

Mutual Coupling Reduction for Dual-Band MIMO Antenna with Simple Structure

Vijaya Kumar Talluri¹, Ashish Niyaz Shaik², Tulasi Ram Yadav Thota³, Sumanth Kumar Yamani⁴,
Jayanth Puttagunta⁵, Ravi Teja Pilli⁶

Asst.Proffesor, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India¹

U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India²

U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India³

U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India⁴

U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India⁵

U.G. Student, Department of ECE, VVIT, Nambur, Guntur, Andhra Pradesh, India⁶

ABSTRACT:The main aim of this project is to reduce the mutual coupling effect for a novel dual-band MIMO antenna with simple structure. The antenna contains two dual-band antenna elements with T-shaped monopole and a \perp -shaped stub resonator. MIMO antenna operating at dual-bands having centre frequencies of 5.5GHz and 2.5GHz are crusted by the monopole and stub resonator. At higher frequencies the stub resonator provide isolation, which reduces dual-band isolation design into a single-band problem. The isolation can be improved at lower band by placing metal strip which cancels out original coupling. The metal strip has a simple texture with a compact size and is the only decoupling structure added in this design. The measured and simulated results show that the designed antenna can operate in all the 2.4/5.2/5.8GHz WLAN bands and isolation is improved by 15 dB.

KEYWORDS:monopole, stub resonator, mutual coupling, isolation, dual-band, multiple-input multiple-output (MIMO) antenna

I. INTRODUCTION

Multiple-input and multiple output (MIMO) technology has the ability to provide high transmission rate with highly reliable link in wireless communication. However, it is a complex technology as it uses of multiple antennas in order to increase channel capacity and to eliminate multipath fading propagation problem. The main problem in this technology is to reduce mutual coupling effect within the antenna elements and these methods provide only narrow band isolation between the antennas. Mutual coupling effect can be reduced using two structures, one is used at lower frequencies and the other at higher frequencies but combining the two structures is complex.

In this method, there is a dual band antenna element with T-shaped monopole and \perp -shaped stub resonator. At low frequencies \perp -shaped stub resonator can be considered as an antenna element as it coupled-fed by the T-shaped monopole. It reduces mutual coupling by suppressing the surface wave propagation at high frequencies as discussed above. In order to improve isolation at lower frequencies we use a metal strip between the antenna elements instead of using neutralization line, which provides supplementary coupling route. The metal strip is the additional decoupling structure added to the design, which is not physically connected to the antenna and has a small effect on initial antenna impedance. By considering the multiple functions of the \perp -shaped stub resonator and metal strip space, this design is simple and occupies less space.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 2, February 2018

II. RELATED WORK

Various techniques and studies had been performed to boost the isolation of the antenna ports. A tree like parasitic structure or mushroom like structure can minimize the mutual coupling among radiating components through restraining the surface wave propagation. The defected ground structure or a simple ground plane modification performing as band stop filter was designed to increase the isolation. Use of a slot has been useful to include a notch in the isolation between the antennas. However these methods have common deficiency of complex structures. A neutralization line is physically linked to the antenna components for improving the isolation. In this structure, the exciting mutual currents on the sufferer antenna are counter balance by implanting 180o out-of-phase currents from an excitation antenna. This neutralization technique is extensively used as it occupies small space. However, this method markedly deteriorates the reflection coefficient and therefore, the trial and error process are required to obtain the suitable dimensions which requires lot of time.

Moreover, most decoupling methods as mentioned above are only suited for narrow band isolation among two antennas. In previous studies of dual-band MIMO antennas, mutual coupling reduction is usually achieved by two isolation structures. One is for lower band and the other is for higher band. However, the combination of two isolation structures may increase complexity of the system, especially when the isolation structures are complex.

