DESIGN OF A RECTANGULAR PATCH ANTENNA

Amandeep Bath[1], Abhishek Thakur[2], Jitender Sharma[3], Prof. Basudeo Prasad[4]
[1,2,3,4]Electronics & Communication Department, IGCE, Punjab, India
[1]amandeep_batth@rediffmail.com, [2]abhithakur25@gmail.com,[3]*er_jitender2007@yahoo.co.in*

Abstract- This paper presents the idea of recent developments and advancements in the field of wireless technology to realize high speed communications which is performed in wideband technology .In this paper the wideband patch antenna is designed and fabricated. A patch antenna is a narrowband, wide beam antenna which is fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, in which a continuous metal layer bonded to the opposite side of the substrate and it produces a ground plane. The simulation is done using ANSOFT HFSS simulation software.

Index Terms- **U**ltra Wide Band (UWB)**;** Wireless Local Area Network (WLAN)**;** Industrial, Scientific, and Medical Band (ISMB)**.**

I. INTRODUCTION

In radio telecommunications, among the antenna designs there are many different categories of micro strip antennas which are also known by the name printed antennas) the most common of which is the micro strip patch antenna or patch antenna. A patch antenna (also known as a rectangular micro strip antenna) is a type of radio antenna with a low profile, which can be constructed on a flat surface. It consists of a flat rectangular metallic sheet or "patch" of metal, mounted over a larger metallic sheet called a ground plane. The assembly is usually covered by a plastic radome, which saves the antenna structure from damage. Patch antennas are very simple to be fabricated and easy to be modified and customized. They are the original type of micro strip antennas which were given by Howell in the year 1972 in which the two metal sheets together produce resonance and form a resonant piece of micro strip transmission line with a length which is around one half wavelength of the radio waves. The radiation process arises from discontinuities or irregularities at each truncated edge of the micro strip transmission line. The radiation produced at the edges causes the antenna to act slightly bigger electrically than its actual physical dimensions, so in order for the antenna to be a resonanting piece of element, a length of micro strip transmission line slightly lesser than one half a wavelength at the frequency is taken. A dielectric substrate is used for the construction of patch antenna, using the same. The easiest and most simple patch antenna uses a patch which is one half wavelength long, created at a precise distance above a larger ground plane, using an intermediary such as a spacer made of a dielectric material between them. Electrically large ground planes produce very rugged and stable patterns and lower environmental sensitivity but of course increase the size of the antenna. It isn't uncommon for the ground plane to be only slightly larger than the active patch. When a ground plane is near to the size of the radiator it can have the phenomenon of coupling and produce currents along the edges of the ground plane which also radiate. The antenna pattern is created as the combination of the two sets of radiating metallic elements. The current which flows is along the direction of the feed wire, so the magnetic vector potential and also the electric field follow the current. A simple and easiest patch antenna of this category radiates a linearly polarized wave. The radiation can be considered as being produced by a number of the "radiating slots'' at top and bottom, or simultaneously as a result of the current flowing on the patch and the ground plane. Commonly made micro strip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible and can be created. Some patch antennas do not use a dielectric substrate and instead are made by using a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but the bandwidth is much wider. Now as such antennas have a very low profile, are mechanically rugged and can be shaped and designed to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated and operated into electronic devices such mobile radio communication equipments.[1-6]

Antenna's features such as frequency, radiation pattern and polarization are reconfigured to achieve the demands for agile radio applications. A lot of researches focus on frequency reconfiguration as future communication systems such as cognitive radio needs an antenna that can do spectrum sensing and communication. In designing of reconfigurable frequency antennas, recently a reconfigurable wide-band to agile narrowband frequencies, using a printed log periodic dipole array antenna, was developed. A wideband slotted antenna has been produced using multifunctional reconfigurable frequency characteristics for various applications such Wireless LAN, WIMAX, Ultra wideband and UMTS has been proposed in a frequency reconfigurable antenna, made up of two structural elements ; one is an ultra-wide band (UWB) and other is a frequency reconfigurable triangular shaped antenna, is proposed for cognitive radio applications

