ISSN 2319 - 6629
Volume 6, No.4, June - July 2017
International Journal of Wireless Communications and Networking Technologies
Available Online at http://warse.org/IJWCNT/static/pdf/file/ijwcnt03642017.pdf

Design and Analysis of Duplex Compacted Patch Antenna

A.Mary Joy Kinol [1], T.Sunitha Biji [2], Sharmila Hemanandh [3] Rajat Kumar Diwbedi [4],
[1] alphonse.kinol@gmail.com, [2] bijiraj29@gamil.com,
[3] sharmilaahemanandh@gmail.com [4] rajatsrr@gmail.com
[1,2,3,4] Department of Electronics and Communication Engineering,
Jeppiaar SRR Engineering college,Padur,Chennai-603103

Abstract: A novel coplanar waveguide (CPW)-fed dual-band dual-mode patch antenna for on-/off-body communications is proposed. The proposed antenna, which comprises a T-shaped patch with parasitic patches, a circular patch, and a CPW feed line, has dimensions of 30 mm × 45 mm × 3.2 mm. The proposed antenna operates in the 2.4 GHz ISM band (2.4 – 2.485 GHz) for off-body communication, and in the 5.8 GHz ISM band (5.725 – 5.875 GHz) for on-body communication. The antenna has a patch-like radiation pattern in the 2.4 GHz ISM band and a monopole-like radiation pattern in the 5.8 GHz ISM band. The parameters like radiation pattern, gain, directivity and VSWR are discussed using HFSS software.

***Keywords*-** CPW, ISM band, VSWR, off-body communication, on-body communication.

1. INTRODUCTION

In this rapid changing world in wireless communication systems, multiband antenna plays an important role for wireless service requirements. The current trend in commercial and government communication systems have been to develop low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. Within this operating range of frequency, the antenna should have stable response in terms of gain, radiation pattern, polarization etc. At the same time it should be of small size, conformal, low cost and should be easily integrated into the RF circuits. Microstrip patch antenna can also be printed directly onto circuit board. Since the slotted microstrip patch antenna requires few materials, it is low cost, easy to manufacture and light weight. These characteristics make slotted microstrip patch antennas ideal for use in cell phones and other small electronic devices. The size of the microstrip patch antenna is inversely proportional to its frequency. For this reason, microstrip patch antennas are generally used for ultra-high frequency signals. Slotted microstrip patch antenna is capable of sensing frequencies lower than microwave would be too large to use. With the rapid development of modern communication and semiconductor technologies, a wide variety of wireless service has been successfully introduced worldwide in the past few years. Antenna plays a vital role in any wireless communication. A well designed antenna relaxes the complexity and improves the performance of the receiver. The dimension, type and the configuration of the antenna depends on the application and the operating frequency. In WBANs, small battery operated on-body or implanted biomedical sensor nodes are used to monitor physiological signs such as temperature, blood pressure, Electro Cardio Gram (ECG),Electro Encephalography (EEG) etc.(1) Dual-mode compact microstrip antenna based on the fundamental backward wave supported by a composite right/left-handed (CRLH) metamaterial transmission line (TL) is demonstrated.(2) A textile microstrip patch antenna on strip line to realise a switchable on/off-body communication system at 2.45GHz is presented. Two PIN diodes are employed to achieve a reconfigurable strip line network with two output strip lines, one for feeding the antenna through an aperture electromagnetically (off body mode), and the other for propagating signals along the transmission line (on body mode).(3)A novel planar inverted-F antenna (PIFA), incorporating a triangular Sierpinski gasket, is presented. The used conducting textile and polyester fleece allow easy on body integration and simple practical fabrication. It shows dual-band response, combining a 16 % band at 2.45 GHz with an upper 12 % band at 5.2 GHz. (4) The resonant-type metamaterial transmission line can provide zeroth-mode resonance at the lower frequency and positive-mode resonance at the upper frequency.(5) This paper also presents the challenges and considerations when designing a suitable wearable antenna. In recent years, there has been increasing concern about the safety of WBAN systems, particularly wearable electronics, over a multitude of applications including medical, entertainment and military.(6) The proposed antenna is implantable in human body for monitoring the patient’s health. Radiation loss and operating bandwidth of the antenna were measured using vector network analyzer (VNA). (7) Dual band patch antenna by loading a U-slot metamaterial structure on the rectangular patch. When one additional U-slot was introduced then antenna covers another two bands that are different from antenna loaded with one U-slot. (8)

