

COMOACT MULTIPLE INPUT MULTIPLE OUTPUT (MIMO) ANTENNA FOR ULTRA WIDE BAND (UWB) APPLICATIONS

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Abstract : This paper consists of a compact antenna system proposed for ultra-wideband (UWB) multiple-input multiple-output (MIMO) applications. Two cup-shaped monopole radiator elements constitute the proposed UWB-MIMO antenna placed on a substrate with an area of $29 \times 40 \text{ mm}^2$. The Antenna operates over the entire (Ultra wide band) UWB frequency band of (3.1 - 10.6 GHz).The electromagnetic isolation between the antenna elements is obtained by introducing the vertical ground stub and slots etched in the ground plane. Isolation of more than 20dB is achieved in most of the frequency band of interest. The proposed antenna system meets the requirements for MIMO applications.

IndexTerms – Diversity, Envelope correlation coefficient, Impedance matching, Isolation, MIMO, UWB

I. INTRODUCTION

Multiple-input multiple-output (MIMO) is a fast growing technology in wireless communication which adopts multiple antennas at both transmitter and receiver terminals. By using MIMO, the capacity of the channel can be enhanced by using the rich scattering environment and without utilizing extra power or spectrum [1]. Due to high speed and high capacity of MIMO, researchers have centralized their focus on the MIMO antennas [2, 3]. MIMO also helps to reduce the multipath fading and hence increases the performance of the system [4].

Since the Federal Communications Commission (FCC) released unlicensed frequency band (3.1-10.6 GHz) [5], Ultra-wideband (UWB) technology became the potential candidate in the race of the wireless world. By utilizing this band of frequency, personal networks can be setup to control different devices within the home or office [5]. Due to extremely low transmitted power of the order of - 41.3 dBm/MHz [5], this technology is restricted to short range communications. To overcome this problem, the combination of MIMO with UWB is found to be one of the promising solutions. This has been systematically first reported by Kaiser et. al [6].

The implementation of MIMO antennas for compact and portable devices is very difficult to achieve because of the mutual coupling between the antenna elements. To overcome this problem, isolation between the antenna elements is increased but the compact size limits this approach. Several approaches have been reported to decrease the coupling, thus achieving wideband isolation over entire UWB by using different decoupling methods to obtain isolation [7-11]. Tree-like structure in the ground plane has been used to achieve decoupling [12], by parasitic stubs [13] and by etching slots in the ground to decrease coupling between the antenna elements [8].

In this paper, a compact UWB antenna is proposed for MIMO applications. The proposed antenna has a size of $40 \times 29 = 1160 \text{ mm}^2$. It exploits approach of using vertical stub and slots in the ground plane to achieve maximum isolation. This antenna covers the entire UWB and achieves an isolation of more than 20dB in most of the frequency band with envelope correlation coefficient (ECC) value below 0.002.

II. GEOMETRY AND ANALYSIS OF ANTENNA

The proposed antenna comprises of two identical elements placed symmetrically about Y-axis as shown in Fig.1. The antenna elements are placed on substrate GML 1000 with thickness of 0.508mm and dielectric permittivity, ϵ_r , of 3.2.

Proposed antenna system consists of two identical monopole radiators to achieve UWB characteristics. For achieving better isolation, radiators share common ground with rectangular slots. Both monopole radiators are fed with 50Ω micro-strip lines. The designing and simulations of the antenna system is done using CST Microwave Studio. The optimized dimensions of the designed antenna system is as follows (millimeters): $W = 40$, $L = 29$, $c = 4$, $eh = 7$, $L_f = 10.52$, $W_f = 1.22$, $L_d = 2.1$, $W_p = 10.81$, $W_s = 1.18$, $L_g = 10.3$, $W_{cg} = 1.22$, $y = 0.7$, $eh' = 0.5$, $L_h = 2.1$, $Wh = 2$, $xy = 8$, $W_g = 18.9$, $L_s = 0.8$. The effect of these parameters and effectiveness of the slots are presented below.

For impedance matching, rectangular slots under the feed lines are made as shown in Fig.1. (b). The effect of these slots on the return loss as well as isolation is shown in Fig.2. The return loss and isolation at 6.7 GHz was improved by making an H-shaped slot in the ground plane between the two radiators. The return loss and isolation was enhanced from 9 to 12 dB and 14 to 18 dB respectively by introducing H-slot as shown in Fig.3.

