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A Tri Shaped Printed Patch Antenna For UWB Applications

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Abstract

In this paper we proposed A Tri shaped printed patch antenna for UWB applications. This antenna consists of a rectangular patch with circle and triangle slots on the top face and a partial ground at the rear end. The antenna is fabricated with substrate FR-4 epoxy dielectric with relative permittivity of 4.3. Investigations based on simulations and experiments are conducted. The simulation is performed using CST Microwave studio. The proposed antenna is successfully implemented and the simulated results show reasonable agreement with the measured results. In this design, a 4.94GHz to 10.4 GHz frequency range for $S_{11} \leq -10$ dB is obtained, VSWR ≤ 2. This paper presents return loss, E-field distribution, H-field distribution, radiation pattern, input impedance and VSWR.

Index Terms: Ultra wideband antenna (UWB), Micro strip patch antenna, VSWR.

Introduction

FOR wireless communication applications antenna is the most important element. With the rapid development of wireless broadband technologies we required low cost, light weight, simple structure and must present Omni-directional radiation patterns and easy fabrication with PCB (Printed Circuit Board). As the Federal Communication Commission (FCC) prescribed the frequency range of 3.1 to 10.6 GHz for commercial ultra-wideband (UWB) communication systems. The demand for UWB systems is increasing very rapidly in the communication systems, particularly wireless multimedia system with high data rate.

In UWB wireless communication is to transmit digital information signals transformed into very short pulses on the order of nanoseconds, which covers a very wide bandwidth in the frequency domain. This technique is able to communicate very fast data rate in hundreds Mbps like an optical communication. Now, it is necessary to present a relatively more simple but robust design of UWB antenna. In this research paper a simple design is proposed, this design is based on a microstrip rectangular patch. Design parameters like shape of radiator, ground plane as well as feeding structure are optimized to obtain the broadband impedance bandwidth. Microstrip antennas are mainly used in aircraft, spacecraft, satellite and missile applications where small size, low cost, high performance and ease of installation are major constraints. Printed rectangular patch with partial ground technique is presented in this paper. Extensive parametric study of slits in patch shape like circle and triangle slots has also been carried out. Increase in overall bandwidth has been observed for effective position of these slots. Details of antenna design, software simulation and measured results are also discussed.

Design, Analysis and Optimization

The dimensions of the proposed antenna are shown in Fig.1. The proposed patch antenna length L_2 is between $\lambda_0/3$ and $\lambda_0/2$ and its width W_2 is smaller than λ_0 and the substrate thickness d is very small. To be resonant antenna, the length L should be around half of the wave length. In this case the antenna can be considered as a $\lambda/2$ transmission line resonant cavity with tri shaped slots on the top face and a partial ground at the rear end.

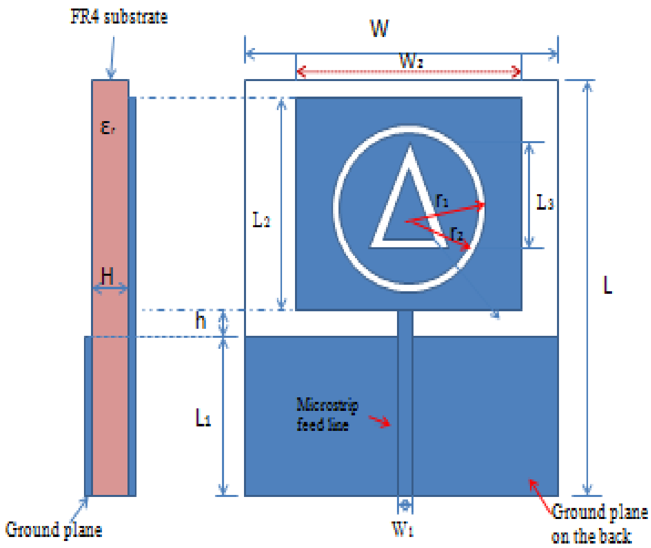


Figure 1: A Tri Shaped Printed Patch Antenna

The radiation comes from tri shaped slots is similar two slot antenna, the radiation pattern in the two principal planes are

E-plane $(\phi = 0^0)$

$$E = \hat{\theta} E_0 \cos\left(\frac{\beta L}{2} \sin\theta\right) \quad (1)$$

H-plane $(\phi = 90^0)$

$$E = -\hat{\theta} E_0 \sin c\left(\frac{\beta L}{2} \sin\theta\right) \cos\theta \quad (2)$$