2. PROPOSED ANTENNA ARRAY

The three essential parameters for the design of a slotted microstrip patch are given below. Frequency of operation (f0): The resonant frequency of the antenna must be selected appropriately. For dual band operation the frequency range selected is from 2-6 GHz. Hence the antenna designed must be able to operate in this high frequency range. The resonant frequency selected for my design is 2.4GHz and 5.8GHz. Dielectric constant of the substrate (□r): The dielectric material selected for our design FR4 which has a dielectric constant of 4.4. A substrate with a low dielectric constant has been selected. Since it increased the bandwidth of the antenna. Height of dielectric substrate (h): For the microstrip patch antenna to be used in dual band applications, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 3.2mm. Hence, the essential parameters for the design are

Frequency of operation (f0) = 2.4 GHz and 5.8GHz.

Dielectric constant of the substrate (□r) = 4.4

Height of the dielectric substrate (h) = 3.2mm

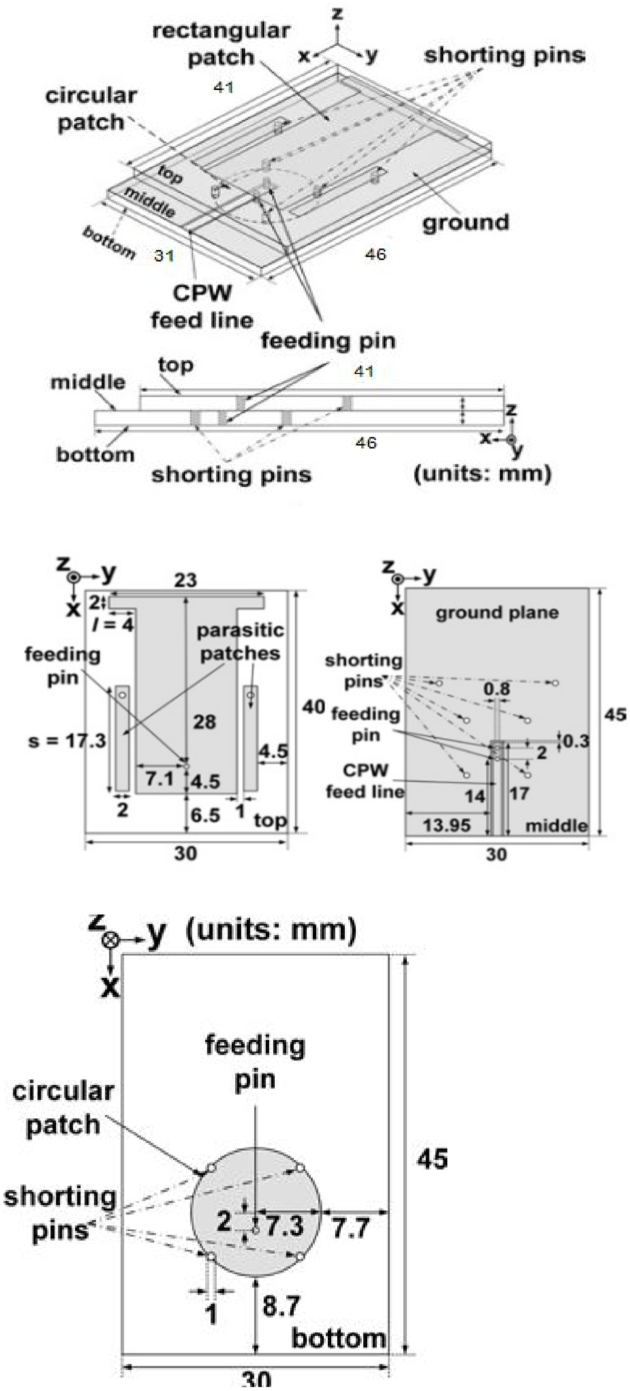

Figure1. Proposed Antenna Geometry

The proposed antenna which indicates the radiator fed with microstrip feed line. The radiator consists of slot along with the feed in the in the radiating edge. These slot with the feed reduce the return loss to a greater extent.The proposed antenna is designed by cutting single slot in patch to make it a slotted antenna. Cutting of slots in antenna increases the current path which increases the current intensity, as a result efficiency is increased. The basic structure of antenna consists of ground plane, substrate, patch and feed line. The transmission line is the preferred method of analysis for calculating the various dimensions of the slotted microstrip patch antenna.The transmission line model is applicable to infinite ground planes only. However, for practical considerations it is essential to have a finite round plane. It has been shown by that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater the patch dimensions by approximately six times the substrate thickness all-round the periphery.