A vertical ground stub is introduced between the two antenna elements to achieve better isolation. This stub acts as monopole and resonates at frequency defined by its length. To achieve good isolation at lower frequencies without any increase in the overall size of the antenna, the rectangular slots next to the vertical ground stub are etched which reflect the lower frequencies

between port 1 and port 2. Thus, reduces the coupling between two radiators at lower frequencies as shown in Fig.4. The addition of the vertical stub between the monopole radiators is the effective method in order to maintain best isolation at compact size. The length of the stub is controlled by the length xy . The width, y of the rectangular slot which is used to increase the length of the vertical stub also plays an important role in impedance matching and isolation.

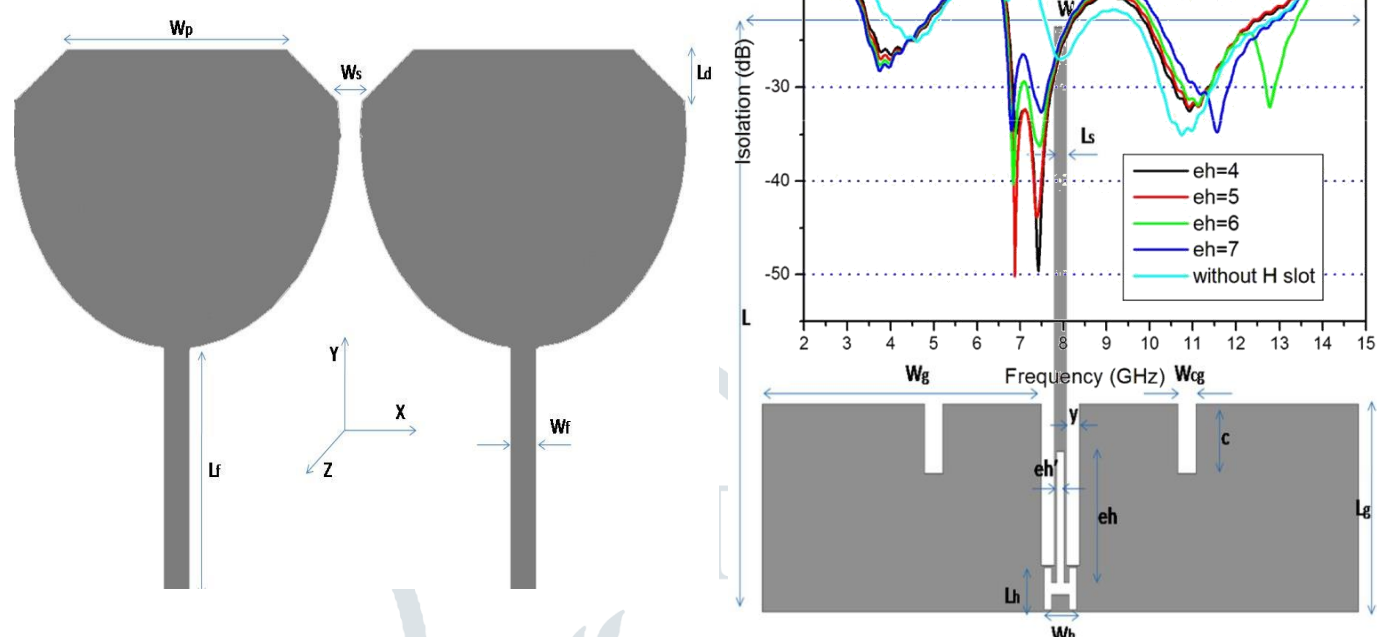


Figure 1. Antenna Configuration (a) Front Side (b) Back Side of MIMO antenna

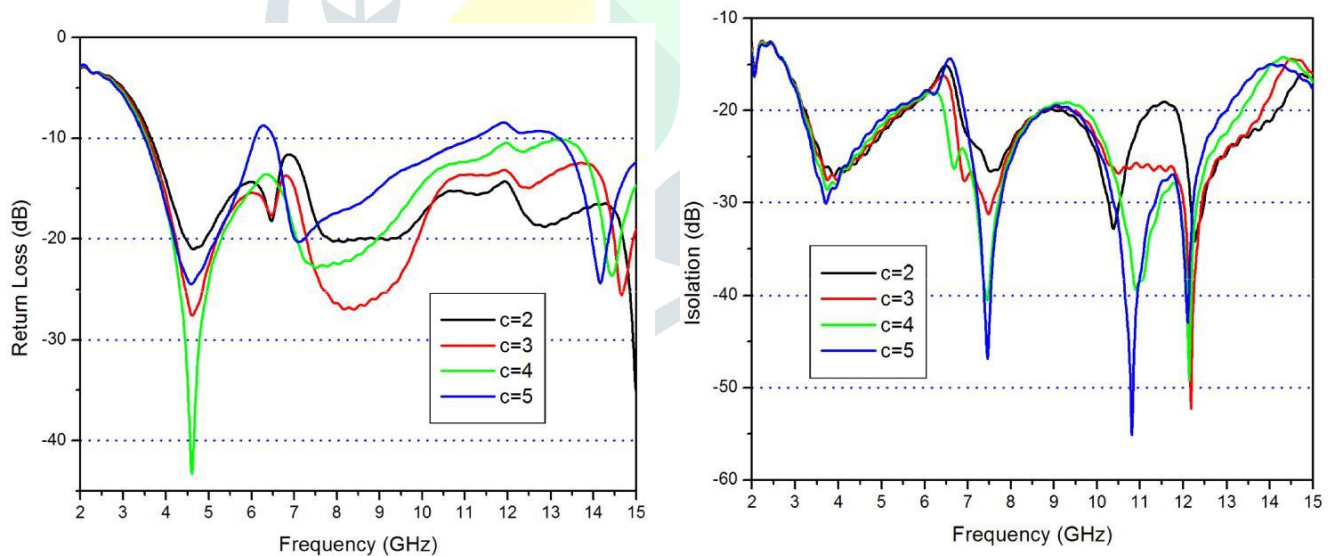
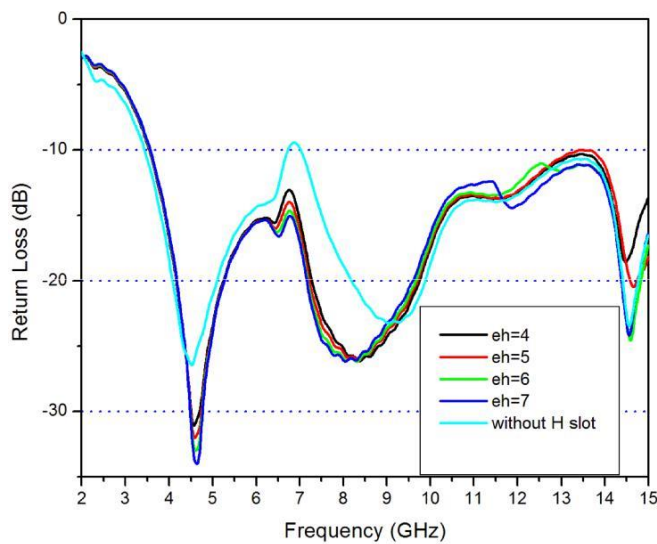
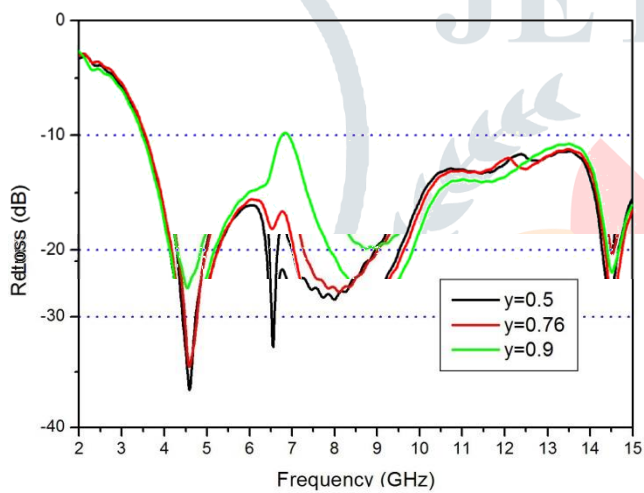


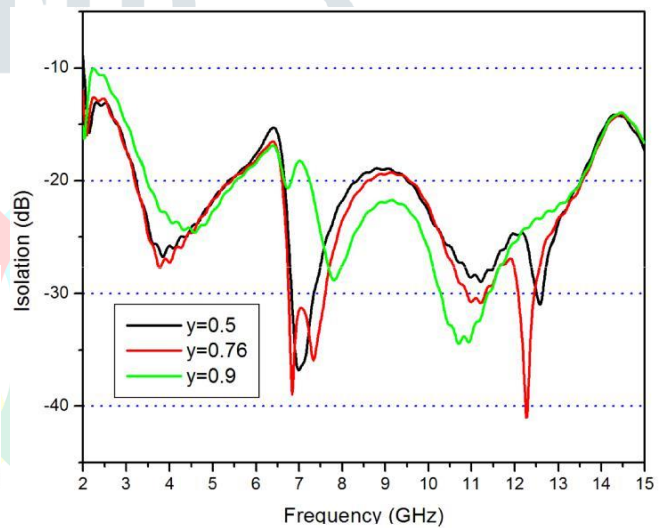
Figure 2. Effect of variations in length c on (a) $|S_{11}|$ (b) $|S_{12}|$



