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A Four-Element Planar UWB-MIMO Antenna System Comprising of Plus-Sign Stub for High Isolation

Swati Gautam, Kanchan Cecil

Abstract: ***A four-element planar UWB-MIMO antenna system with plus-sign stub (for achieving high isolation) is proposed here. The complete antenna system is constructed on 52mm x 52mm, FR-4 substrate (dielectric constant=4.3). The structure consists of 4 identical antenna elements, with each element placed orthogonal to its adjacent element on the top of the substrate. The partial ground plane with circular slots is utilized on the back of the substrate. The antenna is simulated using CST Microwave Studio. Simulated S_{11}<-10dB, in the entire operating band (2.9 -12.9 GHz) and the isolation among the elements is observed to be less than -20 dB in most of the band. Maximum gain of 4.82dB is observed at center frequency (7.9 GHz). VSWR<2 is present throughout the band. The impedance bandwidth of 126.58% shows its candidature for many wireless UWB communication applications.***

Keywords: Four-Element UWB-MIMO Antenna, Orthogonal, Plus-sign Stub, High Isolation.

I. INTRODUCTION

Ultra Wide Band (UWB) technology received its approval in 2002, by FCC (Federal Communication Commission) for the usage of an unlicensed band ranging from 3.1-10.6 GHz. The UWB technology provided advantages like high data rates, low power level and extremely low costs. These features of UWB attracted another important technology towards it; termed as MIMO (Multiple-Input, Multiple-Output) [1]. Researchers merged the concepts of MIMO with the UWB to create UWB-MIMO systems that could achieve superior channel capacity and overcome the multipath fading limitation [2]. MIMO systems are basically the systems designed with multiple antenna elements of similar kind on the same substrate. The use of the multiple antenna elements increases the chance of high electromagnetic coupling among the elements. However, it becomes great deal for the antenna designers to develop the MIMO system with high isolation among the elements with a compact size. Until now, various methods and techniques have been used to increase the isolation among the elements [3]-[7]. Stepped Slots with differential feeding technique [1] was used to achieve wider operating band and high isolation.

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***** Correspondence Author (s)
Swati Gautam*, Research Scholar, Department of Electronics and Communication, Jabalpur Engineering College, Jabalpur (M.P), India.
Kanchan Cecil, Assistant Professor, Department of Electronics and Communication, Jabalpur Engineering College, Jabalpur (M.P), India.

Isolation improvement was also observed in [3] using Quasi-self complementary technique and in [8] by the use of EBG structures for broadband mutual coupling reduction. Defective Ground plane Structures (DGS) were too used to achieve high isolation [5]. Most recently, MIMO systems have found their way in the rapidly growing markets such as professional broadcast video, law enforcement and government sectors. With the today's need of bandwidth requirement for various purposes, MIMO technology proves to be an ideal solution for communication, especially in urban environment (where clear line of sight is harder to achieve). In this paper, a four element planar UWB-MIMO antenna system is proposed that makes use of slots in the design to achieve better return loss below -10dB and a plus-sign stub on the top of the substrate to reduce electro-magnetic coupling among elements. A 50-ohm matched microstrip line is used to feed the structure. The 4 equally sized antenna elements are placed orthogonal to their adjacent elements [4]. Orthogonally placed antenna elements reduce interference via polarization diversity. The antenna operates in the entire band ranging from 2.9-12.9 GHz. High impedance bandwidth of about 126.58% makes it better for the use in wireless communication applications.

