A MIMO antenna for 5G band

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***Abstract*: We are living in the age of modern communication technology where high speed data transmission, better receive reception, better bit error rate is required and for this so much research work has been proposed. Using of MIMO antenna for this is one of them. As MIMO antenna technology promises better receive reception, better bit error rate, high speed data transmission but problem of mutual coupling is the one area which needs to sort out with MIMO design. In this paper we have proposed a 5G band MIMO antenna and a solution for problem of mutual coupling by using a decoupling element. The center frequency of the antenna is between 38-39 GHz.**

Index terms: Microstrip MIMO antenna, MIMO, decoupling element, resonator, microstrip patch antenna, 5G.

Introduction: In today's era communication become a crucial factor of life and thence communication system is additionally need to enhance. There is lot of work is being projected for enhancing the communication system like increasing of bandwidth, gain, channel capacity, reliability etc. In previous few years researchers are showing significant interest towards MIMO (Multiple-Input Multiple-Output). MIMO is become hot topic because with the help of MIMO the reliability, channel capacity, multipath propagation, enhanced data throughput, higher data rates and the most imperative is it's ample use in Wi-Fi LAN, Bluetooth, UMTS and in modern communication technology (5G).

In radio MIMO could be a methodology for multiplying the capability of a communication system using multiple transmit and receive antenna to take advantage of multipath propagation. The design of MIMO antennas are in the form of arrays (fig. 1).

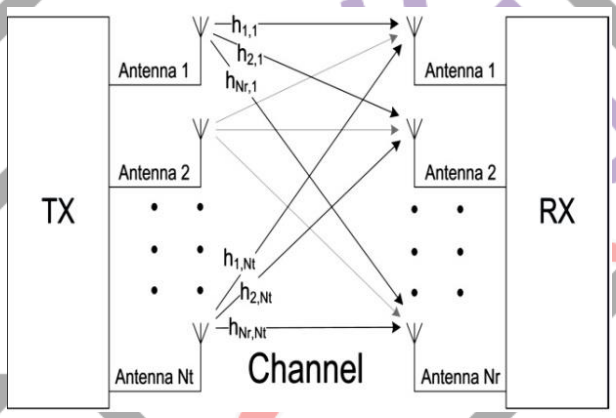


Fig.1 MIMO system

As there are ample of advantages of MIMO antenna there are also having a number of restrictions like these kind of antennas are relatively complex, power expenditures are high as compare to other microstrip patch antenna, these antennas are relatively expensive then the microstrip patch antenna and the main drawback is "Mutual Coupling" among antenna elements due to which there is signal interference among them and as a result the privileged value of mutual coupling degrades the antenna efficiency.

For reducing the mutual coupling among microstrip MIMO antenna ample of works were offered in literature. The most important methods which are used for simulation in literature for reducing the mutual coupling are Defected Ground Structure (DGS), Electronic Band Gap (EBG) Structure and resonators.

This paper presents simulated MIMO antenna and we also tried to reduce the problem of mutual coupling in microstrip MIMO antenna by placing a decoupling element "I Shaped resonator" among antenna element. All the simulation work is done on CST 2016 software.

Antenna designs and results: As discussed in the first section this paper presents design of the MIMO antenna. The patch antenna is prepared by the set of formulas used for calculating of width and length of microstrip patch antenna which is as follow:

Width of the patch (w) is given by

$$w = \frac{C}{2f_0\sqrt{\frac{\epsilon_r + 1}{2}}}$$

Here C is the velocity of light which is $3 \times 10^8\ m/s$, f_0 is the frequency and ϵ_r is the dielectric constant. In this paper we use FR-4 substrate and hence the value of ϵ_r is 4.4.

Effective width

$$W_{eff} = w + 2\Delta W$$

Here $\Delta W = 1.631 \ln\left(\frac{4}{\pi}\right)$

Length of the patch (L) is:

$$L = L_{eff} - 2\Delta L$$

The effective length $L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{reff}}}$

Here ϵ_{reff} is the effective dielectric constant which is give by

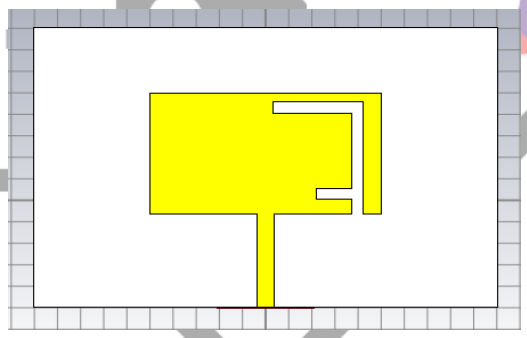
$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + \frac{12h}{w}\right]^{-\frac{1}{2}}$$

Here w is width of patch and h is the height.

