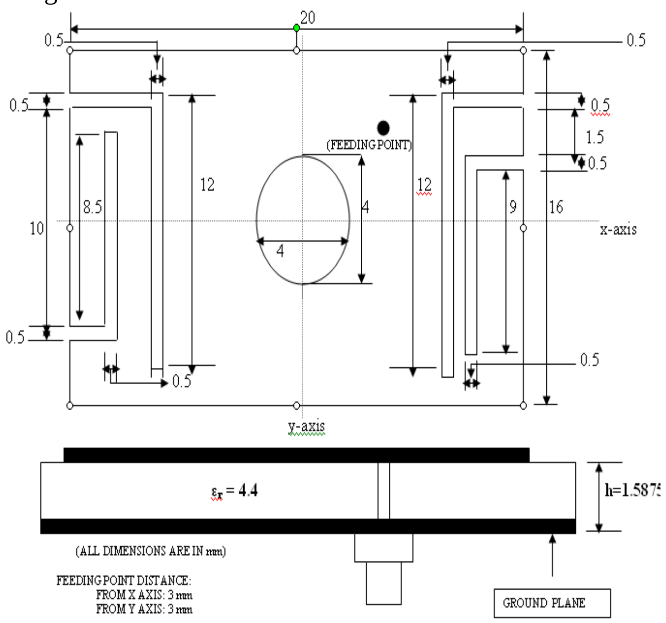

Figure 2: Antenna 2 configuration

III. RESULTS AND DISCUSSION

Simulated (using IE3D [15] results of return loss in conventional and slotted antenna structures are shown in Figure 3-4. A significant improvement of frequency reduction is achieved in antenna 2 with respect to the conventional antenna1 structure.

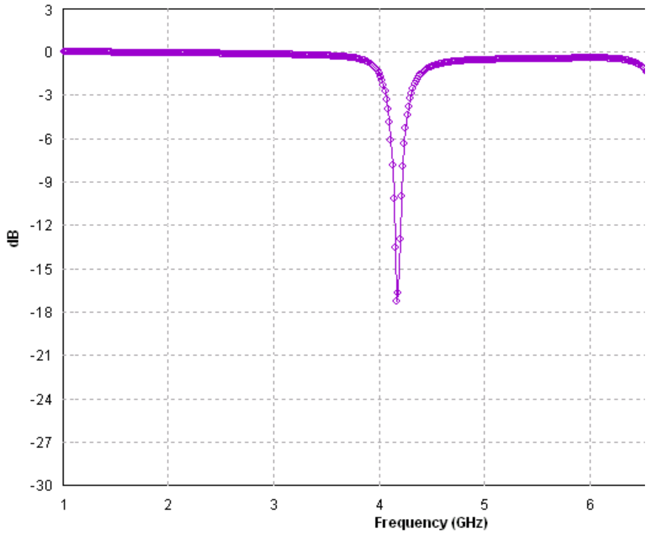

Figure 3: Antenna 1 Return Loss vs. Frequency (Conventional Antenna)

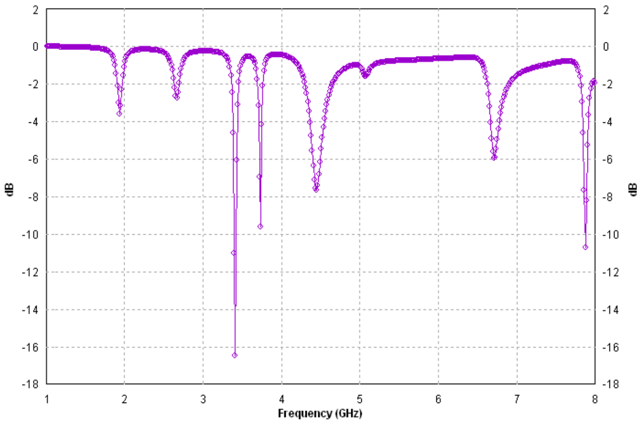

Figure 4: Antenna 2 Return Loss vs. Frequency (Slotted Antenna)

In the conventional antenna return loss of about -17.212 dB is obtained at 4.170 GHz. Corresponding 10 dB bandwidth is 70.91 MHz.

Due to the presence of slots in antenna 2 resonant frequency operation is obtained with large values of frequency ratio. The resonant frequency is obtained at f1=3.412 GHz with return loss of about -16.30 dB. The second resonant frequency is obtained at f_2 = 7.87 GHz with return losses -10.55 dB. Corresponding 10 dB bandwidth obtained for Antenna 2 at f_1, f_2 are 24.9 MHz, 19.12 MHz respectively.