3. ANALYSIS PROCEDURE

(a) Rectangular Patch

Substrate thickness, h = 1.6mm.

Substrate dielectric constant, ε_r = 4.4

Resonant frequency, f_r = 2.45GHZ

Width and Length Of The Rectangular Patch

$$W=\frac{c_0}{2*f_r}\sqrt{\frac{2}{1+\varepsilon_r}}$$

Where, c_0= velocity of light.

$c_0 = 3*10^8$ m/s.

W=22.6 mm.

Width of the rectangular patch, W=23 mm.

$$\varepsilon_{reff}=\frac{1+\varepsilon_r}{2}+\frac{-1+\varepsilon_r}{2}\left[1+\frac{12*w}{h}\right]^{\frac{-1}{2}}$$

ε_{reff} = 3.9495

$$\frac{\Delta L}{h}=0.412*\frac{(0.3+\varepsilon_{reff})\left(0.264+\frac{w}{h}\right)}{(-0.258+\varepsilon_{reff})\left(0.8+\frac{w}{h}\right)}$$

ΔL = 0.07316

$$L=\frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}}-2\Delta L = 31.98\text{mm}.$$

Length of the rectangular patch, L=33.5 mm

(b). CIRCULAR PATCH

Radius of the circular patch, $a=\frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}}$

Where, $F=\frac{8.791*10^9}{f_r\sqrt{\varepsilon_r}}$ and f_r = 5.8GHZ.

F =0.7226

a= 6.82 mm.

Effective radius of the circular patch,

$$A=a\left\{1+\frac{2h}{\pi\varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}$$

A=7.26 mm

A=7.3 mm

Length of the substrate

l=6h+L

l=41.56 mm.

l=40 mm.

Width of the substrate

w =6h+W

w=32.2 mm

w=30 mm.

4. Results and Discussions

The Dual band compact microstrip patch antenna with slot using microstrip feed line as a feeding technique, which gives the return loss or reflection coefficient value as -26dB in the frequency range of 5.2 GHz. The transmission feed used in design to have a frequency range of 2.4 GHz is selected and frequency points are selected over this range to obtain accurate results. The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible. Graphical representation of the spatial distribution of the radiation from an antenna is represented as a function of angle. The proposed antenna is showing Bi directional pattern.

