A Novel Wideband Two Element MIMO Antenna Design with Band Rejection Capability

Revati C.G
Assoc. Professor
Electronics and Communication Engineering
Sharnbasva University
Kalaburagi, India

Rajendra R.Patil
Professor& Head
Electronics and Communication Engineering
GSSS Institute of Engineering and Technology for Women
Mysuru, India

***Abstract*-This paper presents a two element Multiple Input Multiple Output (MIMO) antenna design with band rejection capability. Wideband antenna resonance from 3.2 GHz to 10.2 GHz is achieved with a notch band at 6 GHz (Wi-MAX frequency band). A slot is etched on the elements to provide notch band. Simulation is performed through the 3DEM of mentor graphics software. Simulated parameters are return loss, mutual coupling (|S_{12}|, |S_{21}|) less than -20 dB which represents significant reduction of coupling and gain varies from 2dBi to 5 dBi in the resonance band.**

Keywords— MIMO, Wi-MAX, FR4 substrate, 4G and 5G.

I. INTRODUCTION

Multiple Input Multiple Output antenna technology is a very robust approach for 4G and 5G wireless applications. Ever increasing demands of users such as high data rate and reliability in the communication are full filled by MIMO antenna design. MIMO utilizes spatial multiplexing method to provide high data rate and diversity techniques to achieve strong link capacity in the multipath fading environment which results in the benefit of reliable communication. MIMO faces several challenges in its efficient designing because of mutual coupling effects among its elements.

In the literature several mutual coupling reduction methods are found. Tree like structure is incorporated on ground to weaken the coupling [1], Reverse coupling is created using parasitic elements to nullify original coupling occurring in the design[2], Neutralization line is used in the design to mitigate mutual coupling by introducing counter phased currents[3], Ground stubs are included to block the current reaching to other port from the excited port[4], A narrow slot introduced in the design provides high isolation by distributing current around it at its resonance[5], Two inverted L shaped strips and slot on the ground is built to cut off radiation reaching other element from the excited element[6], High isolation is achieved through polarization diversity[7], To suppress mutual coupling author presented L shaped strips on ground[8].

In this paper two element MIMO antenna is designed with stubs introduced on ground to reduce coupling effect thereby enhancing the isolation.

II. ANTENNA DESIGN

Two identical element MIMO antenna with the dimension of 26 x 31 mm^2 is designed on economical FR4 substrate of dielectric constant 4.3, thickness 0.8mm. Each element of the MIMO antenna is a rectangular monopole antenna.

Fig.1 and Fig.2 are the geometry of MIMO antenna without and with stub structure on ground respectively. A Slot is introduced in the design to obtain notch band at 6 GHz (Wi-MAX frequency band). Antenna dimensions are tabulated in TABLE I.

