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DESIGN OF COMPACT MULTIBAND SLOT ANTENNA FOR WIDEBAND APPLICATIONS

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ABSTRACT

The design of a compact multiband slot MIMO antenna for wideband application using defected ground structure (DGS) is presented. The overall dimension of the antenna is 25.7x36x1.6mm^3. It covers two frequency bands, the lower band is resonating at 5.05GHz with the bandwidth of 250MHz and the higher band is resonating at 9.25GHz with the bandwidth of 650MHz. Here, the multiband is obtained by the proposed antenna with the microstrip feed and isolation S_{21}<-10dB is obtained by I shaped slot over the ground plane. The simulated return loss, isolation, gain, directivity, Envelope correlation coefficient (ECC), radiation pattern are presented using advanced design software (ADS) software.

***Keywords*— Multiple input Multiple output (MIMO), defected ground structure (DGS), isolation, microstrip feed, multiband.**

I. INTRODUCTION

Multiple Input Multiple Output (MIMO) antenna plays a vital role in modern wireless communication due to their high data rates, channel capacity, consumes less power for multipath propagation through multiple antennas [1]. In recent years, MIMO antenna with multiple operating bands and omni-directional radiation is widely used. Defected ground structure (DGS) is the popularly known technique to design a antenna, used for wide range of applications. The equivalent circuit model for various DGS structure is discussed in [2].

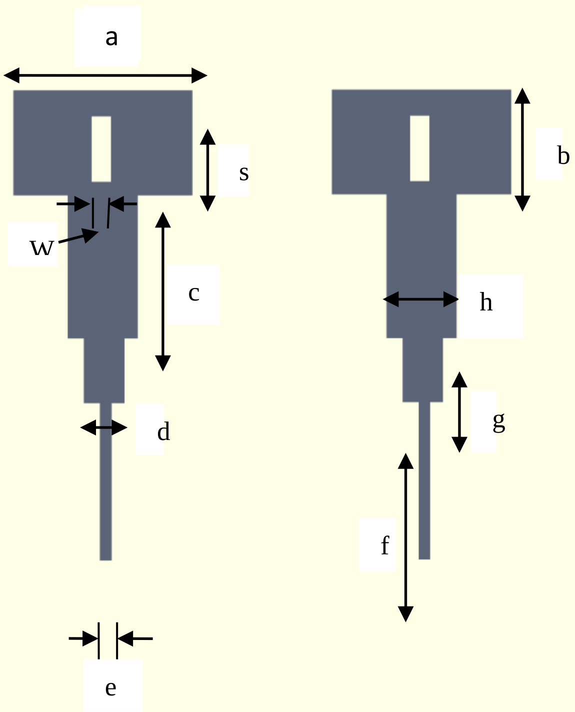
Multiband antenna is the type of antenna which is capable of operating in multiple bands of frequencies. A compact multiband antenna applicable for mobile handset and tablet is presented. The overall dimension of the radiating antenna is 35x11x5mm^3 which is larger compared to the proposed antenna. Moreover, here the ceramic substrate is used, which is costly compared to the formal FR4 substrate [3]. Two F-Shaped slots were etched on the radiator with defected ground structure is discussed in [4] for triple band operation. Three co-located slots on a square columnar structure for penta-band is presented. Here , the slots play the roles of radiating element also as defected ground structure for impedance matching [5]. Bow-tie broadband slot antenna with asymmetric coplanar waveguide feed with high gain of 5.53dBi. This antenna can operate from 2.76GHz to 8.1GHz is discussed [6]. A compact MIMO antenna with H-shaped directive element is presented with high isolation and good directivity. Here, coupling between the antenna elements is obtained by placing the antenna in proper way [7]. A four port reconfigurable MIMO antenna for WLAN application is proposed. The frequency of operation of antenna is from 4.9GHz to 5.725GHz with the isolation greater than -14dB. The overall size of the antenna is 40x20x1.6mm^3 and is printed on FR-4 substrate [8].