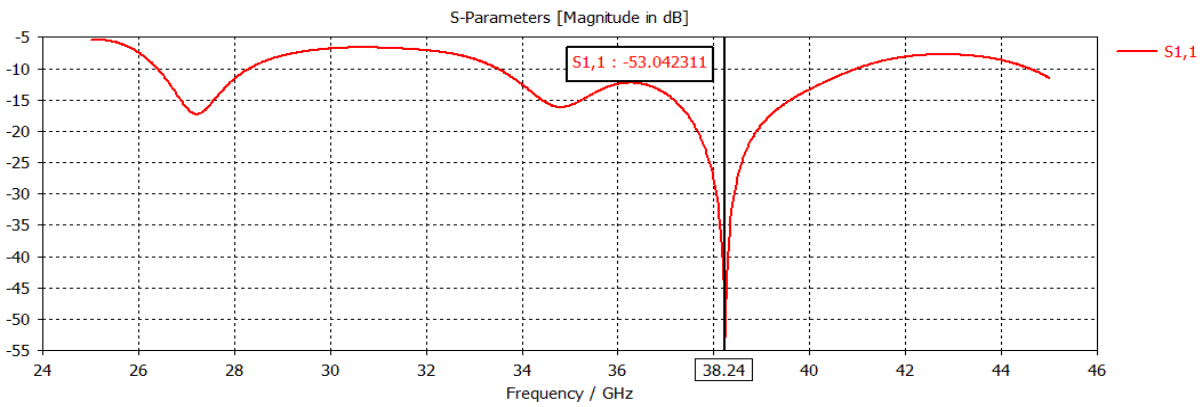
After successful construction of patch the next process is to give supply to the antenna. Feeding is essentially used with the purpose of conversation in antenna, the conversation of radio signal into electric signal or vies versa and for this reason it is considered to be a component of antenna. We are using Microstrip Line Feeding for our proposed antennas.

A. SISO antenna

The SISO (SINGLE INPUT SINGLE OUTPUT) antenna is the simplest structure of MIMO antenna. It is a low profile microstrip patch antenna with less complication and uncomplicated to manufacture and cost efficient [1]. The proposed antenna design, along with graph of S-parameter is shown in fig. 2. The proposed antenna works at 38.24 GHz frequency and have return loss around -53.042311 dB.