IV. RADIATION PATTERN

For the antenna 1 (Conventional Antenna) radiation patterns of E plane & H plane are shown in Figure 5-6. The simulated E plane radiation pattern of antenna 1 (Conventional Antenna) for 4.17 GHz is shown in figure 5.

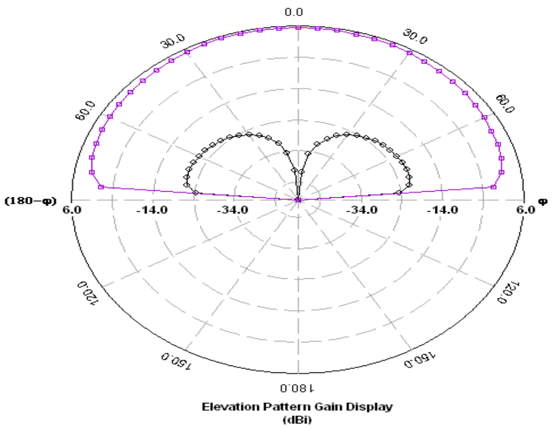

Figure5: E plane Radiation Pattern for Antenna 1 at 4.17 GHz

The simulated H plane radiation pattern of antenna 1 (Conventional Antenna) for 4.17 GHz is shown in figure 6.

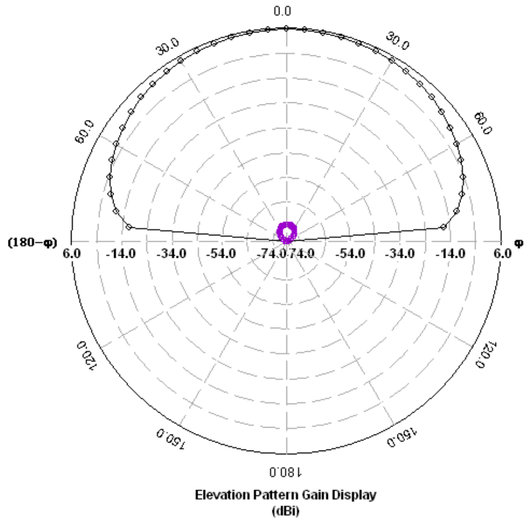

Figure 6: H plane Radiation Pattern for Antenna 1 at 4.17 GHz

For the antenna 2 (Slotted Antenna) radiation patterns of E plane & H plane are shown in Figure 7-10. The simulated E plane radiation pattern of antenna 2 (Slotted Antenna) for 3.41 GHz is shown in figure 7.

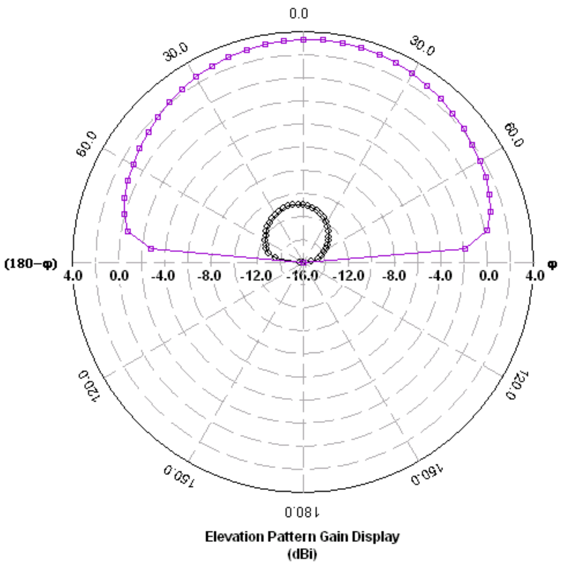

Figure 7: E plane Radiation Pattern for Antenna 2 at 3.41 GHz

The simulated H plane radiation pattern of antenna 2 (Slotted Antenna) for 3.41 GHz is shown in figure 8.

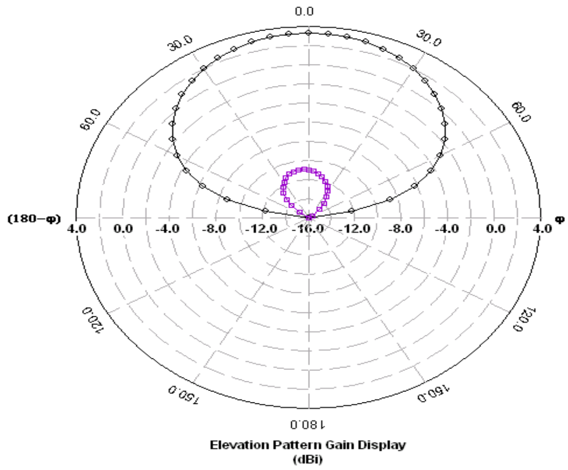

Figure 8: H plane Radiation Pattern for Antenna 2 at 3.41 GHz

The simulated E plane radiation pattern of antenna 2 (Slotted Antenna) for 7.87 GHz is shown in figure 9.

