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

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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](image1)

![Fig.2. Antenna geometry with stub structure](image2)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dimensions in mm</th>
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<td>W</td>
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</table>

TABLE I: DIMENSIONS OF THE DESIGNED ANTENNA
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.
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