II. ANTENNA GEOMETRY

The proposed four element planar UWB-MIMO antenna system is constructed on 1.5mm high , low cost FR-4 substrate (dielectric constant=4.3). The antenna covers the overall size of 52mm x 52mm which makes it compact. Four similar sized circular-shaped antenna elements with circular slots are created on the top of the substrate. A 50-ohm matched micro strip line of width 2.74mm is used to feed the structure. Each of the elements is placed orthogonal to its adjacent antenna elements to achieve polarization diversity. The partial ground planes with circular slots in it are made on the back of the substrate to achieve wide operating range from 2.9-12.9 GHz. As the circular slots works well with the circular designs, this combination gives returns loss below -10dB throughout the range. Addition of plus-sign stub on the top of the substrate gives isolation below -20dB in most of the band, which was below -15dB without the stub. The positioning of the slots causes the variation in the return loss graph. To get the return loss below -10dB, the parameters have been optimized. The optimized parameters of the antenna are detailed in Table 1. The top view of the antenna, without stub and with stub are shown in Fig 1(a) and 1(b) respectively and the bottom view is described in Fig 1(c).

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Table 1: Optimized Parameters

Parameter Description	Parameter Values (in mm)
Length of the substrate	52
Width of the substrate	52
Height of the substrate	1.5
Radius of circular patch	7.8
Radius of bigger central patch slot	2
Radius of smaller central patch slot	1
Radius of smaller edge patch slots	0.8
Width of the feed	2.74
Length of the stub	50
Width of the stub	0.5
Thickness of the patch	0.035
Length of the ground	17.50
Width of the ground	6
Radius of the edge ground slots	2
Radius of the central ground slot	2