Dual frequency orthogonally polarized rectangular patch antenna integrated with DGS is presented with high isolation using microstrip line feed. High isolation is obtained by spiral shaped DGS under the feed line [9]. For conventional antenna, most of the antenna parameters need to be considered while designing it. Among them, return loss, isolation, directivity were the important parameters for multiple input multiple output antenna. Enhancement of return loss for the microstrip patch antenna with and without using metamaterial structure. Improvement in return loss of around 6dB is demonstrated in [10].

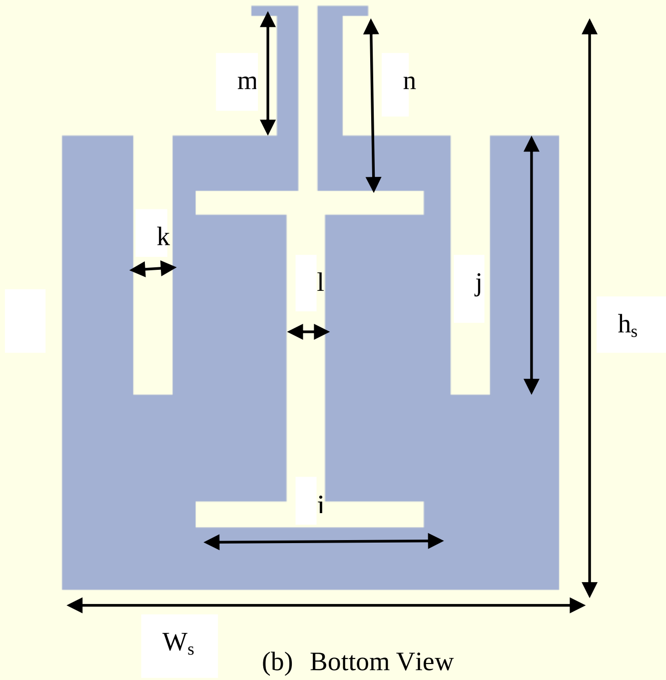
II. MULTIBAND MIMO ANTENNA DESIGN

A. MIMO Antenna Configuration

Fig. 1 illustrates the geometry and dimensions of the proposed microstrip multiband slot MIMO antenna for wideband applications. It consist of two symmetric antenna elements fed through the ports 1 and 2. The distance of separation between the two antenna elements is D=7.2mm. The radiating elements consist of a rectangular patch with a slot in it. There will be a gradual decrease in the dimension of the radiating element towards the feed. It should be noted that the patch width is minimum near the ports.



(a) TopView



(b) Bottom View

Fig.1 .Geometry of the proposed multiband slot MIMO antenna.

Both the antenna elements were printed on the front side of the FR4 substrate of dimension 25.7mmx36mmx1.6mm with the relative permittivity of 4.6 and loss tangent of 0.01. On the other side, comes defected ground structure (DGS) which is etched on the ground plane so that the mutual coupling between the antenna elements can be greatly reduced.

The optimized dimensions of the proposed multiband slot antenna are given in Table 1. Advanced design software is used for simulating the proposed microstrip multiband slot MIMO antenna.

TABLE I

DIMENSION OF THE PROPOSED MIMO ANTENNA

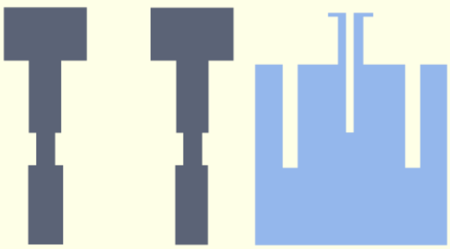
Parameters	Value (mm)	Parameters	Value (mm)
a	9.25	j	15.9
b	8	k	2
c	10.95	l	1.97
d	2.1	m	7.4
e	0.6	n	10.71
f	11.98	h_s	36
g	4.92	w_s	25.7
h	3.6	w	1
i	11.96	s	5

