ISSN: 0975-5662, Dec, 2013 www.ijrct.org

Performance evaluation of U shaped Monopole Antenna for Tri & Penta Band Wireless Applications

B. Raja Ramesh[1], D.Ramesh[2], USN Rao[3]

1. Department of ECE, Adams Engineering College, Paloncha, India e-mail: rajasgsbr@gmail.com,
2. Department of ECE, Medha institute of science & technology for women,khammam, INDIA e-mail: dasariramesh1985@gmail.com,
3. School of Electronics, Vignan University, INDIA, Vadlamudi, India e-mail: snece1980@gmail.com.

Abstract

In this paper, we have examined the behavior of a printed U-Shaped mono pole antenna. This antenna is in general a printed microstrip antenna with etched ground plane used for multi-band applications. To achieve this, we have designed and tested printed U-Shaped monopole antenna for tri-band and penta-band applications. First Printed U-Shaped monopole antenna has been designed for penta-band applications and later for tri-band applications. To do the design and analysis, microstrip patch antennas could be useful. As this type of antennas have low profile, confirmed to planar and non-planar surfaces, and are less expensive to fabricate. In this paper we have simulated U-shape Printed monopole antennas mainly for tri-band and penta-band applications and checked the important parameters. The concluding design structures have been presented after doing an extensive simulation study and analysis and presented relevant results.

Keywords:
Printed U-shaped, monopole, micro strip patch, radiation pattern, multi-band.

1. INTRODUCTION

Antennas, which can work properly in more than one frequency region either for transmitting or receiving electromagnetic (EM) waves, are termed as Multi-band antennas [1]. Such antennas are usually for tri-band, penta-band etc applications. Multi-band antennas are difficult in their design, structures and operations to single band antennas. In this paper we will investigate printed U-shape Printed monopole antennas with etched ground plane as shown in Figure 1(a) for tri-band and penta-band applications. The Multiband Antenna Technology has many significant developments as well as several applications in wireless and mobile communications. We can use single Multiband antenna instead of using several antennas for different frequency bands, which are called as "Multiband Antennas" for example WLAN integrated antennas (IEEE 802.11b/g), operate at 2.4GHz as well as 5GHz frequency bands respectively [4]- [5].

2. SIMULATION AS WELL AS EXPERIMENTAL RESULTS

2.1 Printed U-shaped Monopole antennas for Multi-band Applications

The U-shaped printed monopole antenna with partially etched ground plane designed for 2.4 GHz frequency of operation and fabricated on FR4 substrate with 4.4 dielectric constant and 1.6 mm thickness [16]. Antenna impedance is exactly 50 Ω. This U-Shaped Printed monopole antenna has designed directly from conventional rectangular printed monopole antennas by etching/removing some portion of rectangular radiating patch, eventually the Rectangular patch became U-Shape radiating patch. This modified monopole antenna have good Radiation Efficiency, huge bandwidth compare to rectangular printed monopole antennas and good impedance matching. This U-

Shape Printed monopole antenna can work for Multi -Band Applications.

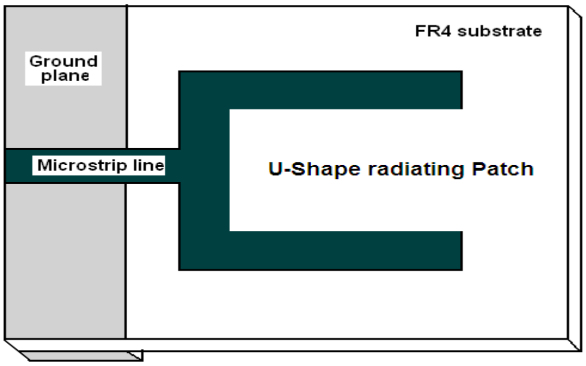


Fig 1(a) U-Shape monopole antenna with etched ground plane

The final dimensions are

1. Dimensions of Patch: W = 38.01mm and L = 30mm & t =0.035mm
2. Dimensions of Substrate: W = 38.01mm and L = 30mm & t =1.6mm
3. Dimensions of Micro strip line: W=3.12mm, L = 14.5mm & t =0.035mm
4. Dimensions of Ground: W = 42.01mm and L = (14.5-g) mm & t =0.5mm where 'g' = 4mm