The directivity of patch antenna can be expressed as

$$D = \frac{8W}{\lambda_0} \quad (3)$$

The impedance of the resonant microstrip antenna is ranges from 50 to 400 *Ω* and the radiation impedance of the patch is

$$Z = 90 \frac{\varepsilon_r^2}{\varepsilon_r - 1} \left(\frac{L}{W}\right)^2 (\Omega) \quad (4)$$

Thus, the impedance is determined with substrate material FR-4 epoxy, relative permittivity, length and width of patch. The fractional bandwidth of antenna whenever VSWR < 2 is

$$\frac{\Delta f}{f_0} = \frac{16}{3\sqrt{2}} \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{Ld}{\lambda W} \quad (5)$$

The ground plane is part antenna. Generally, the ground plane should be as monopole antenna is generated fringing field between the patch and ground plane, the minimum size of the ground plane is related to the thickness of the dielectric substrate.

Because of fringing effects the patch of the antenna looks larger dimensions, the enlargement on L is given by

$$\Delta L = \frac{0.412d(\varepsilon_{reff} + 0.3)(W/d + 0.264)}{(\varepsilon_{reff} - 0.258)(W/d + 0.8)} \quad (6)$$

Where the effective permittivity is

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12d/W}} \quad (7)$$

The effective length is

$$L_{eff} = L + 2\Delta L \quad (8)$$

The resonant frequency is

$$f_r = \frac{1}{2L_{eff}\sqrt{\varepsilon_{reff}}\sqrt{\varepsilon_0\mu_0}} \quad (9)$$

The dimensions of the tri shaped printed patch antenna are presented in Table 1.

Table 1: Dimensions of printed patch antenna

S. No	Parameter Description	Value/mm
1	Substrate Length, L	60
2	Substrate Width, W	52
3	Substrate Thickness, d	1.6
4	Substrate Relative Permittivity, ε_r	4.3
5	Ground Height, L_1	21.1097
6	Height of the feed gap, h	1.857
7	The width of the Feed line, w_1	1.4
8	Rectangle Patch Length,L_2	31
9	Rectangle Patch Width, W_2	30
10	Circle inner Radius, r_1	10.5
11	Circle Outer Radius, r_2	11.5
12	Triangle height, L_3	14

Figure 2: A Fabricated Antenna

Results and Discussion

The CST software is used to simulate the proposed model a Tri shaped printed patch antenna. The Vector Network Analyzer (N5224A) is used to measure the Return Loss S_{11} and VSWR.

The simulated and measured Return loss (S_{11}) result of the proposed antenna is shown in Fig. 3. The measured results are in good agreement with the simulated results having a value of $S_{11} \leq 10$ dB is from 4.94 GHz to 10.4 GHz.

The simulated and measured VSWR results of the proposed antenna are shown in Fig. 4. The simulated and experimental verified bandwidth of VSWR ≤ 2 is from 4.94 GHz to 10.4 GHz. Both of them cover almost the UWB of 3.1 – 10.6 GHz for short wireless communications.