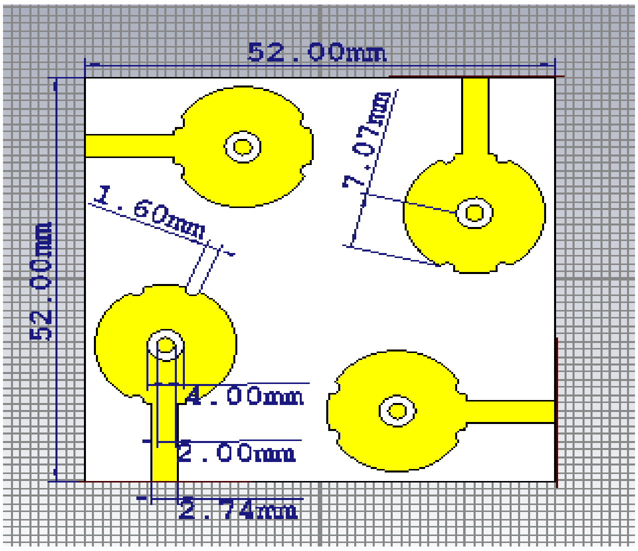

Fig 1(a) Top View Without Stub

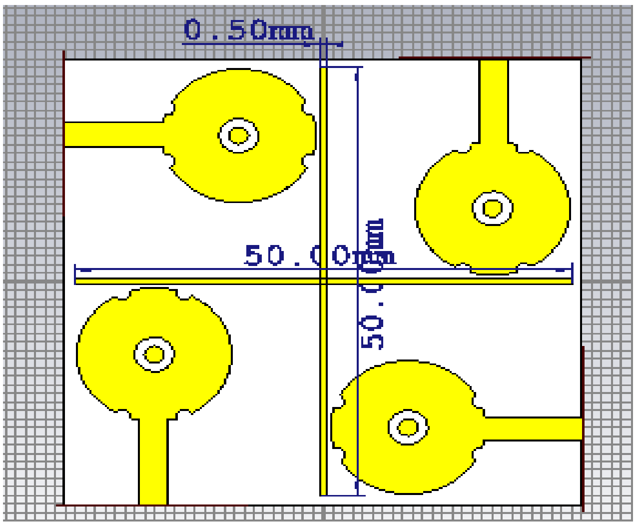

Fig 1(b) Top View With Stub

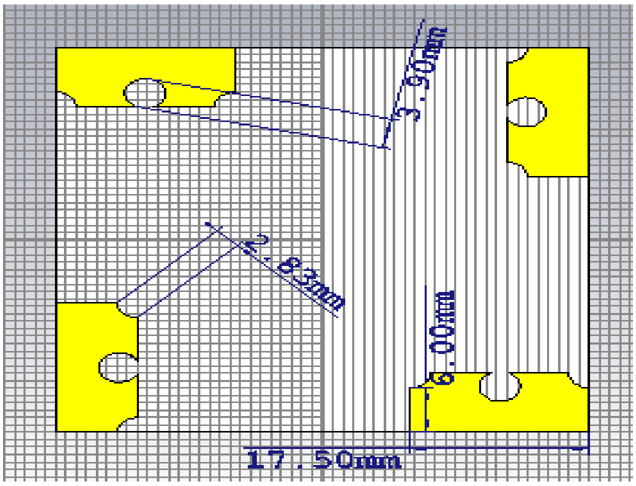

Fig 1(c) Bottom View

III. RESULT ANALYSIS

A. Return Loss (S_{11}) Analysis

Return Loss, more commonly described as S_{11} parameter is the one that confirms the performance of any antenna system. Since, here four element antenna system has been described, hence, each port has its own parameter given by S_{11}, S_{22}, S_{33}, and S_{44} for Port 1, Port 2, Port 3 and Port 4 respectively. And each one of them are found to be below -10dB from 2.9-12.9 GHz. Return loss analysis of each port without stub and with stub is described in Fig 2(a) and 2(b) respectively.

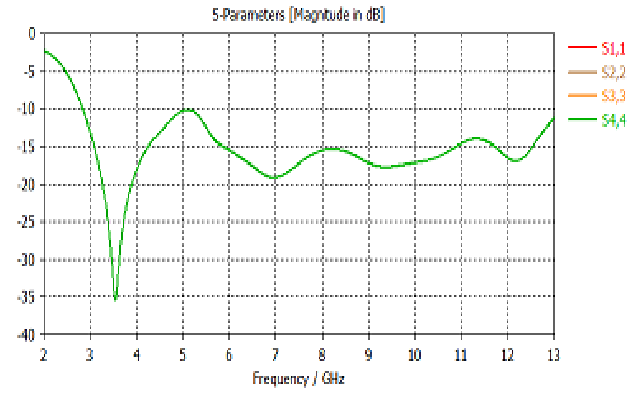

Fig 2(a) Return Loss Analysis without stub

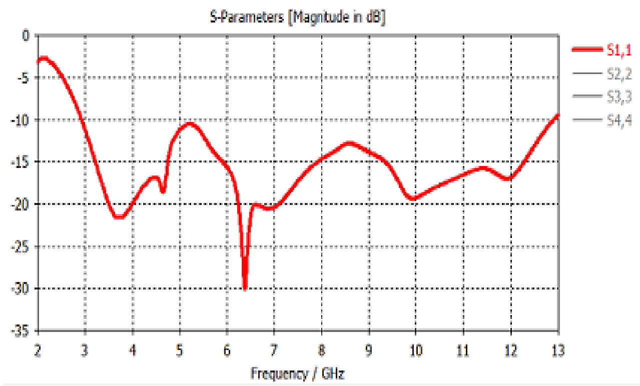

Fig 2(b) Return Loss Analysis with stub

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B. Isolation Parameters Analysis

The electromagnetic coupling between the antenna elements is the serious issue while designing a MIMO system. Here, a plus sign stub on the top of the substrate has been used to get the improvement in isolation. Isolation of about less than -20dB is obtained in most of the band after adding stub. Fig 3(a) and 3(b) describes the isolation among the elements without stub and with stub respectively.