1) Ultra-wide band antennas have already been used in applications such as satellite communication, remote sensing, ultra wide band radar technology and so on. Currently, the wireless area network (WLAN) in the 2.4-GHz (2.4-2.485 GHz) and 5-GHz (5.l5-5.875 GHz) bands is the most renowned networks for accessing the internet and also the antenna for an AP not only requires dual band operation but also needs to have an appropriate radiation profile in both bands, namely equal gain, wide beam width, and high front-to-back ratio. Wireless communications is enjoying exponential growth in Industrial, Scientific, and Medical (ISM) band. The future generation wireless networks require systems with broad band capabilities in various environments to satisfy numerous applications as smart grid, personal communications, home, car, and office networking .On the other hand, many modern wireless communication systems such as radar, navigation, satellite, and mobile applications use the circular polarized (CP) technology and radiation pattern. For the best UWB performance, the transmitter and receiver (T/R) antennas should have flat and high directive gain, narrow beam low side and back lobes over the operational frequency band; to achieve the largest dynamic range, best focused illumination area, lowest T/R coupling, reduced ringing and uniformly shaped impulse radiation.UWB has generally offers high data rates at short distances with low power, primarily due to high resolution bandwidth.[7-11]

II. ANTENNA DESIGN AND CONFIGURATION

The geometry and configuration of the proposed antenna is shown in the figure. Initially the design properties are selected by adjusting the local variables such as the substrate thickness, height, material, transparency and position as well. As shown in the figure the proposed antenna consists of a substrate on which a cylindrical coax of Teflon is developed. The cylindrical coax pin is made up of the material pec. Also the height and radius of the coax are – 16.67mm and 0.283mm respectively. The feed pin is also cylindrical with a radius of 0.083mm and the height of 62mil. Before covering the design with a radiation air box the circular wave port on the substrate with a radius of 0.283mm is made. Finally the design is covered with a vacuum air box before the simulation and analysis.

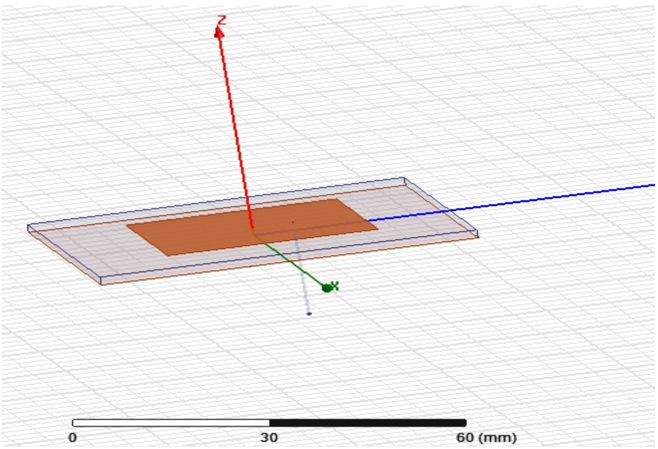

Fig. 1: Rectangular patch antenna

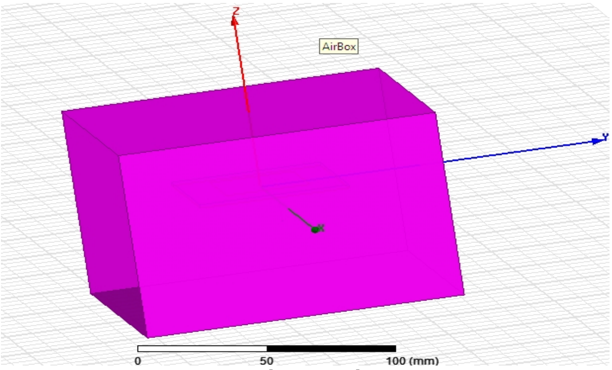

Fig. 2: Air box over the antenna

The impedance bandwidth of a patch antenna is strongly influenced by the spacing between the patch and the ground plane. As the patch is moved closer to the ground plane, less energy is radiated and more energy is stored in the patch capacitance and inductance: that is, the quality factor Q of the antenna increases.