B. Working Mechanism

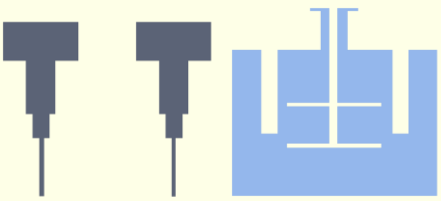
The proposed two port MIMO antenna is configured side-to-side to attain better isolation. Due to reduced space between the two antenna elements high mutual coupling is achieved. The mutual coupling between the antenna elements is due to flow of large amount of surface current from the excited port to the other port. The radiating patch is designed in such a way that it resonates at two frequencies, 5.05GHz and 9.25GHz. Return loss of the microstrip MIMO antenna is greatly improved by etching the radiating patch as shown in Fig.1.

Defected ground structure involves etching of I shaped slot over the ground plane of proper dimension as shown in TABLE 1. Fig.2. shows the antenna geometry evolution of the proposed MIMO antenna. Here, antenna 1 is employed with wider microstrip feed and three slots were etched on the ground plane. Return loss were found to be poor as shown in Fig.3. So that antenna 2 was evolved. Then, the microstrip feed width was reduced in antenna 2. Return loss was found to be improved considerably is shown in Fig.4. Mutual coupling between the closely placed antenna elements needs to be high for MIMO antennas. Considering this factor, moved on to antenna 3. Return loss was found to be good as shown in Fig.5.

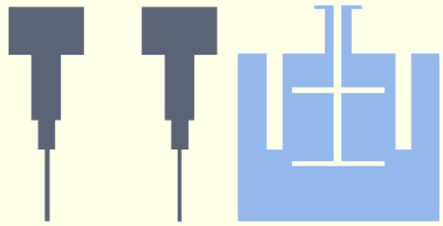
By incorporating additional slots over the radiating patch, return loss was found to be enhanced over other antennas, shown in Fig.6 (proposed). Also by etching I shaped slot over the ground plane of optimized dimension, results in improved isolation.



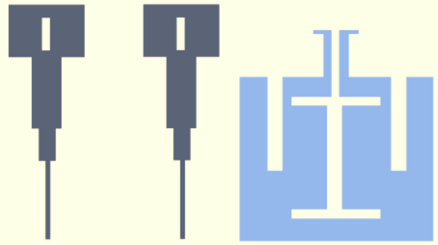
Antenna 1



Antenna 2



Antenna 3



Antenna 4 (proposed)

Top view

Bottom view

Fig.2. Antenna geometry evolution for the proposed

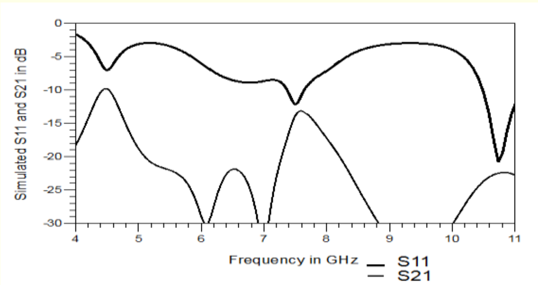


Fig. 3. Simulated return loss and isolation versus frequency of antenna 1.

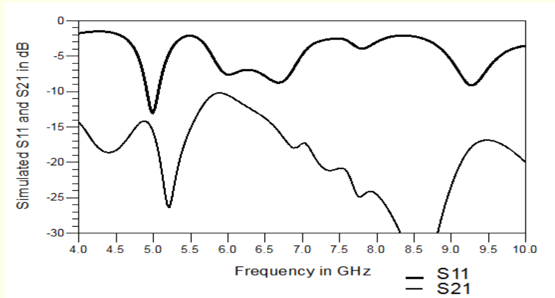


Fig. 4. Simulated return loss and isolation versus frequency of antenna 2.

