Journal of Network Communications and Emerging Technologies (JNCET) www.jncet.org
Volume 7, Issue 8, August (2017)

Design of Compact Annular Ring MicroStrip Antenna for Multiband Communication System

Mahesh N Naik
Department of Telecommunication Engineering, Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka, India.

Prashanth C R
Professor, Dr. Ambedkar Institute of Technology, Bengaluru, Karnataka, India.

Abstract – An Annular Ring MicroStrip Antenna (ARMSA) with a Defected Ground Structure for Multi-Band operation is proposed. Defected Ground Structure is produced by integrating a circular slot in the ground plane having different centre with the annular ring radiator patch. MicroStrip Line Feed is used to excite the Annular Ring Patch Antenna placed on an FR4 substrate (dielectric constant ε_r = 4). The proposed antenna is suitable for S, C and X band wireless communication system. The antenna shows four bands at f_1 = 2.96 GHz, f_2 = 5.57 GHz, f_3 = 7.91 GHz and f_4 = 10.57 GHz respectively in S, C and X bands. At first antenna is designed for Dual band operation in frequency range of 1 GHz to 11.8 GHz then by introducing slots on a circular patch, a multiband antenna can be defined.

Index Terms – Annular Ring, MicroStrip Antenna, Multi band, Defective Ground, ARMSA, MicroStrip Feed.

1. INTRODUCTION

In today's modern era there is constant growth and requirement of development in the field of multi-band communication system. A communication network enables users to transfer information in the form of text, audio, video, e- mail and other computer files. The major step in the evolution of communication networks provides services that users need. In high performance space crafts, satellites and missile applications low-profile antennas are used. Other than these many government and commercial applications needs optimized communication system that uses optimized antenna parameters [2]. MicroStrip antennas have several advantages over conventional microwave antenna and therefore are widely used in many practical applications. MicroStrip patch antennas are designed to operate in single band, dual-band and multi-band applications either dual or circular polarization [14].

The simple MicroStrip patch Antenna [3] consists of a dielectric substrate having fixed dielectric constant. Radiating patch is present on one side of a dielectric substrate and a ground plane is present on other side of a substrate. The metallic patch may take any geometrical shapes like Rectangular, Triangular, Circular, Helical, Ring, Elliptical etc. The dimension of the patch corresponds to the resonant frequency of antenna. MicroStrip antennas are characterized by a larger number of physical parameters than are conventional microwave antennas. They can be designed to have many geometrical shapes and dimensions [2].

Antennas are basic components of any transducer system for point-to-point or multipoint communication purpose for which increased gain and reduced wave interference are required. Sir Olive Lodge demonstrated microwave guide transmission line in 1894, later in 1897 Sir Jagadish Chandra Bose constructed first horn antenna. Yagi-uda antennas are developed during 1920s, later array antennas during 1940s. Patches are developed in 1970s and waveguides in 1980s. The patch antenna can be improved in its structure. Antenna is implemented through various optimization techniques one such method using HFSS is proposed in this work [9].

Compact and multi-band antennas are a vital part of modern wireless communication devices which support multi-services operating at different frequency bands [8] simultaneously. The objective of this work is to design an Annular Ring MicroStrip Antenna (ARMSA) with defected ground structure fed by MicroStrip line so that, it can operate on multiple frequency bands i.e. S,C,X bands. Thus, a new design is being investigated along with the simulation and measurements obtained.

2. RELATED WORK

In this chapter various work done by the Authors in the field of MicroStrip Antennas, Defective Ground Structure, Dual-Band Applications, Multi-Band, Annular Ring Antennas, Circular Patches and Feeding Techniques are listed and discussed.