Table I: Various parameters of Single Printed Monopole Antenna

W of GND Plane Mm	'g' value in mm	F_{LOW} GHz	F_{HIGH} GHz	Antenna Impedance Ω s	Band of Frequencies GHz	Radiation Efficiency %
10.5	4	1.35	3.4	50	2.05	97

In this antenna structure, some portion of ground plane was etched and some gap (g) was existed between the U-Shape radiating patch and ground plane below the substrate. This gap was played vital role in order to get broad bandwidth as well as impedance matching. After extensive simulation study, the final antenna dimensions were fixed. At particular value of gap (i.e. g = 4mm), the antenna is having maximum radiation efficiency and % bandwidth. The values of g are increased step by step then the antenna impedance, % bandwidth and antenna radiation efficiency are increasing proportionally.

2.2 Antenna Return loss Vs Frequency

The plot of antenna return loss (i.e., the scattering parameters S_{11} in dB, it can be seen that the bandwidth below -10dB ranges) versus frequency in GHz from 1.3 to 3.4 for the Printed monopole antenna and there are some small upward arrows indicates the resonant peaks. Note that this U-Shape Printed monopole antenna can work well for both tri-band and penta-band applications than conventional rectangular printed monopole antennas in frequency bandwidth.

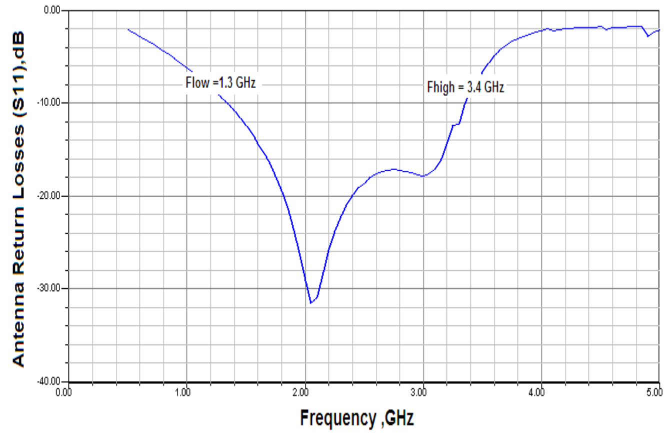


Figure 1(b): Simulated results of Printed U-Shaped monopole antenna (s_{11} Vs frequency)

Bandwidth of the monopole antenna is starting from 1.3GHz to 3.4 GHz. Note that the present L band (1-2GHz), this antenna can work well for S-band (2-4 GHz) applications, viz. Digital Communication System (DCS, 1710-1880MHz), Personal Communication System (PCS, 1850-1990MHz), Universal Mobile Telecommunication System (UMTS, 1920-2170MHz), Global Positioning System (GPS, 1575.42MHz, 1227.60MHz, 1371.913 MHz, 1381.05MHz) and Digital Audio Broadcasting (DAB L Band, 1452 MHz to 1490 MHz).

2.3 Antenna Impedance Vs Frequency

The figure below shows that the real part of the impedance of antenna at the point (frequency) where the imaginary part of impedance is zero i.e. reactance = 0 and resistance is equal to antenna impedance. Here antenna is fed with 50 Ohms characteristic impedance. Micro strip line and antenna impedance is exactly 50 Ohms (i.e. load impedance is matched with the source impedance)