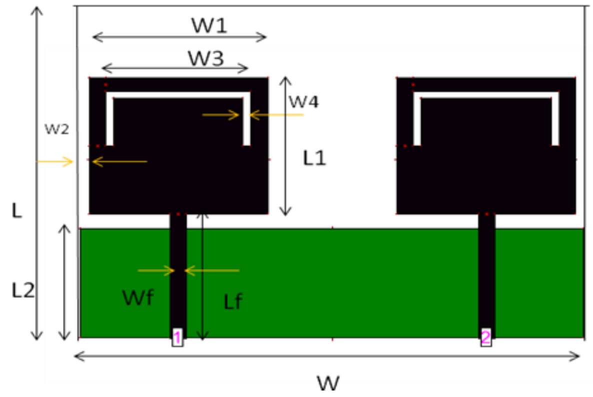

Fig.1. Antenna geometry without stub structure

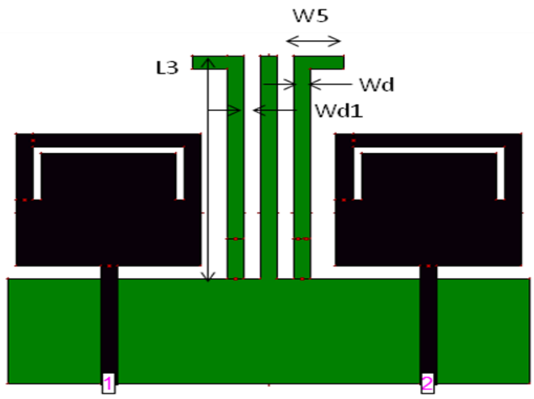

Fig.2. Antenna geometry with stub structure

TABLE I: DIMENSIONS OF THE DESIGNED ANTENNA

Parameters	Dimensions in mm
L	26
W	31
L1	10
L2	8
L3	17
Lf	9
W1	11
W2	0.5
W3	9
W4	0.5
W5	3
Wd	1
Wd1	1
Wf	1

Antenna geometry in Fig.2 shows that a stub structure has three stubs on the ground plane aiding to have increased isolation. Among three stubs two stubs are in the form of inverted L shape and all the stubs have same width of 1mm.

III. RESULTS AND DISCUSSION

Antenna performance is investigated by carrying simulation on 3DEM of mentor graphics software.

Fig. 3 shows s-parameters $|S_{11}|$ and $|S_{12}|$ for the antenna in Fig. 1. $|S_{11}|$ which represents return loss, shows that antenna resonates in the frequency band from 2.55 GHz to 9.9 GHz with the band rejection at 6 GHz i.e from 5.7 GHz to 6.65 GHz and poor impedance matching in the frequency band from 3.6 GHz to 5 GHz. Mutual coupling $|S_{12}|$ is greater than -3 dB in lower frequency band which represents very poor performance due to more coupling among antenna elements and in the higher frequency bands it is below -12dB.

Since two antenna elements are identical $|S_{22}|$ and $|S_{21}|$ are same as $|S_{11}|$ and $|S_{12}|$ respectively.

Fig. 4 shows s-parameters $|S_{11}|$ and $|S_{12}|$ for the antenna in Fig. 2. $|S_{11}|$ which represents return loss shows that antenna resonates in the frequency band from 3.2 GHz to 10.2 GHz with a band rejection at 6 GHz i.e. from 5.7 GHz to 6.35 GHz to avoid interference from this Wi-MAX frequency band. Since two antenna elements are identical $|S_{22}|$ and $|S_{21}|$ are same as $|S_{11}|$ and $|S_{12}|$ respectively. Simulated results show that $|S_{12}|$ in the entire antenna resonance band is below -20 dB which represents significant reduction in the mutual coupling compared to the design without stub and $|S_{11}|$ indicates wideband impedance matching is achieved compared to the geometry in Fig.1.

By comparing the results obtained with and without stub structure it is found that MIMO antenna with stub structure has improved impedance matching thereby results in wideband characteristic and also more isolation is achieved by the reduction of coupling.

Fig. 7 and Fig. 8 represent the gain of the two MIMO antenna geometry of Fig.1 and Fig.2 respectively.
Gain varies from 1.6 to 5 dBi in the case of without stub structure and between 2 to 5dBi in the case of with stub structure.

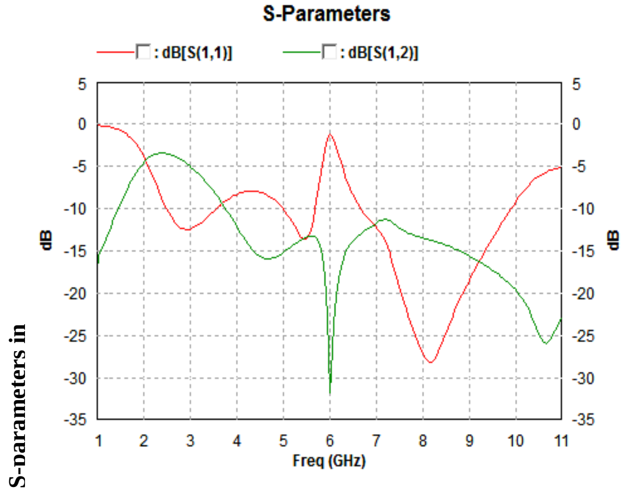

Fig.3. S-parameters without stub structure (**$|S_{11}|$, $|S_{12}|$**)