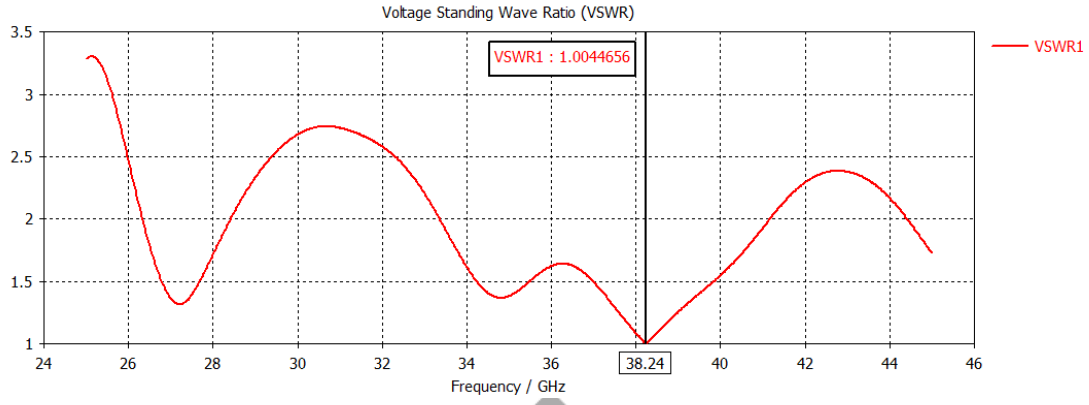
(a) Proposed antenna design



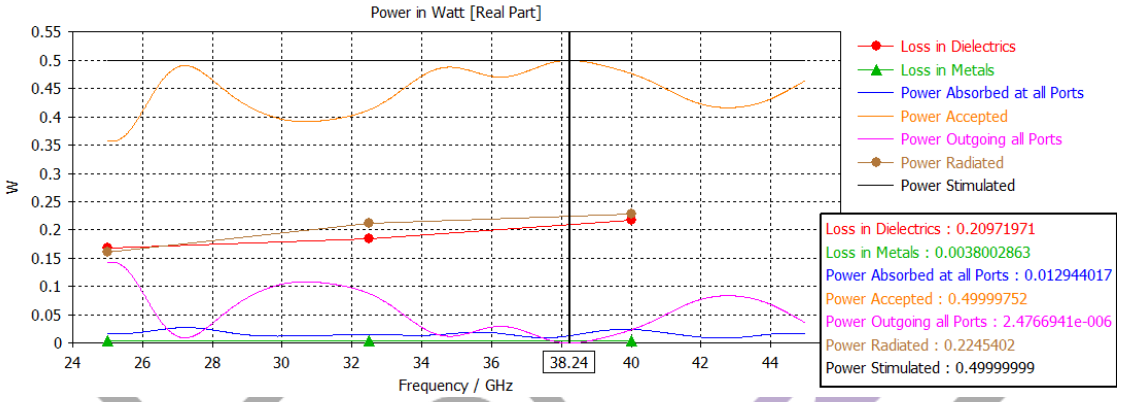
(b) Return loss of proposed antenna design

Fig. 2 proposed antenna design and return loss

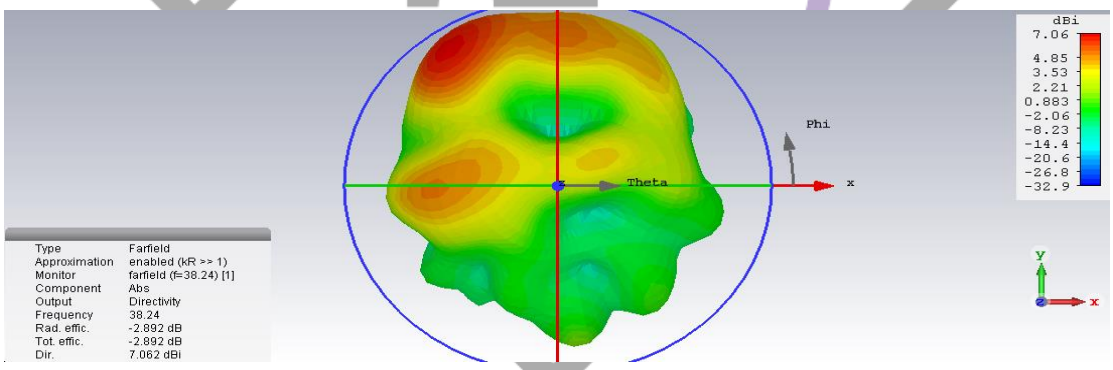
The SISO antenna is mainly used in radio, GSM and CDMA systems. But as the technology advances the recruitment of the higher data rate, better Bit Error Rates are necessary which does not satisfied by the SISO system. The other results like VSWR, Gain are shown below.