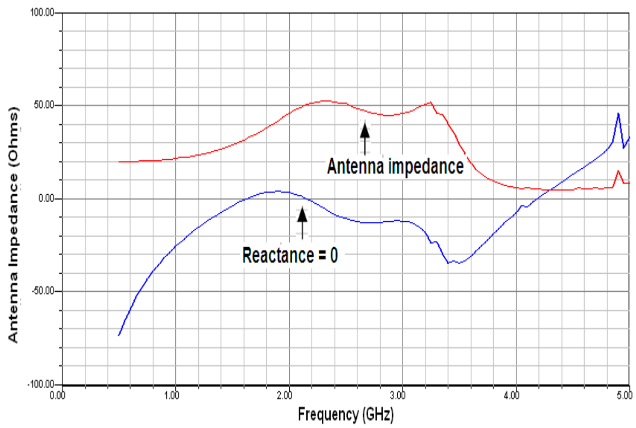
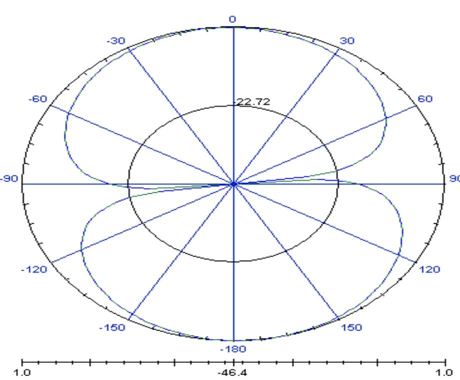


Figure 1(c): Antenna impedance vs frequency (real part and imaginary part of antenna impedance)

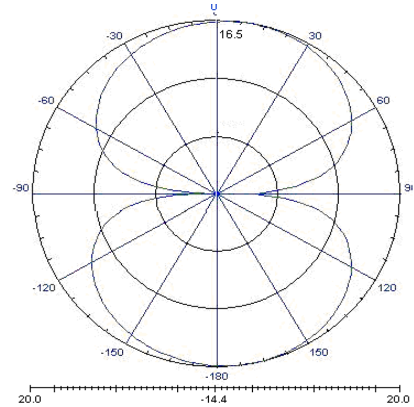
Throughout the bandwidth of the Printed monopole antenna, the real part of the antenna impedance varies from 50 Ω to 55 Ω whereas the imaginary part of the antenna impedance is in the range -10 Ω to 0 Ω that is not a major variation of the antenna impedance (it indicates good impedance matching).

2.4 Simulated E-plane Radiation Pattern

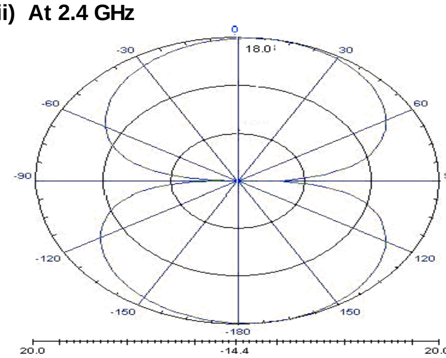
The simulated E-Plane radiation patterns (vertical plane or vertical cut of 3D radiation pattern) of the Printed U-Shaped monopole antenna at 'g' value 4 mm at different frequencies are shown in the figure below from lower cutoff frequency to higher cutoff frequency in the band of frequencies. The radiation pattern is a function of **(θ, φ).** The E-planes are measured at fixed value of **"θ** (Elevation angle)**"**, varying the value of "**φ** (Azimuth angle)**"** from 0 degrees to 360 degrees [18].



(i) At 1.3 GHz



(ii) At 2.4 GHz



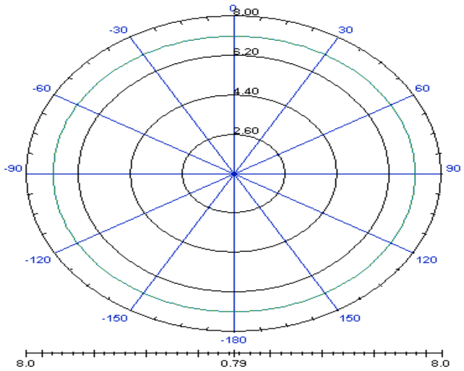
(iii) At 3.4 GHz

Figure 1(d): E-plane radiation patterns (i) at 1.3GHz (ii) at 2.4GHz (iii) at 3.4GHz