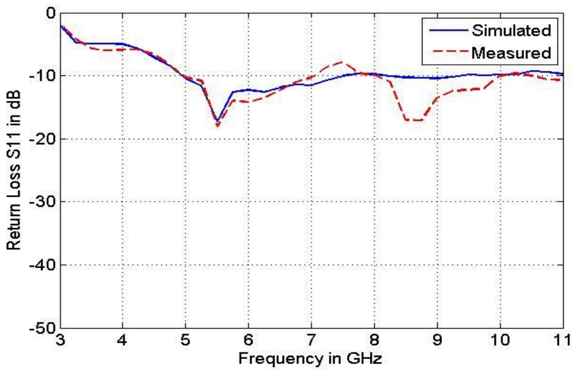


Figure 3: Frequency Vs. Return Loss

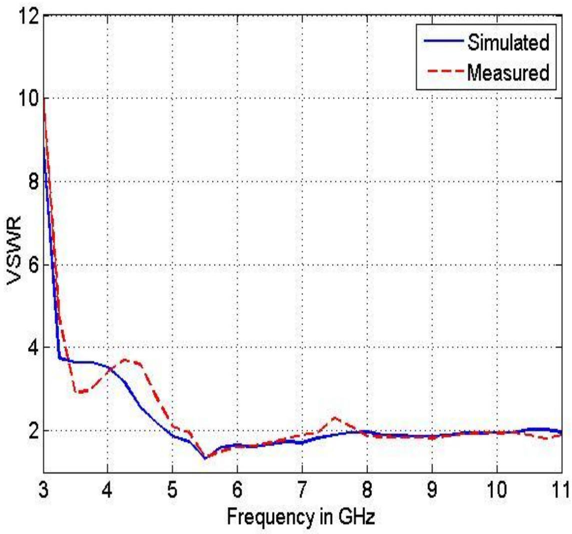
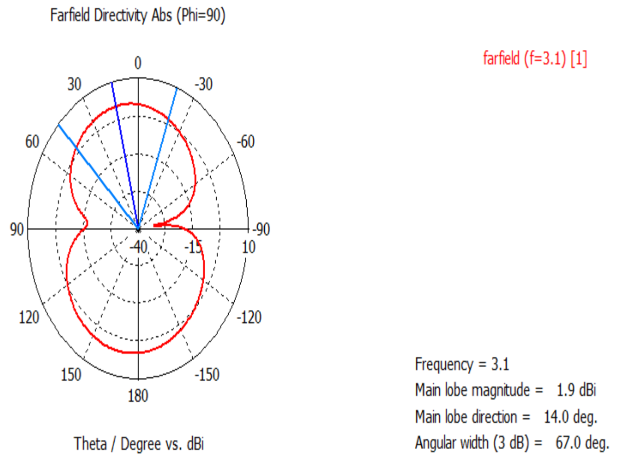
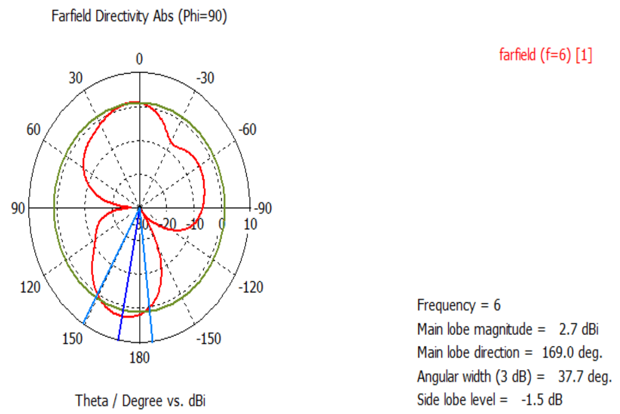


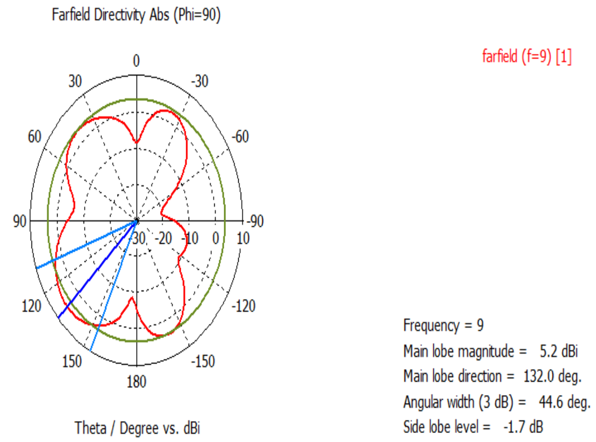
Figure 4: Frequency Vs VSWR Curve



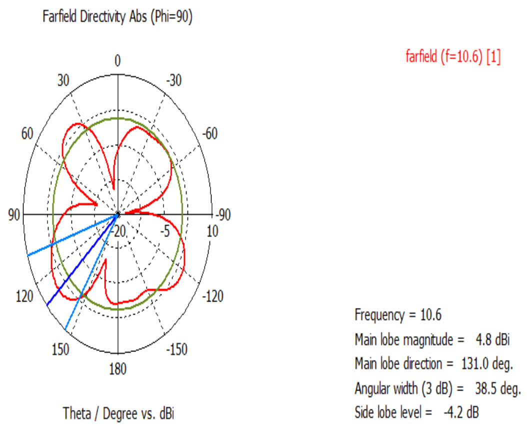
(a) Far field radiation pattern at 3.1 GHz