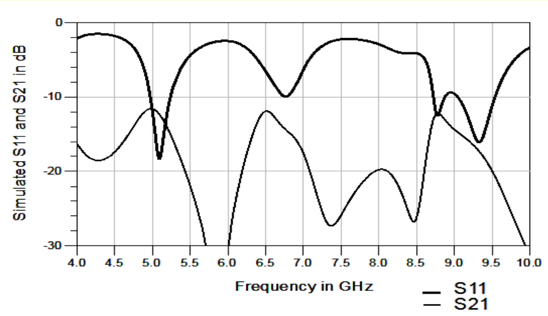


Fig. 5. Simulated return loss and isolation versus frequency of antenna 3.

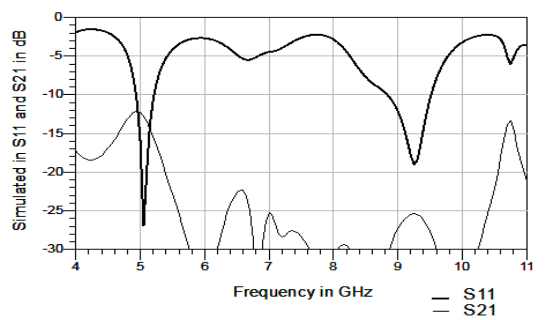
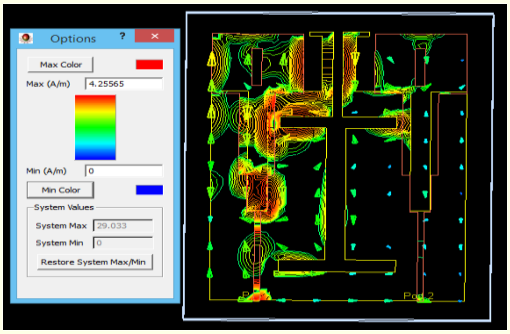
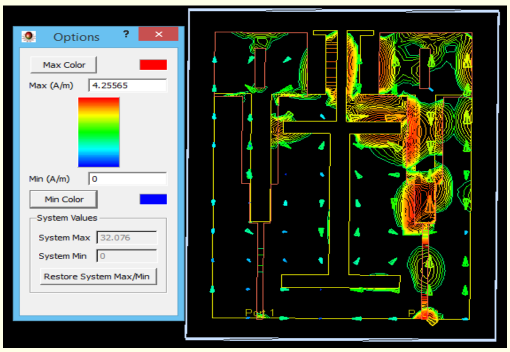


Fig. 6. Simulated return loss and isolation versus frequency of antenna 4 (proposed).



(a)



(b)

Fig.7. Surface current distribution of the proposed antenna. (a) excitation at port 1. (b) excitation at port 2.

The distribution of surface current during the excitation of both the ports were shown separately in the Fig.7. The animation of surface current distribution were done using ADS software.

III. RESULTS AND DISCUSSION

The comparison of simulated return loss for various antenna configuration is shown in the Fig.8. The proposed antenna is resonating at 5.05GHz with the reflection coefficient of -27.04dB and at 9.25GHz with the reflection coefficient of -19dB. The isolation of the proposed antenna is shown in Fig.9.

The proposed antenna has a isolation of -12.70dB at 5.05GHz and -25.36dB at 9.25GHz. The much isolation is achieved due to the I shaped slots along with the additional slots over the ground plane along the patch on the front side. This antenna is designed with FR4 substrate with overall dimension of 25.7x36x1.6mm^3. Thus, compactness is achieved with good results.

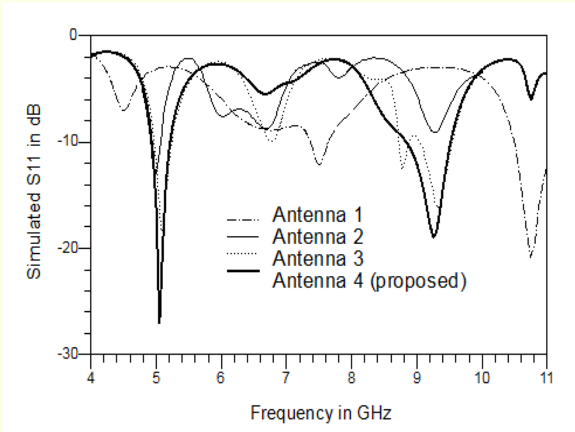


Fig. 8. Comparison of simulated return loss versus frequency for various antenna configuration