III. ANTENNA STRUCTURE

The specifications of the dual-band MIMO antenna is as shown in the Fig.1 below. The antenna is printed on a FR4 substrate which has relative dielectric constant of 4.4 and loss tangent of 0.02. The MIMO antenna has two T-shaped monopole elements and two \perp -shaped stub resonators and a metal strip. A dual-band antenna element is formed by joining a T-shaped monopole and a \perp -shaped stub resonator together. These two dual-band antenna elements are printed symmetrically. Metal strip and the \perp -shaped structure in the antenna element provides high isolation.

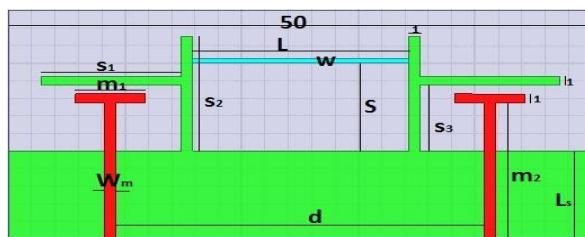


Fig 1: Geometry of dual-band MIMO antenna: $L=17.6$,
 $w=0.5$, $S=11$, $s_1=12$, $s_2=13$, $s_3=7.5$, $m_1=7$, $m_2=15$,
 $W_m=1$, $L_s=10$, and $d=30.5$. (All dimensions are
in millimetres)

IV. ANTENNA DESIGN

The above discussed structure is designed and simulated in HFSS software. The acronym for HFSS is High Frequency Structure Simulator. With the geometry given above a FR4 substrate is designed with thickness of 0.8 mm having relative dielectric constant of 4.4 and loss tangent of 0.02. The monopole element is designed by uniting both horizontal and vertical structure using Boolean function in HFSS. In the same way the other monopole element is designed and placed on the above surface of the substrate separated by the distance d as shown below. A ground structure is designed with given geometry in order to place the stub resonators. The \perp shaped stub resonators are also designed as monopole element, is placed at bottom surface of the substrate, and is united with the ground. This composite design is called dual-band element.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 2, February 2018

In order to provide the feed to this dual-band element we use a 50Ω microstrip line is used. When this dual-band element is excited, the monopole elements have an operating frequency of 5.5GHz and the \perp -shaped stub resonator provides a resonating frequency of 2.5GHz. This improves impedance matching from 5 to 6 GHz. It acts as a radiating element at 2.4-2.6 GHz band, works as a reflective component at other bands. But in this design the S_{11} of antenna is less than 10 dB and S_{12} is also less than 10 dB. In order increase the reflection coefficient we add a simple decoupling structure to the design which is not connected physically to the antennas.

The additional decoupling structure added to improve the isolation is metal strip. It provides isolation at higher frequencies and reduces mutual coupling effect during the lower frequency bands. This is different from the neutralization line as it is connected perpendicular to the microstrip line and is placed between the antenna elements. The designed antenna is as shown below.

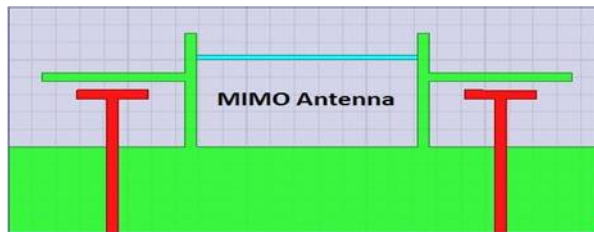


Fig 2: Designed MIMO antenna

V. EXPERIMENTAL RESULTS

The figures 3 and 4 shows the results of the simulated antenna designs.

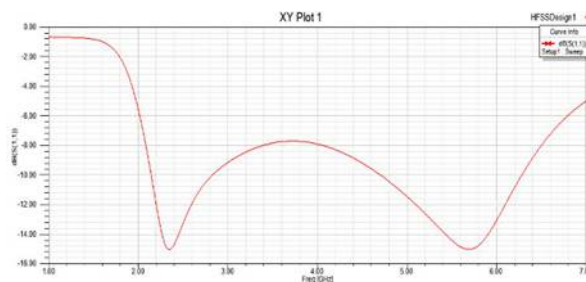


Fig 3: S_{11} of designed MIMO antenna

Here, Fig.3 represents the return loss of the designed antenna. S_{11} represents how much power is reflected from the antenna, and hence is known as reflection coefficient. If $S_{11} = 0$ dB, then all the power is reflected from the antenna and nothing is radiated. Here S_{11} is greater than -15 dB, it means if 3 dB of power is delivered to the antenna, -12 dB is the reflected power. The remainder of the power was accepted by or delivered to the antenna. This accepted power is either radiated or absorbed as losses within the antenna. Since the antennas are typically designed to be low loss, ideally the majority of the power delivered to the antenna is radiated.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 2, February 2018