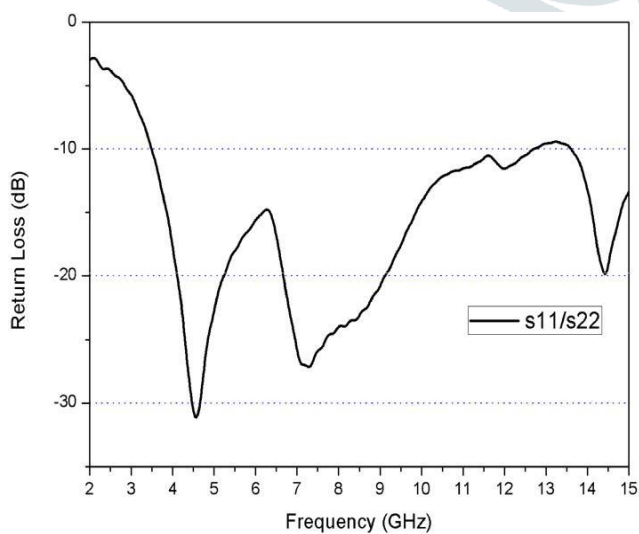
(a)

Figure 3. Effect of variations in length eh and H -slot on (a) $|S_{11}|$ (b) $|S_{12}|$ 

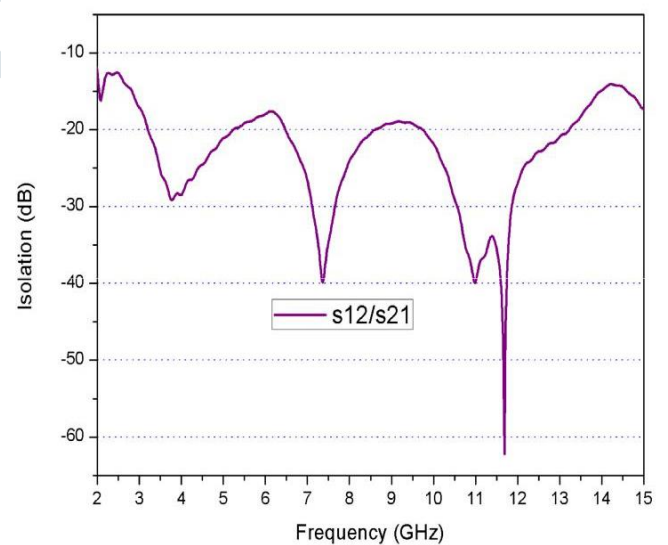
(a)



(b)

Figure 4. Effect of variations in length y on (a) $|S_{11}|$ (b) $|S_{12}|$ 

(a)



(b)

Figure 5. Simulated S-parameters of Band Notched MIMO antenna (a) $|s_{11}|$ (b) $|s_{12}|$

III. RESULTS AND DISCUSSION

The MIMO antenna is designed and simulated using CST MWS with the optimized dimensions given above. The return loss and the isolation between the monopole radiators are plotted in Fig.5. The MIMO antenna covers the whole UWB band ranging from (3.1-10.6 GHz). Also, the $|S_{11}|$ and the $|S_{12}|$ of the antenna system is greater than 15 dB and 20 dB respectively.

In order to receive the low fade signals, diversity i.e., multiple numbers of transmitter and receiver antennas are used. The diversity performance is measured in terms of ECC and is given below by equation1 [12]:

$$\rho_e = \frac{|S_{11} * S_{12}^* + S_{21} * S_{22}^*|^2}{(1 - |S_{11}|^2 - |S_{21}|^2)(1 - |S_{22}|^2 - |S_{12}|^2)} \quad (1)$$

Where, S_{12} , S_{21} represents isolation and S_{11} and S_{22} the return losses of the individual antennas. As shown in the Fig.6, the ECC is less than 0.002 in the entire UWB.