A patch printed onto a dielectric board is often more convenient to fabricate and is a bit smaller, but the volume of the antenna is decreased, so the bandwidth decreases because the Q increases, roughly in proportion to the dielectric constant of the substrate. Patch antennas utilized by industry often use ground planes which are only modestly larger than the patch, which also alters their performance.[12-13]

A. Rectangular patch

The most commonly designed micro strip antenna is a rectangular patch. The rectangular patch antenna is around a one half wavelength long strip of rectangular micro strip transmission line. When air is taken as the antenna substrate, the length of the rectangular micro strip antenna is approximately one half of a free space wavelength. Antenna is loaded with a dielectric substrate. The length of the antenna reduces as the relative dielectric constant of the substrate element increases. The resonant length of the antenna is slightly lesser because of the increased electric "fringing fields" which increase the electrical length of the antenna slightly. An old model of the micro strip antenna is a section of micro strip transmission line with equivalent loads on either end to represent the radiation loss.

B. Planar inverted F antenna

Another category of patch antenna is the Planar Inverted-F Antenna (PIFA) common in cellular phones with built-in antennas. (The Planar Inverted-F antenna (PIFA) is highly used in the mobile phone market. The antenna is resonant at a quarter-wavelength (thus decreasing the required space needed on the phone), and also typically has good SAR properties. This antenna resembles an inverted F, which explains the PIFA name. The Planar Inverted-F Antenna is renowned because it has a low profile and an Omni directional pattern. These antennas are produced from a quarter wave half patch antenna. The shorting plane of the half-patch is decreased in length which decreases the frequency of resonance. Often PIFA antennas have multiple branches for resonating at the multiple cellular bands. On some phones, grounded parasitic elements are applied to improves the radiation bandwidth characteristics. [14-16]

C. Advantages

Micro strip antennas are comparatively inexpensive to manufacture and fabricate because of the easy 2 dimensional physical construction and geometry. They are usually employed at UHF and other higher frequencies because the size of the antenna is directly related to the wavelength at the frequency of resonance. A single patch antenna gives a maximum directive gain of around 6bB to 9dB. It is relatively easy to print an array of patches on a single (large) substrate and lithographic techniques are used for this. Patch arrays can give much higher gains than a single patch at little additional expense; matching and adjustment of phase can be performed with printed micro strip feed structures, again in the same operations that produces the radiating patches. The capability to create high gain arrays in a low-profile antenna is one reason that patch arrays are commonly used on airplanes and in other military applications. Such an array of patch antennas is an easy way to design a phased array of antennas with dynamic beam forming capability. An advantage inherent to patch antennas is the skill to have polarization diversity. Patch antennas can easily be fabricated to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations or different kinds of polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. This unique feature enables patch antennas to be used in many types of communications links that may have varied requirements.

III. PATCH ANTENNA DESIGN CONSIDERATION

Wideband antenna are designed and fabricated for smart grid applications with a frequency bandwidth of 40% and gain of 3db to 4db . The antenna design and simulation was carried out using ANSYS' HFSS that is the high frequency structure simulator software which is the industry standard simulation tool for the simulation of 3D full wave electromagnetic field. The most commonly employed micro strip antenna is a rectangular patch. The rectangular patch antenna is around a one half wavelength long strip of rectangular micro strip transmission line. When air is kept as the antenna substrate, the length of the rectangular micro strip antenna is approximately one half of a free space wavelength. The length of the antenna reduces as the antenna is loaded with a dielectric as its substrate as well as the relative dielectric constant of the substrate highly increases. The resonant length of the antenna is slightly lesser because of the incerased electric "fringing fields" which improve the electrical length of the antenna a little. An old model of the micro strip antenna is a strip of micro strip transmission line with equal loads on either end to represent the radiation losses.