(b) Far field radiation pattern at 6 GHz

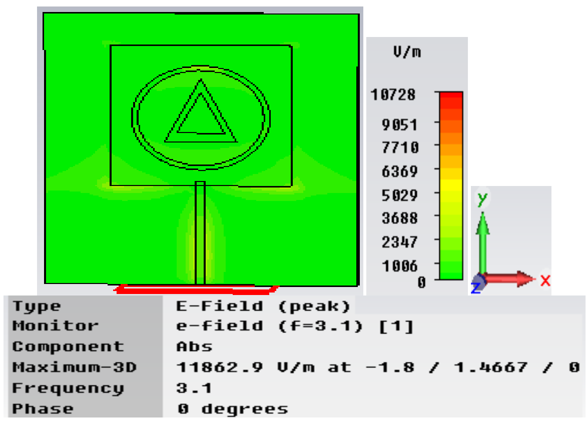


(c) Far field radiation pattern at 9 GHz

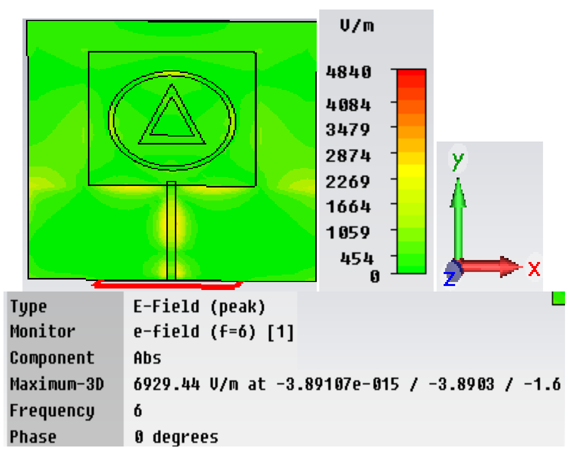


(d) Far field radiation pattern at 10.6 GHz

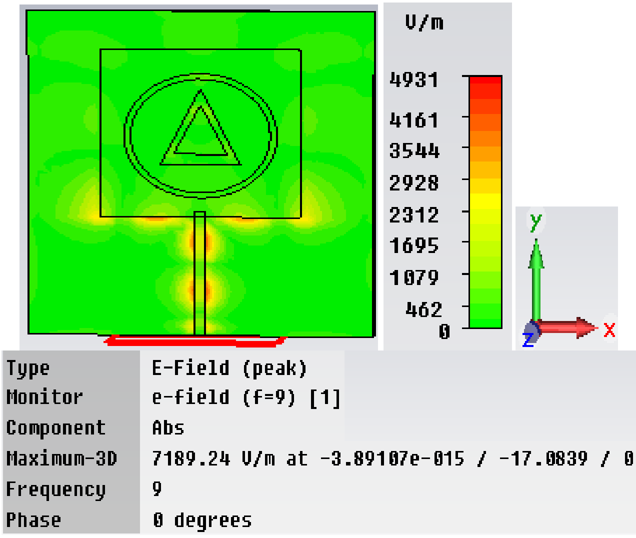
Figure 5: The simulated Far field radiation patterns at different frequencies (a) 3.1GHz (b) 6 GHz (c) 9 GHz (d) 10.6 GHz.