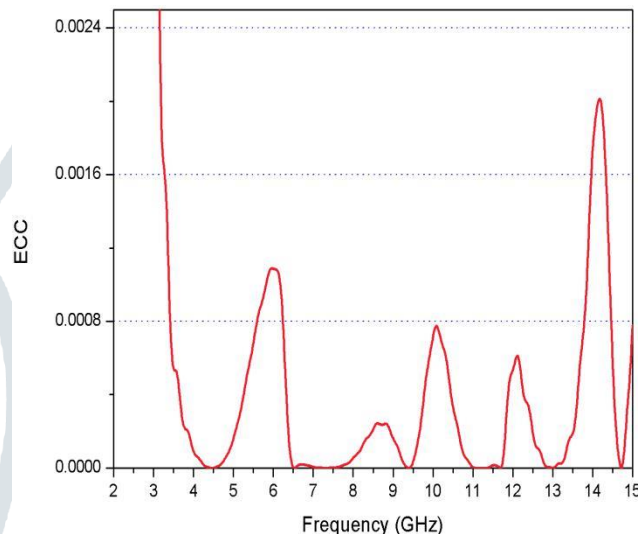


Figure 6. Simulated ECC of the proposed antenna

IV. CONCLUSION

Band notched MIMO antenna covering the entire UWB is designed. The antenna consists of two monopole radiators placed on a substrate having thickness and dimensions of 0.508mm and $29 \times 40 = 1160\text{ mm}^2$. Impedance matching and Decoupling between the antenna elements is achieved by introducing slots and stub. Also, the ECC is below 0.002 in the entire UWB making this antenna appropriate candidate for UWB applications

REFERENCES

- [1] Foschini, G. J., "Layered space-time architecture for wireless communication in a fading environment when using multi-element antennas," *Bell Labs Technical Journal*, 41–59, 1996.
- [2] Dong, L., H. Choo, R. W. Heath, Jr., and H. Ling, "Simulation of MIMO channel capacity with antenna polarization diversity," *IEEE Transactions on Wireless Communication*, Vol. 4, No. 4, Jul. 2005.
- [3] Manteuffel, D., "MIMO antenna design challenges," *2009 Loughborough Antennas & Propagation Conference*, Loughborough, UK, Nov. 16-17, 2009.
- [4] Foschini, G.J.; Gans, M.J.: On limits of wireless communications in a fading environment when using multiple antennas. *Wireless Pers. Commun.*, 6 (1998), 311–335.
- [5] "Federal communications commission revision of Part 15 of the commission's rules regarding ultra-wideband transmission system from 3.1 to 10.6GHz," ET Docket No. 98-153, Federal Communications Commission, Washington, DC, 2002.
- [6] Kaiser, T., F. Zheng, and E. Dimitrov, "An overview of ultrawideband systems with MIMO," *Proc. of the IEEE*, Vol. 97, No. 2, 285–312, 2009.
- [7] Zhang, S.; Ying, Z.; Xiong, J.; He, S.: Ultrawideband MIMO/diversity antennas with a tree-like structure to enhance wideband isolation. *IEEE Antennas Wireless Propag. Lett.*, 8 (2009), 1279–1282.
- [8] Gogosh, N.; FarhanShafique, M.; Saleem, R.; Usman, I.; Faiz, A.M.: An UWB diversity antenna array with a novel h-type decoupling structure. *Microw. Opt. Technol. Lett.*, 55 (2013), 2715–2720.
- [9] Gallo, M.; Daviu, E.A.; Bataller, M.F.; Bozzetti, M.; Pardo, J.M.; Llacer, L.J.: A broadband pattern diversity annular slot antenna. *IEEE Trans. Antennas Propag.*, 60 (3) (2012), pp. 1596–1600.
- [10] Li, J.F.; Chu, Q.X.; Huang, T.G.: A compact wideband MIMO antenna with two novel bent slits. *IEEE Trans. Antennas Propag.*, 60(2) (2012), 482–489.

- [11] Gao, P.; He, S.; Wei, X.; Xu, Z.; Wang, N.; Zheng, Y.: Compact printed UWB diversity slot antenna with 5.5-GHz band-notched characteristics. *IEEE Antennas Wireless Propag. Lett.*, 13 (2014), 376–379.
- [12] Hallbjörner, P.: The significance of radiation efficiencies when using S-parameters to calculate the received signal correlation from two antennas. *IEEE Antennas Wireless Propag.*, 4 (2005), 97–99.
- [13] Hong, S., K. Chung, J. Lee, S. Jung, S.-S. Lee, and J. Choi, “Design of a diversity antenna with stubs for UWB applications,” *Microw. Opt. Technol. Lett.*, Vol. 50, No. 5, 1352–1356, 2008.