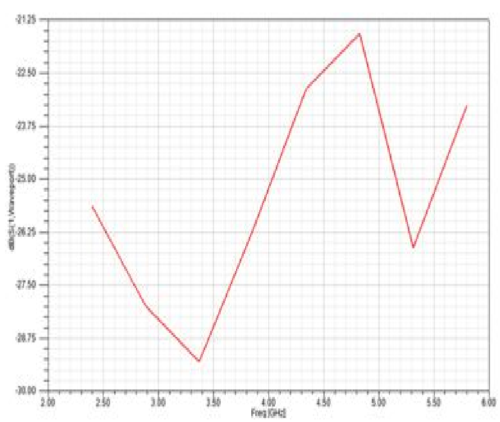

FIG 4.1 S-PARAMETER

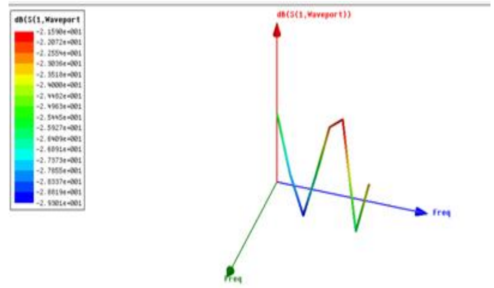

FIG 4.2 3-D S-PARAMETER

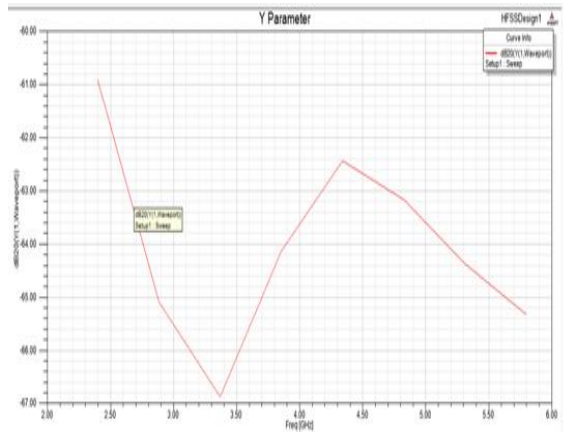

FIG 4.3 Y-PARAMETER

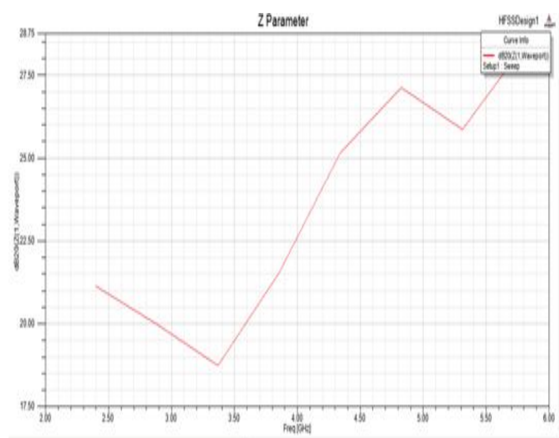

FIG 4.4 Z-PARAMETER

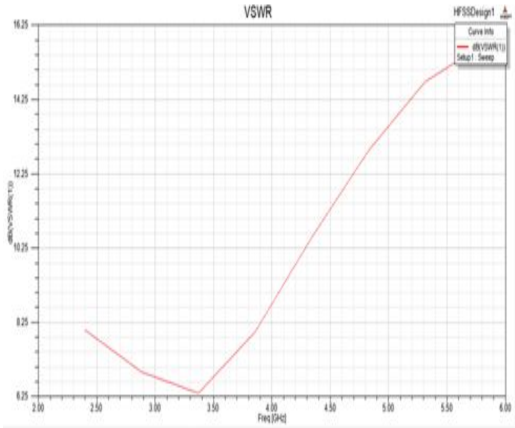

FIG 4.5 VSWR

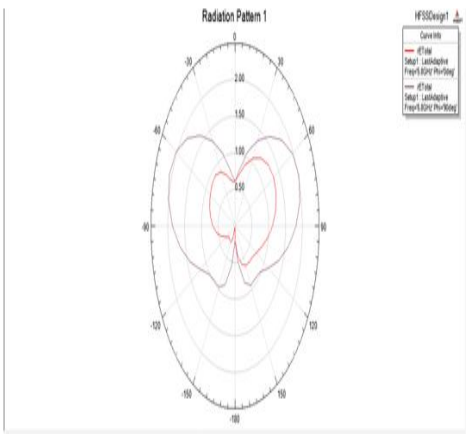

FIG 4.6 XZ-PLANE RADIATION PATTERN

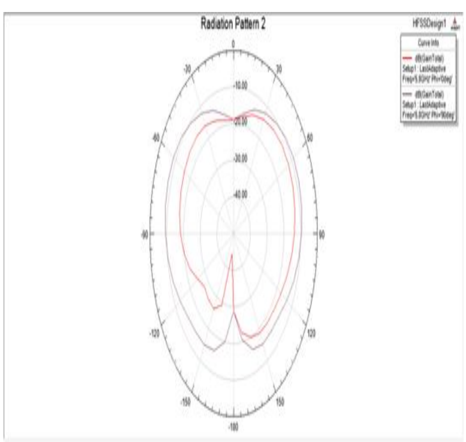

FIG 4.7 YZ-PLANE RADIATION PATTERN

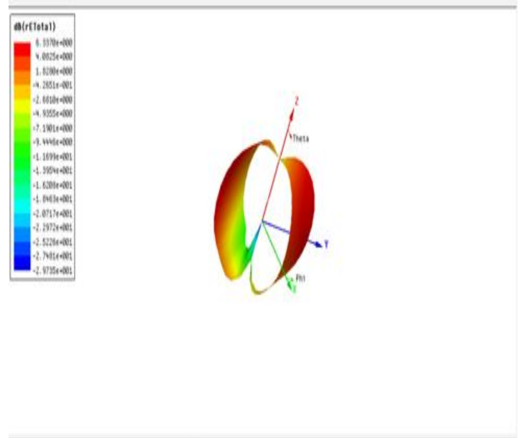

FIG 4.8 3D RADIATION PATTERN

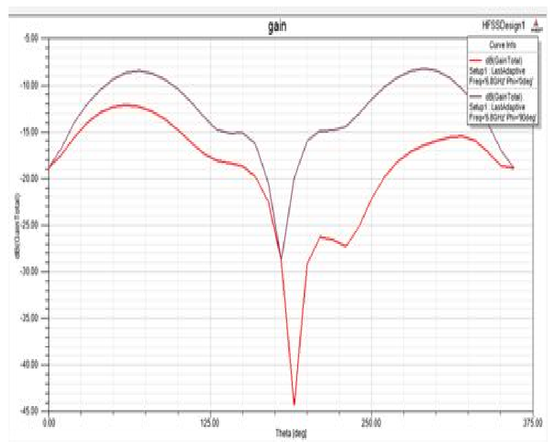

FIG 4.9 GAIN

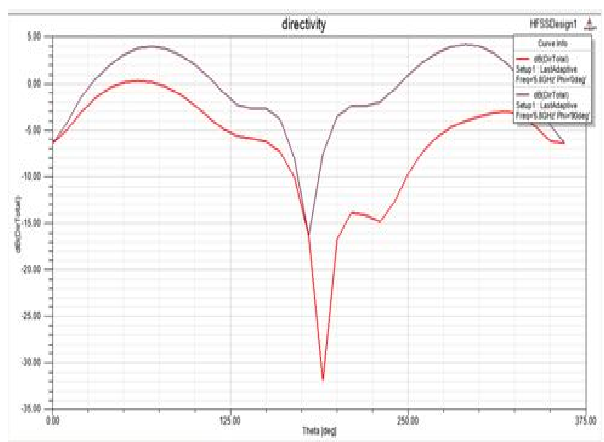

FIG 4.10 DIRECTIVITY

5.CONCLUSION

A patch antenna in the radiator and partial ground plane has been designed and simulated. The proposed antenna exhibits two bands; it supports for 2.4 GHz and 5.8GHz as well as good radiation properties. Therefore this antenna suitable for Super High Frequency application are other wireless applications that works in these frequencies.

Patch antenna for dual band frequency for wireless body area applications is simulated.

REFERENCES

[1] S. Gao, Q. Luo, and F. Zhu, **"Circularly polarized antennas,"** Wiley IEEEPress, New York, November 2013.

[2] S. Verma and P. Kumar, **"Compact triple-band antenna for WiMAX andWLAN applications**," Electron. Lett., vol. 50, no. 7, pp. 484–486, 2014.