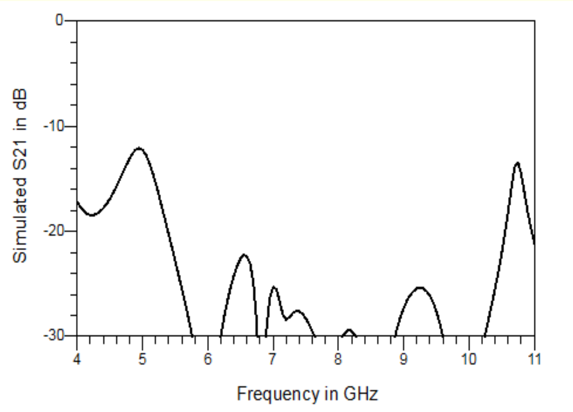


Fig. 9. Simulated isolation against frequency of the proposed MIMO antenna

.A. Radiation Pattern

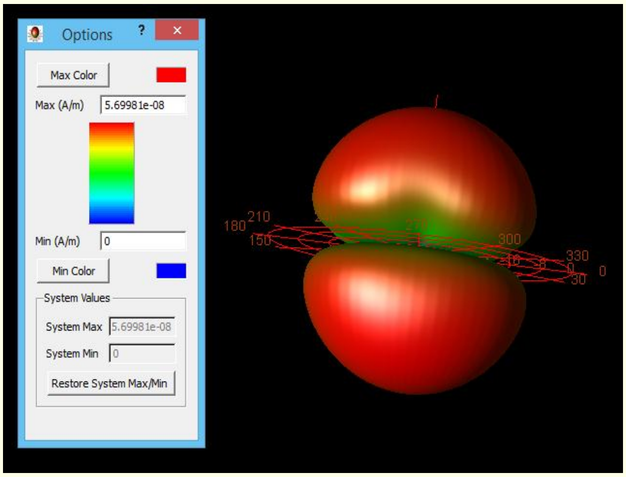
Radiation characteristics of the proposed multiband MIMO antenna are investigated and shown in Fig.10 for both the operating frequencies. Generally, radiation pattern refers the variation of power radiated by the antenna as a function of direction away from the antenna. Fig. 10 shows the 3D radiation pattern of the proposed antenna at 5.05GHz and 9.25GHz respectively. The pattern infers that the radiation pattern of the proposed MIMO antenna is omni-directional.

B. Envelope correlation coefficient (ECC)

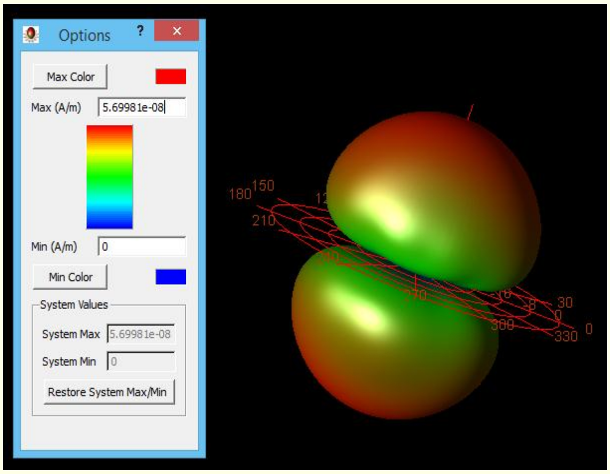
For MIMO antennas, envelope correlation coefficient (ECC) is considered as one of the quality factor for diversity applications. Always high correlation will leads to low data rates. So, that the isolation needs to be high. ECC should be less than 0.5 for good isolation. ECC is calculated from the formula,

$$\rho=\frac{|S11^{*}S21-S12^{*}S22|^{2}}{(1-|S_{11}|^{2}-|S_{21}|^{2})(1-|S22|^{2}-|S12|^{2})} \quad .... (1)$$

For the proposed MIMO antenna, ECC is found to be 0.037 which is less than 0.5. Hence, it offers good isolation for MIMO communication systems.