Nikesh Kumar Sahu et al., [1] presented a work on modified annular ring patch fed cylindrical dielectric resonator antenna in two different hybrid models i.e, HE_{11} and HE_{12} modes. The proposed antenna is suitable for WLAN at 5.15-5.35/5.725-5.825 GHz, WiMAX at 5.25-5.85 GHz and uplink/downlink of Amateur Satellites Applications at 5.83-5.85 GHz. Mukhesh Kumar Khandelwal et al., [2] presented on fundamentals of defective ground structure, Analysis and applications in modern wireless trends. Circuit model and different shapes of defective ground structure are discussed in the paper. Defective ground structure in the field of microwave engineering and microstrip antenna with various applications with defective ground structure is discussed. Devashree S. Marotkar et al., [3] presented on Bandwidth Enhancement of Microstrip Antenna with a bandwidth of 67 MHz uses defective Ground Structure. Bandwidth improvement is observed to be 302 MHz at 2.4 GHz frequency. It can be used for WLAN Applications. Shivangi Verma et al., [4] proposed on Microstrip antenna for various 5G applications. Antenna operated over 10.15 GHz frequency that is 5G band. It operates over multiband and 5G band with 4.46 dBi gain. Returnloss is observed to be -18.27 dB over frequency of 9.95 to 10.35 GHz, VSWR of 2.5 dB and gain of 4.46 dB. KA Ming Mak et al., [6] presented work on circularly polarized patch antenna for 5G mobile applications. In this work Miniaturization and beam width are chosen as main parameters of interest, impedance bandwidth is observed to be 10% over half-power beam width of 124^0.

Yong Seok Seo et al., [8] have presented the design of a coplanar waveguide fed dual wideband antenna formed by circular monopole antenna. It gives the performance of 2.4 – 5.2 GHz effectiveness in WLAN applications. Impedance bandwidth reaches about 1.27 GHz; 58.8% at center frequency of 5.47 GHz. Muhammad R Khan et al., [12] presents a compact multiband planar monopole microstrip antenna for WLAN applications. It is operated in dual frequency band with -10 dB impedance bandwidth of 15.68% and 84.67% centered at 2.5 GHz and 5 GHz respectively, covers 2.4/5.2/5.8 GHz WLAN operating bands. P. Mythili et al., [13] proposed on design of compact multiband antennas over frequency range of 900 MHz to 5.35 GHz. These bands are operated in GSM and GPS band operations. Return loss is optimized over -17 dB. A modified ground plane is explained in this work with double sided comb structure. The no of strips and the strip width of ground plane are optimized to give maximum compactness. Pencheng Li et al., [14] presented the design of elliptical/ circular slot antennas, and performance characteristics are shown. It has been inferred that the designed antenna is best suitable to operate in UWB applications with miniaturized antenna design.

3. PROPOSED MODELLING

The design of the ring shaped antenna is shown in figure 1. The structure of MicroStrip Antenna consists of circular patch on one side of substrate and on other side consists of ground plane [7]. The two annular ring slots are made concentric, centered at C_1 both coupled to each other and excited by the same feed. The antenna consists of a defected ground structure and circular radiating patch connected to a MicroStrip feed line. MicroStrip Provides planar structure [11].

The port selected is the wave port for optimized design parameters. The antenna is designed on FR4 substrate with dielectric constant of ε_r =4.4, thickness of h=1.6mm and loss tangent of tanδ = 0.024. The overall size of the antenna is 35 X 30X 1.6 mm^3. The width of MicroStrip feed is fixed at 1.5 mm to achieve 50Ω characteristics impedance, length is chosen to 7.5 mm and can be varied. Annular patch consists of outer radius, R_1 = 11 mm and inner radius R_2 = 6 mm centered at C_1 = (0, 0) provided by feed of width W_f = 1.5 mm and length L_f = 7.5 mm.