[3] T. Wu, X. W. Shi, P. Li, and H. Bai, **"Tri-band microstrip-fed monopoleantenna with dual-polarisation characteristics for WLAN and WiMAXapplications,"** Electron. Lett., vol. 49, no. 25, pp. 1597–1598, 2013.

[4] T. T. Le and H. C. Park, **"Very simple circularly polarised printed patchantenna with enhanced bandwidth,"** Electron. Lett., vol. 50, no. 25, pp.1896–1898, 2014.

[5] J. G. Baek and K. C. Hwang, **"Triple-band unidirectional circularlypolarized hexagonal slot antenna with multiple L-shaped slits,"** IEEETrans. Antennas Propag., vol. 61, no. 9, pp. 4831–4835, 2013.

[6] X. L. Bao and M. J. Ammann, **"Printed triple-band circularly polarisedantenna for wireless systems,"** Electron. Lett., vol. 50, no. 23, pp.1664–1665, 2014.

[7] T. V. Hoang and H. C. Park, **"Very simple 2.45/3.5/5.8 GHz triple-bandcircularly polarised printed monopole antenna with bandwidthenhancement,"** Electron. Lett., vol. 50, no. 24, pp. 1792–1793, 2014.

[8] K. Agarwal, Nasimuddin, and A. Alphones, **"RIS-Based compactcircularly polarized mircostripantennas,"**IEEE Trans. Antennas Propag.,vol. 61, no. 2, pp. 547–554, 2013.

[9] K. Agarwal, Nasimuddin, and A. Alphones, **"Triple-band compactcircularly polarised stacked microstrip antenna over reactive impedancemeta-surface for GPS applications**," IET Microw. Antennas Propag., vol.8, no. 13, pp. 1057–1065, 2014.