(a) At 5.05GHz



(b) At 9.25GHz

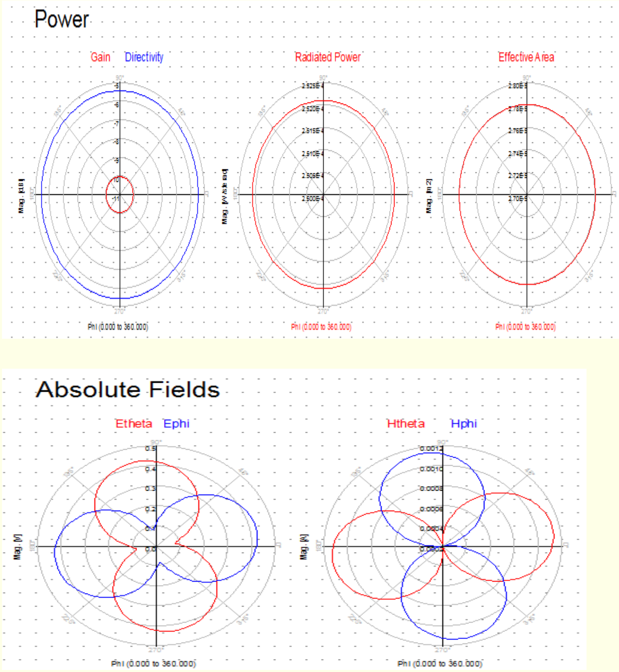
Fig.10. 3D radiation pattern of the proposed antenna.

B. Gain and Directivity

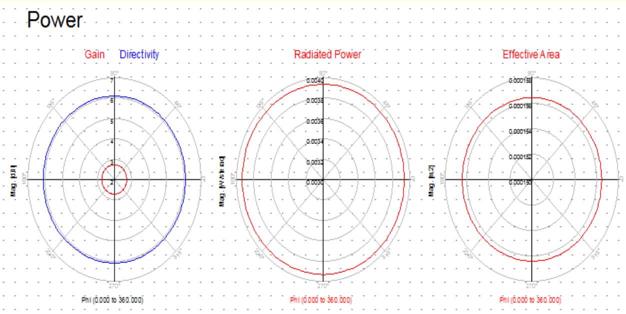
Gain determines the ability of the antenna to direct the radio frequency in a particular direction. Directivity ensures the power density the antenna radiates in the particular direction versus the isotropic radiator (emits radiation uniformly in all direction). Table II shows the gain and directivity of the proposed multband antenna for both frequencies.

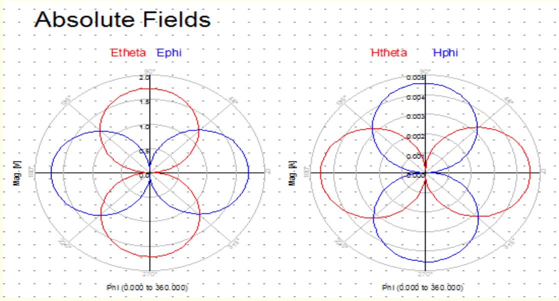
TABLE II

Parameters	5.05GHz	9.25GHz
Gain (dBi)	1.623	3.78
Directivity (dBi)	6.21	7.14
Bandwidth (MHz)	250	650



(a)





(b)

Fig.11. Power and absolute fields of the proposed antenna. (a) at 5.05GHz (b) at 9.25GHz

IV. CONCLUSION

A compact multiband slot MIMO antenna with good isolation and minimal return loss is proposed. This MIMO antenna has good isolation of -12.7dB and -25.36dB with the minimal return loss of -27.04dB and -19dB at 5.05GHz and 9.25GHz respectively. The proposed microstrip MIMO antenna features compact size, good dualband operating bandwidth of 250MHz at 5.05GHz and 650MHz at 9.25GHz with stable omni-directional radiation pattern. The proposed antenna can be used for UWB MIMO communication systems. Especially suitable for, airborne weather radar applications.