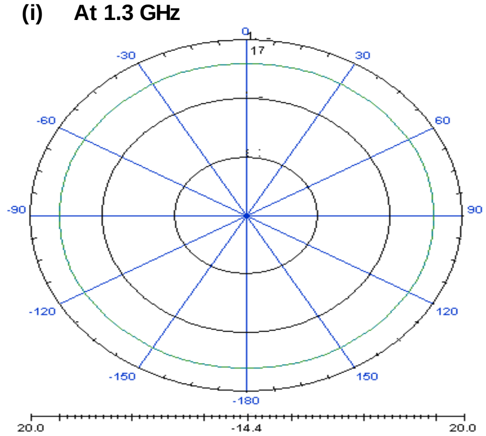
Figure 1(d) depicts the radiation pattern of the Printed U-Shaped monopole antenna at mid-band frequency of 2.4 GHz. It has a null at z = 0 and it is in the form of 8. In overall radiation patterns assume the form of an Omni directional pattern. If the width of the patch is varied, we cannot control and obtain the desired impedance and resonant frequency of the antenna properly.

2.5 Simulated H-plane Radiation Pattern

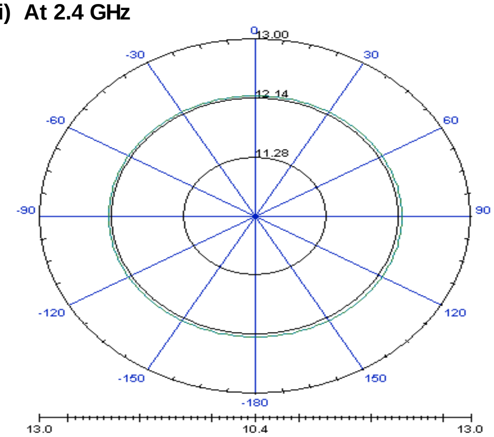
The simulated H-Plane radiation patterns (horizontal plane or horizontal cut of 3D radiation pattern) of the Printed monopole antenna with at 'g' value 4 mm at different frequencies are shown in the figure below. The radiation pattern is a function of **(θ, φ).** The H-planes are measured at fixed value of "**φ"**, varying the value of "**θ"** from 0 degrees to 180 degrees in both clock wise and counter clock wise directions.



(i) At 1.3 GHz

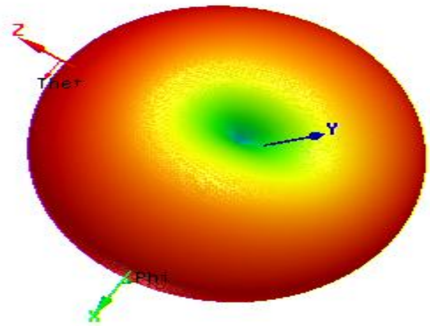


(ii) At 2.4 GHz

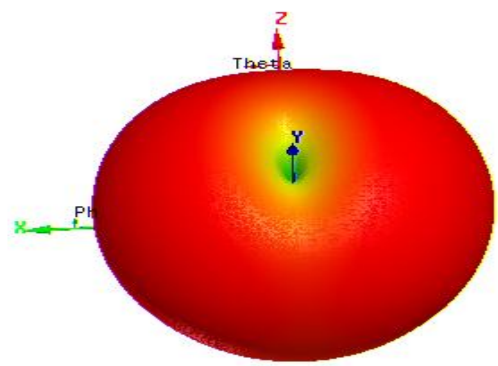


(iii) At 3.4 GHz

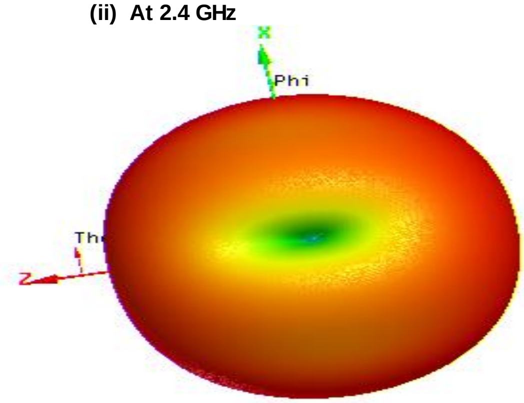
Figure 1(e): H-plane radiation patterns (i) at 1.3GHz (ii) at 2.4GHz (iii) at 3.4GHz