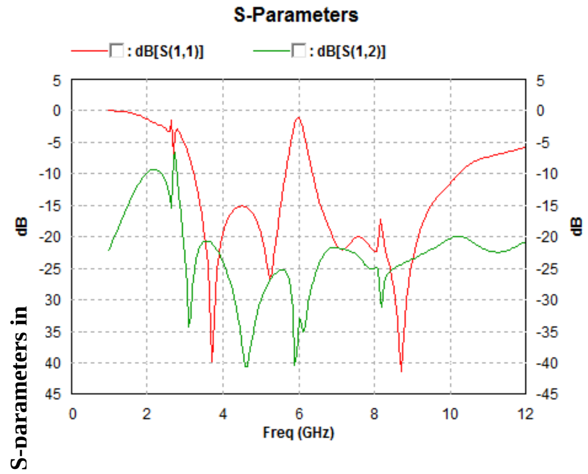

Fig.4. S-parameters with stub structure (**$|S_{11}|$,$|S_{12}|$**)

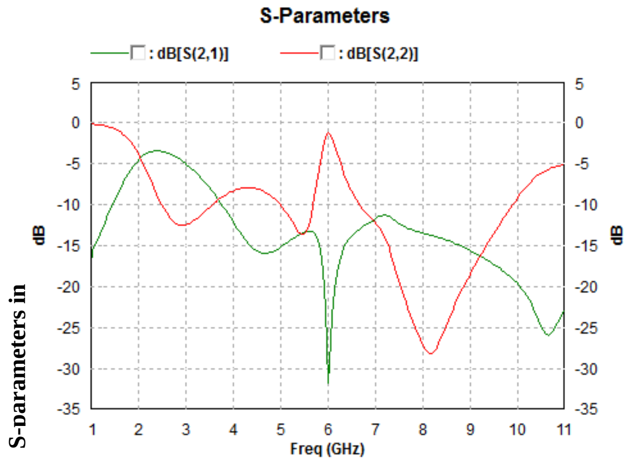

Fig.5. S-parameters without stub structure (**$|S_{22}|$, $|S_{21}|$**)

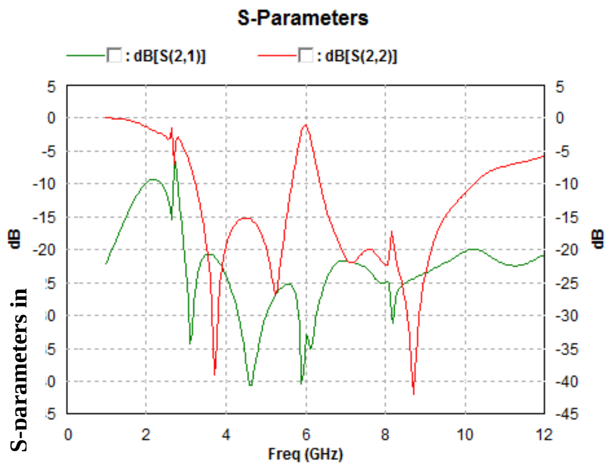

Fig.6. S-parameters with stub structure (**$|S_{22}|$, $|S_{21}|$**)

Fig. 5 and Fig. 6 show the $|S_{22}|$ and $|S_{21}|$ of the MIMO antenna without and with stub structure.