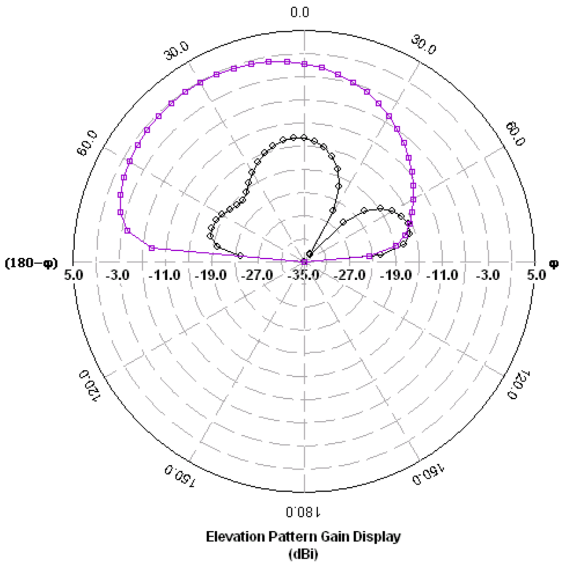

Figure 9: E plane Radiation Pattern for Antenna 2 at 7.87 GHz

The simulated H plane radiation pattern of antenna 2 (Slotted Antenna) for 7.87 GHz is shown in figure 10.

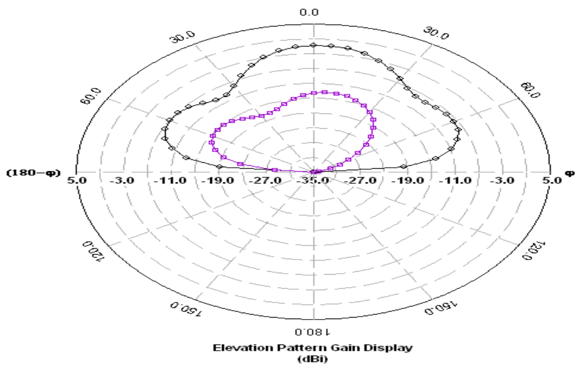

Figure 10: H plane Radiation Pattern for Antenna 2 at 7.87 GHz

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

TABLE I:
SIMULATED RESULTS FOR ANTENNA 1 AND 2

ANTENNA STRUCTURE	RESONANT FREQUENCY (GHZ)	RETURN LOSS (DB)	10 DB BANDWIDTH (MHZ)
1	f_1= 4.17	-17.212	70.91
2	f_1= 3.41	-16.30	24.90
	f_2= 7.87	-10.55	19.12

TABLE II:
SIMULATED RESULTS FOR ANTENNA 1 AND 2

ANTENNA STRUCTURE	RESONANT FREQUENCY (GHz)	FREQUENCY RATIO	3 DB BEAM WIDTH (^{0})	ABSOLUTE GAIN (DBI)
1	f_1= 4.17		170.92^0	5.43
2	f_1= 3.41		170.52^0	3.29
	f_2= 7.87	f_2/ f_1= 2.308	101.33^0	0.71

V. EXPERIMENTAL RESULTS AND DISCUSSION

The prototype of the antenna 2 (proposed antenna) was fabricated and tested, which are depicted in Fig.s 11-12 the measurements were carried out using Vector Network Analyzer (VNA) Agilent N5 230A.

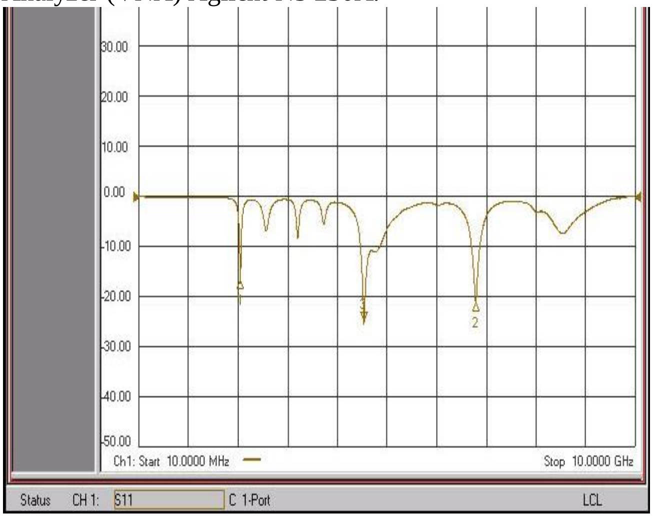

Figure 11: Measured return loss for proposed antenna.