(a) E-field distribution at 3.1GHz

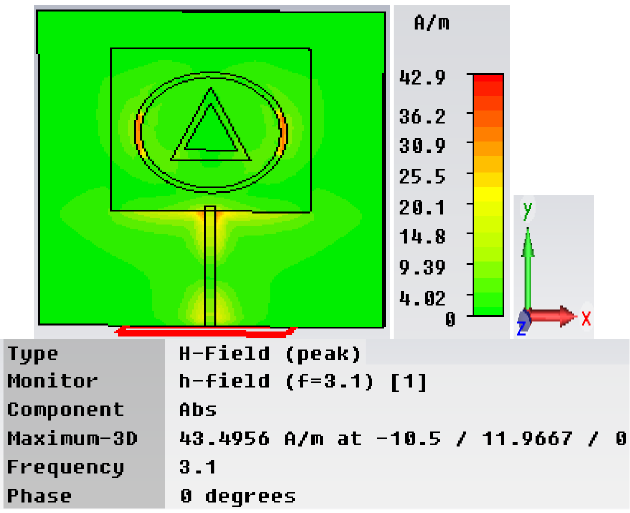


(b) E-field distribution at 6 GHz

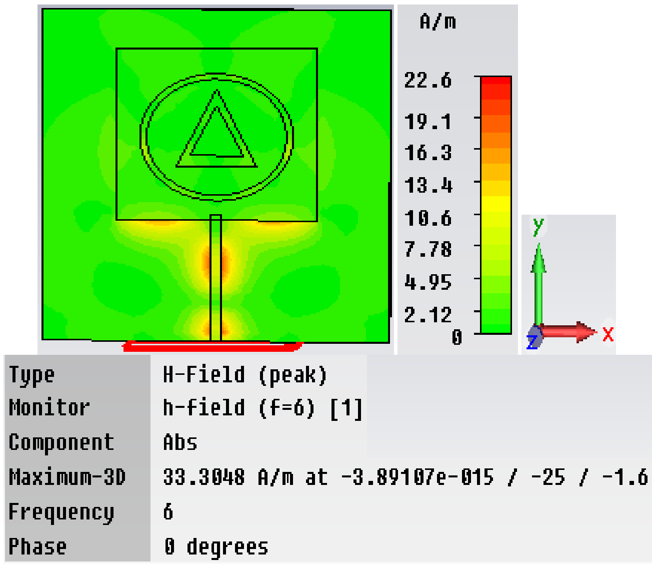


(c) E-field distribution at 9 GHz

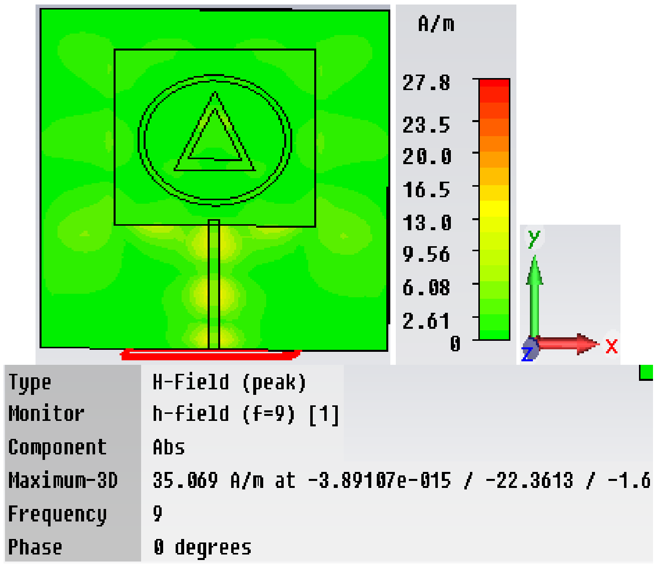
Figure 6: The simulated E-field distribution at 3.1GHz, 6GHz and 9GHz (a-c) of A Tri Shaped printed patch antenna.



(a) Current distribution of h-field at 3.1 GHz.



(b) Current distribution of h-field at 6 GHz



(c) Current distribution of h-field at 9 GHz

Figure 7: Simulated current distributions of h-field (a-c) of A Tri Shaped printed patch antenna.