REFERENCES

[1] Hyunwoo Lee and Byungje Lee, "Compact Broadband Dual-Polarized Antenna for Indoor MIMO Wireless Communication Systems," *IEEE Trans. Antennas Propag.*, vol. 64,no. 2, Feb. 2015.

[2] L.H.Weng, Y.C.Guo, X.W.Shi, and X.Q.Chen, "An Overview on Defected Ground Structure," *Progress in Electromagnetics research B*, vol.7, 173-189, 2008

[3] Yu-Jiun Ren, "Ceramic Based Small LTE MIMO Handset Antenna," *IEEE Trans. Antennas Propag*., vol 61, no. 2, Feb 2013.

[4] Lalit Kumar, Anil Kumar Gautam, Member, *IEEE*, Lalit Kumar Kanauia, Member, *IEEE* and Karumudi Rambabu,Member, *IEEE*, "Design of Compact F-Shaped Slot Triple Band Antenna for WLAN/WiMAX Applications," *IEEE Trans. Antennas Propag.*, doi 10.1109/TAP.2015.2513099.

[5] Yue Li, *Member, IEEE*, Zhijun Zhang, *Senior Member, IEEE*, Zhenghe Feng, *Fellow, IEEE*, and Magdy F. Iskander, *Life Fellow, IEEE*," Design of Penta-Band Omnidirectional Slot

Antenna with Slender Columnar Structure," *IEEE Trans. Antennas Propag.*, vol 62, no. 2, Feb 2014.

[6] Lina Xu, Li Liand Wenmai Zhang,"Study and Design of Broadband Bow-tie Slot Antenna Fed With Asymmetric CPW," *IEEE Trans. Antennas Propag.*, vol 63, no. 2, Feb 2015.

[7] Yu Luo, Student Member, *IEEE*, Qing-Xin Chu, Senior Member, *IEEE*, Jian-Feng Li, and Yu-Ting Wu, "A Planar H-Shaped Antenna and Its Application in Compact MIMO Antenna," Copyright(c) 2013. *IEEE*,pubs-permission@ieee.org.

[8] Saber Soltani, Parisa Lotfi, and Ross D.Murch, "A Port and Frequency Reconfigurable MIMO Slot Antenna for WLAN Applications," *IEEE Trans. Antennas Propag.*, doi10.1109/TAP,2016,2522470.

[9] Younku Chung, Student Member,*IEEE*, Seong-Sik Jeon, Student Member, *IEEE*, Dal Ahn, Member, *IEEE*, Jae-Ick Choi, and Tatsuo Itoh, Fellow,*IEEE* , "High Isolation Dual-Polarized Patch Antenna Using Integrated Defected Ground Structure," *IEEE Microw.,Wireless.,Comp.,Lett.*,vol. 14, no.1, Jan 2004.

[10] Rahul Tiwari, "Return Loss Enhancement of Patch Antenna," *Int.,Society of Thesis Publication.,Journals of Research in Electrical and Electronics Engineering.*

[11] Alexander Ye. Svezhentsev, Vladimir Volski, Sen Yan, Ping Jack Soh, and Guy A.E.Vandenbosch, "Omnidirectional Wideband E-Shaped Cylindrical Patch Antennas," *IEEE Trans. Antennas Propag.*, vol. 64,no. 2, Feb. 2016.

[12] Mouloud Challah, Arab Azrar, and Mokrane Dehmas, "Rectangular Patch Antenna Performances Improvement Employing Slotted Rectangular Shaped for WLAN Applications,"*IJCSI Int.,Journal of Computer Science Issues,* vol.8 , Issue 3, no. 1, May 2011.

[13] T.K. Roshna, U. Deepak, V.R.S ajitha, K. Vasudevan, and P. Mohanan, "A Compact UWB MIMO Antenna With Reflector to Enhance Isloation," *IEEE Trans. Antennas Propag.*, vol. 63,no. 4, April 2015.