Another concentric ring of radius R_3 = 12 mm positioned at C_2 = (-3.5, 0) is placed between patch and substrate and is etched in ground plane to make defected to form defective ground structure [2] as shown in figure 2. Following parameters of the proposed antenna has been chosen is shown in table 1 below:

Table 1: Proposed antenna design parameters

Parameters	**Units (mm)**
L_1	35
W_1	30
R_1	11
R_2	6
R_3	12
L_f	7.5
W_f	1.5
h	1.6
C_1	0, 0
C_2	-3.5, 0

The simulation software High Frequency Structure Simulator (HFSS) [5] is used to optimize the dimensions of the proposed design on the basis of best performance. HFSS software is widely used in industries for analysis, simulation and design of different Antennas, with highly accurate and high speed structures to solve problems faced by the modern equipments; like optimizing the size of antennas, bandwidth, minimized time and high efficiency.

HFSS provides solution to both near field and far field; electric and magnetic field regions [10]. HFSS is the best tool to optimize the challenges faced by antennas performances. Antenna performance is characterized by several parameters like return loss, VSWR, gain, directivity, impedance and efficiency are analyzed using HFSS.

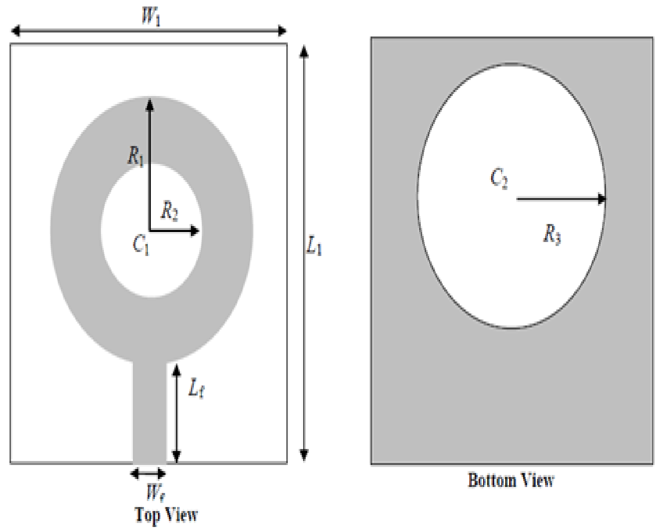

Figure 1: Structure of Annular Ring MicroStrip Antenna

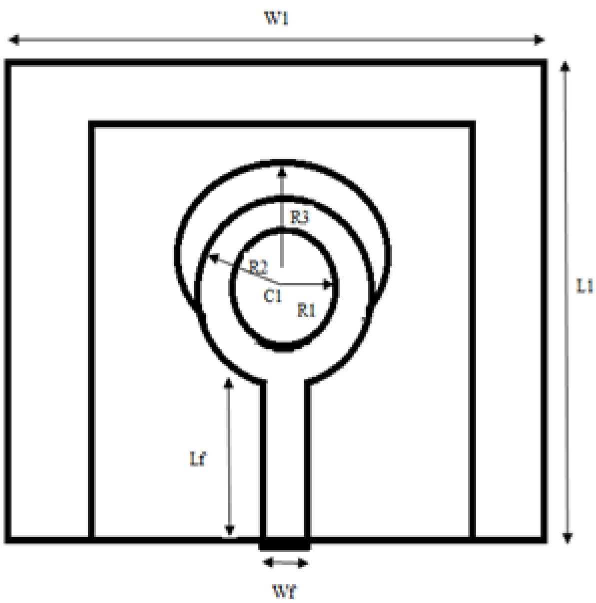

Figure 2: Model of Annular Ring MicroStrip Antenna

4. RESULTS AND DISCUSSIONS

The Annular Ring Microstrip Antenna with Defective Ground Structure.has been designed and fabricated on FR4 substrate with the dielectric constant, $\varepsilon_r = 4.4$ and thickness, h =1.53 mm. The Annular Ring Microstrip Antenna has been fed with Wave port- feed. In Wave port- feed, the 50 Ω impedance is achieved by taking the width W_f =1.5 mm of the inner conductor, Length of L_f =7.5mm and the gap width g = 0.5 mm between the ground plane and the inner conductor. The designed Annular Ring Microstrip Patch Antenna is analyzed in terms of Return loss, VSWR (Voltage Standing Wave Ratio), Directivity, Gain parameters and a comparison is made between them.