[10] H. L. Zhu, S. W. Cheung, K. L. Chung, and T. I. Yuk, **"Linear-to-circularpolarization conversion using metasurface,"** IEEE Trans. AntennasPropag., vol. 61, no. 9, pp. 4615–4623, 2013.

[11] S. Clavijo, R. E. Diaz, and W. E. McKinzie, **"Design methodology forsievenpiper high-impedance surfaces: An artificial magnetic conductorfor positive gain electrically small antennas,"** IEEE Trans. AntennasPropag., vol. 51, no. 10, pp. 2678–2690, 2003.

[12] A. E. I. Lamminen, A. R. Vimpari, andJ. Saily**, "UC-EBG on LTCC for60-GHz frequency band antenna applications,"** IEEE Trans. AntennasPropag., vol. 57, no. 10, pp. 2904–2912, 2009.

[13] F. Yang and Y. Rahmat-Samii, **"A low profile single dipole antennaradiating circularly polarized waves,"** IEEE Trans. Antennas Propag.,vol. 53, no. 9, pp. 3083–3086, 2005.

[14] H Gidden, D.L Paul, G S Hilton and J. P McGeehan, **" Influence of body Proximity on the Efficiency of Wearable Textile Patch Antenna, "** EUCAP 2012

[15] E. F. Sundarsingh, S. Velan, M. Kanagasabai, A. K. Sarma, C. Raviteja, and M. G. N. Alsath, **"Polygon-Shaped Slotted Dual-Band Antenna for Wearable Applications"**, IEEE Antennas and Wireless Propagation Letters, 2014, vol.13, pp. 611-614.

[16] M. A. R. Osman,M. K. A. Rahim,M. Azfar, N. A. Samsuri, F. Zubir, and K. Kamardin, **"Design, implementation and performance of ultrawideband textile antenna,"** Prog. Electromagn. Res. B, 2011, vol. 27, pp. 307–327.

[17] W. A. M. Alashwal, K. N. Ramli, **"Small Planar Monopole UWB Wearable Antenna with Low SAR",** IEEE Region 10 Symposium,2014, pp. 235-239.

[18] W. A. M. AlAshwal, K. N. Ramli, **"Compact UWB Wearable Antenna with Improved Bandwidth and Low SAR",** IEEE International RF and Microwave Conference, 2013, pp. 90-94.

[19] J. H. Kim, H. M. Lee**, "Low Specific Absorption Rate Wearable Antenna for WLAN Band Applications",** Antenna and Propagation (EuCAP), 2010, pp. 1-5

[20] N. Vidal, S. Curto, J. M. Lopez, J. Sieiro and F. M. Ramos**, "Detuning study of implantable antennas inside the human body",** PIER, Vol.124, pp. 265-283, 2012.

[21] Ebrahim S. A, M. R. Kamarudin, T. A. Rahman and H. U. Iddi, **"P-Shape monopole antenna design for WBAN application",** PIERS proceedings, Taipei, 2013.

[22] C. H. Kang, S. J. Wu and J. H. Tarng, **"A Novel Folded UWB Antenna for Wireless Body Area Network,"** IEEE Trans. On Antenna and Propagation, Vol.60, no.2, Feb 2012.

[23] Kirti Vyas, Arun K. Sharma and Promod K. Singhal, **"Design and Analysis of Two Novel CPW-Feed Dual Band-Notched UWB Antennas with Modified Ground Structures",** Progress In Electromagnetic Research C, Vol.49, 159-170, 2014.

[24] K. Itol, N. Chahat, R. Saulean and M. Zhadobov, **"A Compact UWB Antenna for On-body Applications",** IEEE Trans. On Antenna and Propagation, Vol.54, No.4, April 2011.

[25] S. A. Alsherhri and S. Khatun, **" UWB Imaging for Breast Cancer Detection using Neural Network".** PIER C, Vol.7, pp.79-93,2009.

[26] Rashid A. Fayadh1 , F. Malek2 , Hilal A. Fadhil3 **"Multiple Antennas Effect on UWB Rake Receiver Performance"** International Journal of Wireless Communication and Networking Technologies, Volume 3, No.3, April - May 2014.

[27] Gnanishivaram K, Dr. S. Neeraja **"FFT/IFFT Processor Design for 5G MIMO OFDM Systems"** International Journal of Wireless Communications and Networking Technologies, Volume 3, No.3, April - May 2014