(i) At 1.3 GHz



(ii) At 2.4 GHz



(iii) At 3.4 GHz

Figure 1(f): 3D patterns (i) at 1.3GHz (ii) at 2.4GHz (iii) at 3.4GHz

2.6 Simulated 3D Radiation Plot

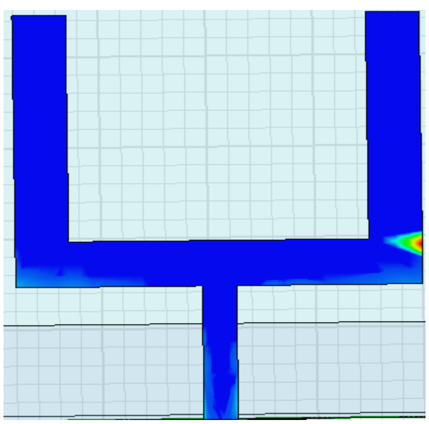
The simulated 3D radiation pattern of the resonances are shown in the below figure. The radiation pattern looks like a doughnut, similar to that of a dipole pattern, at the lower cut off frequency i.e. 1.3GHz. At the mid frequency i.e. at 2.4GHz and the Higher cut off frequency i.e. at 3.4 GHz the radiation pattern is slightly distorted somewhat like pinched doughnut (i.e. Omni directional). As the frequency moves toward the upper end of the bandwidth the radiation pattern is slightly distorted as it reaches higher frequencies (i.e. 3.4GHz.).

The transition of the radiation patterns from a simple doughnut at the Lower cut off frequency to the complicated radiation patterns at the higher frequencies indicates that this antenna must have gone through major changes in its behavior but it had Omni directionality, this was possible because of the partial ground plane [17] i.e. 'g' the gap between the ground plane and the patch which was a major factor for perfect impedance matching of the antenna, due to the proper impedance matching the antenna has very less reflections. As the impedance matching was good the radiation power and radiation intensity were very high. After extensive simulation study the 'g' value was fixed at 4mm.

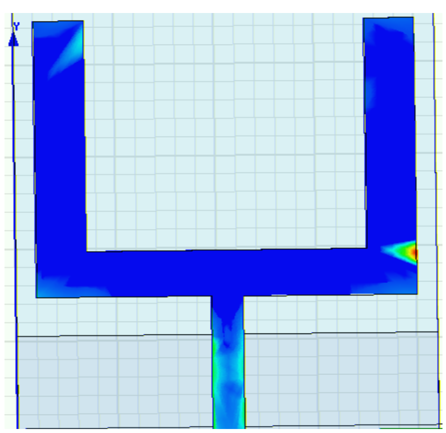
ISSN: 0975-5662, Dec, 2013 www.ijrct.org

2.7 Simulated Current Distribution Plot

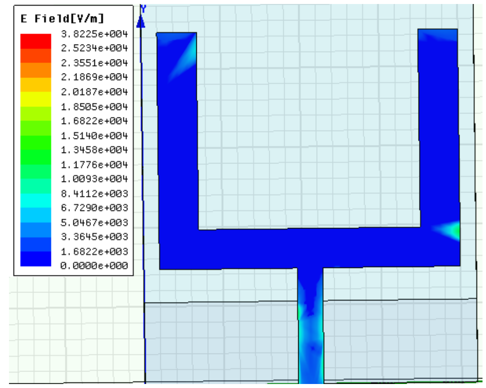
The simulated current distribution pattern of the frequencies are shown in the below figure. It can be observed from the figure that the current distribution at 1.3GHz is indicating a first order harmonic, at 2.4GHz its indicating second harmonic. As frequency increases the current distribution becomes more complicated indicating to a third order harmonic at 3.4GHz. At the Lower cut off frequency, the current is oscillating and having a pure standing wave pattern along most part of the edges of the patch. So the patch acts as oscillating monopole, but the variation of current becomes more complicated at higher frequencies. The antenna operates in a hybrid mode of traveling waves and standing waves at higher frequencies, but the ground plane on the other side of the substrate cannot form good slot with the patch to support traveling waves. Therefore the impedance matching becomes worse for the traveling wave dependent modes at higher frequencies.