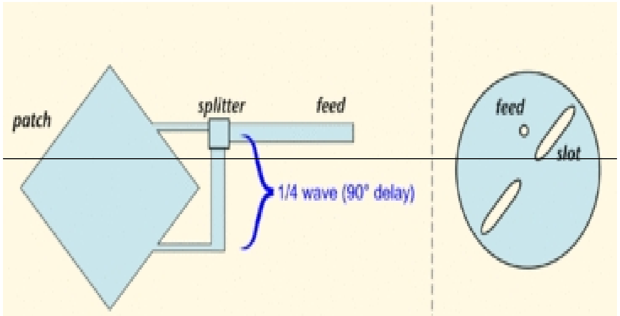

Fig. 3: Patch antenna design

It is possible to fabricate patch antennas that radiate waves which are circularly polarized. One approach is to excite a single square patch using two feeds, with one feed with a phase difference of 90° with respect to the other. This drives each transverse mode and with equal amplitudes and the required 90 degrees out of phase. Each mode radiates separately and combines to produce circular polarization. This feed condition is often available using a 90 degree hybrid coupler. When the antenna is fed in this manner, the vertical current flow is maximized and is high as the horizontal current flow becomes zero, so the radiated electric field will be vertical; one quarter cycle later, the situation will have reversed and becomes opposite and the field will be horizontal. The radiated field rotates in time, producing a circularly polarized wave. An alternative is to use a single feed but introducing some sort of asymmetric slot or other feature on the patch, causing the current distribution to be completely displaced. A square patch which has been perturbed slowly to produce a rectangular micro strip antenna can be driven along a diagonal and create circular polarization. The aspect ratio of this rectangle is chosen so each orthogonal mode is both non resonant. At the driving point of the antenna one mode is +45 degrees and the other -45 degrees and it is required to produce the 90 degree phase shift for circular polarization.[16-20].

IV. RESULTS AND DISCUSSION

Now In this section the rectangular patch antenna is designed and the numerical and experimental results regarding the radiation characteristics are presented and discussed. The simulated results are obtained by using the Ansoft simulation software high frequency structure simulator. The measured and simulated characteristics of the antenna are shown from the far field report of the rectangular plot, the 3D polar plot and radiation characteristics.

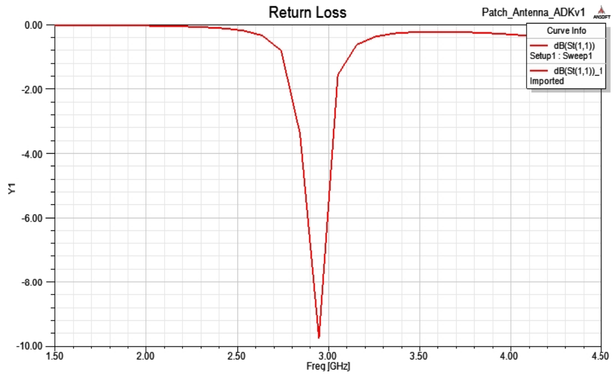

Fig. 4: Return loss of antenna

A diagrammatic radiation pattern for a linearly-polarized 900MHz patch antenna is presented below. The figure shows a cross-section of a horizontal plane; the pattern in the vertical plane resembles though it is not exactly identical. The scale is logarithmic, so the power radiated at 180° (90° to the left of the beam center) is about 15 dB less than the power in the center of the beam. The beam width is around 65° and the gain is approximately 9dB. An infinitely-big ground plane prevents any radiation which comes to the back of the antenna (angles from 180 to 360°), but the actual antenna has a fairly short ground plane, and the power which comes in the backwards direction is only around 20 dB down from that in comparison to the main beam.