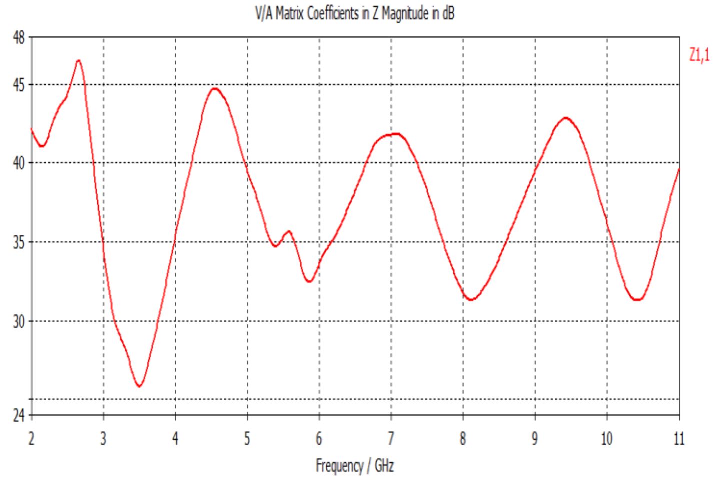


Figure 8: Impedance Vs Frequency

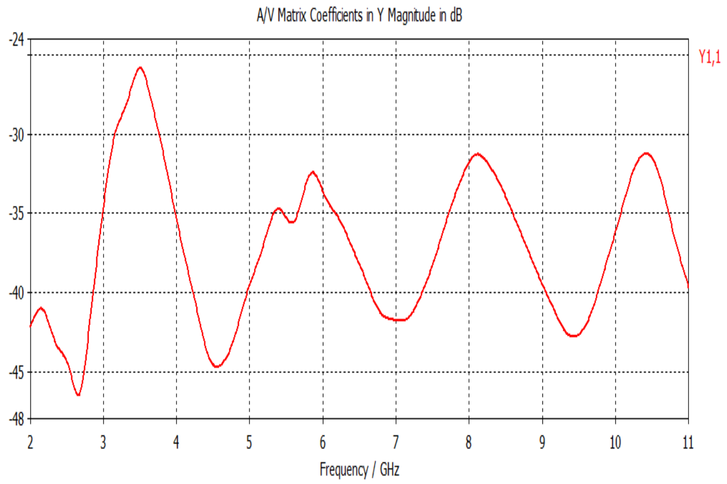


Figure 9: Admitance Vs Frequency

Fig.5. shows the simulated Far field radiation patterns at different frequencies (a) 3.1GHz (b) 6 GHz (c) 9 GHz (d) 10.6 GHz are approximately Omni-directional.

Fig.6. and Fig.7. Shows the simulated E-field distribution and current distributions of H-field at 3.1GHz, 6 GHz and 9 GHz (a-c) of a tri shaped printed patch antenna for UWB. Fig.8 and Fig.9 shows the Impedance Verses frequency and Admittance Verses frequency respectively.

Conclusion

A new ultra wideband (UWB) antenna has been proposed for UWB applications. The simulated results conducted by the CST Microwave simulator show reasonable agreement with the measured results. The entire frequency band almost obtained for

$S_{11} \leq 10$ dB and VSWR ≤ 2 is obtained from 4.94 GHz – 10.4 GHz. This antenna also applicable to non cooperative radar imaging, target sensor data collection and tracking .

Acknowledgment
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References

[1] Jianxin Liang, Choo C.Chiau, Xiaodong Chenan Clive G.Parini, "Study of a Printed Circular Disc Monopole antenna for UWB Systems IEEE Transactions on Antennas and Propagation, Vol.53, No.11, November 2005.

[2] C.C. Lin,Y.C.Lin, L.C.Kuo and H.R.Chuang , "A Planar Triangular Monopole Antenna for UWB Commnication,"IEEE Microwave and Wireless ComponentsLetters, Vol.15, No.10, October 2005.

[3] Seok. H.Choi, Jong K. Park, Sun K. Kim and Jae Y.Park "A New Ultra - Wideband Antenna for UWB Applications" Microwave and Optical Technology Lett. / Vol.40, No.5, March 5 2004.

[4] Ramu Pillalamarri , G. Sasi Bhushana Rao and S. Srinivasa Kumar, "Compact Printed Semi Circular Disc Micro strip Line fed Monopole Antennas for UWB Applications," Journal of Physical Sciences, Vol.13, 2009, 217-222.

[5] Mohamed Nabil Srifi, Symon K. Podilchak, Mohamed Essaaidi and Yahia M. M .Antar "Compact Disc Monopole Antennas for Current and Future UWB Applications," IEEE Transactions on Antennas and Propagation, Vol. 53, No .11, November 2005.

[6] Nenad Hecimovic and Zdenko Marincice "The Improvements of the Antenna Parameters in Ultra Wideband Communications".

[7] Fangfang Yan and Jiadong Xu "Design of Planar Monopole Antenna with Annulus Shape for Ultra Wide band Applications," PIERS Proceedings, Xi'an, China,March 22-26,2010.

[8] Garish Kumar and K.P.Ray, Broadband Microstrip antennas, Norwood: Artech House 2003.

[9] Micrstrip patch Antenna Design Hand Book by Ramesh Garg, Prakash Bhartia, Inder Bahl.

[10] Microstrip Patch Antennas by Rodney B. Water house.