(i) At 1.3 GHz



(ii) At 2.4 GHz



(iii) At 3.4 GHz

Figure 1(g): Current distribution plots: (i) at 1.3GHz (ii) at 2.4GHz (iii) at 3.4GHz

The dimensions of the Printed U-Shaped monopole antenna illustrated in Fig 1 (a) using FR4 substrate after doing an extensive simulation study were calculated as patch and substrate W=38.01mm, L=30mm, ground width chosen are W=42.01mm, L=(14.5-g)mm, gap between the ground plane and patch antenna g=4mm.The scattering parameters S_{11} in dB versus frequency in GHz from 1.3GHz to 3.4GHz for the compact Printed U-Shaped monopole antenna, which can be fitted in a cellular mobile phone, is obtained using Network Analyzer and is plotted in fig 1(b). The printed U Shaped monopole antenna bandwidth is from 1.3GHz to 3.4GHz at the mid frequency of 2.4GHz. U-Shape Printed monopole antenna can work well for both tri-band 1-2GHz and penta-band 2- 4 GHz applications than conventional rectangular printed monopole antennas in frequency bandwidth, viz. Digital Communication System (DCS, 1710-1880MHz), Personal Communication System (PCS,1850-1990MHz),Universal Mobile Telecommunication System (UMTS, 1920-2170MHz), Global Positioning System (GPS, 1575.42MHz,1227.60MHz,1371.913 MHz, 1381.05MHz) and Digital Audio Broadcasting (DAB L Band, 1452 MHz to 1490 MHz). The radiation pattern of the Printed U-Shaped monopole antenna is depicted in Fig. 1(d) and Fig 1 (e). The radiation pattern looks like a doughnut, similar to that of a dipole pattern, at the lower cut off frequency i.e. 1.3GHz. At the mid frequency i.e. at 2.4GHz and the Higher cut off frequency i.e. at 3.4 GHz the radiation pattern is slightly distorted somewhat like pinched doughnut (i.e. Omni directional). As frequency increases the current distribution becomes more complicated indicating to a third order harmonic at 3 GHz.

3. CONCLUSION

In this paper we have investigated Printed U-Shaped printed monopole antenna which is basically a printed micro strip

ISSN: 0975-5662, **Dec, 2013** **www.ijrct.org**

antenna with etched ground plane for multi-band antennas for both tri-band 1-2GHz and penta-band 2- 4 GHz applications . Printed monopole antennas are less fragile, planar and can be integrated with the integrated circuits [16] unlike monopole antennas which have non-planar or protruded structures above the ground plane. In particular we have fabricated and tested printed monopole antennas for multi-band applications. U-Shaped printed monopole antenna was analyzed and designed directly from the simple rectangular printed micro strip patch antenna with some modifications on the radiating patch (i.e. etching some part of the rectangular patch) and the remaining structure is kept the same, eventually the rectangular patch become U-Shape radiating patch. The value of "g" is fixed at 4mm for this monopole antenna. After doing an extensive simulation study only, the final dimensions are fixed and designed as per the frequency regulations for both tri-band and penta-band applications.

REFERENCES

1. C. A. Balanis, Antenna Theory Analysis and Design, John Wiley & Sons Inc., 1997.
2. D. M. Pozar, Microwave Engineering, John Wiley & Sons Inc., NJ, 2005.
3. K. P. Ray and Y. Ranga, "Printed Rectangular Monopole Antennas," IEEE Antennas and Propagation Society International Symposium, pp.1693-1696, 9-14 July, 2006.
4. N. P. Agrawall, G. Kumar and K. P. Ray, "Wide-Band Planar Monopole Antennas," IEEE Transactions on Antennas and Propagation, vol. 46, no. 2, February 1998, pp. 294-295.