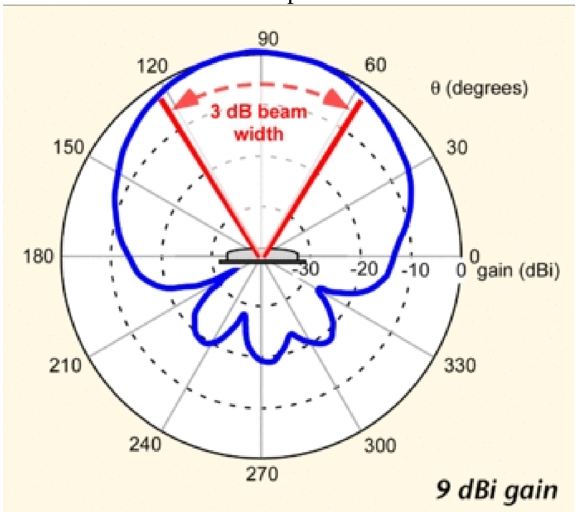

Fig. 5: Radiation pattern of antenna

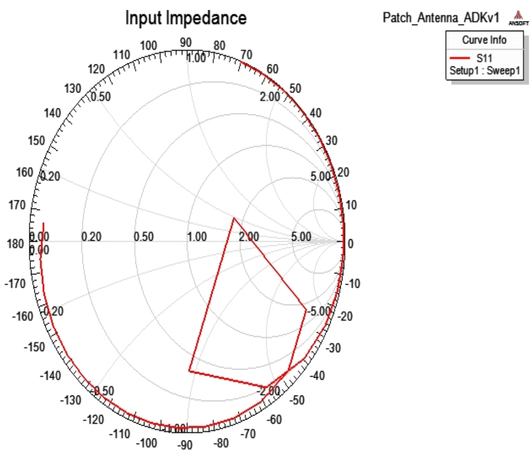

Fig. 6: Input impedance of antenna

Unlike other antennas mentioned in literature to date, the proposed antenna presents a good Omni directional radiation pattern even at the very high frequencies. The designed antenna has a very small size and even the return loss is low and radiation pattern characteristics are obtained in the frequency band which is used. The simulated and experimental results gives the idea how that the proposed antenna could be a good candidate for UWB applications.

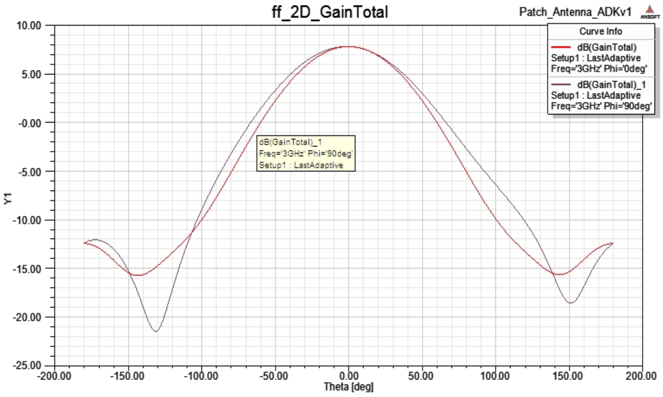

Fig. 7:ff_2D_Gain total of antenna

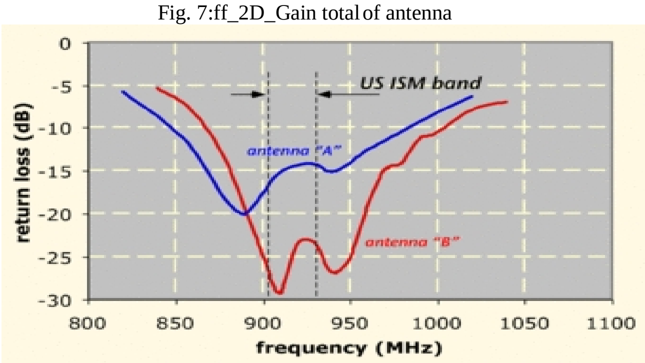

Fig. 8: Return loss of antenna

As the length of the patch, half a wavelength, is about the similar as the length of a resonating dipole, we get about 2 dB of gain out of the directivity relative to the vertical axis of the patch antenna. If the patch is completely square, the pattern in the horizontal plane will be directional, somewhat as if the patch were a pair of dipoles which were separated by a half-wave; this counts for about another2-3 dB. Finally, the addition of the ground plane removes most or all radiation behind the antenna, decreasing the power averaged over all directions by a factor of around 2 (and thereby increasing the gain by a factor of 3 dB). Summing this all up, we get about 7-9 dB for a square element patch, in good agreement with more recognized approaches