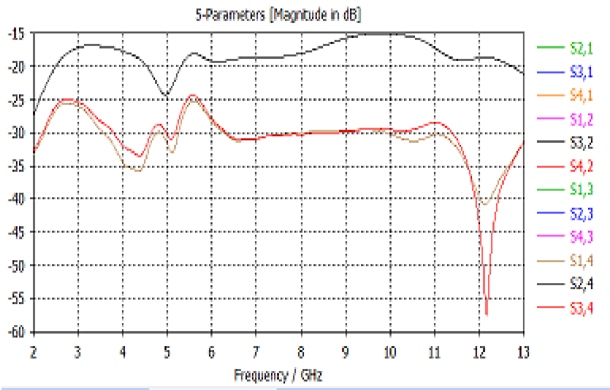

Fig 3(a) Isolation Analysis without stub

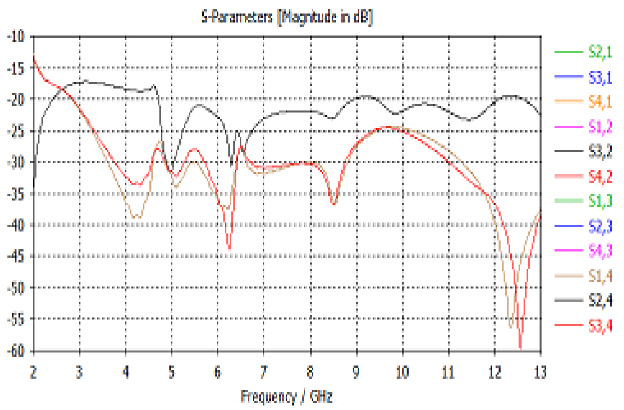

Fig 3(b) Isolation Analysis with stub

C. VSWR Analysis

The voltage standing wave ratio (VSWR) of the antenna system is observed to be below 2 throughout the entire operating band. The VSWR graph is described in Fig 4.

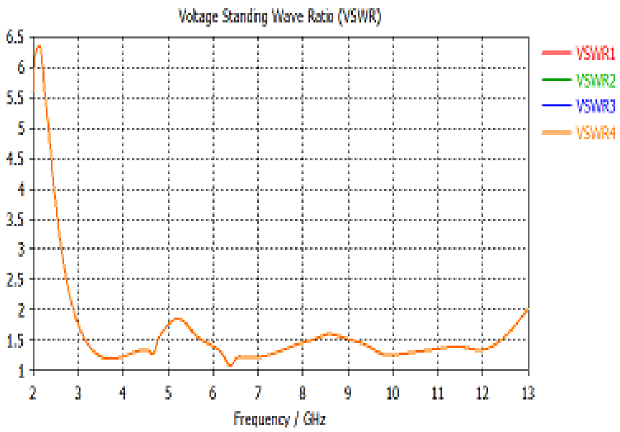

Fig 4. VSWR Analysis

D. Radiation Pattern and Gain Analysis

E-plane (phi=0) and H-plane (phi=90) plots of the proposed antenna system at the center frequency 7.9GHz are described in Fig 5(a) and 5(b) respectively.