5. K. R. Carver and J. Mink, "Microstrip Antenna Technology," IEEE Trans. Antennas Propagation., vol. AP-29, no. 1, pp. 74-77, Jan. 1981.
6. S. K. Palit, and A Hamadi, "A dual-band notch microstrip antenna for mobile communications," Asia-Pacific Microwave Conference Proceedings, Dec. 1996, vol. I, pp. 299-302.
7. G. L. Matthaei, L. Young and E. M. T. Jones, Microwave filters, Impedance-matching networks and coupling structures, Artech House, MA, 1980.
8. J. Liang, C. Chiau, X. Chen and J. Yu, "Study of a circular disc monopole antennas for ultra wideband applications," 2004 International Symposium on Antennas and Propagation, 17-21 August, 2004.
9. R. Pillalamarri and R. S. Kshetrimayum, "Single Printed Monopole Antenna and Notched Antenna with Triangular Tapered Feed Lines for Triband and Penta band Applications," in Proc. IEEE Indicon 2007, Bangalore, Sept. 2007.
10. R. Pillalamarri, R. S. Kshetrimayum and D. Dey, "Accurate Determination of Antenna Impedance of Microstrip Line-Fed Patch Antennas," in Proc. IEEE Indicon 2007, Bangalore, Sept. 2007.
11. S.-T. Fan, Y.-Z. Yin, H. Li, S.-J. Wei, X.-H. Li, and L. Kang "A NOVEL TRI-BAND PRINTED MONOPOLE ANTENNA WITH AN ETCHED \-SHAPED SLOT AND A PARA- SITIC RING RESONATOR FOR WLAN AND WIMAX APPLICATIONS" in Progress in Electromagnetics Research Letters, Vol. 16, pp 61-68, 2010.
12. L. Zhu, R. Fu and K. L. Wu, "A novel broadband microstrip-fed wide slot antenna with double rejection zeros," IEEE Antennas and Wireless Propagation Letters, vol. 2, 2003.
13. J. Jung, W. Choi, and J. Choi, "A Small Wideband Microstrip-fed Monopole Antenna" IEEE Microwave and Wireless Components Letters, vol. 15, No. 10, October 2005, pp. 703-705.
14. Shams, K. M. Z., M. Ali, and H.-S. Hwang, "A planar inductively coupled bow-tie slot antenna for WLAN application" *Journal of Electromagnetic Waves and Applications*, Vol. 20, No. 7, pp 861-871, 2006.
15. M. N. Suma, R. K. Raj, M. Joseph, P. C. Bybi and P. Mohanan , "A compact dual band planar branched monopole antenna for DCS/2.4-GHz WLAN applications," *IEEE Microw. Wireless Comp. Lett.*,vol. 16,no.5, pp.275-277, May 2006.
16. Ramu Pillalamarri, Jyothi Rnjan, and Rakesh Singh Kshetrimayum, "Printed UWB Circular and Modified Circular Disc Monopole Antennas", ACEEE International Journal on Communication, Vol.1, No.1, Jan 2010, pp. 13-15.
17. Ramu Pillalmarri, G. Sasi Bhushana Rao and S. Srinivasa Kumar, "Novel Printed Circular Disc Microstrip Line fed Monopole Antennas for UWB Applications", ACTA ELECTROTECHNICA, Vol. 50, No.3, 2009, pp. 205-209.

18. Rec. ITU-R P.681-6 "Propagation data required for the design of Earth-space land mobile telecommunication systems" pp.1-27.

B. Raja Ramesh received the B.Tech. Degree in Electronics and Communication Engineering from Jawaharlal Nehru Technological University, Hyderabad and M.Tech in Systems and Signal Processing from Jawaharlal Nehru Technological University, Hyderabad, is a faculty member at the department of Electronics and Communication Engineering, Adams Engineering College, Paloncha and presently working as Associate Professor. His research interests include Broadband, Multiband and UWB Antennas.

D. Ramesh received the B.Tech. Degree in Electronics and Communication Engineering from Jawaharlal Nehru Technological University, Hyderabad in 2006 and M.Tech in Systems and Signal Processing from Jawaharlal Nehru Technological University, Hyderabad in 2011, is a faculty member in the department of Electronics and Communication Engineering, Medha Institute of Science and Technology for Women, Khammam and presently working as Associate Professor. His research interests include VLSI, Signal processing, Antennas.

USN Rao received B. Tech degree in Electronics and Communication Engineering from JNTU Hyderabad and M. Tech from NIT Bhopal, is currently

ISSN: 0975-5662, Dec, 2013 www.ijrct.org

working at Vignan University Guntur as Asst Professor in School of Electronics. His research interests include Renewable Energy Technologies, Digital Signal Processing, and Antenna Design.