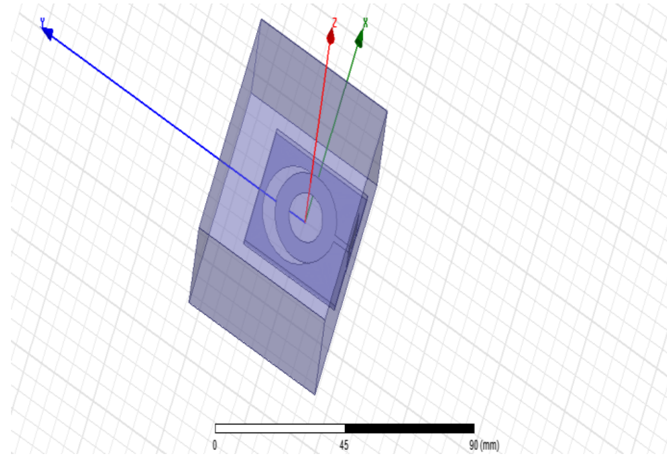

Figure-2: MicroStrip Antenna with Defective Ground

The figure-2 shown above is the topview of the designed Annular Ring Microstrip Antenna with Defective Ground Structure. It consists of inner annular ring with inner radius R_1 and outer radius R_2. It is defected by third annular ring R_3 along Y axis, plotted on dielectric medium of ε_r =4.4 and excited through wave port. The entire setup is placed inside radiation box to avoid leakage of radiation in free space.

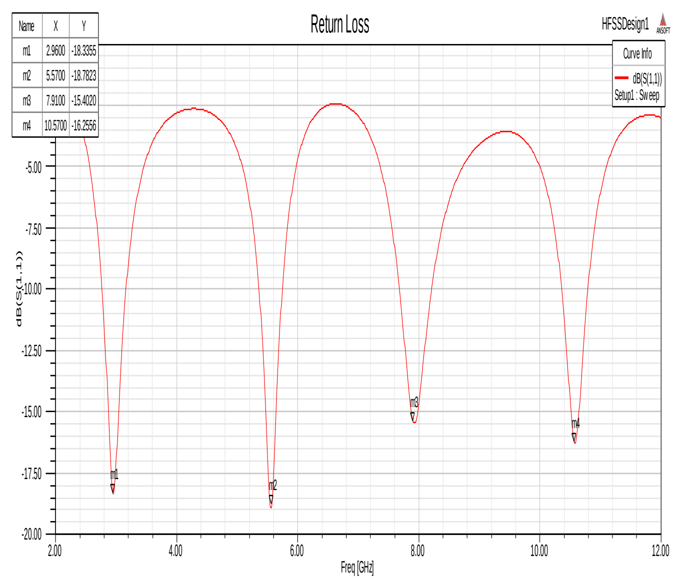

Figure-3: Return loss of MicroStrip Antenna with Defective Ground

The simulation results for AnnularRing Microstrip Patch antenna is shown in figure-3. The return loss characteristic of annular-ring microstrip patch antenna is plotted. The return loss versus frequency graph shows that the antenna resonates at four resonant frequencies viz. 2.96 GHz, 5.57 GHz, 7.91GHz and 10.57 GHz showing MultiBand behavior, with maximum Return loss of -15.4dB.