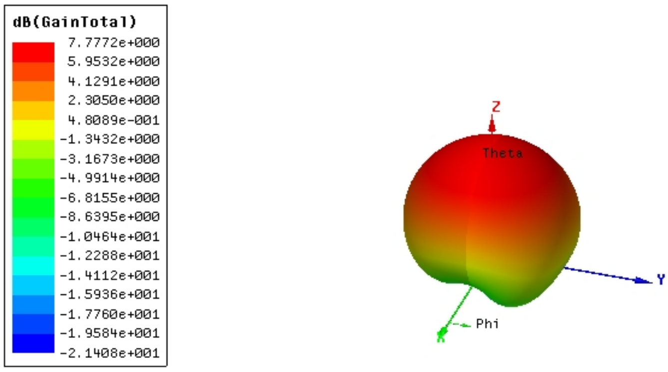

Fig. 9: 3D polar plot of antenna

V. CONCLUSSION AND FUTURE WORK

With the rapid development of wireless technology in recent years, various wireless systems such as GSM, WCDMA/UMTS, Bluetooth, WLANs, and GPS have been highly integrated into the mobile equipments, and in order to fulfill the RF system requirements using the different frequency band, antenna technology is required to wideband characteristics .On the other hand, many modern wireless communication systems such as radar, navigation, satellite, and mobile applications use the circular polarized (CP) radiation pattern. The attractive features of the CP antenna are existed as follows. Firstly, since the CP antennas transmit and receive in all planes all around, it is strong for the reflection and absorption of the radio signal. In the multi-path fading channel environment, the CP antenna overcomes out of phase problem which can create dead-spots, decreased throughput, reduced overall system performance. Further advancements could be done by using antenna substrates with higher dielectric constants in order to minimize the size a broad band wide beam circular polarization micro strip antenna. The configuration of the antenna is the simplest and easiest to be fabricated as compared with conventional micro strip antenna, the radiation beam is broadened a lot. Further research on circularly polarized wideband micro strip antenna is required as it gives the best performance and overall improvement of antenna parameters.

REFERENCES

[1] Gaboardi P., Rosa L., Cucinotta A., and Selleri S., "Patch Array Antenna for UWB Radar Applications", in 3rdEuropean Radar Conference, 2006, p.281-284.

[2] Letestu and Ala Sharaiha, "Size reduced multi-band printed quadrifilar helical antenna," IEEE Trans. Antennas Propag., vol. 59, pp. 3138-3143, 2011.

[3] A. Siligaris et al., "A 65-nm CMOS fully integrated transceiver module for 60-GHz Wireless HD applications," IEEE Journal of Solid-State Circuits, vol. 46, no. 12, pp. 3005-3017, Dec. 2011.

[4] S. Manafi, S. Nikmehr, and M. Bemani, "Planar reconfigurable multifunctional antenna for WLAN/ wimax/ UWB/ pcsdcs/ UMTS applications," Progress In Electromagnetic Research C, Vol. 26, 123- 137, 2012.

[5] F. Ghanem, P. S. Hall and J. R. Kelly, "Two port frequency reconfigurable antenna for cognitive radios", Electronics Letters,vol.45, 2009,pp.534-536.

[6] C. R. Medeiros, E. B. Lima, 1. R. Costa, and C. A. Fernandes, "Wideband slot antenna for WLAN access point," IEEE Antenna Wireless Propagate. Lett., vol. 9,pp. 79-82, 2010.

[7] E. Ebrahimi, J. R. Kelly and P. S. Hall, "A reconfigurable Narrowband antenna integrated with wideband monopole for cognitive radio applications", IEEE Antennas and Propagation Society International Symposium (APSURSI), 2009.

[8] J. W. Baik, S. Pyo, T.H. Lee, and Y.S. Kim, "Switchable printed Yagi Uda antenna with pattern reconfiguration", ETRI Journal, vol.31 2009,pp.318-320.

[9] M. Sanad, "A Small Size Micro strip Antenna Circuit", IEEE International Conference on Antenna and Propagation, vol. 1, pp. 465-471, April1995.