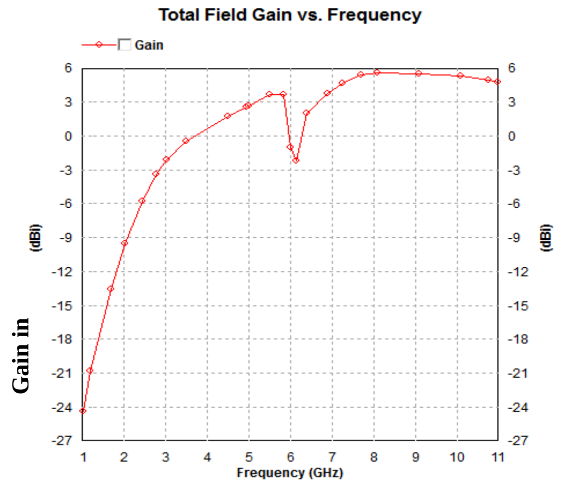

Fig.7. Gain without stub structure

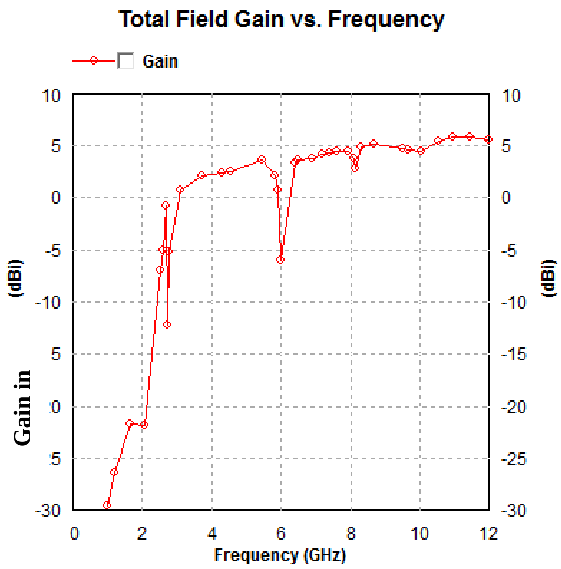

Fig.8. Gain with stub structure

IV. CONCLUSION

A novel design of two element MIMO antenna for wideband applications is presented. The proposed antenna has band rejection capability at 6 GHz to avoid interference. A decoupling stub structure is introduced in the proposed antenna system which results in significant reduction in mutual coupling to less than -20 dB in the resonance band. Obtained isolation indicates that MIMO antenna designed is good choice in the multipath fading environment.

Since antenna has wideband characteristic it is suitable choice for WLAN and some of the Wi-MAX based wireless applications.

REFERENCES

[1] Shuai Zhang, , Zhinong Ying,, Jiang Xiong, Sailing He, "Ultrawideband MIMO/Diversity Antennas With a Tree-Like Structure to Enhance Wideband Isolation ", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, Vol. 8,2009.

[2] Zhengyi Li, Zhengwei Du, Masaharu Takahashi, Kazuyuki Saito, Koichi Ito," Reducing Mutual Coupling of MIMO Antennas with Parasitic Elements for Mobile Terminals," IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION , Vol. 60, No. 2, Feb 2012.

[3] Saou-Wen Su, Cheng-Tse Lee, Fa-Shian Chang," Printed MIMO Antenna System using Neutralization-Line Technique for Wireless USB Dongle Applications," IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION , Vol. 60, No. 2, Feb 2012.

[4] Li Liu, S. W. Cheung,& T.I.Yuk" Compact MIMO Antenna for Portable Devices in UWB Applications", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, Vol. 61, No. 8, August 2013.

[5] Jian Ren, Wei Hu, Yingzeng Yin and Rong Fan," Compact printed MIMO Antennas for UWB Applications", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, Vol. 13,2014.

[6] Sultan Shoaib, Imran Shoaib, Nosherwan Shoaib, Xiaodong Chen and Clive G. Parini," Design and Performance Study of a Dual-Element Multiband Printed Monopole Antenna Array for MIMO Terminals.", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, Vol. 13,2014.

[7] M.S. Khan, A.D. Capobianco, A. Naqvi, M.F.Shafique, B. Ijaz and B.D. Braaten, " Compact planar UWB MIMO antenna with on demand WLAN rejection", EECTRONICS LETTERS 25th june 2015, vol. 51,No. 13.

[8] Richa Chandel, Anil Kumar Gautam and Karumudi rambabu, "Tapered Fed Compact UWB MIMO-Diversity Antenna With Dual Band-Notched Characteristics", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, Vol. 66, No. 4, April 2018.