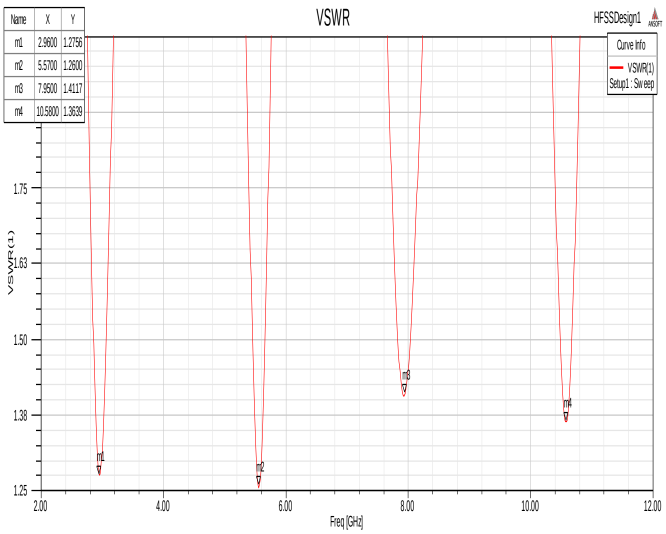

Figure-4: VSWR of MicroStrip Antenna with Defective Ground

The simulation results for Annular Ring Microstrip Patch antenna is shown in figure-4. The VSWR versus frequency graph shows that the antenna resonates at four resonant frequencies viz. 2.96 GHz, 5.57 GHz,7.91 GHz and 10.57 GHz showing MultiBand behavior, with maximum VSWR of 1.256 dB.

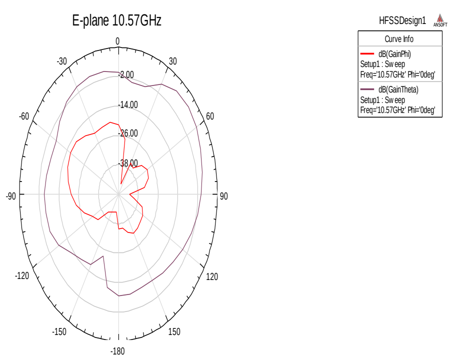

Figure-5: E-Plane plot at 10.57 GHz

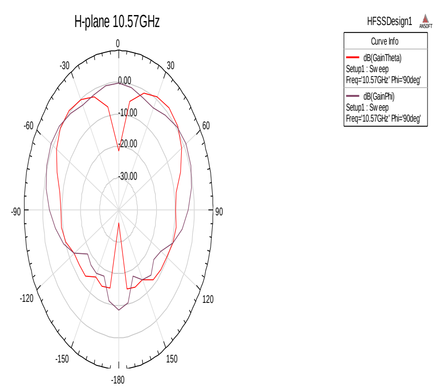

Figure-6: H-Plane plot at 10.57 GHz

The simulation results of E-Plane and H-Plane plots for Annular Ring Microstrip Patch antenna are shown in figure-5 and figure-6, at four resonant frequencies viz. 2.96 GHz, 5.57 GHz,7.91 GHz and 10.57 GHz with radiation efficiency of nearly 85%.

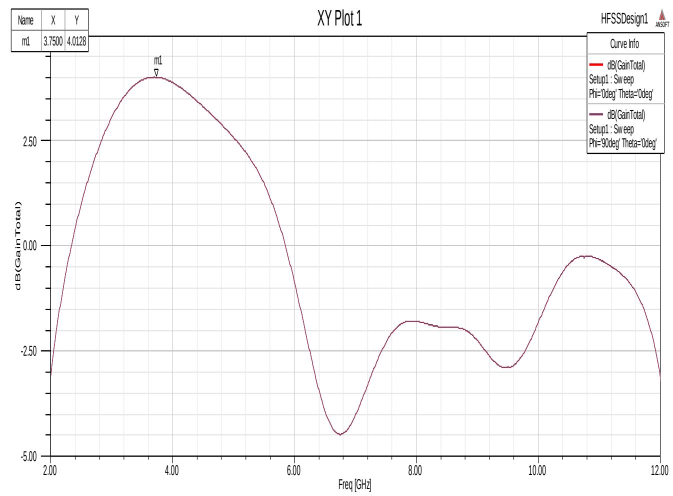

Figure-7: Gain of MicroStrip Antenna with Defective Ground

The simulation results for Annular Ring Microstrip Patch antenna is shown in figure-7. The gain versus frequency graph shows that the antenna resonates at four resonant frequencies viz. 2.96 GHz, 5.57 GHz, 7.91 GHz and 10.57 GHz showing MultiBand behavior, with maximum gain of 4.1 dB at 3.7 GHz frequency. Another peak gain can be obtained at 12 GHz by further optimized.