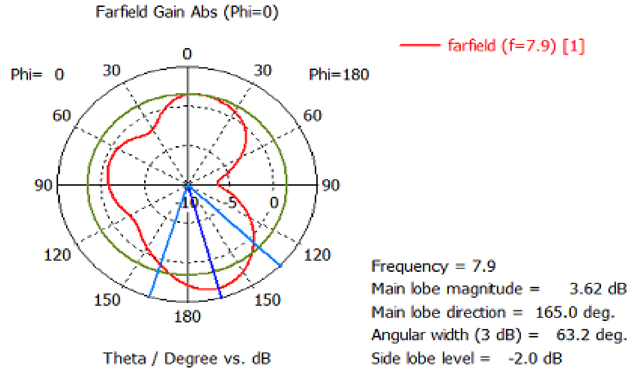

Fig 5(a) E-plane plot at 7.9 GHz

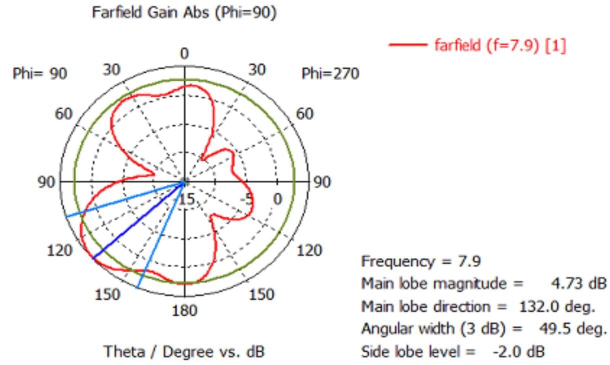

Fig 5(b) H-plane plot at 7.9 GHz

3-D radiation pattern of the antenna system describing all the four ports at 7.9 GHz is shown in Fig 6 along with the gain. Antenna gain of about 4.82dB is observed at the center frequency (7.9 GHz).

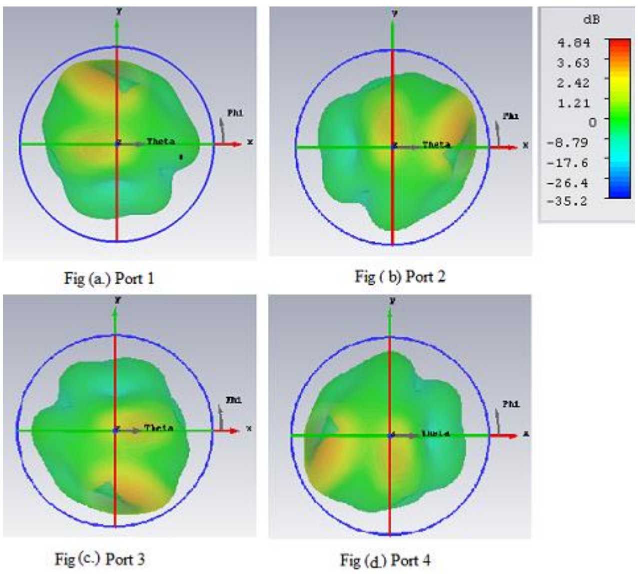

Fig 6 3-D Radiation Pattern and Gain of the Antenna at 7.9 GHz of all the Ports.

E. Radiation Efficiency Analysis

Radiation Efficiency of an antenna is determined by the radiated power and the input power accepted by the antenna. Hence, the maximum radiation efficiency is observed to be 76% at 3.6 GHz, described in Fig 7.

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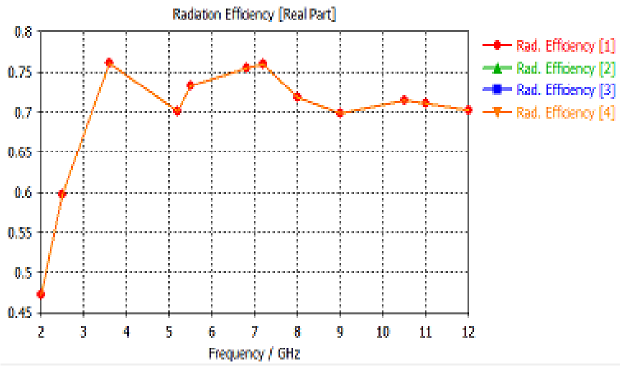

Fig 7 Radiation Efficiency of Antenna

IV. COMPARATIVE STUDY OF VARIOUS 4-ELEMENT MIMO SYSTEMS

The comparison of the various 4-element UWB-MIMO antenna systems is detailed in Table 2 below:

Table 2: Comparison Table

Paper	Size of Antenna	Operating Bandwidth (in GHz)	IMB (Isolation in most of the band)
[1]	44mm x 44mm	2.9 -10.8	<18dB
[2]	60mm x 50mm	3 – 10.6	<15.5dB
[3]	60mm x 41mm	3.1- 10.6	<19dB
[9]	50mm x 50mm	3 -12	<16dB
This Work	52mm x 52mm	2.9-12.9	<20dB

V. CONCLUSION

A four-element planar UWB-MIMO antenna system has been proposed with an overall cross-sectional area of 52mm x 52mm which makes it compact. Meanwhile, a plus-sign stub on the top provides isolation below -20dB. The antenna operates over the band ranging from 2.9 – 12.9 GHz that covers the entire UWB range i.e. 3.1-10.6 GHz. Return loss characteristics are observed below -10dB that provide an impedance bandwidth of 126.58% ensuring its application in wireless communication areas and all the other applications falling in UWB range. The antenna has a VSWR<2 throughout the operating band.