[10] P. Suraj and V. R. Gupta, "Analysis of a Rectangular Monopole Patch Antenna" International Journal of Recent Trends in Engineering, Vol. 2, No. 5, pp. 106-109, November 2009.

[11] M. N. Srifi, M. Meloui and M. Essaaidi, "Rectangular Slotted Patch Antenna for 5-6GHz Applications", International Journal of Microwave and Optical Technology, Vol.5 No. 2, pp., 52-57 March 2010.

[12] Ansoft Corporations, HFSS V.12- Software based on the finite element method.

[13] G. Augustin, S. V. Shynu, C. K. Aanandan, and K. Vasudevan, "Compact dual band antenna for wireless access point, " Electron. Lett., vol. 42, no. 9, pp. 502-503, Apr. 2006.

[14] S. W. Su, "Concurrent dual-band six-loop-antenna system with wide 3-dB beam width radiation for MTMO access point, " Microwave Opt. Techn. Lett., vol. 52, no. 6, pp. 1253-1258, Jun. 2010.

[15] S. W. Su, "High-gain dual-loop antenna for MTMO access point in the 2.4/5.2/5.8 GHz bands, " IEEE Trans. Antenna Propag., vol. 58, no. 7, pp. 2412-2419, Jul. 2010.

[16] K.B. Hsieh, M.H. Chen, and K.L. Wong, "Single feed Dual Band Circularly Polarized Micro strip antenna," Electron. Lett. VOL. 34, pp.1170-1171,Jun.1998

[17] G. P. Jin, D.L. Zhang and R.L. Li, "Optically controlled Reconfigurable antenna for cognitive radios applications", Electronics Letters, vol.47, pp.948-950, 2011.

[18] Wang Yazhou, Su Donglin, Xiao Yongxuan, "Broadband circularly polarized square micro strip antenna", Antennas, Propagation and EM Theory, 2006, ISAPE 2006 7th International Symposium on, pp.1–4,2006.

[19] LTCC hybrid coupler, "RCP1850S03N", RN2 Technologies co.

Zhen-Yu Zhang, Yong-Xin Guo, Ling Chuen Ong, Chia M.Y.W., "A New wide-band planar balun on a single layer PCB", Microwave and Wireless Components Letters, IEEE, Vol. 15, No. 6, pp. 416–18, Jun. 2005.

AUTHORS

First Author – Amandeep Batth M. Tech. in Electronics and Communication Engineering from Punjab Technical University, MBA in Human Resource Management from Punjab Technical University , Bachelor in Technology (B-Tech.)from Punjab Technical University . Six years of work experience in teaching. Area of interest: Antenna Design and Wireless Communication. International Publication: 1, National Conferences and Publication: 4. Working with Indo Global College of Engineering Abhipur, Mohali, P.B. since 2008.

Email address: amandeep_batth@rediffmail.com

Second Author– Abhishek Thakur: M. Tech. in Electronics and Communication Engineering from Punjab Technical University, MBA in Information Technology from Symbiosis Pune, M.H. Bachelor in Electronics (B.E.) from Shivaji University Kolhapur, M.H. Five years of work experience in teaching and one year of work experience in industry. Area of interest: Digital Image and Speech Processing, Antenna Design and Wireless Communication. International Publication: 7, National Conferences and Publication: 6, Book Published: 5 (Microprocessor and Assembly Language Programming, Microprocessor and Microcontroller, Digital Communication and Wireless Communication). Working with Indo Global College of Engineering Abhipur, Mohali, P.B. since 2011.

Email address: abhithakur25@gmail.com

Third Author – Jitender Sharma: M. Tech. in Electronics and Communication Engineering from Mullana University, Ambala, Bachelor in Technology (B-Tech.)from Punjab Technical University . Five years of work experience in teaching. Area of interest:, Antenna Design and Wireless Communication. International Publication: 1 National Conferences and Publication:6 and Wireless Communication). Working with Indo Global college since 2008
E-mail address:er_jitender2007@yahoo.co.in