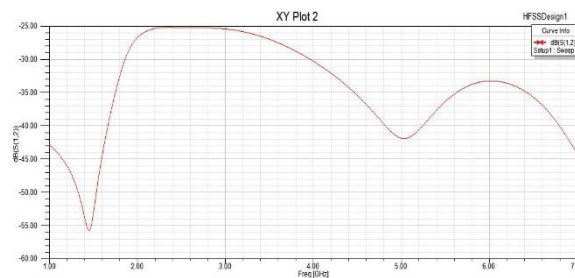


Fig 3: S_{12} of designed MIMO antenna

Here, Fig.4 shows reverse voltage gain of the designed antenna. It represents power transferred from port 2 to port 1. It is also called as reverse transmission coefficient. In this figure the value of S_{12} is above -30 dB.

VI. CONCLUSION

We have designed a dual-band MIMO antenna with reduced mutual coupling effect using a simple and compact structure for WLAN applications. The monopole element and radiating element within the structure provide high isolation at higher frequencies whereas the additional decoupling structure, the metal strip provides isolation at lower frequencies.

REFERENCES

- [1] YAN, S., SOH, P. J., VANDENBOSCH, G. A. E. Dual-band textile MIMO antenna based on substrate-integrated waveguide (SIW) technology. *IEEE Transactions on Antennas and Propagation*, 2015, vol. 63, no. 11, p. 4640–4647. DOI:10.1109/TAP.2015.2477094
- [2] RISCO, S., ANGUERA, J., ANDUJAR, A., et al. Coupled monopole antenna design for multiband handset devices. *Microwave and Optical Technology Letters*, 2010, vol. 52, no. 2, p. 359–364. DOI: 10.1002/mop.24893
- [3] SU, H., HSU, C., LIN, K. Dual-band insulator design by stacking capacitively loaded loops for MIMO antennas. *Electronics Letters*, 2010, vol. 46, no. 20, p. 1364–1365. DOI: 10.1049/el.2010.1756
- [4] ANDUJAR, A., AUGUERA, J. MIMO multiband antenna system combining resonant and nonresonant elements. *Microwave and Optical Technology Letters*, 2014, vol. 56, no. 5, p. 1076–1084. DOI: 10.1002/mop.28282
- [5] PARK, J., CHOI, J., PARK, J. Y., et al. Study of a T-shaped slot with a capacitor for high isolation between MIMO antennas. *IEEE Antennas and Wireless Propagation Letters*, 2012, vol. 11, p. 1541–1544. DOI: 10.1109/LAWP.2012.2226695
- [6] FOSCHINI, G. J., GANS, M. J. On limits of wireless communications in a fading environment when using multiple antennas. *Wireless Personal Communications*, 1988, vol. 6, no. 3, p. 311–335. DOI: 10.1023/A:1008889222784
- [7] GHOSH, S., TRAN, T., LE-NGOC, T. Dual-layer EBG-based miniaturized multi-element antenna for MIMO systems. *IEEE Transactions on Antennas and Propagation*, 2014, vol. 62, no. 8, p. 3985–3997. DOI: 10.1109/TAP.2014.2323410
- [8] YANG, F., RAHMAT-SAMII, Y. Microstrip antennas integrated with electromagnetic band-gap EBG structures: A low mutual coupling design for array applications. *IEEE Transactions on Antennas and Propagation*, 2003, vol. 51, no. 10, p. 2936–2946. DOI: 10.1109/TAP.2003.817983