REFERENCES

1. Yan-Yan Liu, Zhi-Hong Tu, “Compact Differential Band-Notched Stepped-Slot UWB-MIMO Antenna with Common-Mode Suppression”, IEEE Antennas and Wireless Propagation Letters, 2016.
2. Ahmed A. Ibrahim, Mahmoud A. Abdalla, John L. Volakis, “4 Elements UWB MIMO Antenna for Wireless Applications”, Antennas and propagation and USNC/URSI National Radio Science Meeting IEEE Symposium, 19 October 2017.
3. X.–L. Liu, Z.–D. Wang, Y.–Z. Yin, J. Ren, and J.–J. Wu, “A Compact Ultrawideband MIMO Antenna Using QSCA for High Isolation”, IEEE Antennas and Wireless Propagation Letters, pp no. 1497 – 1500, vol.13, 17 July 2014.
4. Deepika Sipal, Mahesh P. Abegaonkar, and Shiban Kishen Koul, “Easily Extendable Compact Planar UWB MIMO Antenna Array”, IEEE Antennas and Wireless Propagation Letters, Vol. 16, 2017.
5. Yashika, Monika Sharma, Sachin Sharma, Kumar Goodwill, Jagannath Malik, “A CPW Fed Antenna Design for UWB-MIMO Communication System for High isolation” , International Conference on Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH14) 28 & 29 November 2014.
6. P Naveen Kumar Reddy, S Anuradha, “A Compact Four Element UWB MIMO Antenna” , International Conference on Trends in Electronics and Informatics ICEI 2017.
7. R. Saleem, M. Bilal, K.B. Bajwa and M.F. Shafique, “Eight-element UWB-MIMO array with three distinct isolation mechanisms”, ELECTRONICS LETTERS, Vol. 51 No. 4 pp. 311–313, 19th February 2015.
8. Qian Li, Alexandros P. Feresidis, Marina Mavridou, and Peter S. Hall, “Miniaturized Double-Layer EBG Structures for Broadband Mutual Coupling Reduction Between UWB Monopoles”, IEEE Transactions on Antenna and Propagation, Vol. 63, No. 3, March 2015.
9. Jianfeng Zhu, Shufang Li, Botao Feng, Li Deng, and Sixing Yin, “Compact Dual-Polarized UWB Quasi-Self-Complementary MIMO/Diversity Antenna With Band-Rejection Capability”, IEEE Antennas and Wireless Propagation Letters, Vol. 15, 2016.

AUTHOR PROFILE

Miss. Swati Gautam was born in Satna, Madhya Pradesh, in 1992. She completed her Bachelor of Engineering in Electronics and Communication Engineering, being a Gold Medalist from RGPV. She started her Master of Engineering Degree in Microwave Engineering from Jabalpur Engineering College, Jabalpur, Madhya Pradesh, in 2016. Currently, she is working on UWB-MIMO (Multiple input, Multiple output) Antenna systems.

Mrs. Kanchan Cecil, is an Assistant professor in Electronics and telecommunication Engineering Department in Jabalpur Engineering college, Jabalpur. She has done her Bachelor’s of Engineering degree in E&TC Engineering from Ujjain Engineering College, Ujjain in 2003 and her Master's of technology degree in Digital communication from MANIT, Bhopal in 2009. Currently she is pursuing her Ph. D in Micro-Nano Electronics from IIITDM, Jabalpur.

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