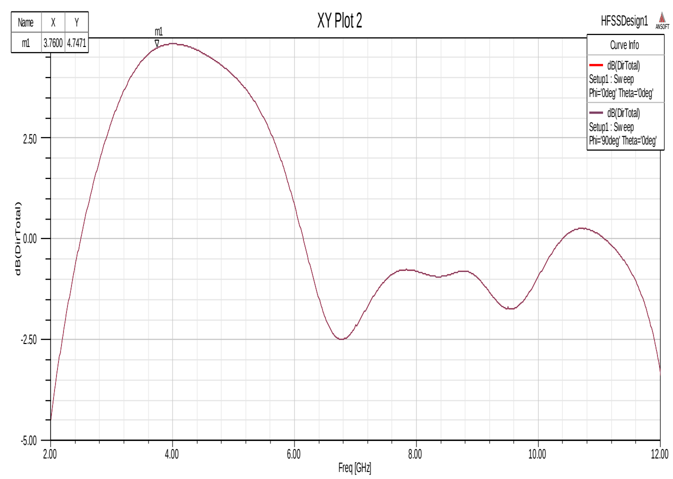

Figure-8: Directivity of MicroStrip Antenna with Defective Ground

The simulation results for Annular Ring Microstrip Patch antenna is shown in figure-8. The directivity versus frequency graph shows that the antenna resonates at four resonant frequencies viz. 2.96 GHz, 5.57 GHz, 7.91 GHz and 10.57 GHz showing Multi-Band behavior, with maximum directivity of 4.7 dB at 3.7 GHz frequency. Peak directivity can be obtained at 12 GHz by further optimized.

Table-2: comparison of performance parameters

MicroStrip Antenna↓	Return loss (dB)	VSWR	Gain (dB)	Directivity (dB)
Without Internal Ring	-11.7697	1.7606	8.8500	11.0320
With Internal Ring	-18.0656	1.2856	10.1635	10.4718
With ARMSA without DGS	-27.6009	1.5760	7.2451	5.5546
With ARMSA with DGS	-15.4020	1.2600	4.0128	4.7471

The design is carried out using Structural Simulator Ansoft HFSS tool. The simulation outputs are compared with previously simulated results; there is improvement in the performance.

Return loss of microstrip antenna without internal ring is observed to be -11.7 dB, with internal ring is -18.06 dB, without Defective Ground is -27.6 dB, for Antenna with Defective Ground is –15.4 dB and VSWR of microstrip antenna without internal ring is observed to be 1.76 dB, with internal ring is 1.28 dB, without Defective Ground is 1.56 dB, for Antenna with Defective Ground is 1.26 dB and, which has improvement than antenna without annular ring and without defective ground, observed to be -18.33dB and VSWR of 1.2564dB, which is desirable to operate at multiband operations with omni-directional radiation.

Gain of microstrip antenna without internal ring is observed to be 8.85 dB, with internal ring is 10.1 dB, without Defective Ground is 7.2 dB, for Antenna with Defective Ground is 4 dB. Gain of microstrip antenna without internal ring is observed to be 11 dB, with internal ring is 10.4 dB, without Defective Ground is 5.5 dB, for Antenna with Defective Ground is obtained to be 4.7 dB.

Table-3: comparison of performance parameters

Varying Patch width	1mm	-24.8014	1.5014
	1.5mm	-18.3355	1.1832
	2mm	-14.1069	1.0824

5. CONCLUSION

The comparison made for different parameters with different conditions are shown in table-2. From table-2 I can confirm that the antenna that is designed by me is of optimized type; that can be operated over MultiBand that gives maximum efficiency for a computed Annular Ring MicroStrip Antenna is achieved to be nearly 85%. Further varying parameter of length of patch will not affect the design is shown and varying width of patch have good return loss and VSWR; but gain and directivity are not compromised as shown in table-3. Further optimizing can be done for the designed antenna that can be operated by varying width of patch.