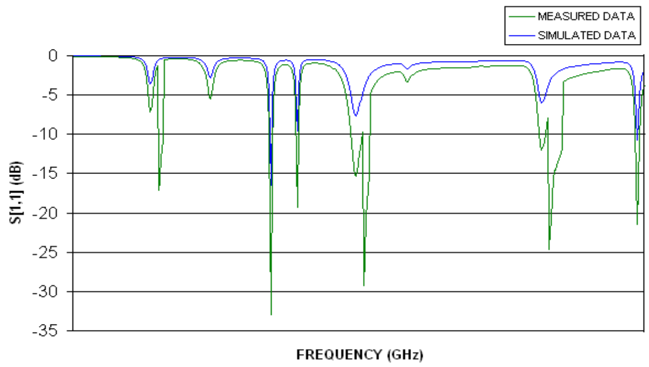

Figure 12: Comparison between simulated & measured return loss for proposed antenna.

The comparisons of the measured return loss with the simulated ones for conventional antenna are shown in Fig.13. Discrepancy between the measured and simulated results is due to the effect of improper soldering of SMA connector or fabrication tolerance.

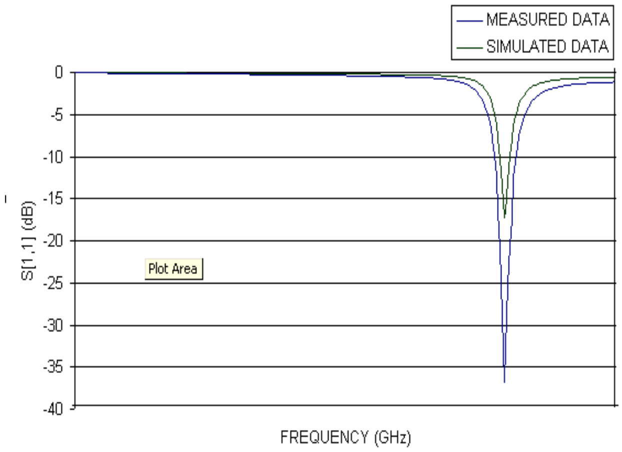

Figure 13: Comparison between simulated & measured return loss for conventional antenna.

VI. CONCLUSION

Theoretical investigations of a single layer single feed micro strip printed antennas have been carried out using Method of Moment based software IE3D. Introducing slots at the edge of the patch size reduction of about 41.8% has been achieved. The 3dB beam-width of the radiation pattern 170.52° which is sufficiently broad beam for the applications for which it is intended.

The resonant frequency antenna presented in the paper for a particular location of feed point (3mm, 3mm considering the centre as the origin) was quite large as is evident from table1. 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 Nov. 2009, Loughborough, UK.
2. 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.
3. Samiran Chatterjee, Joydeep Paul, Kalyanbrata Ghosh, P. P. Sarkar, D.Chanda (Sarkar) and S. K. Chowdhury "A Compact Microstrip Antenna for WLAN Communication", National Conference of Electronics, Communication and Signal Processing, 2011, Paper ID: 116
4. 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.
5. U. Chakraborty, S. Chatterjee, S. K. Chowdhury, and P. P. Sarkar, "Triangular Slot Microstrip Patch Antenna for Mobile Communication", India Conference (INDICON), 2010

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Annual IEEE, pp 4-7, Paper ID: 511

6. 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.
7. S. Chatterjee, U. Chakraborty, I.Sarkar, S. K. Chowdhury, and P. P. Sarkar, "A Compact Microstrip Antenna for Mobile Communication", India Conference (INDICON), 2010 Annual IEEE, pp 1-3, Paper ID: 510
8. Danideh, A., R. S. Fakhr, and H. R. Hassani, "Wideband coplanar microstrip patch antenna," Progress In Electromagnetics *Research Letters*, PIER 4, 81–89, 2008.
9. 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
10. J. Bahl and P. Bhartia, " Microstrip Antennas", Artech House, Dedham, MA, 1980.
11. U. Chakraborty, S. Chatterjee, S. K. Chowdhury, and P. P. Sarkar, "A compact microstrip patch antenna for wireless communication," *Progress In Electromagnetics Research C*, Vol. 18, 211-220, 2011
12. R.Fallahi, A.-A.Kalteh, M. Golparvar Roozbahani, "A novel UWB elliptical slot antenna with band-notched characteristics," *Progress In Electromagnetics Research C*, Vol. 18, 211-220, 2011
13. E. O. Hammerstad, " Equations for Microstrip Circuit Design", Proc. Fifth European Microwave Conf. Pp 268-272, September 1975.
14. C. A. Balanis, "Advanced Engineering Electromagnetic", John Wiley & Sons., New York, 1989.
15. Zeland Software Inc. IE3D: MOM-Based EM Simulator. Web: http://www.zeland.com