REFERENCES

[1] Nikesh Kumar Sahu, Anand Sharma, Ravi Kumar Gangwar, “Modified annular ring patch fed cylindrical dielectric resonator antenna for WLAN/WIMAX applications”, *Microwave and Optical Technology Letters*, vol. 59 , pp. 12-125, January-2017.

[2] Mukesh Kumar Khandelwal, Binod Kumar Kanaujia and Sachin Kumar, “Defected Ground Structure: Fundamentals, Analysis, and Applications in Modern Wireless Trends”, *International Journal of Antennas and Propagation*, vol. 2017, pp. 22, 2017.

[3] Devashree S. Marotkar, Prasanna Zade, “Bandwidth Enhancement of MicroStrip Patch Antenna using DGS”, *International Conference on Electrical and Optimization Techniques*, vol. 978, no. 1-4673, pp. 9939-9943, 2016.

[4] Shivangi Verma, Leena Mahajan, Rajesh Kumar, H. S Saini, Naveen Kumar, “A MicroStrip Patch Antenna with for future 5G Applications”, *International Journal of Computer Applications*, vol. 978, no. 1-5090, pp. 460-463, February-2016.

[5] Nuraddeen Ado Muhammad, Yusuf Idris, “ Design and Analysis of Rectangular Microstrip Patch Antenna for Global WLAN Applications Using Matlab and CST Microstudio Software”, *International Journal of Engineering Science and Computing*, vol. 6, no. 4, pp. 3732-3737, April-2016.

[6] KA Ming Mak, Hau Wah Lai, Kwai Man Luk, Chi Hou Chan, “Circular Polarised Patch Antennas for future 5G Mobile Phones”, *IEEE Publications*, vol. 2,no. 2169-3536, pp.1521-1529, January 2015.

[7] Nikitha Sharma, Bhavana Jain, Pradeep Singla, R .R Prasad, “Rectangular Patch MicroStrip Antenna : A Survey”, *International Advanced Research Journal in Science and Engineering Technology*,vol.1, issue 3, pp. 144-147, November-2014.

[8] Yongseok Seo, Hyeonjin Lee and Yeongseog Lim, “Design of a circular ring monopole antenna with Inverted T-Strip Line for dualband operation”, *Microwave and Optical Technology Letters*, vol.55, pp.2174-2177, September-2013.

[9] J.T Rayno, T.T.S Haing, S.K Sharma, “Novel Multiband Segmented Dual Aperture Coupled AnnularRing Microstrip Patch for Wireless Router MIMO Antenna System”, *Antennas and Propogation Society International Symposium*, Orlando, pp.368-369, July-2013.

[10] C.M Wu, Y.L Chen and W.C Liu, “A compact UWB slotted patch antenna for wireless USB dongle applications”, *IEEE Antennas and Wirless propogation letters*, pp. 596-599, November-2012.

[11] Yongseok Seo, Jinwoo Jung, Hyeon Lee and Yeongseong Lim, “Design of monopole antenna with symmetrically folded stub for WLAN applications”, *Microwave and Optical Technology Letters*, vol.54, no.7, July-2012.

[12] Muhammad R .Khan, Mohamed M. Morsy and Frances J.Harachiewicz, “Dual band antenna for wireless network applications”, *IEEE Transactions on Antennas and wave propagation*, 2011.

[13] P.Mythili, P. Cherian, S. Mridula, Binu Paul, “Design of Compact Multiband MicroStrip Antenna”, *IEEE Transactions on Antennas and propagation*, vol.978, pp. 4244-4859, 2009.

[14]Pencheng Li, Lianxin Liang, Xiaodong Chen, “Study of printed Elliptical/Circular disc Monopole Antenna for UWB Applications”, *IEEE Transactions on Antennas and propagation*, vol.54, no.6, pp. 1670-1675, June-2006.