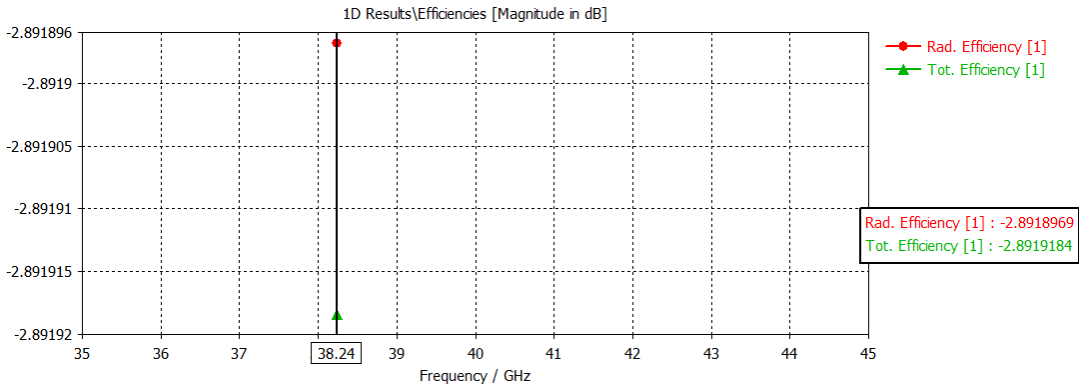
(a) VSWR of proposed antenna design



(b) Different power losses



(c) Directivity of proposed antenna



(d) Efficiency of proposed antenna

Fig. 3 Results of the proposed SISO antenna

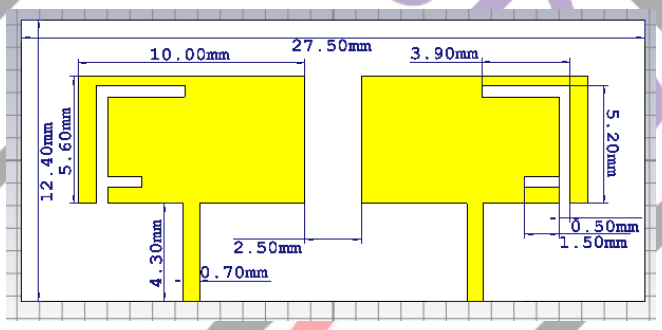
B. MIMO antenna

The Multiple Inputs Multiple Outputs antenna has more than one transmitting and receiving channels. This antenna works on multipath propagation phenomena due to which the probability of receive reception increased. It also increases the data throughput and has very low Bit Error Rate as compare to the SISO and SIMO antenna. This is the reason why it is most usually used in next generation communication system. As MIMO antenna is having upper hand as compare to the other microstrip patch antennas it has some disadvantages also like as there are multiple channels the design of MIMO antenna becomes more complex as well as it also increase the overall cost of the antenna. One major problem with the MIMO antenna is Mutual Coupling. As the MIMO antenna has multiple channels which are placed closely to each other and having multiple inputs as well it is the main reason for mutual coupling between antenna channels. This mutual coupling is the main reason for reduction in gain and distorted beam pattern.

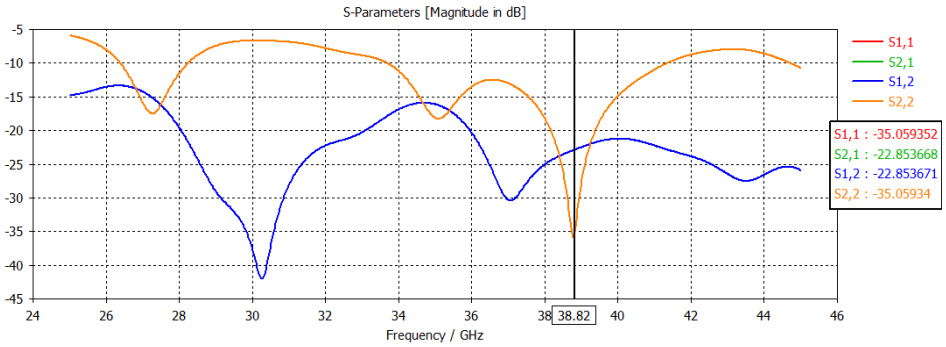
In past few years ample of work was presented to reduce the Mutual Coupling by using DGS, EBG configuration or by the use of resonators. DGS and EBG configuration placed within the ground plane offer unwanted back radiation. By the employing these techniques mutual coupling has been reduced appreciably at the cost of various sophisticated construction at the ground plane and it experiences dreadful conditions in radiation pattern [3]. The DGS and EBG structures are more convoluted structures and best possible deigns are more difficult to understand [4] and hence this paper presents use of "I shaped resonator for reducing the mutual coupling" as a decoupling element.

The basic concept for reducing the Mutual Coupling is the presence of one or more decoupling elements or networks. The decoupling components are situated between neighboring channels of MIMO antenna. These decoupling components alleviate the mutual coupling problem between closely spaced antenna elements [5]. This decoupling element resists the signal going straightforwardly from component to component. Here we should note that the inserted decoupling element does not degrade the antenna's radiation pattern, return loss, gain.

In this paper we proposed a MIMO antenna with two channels & two ports MIMO antenna The proposed MIMO antenna is formed from the proposed SISO antenna design. Fig.4 is the two channel two ports MIMO antenna with the return loss. Here fig. 4 is the proposed MIMO antenna design without decoupling element (I shaped resonator) but fig. 5 is the proposed MIMO antenna with decoupling element (I shaped resonator) along with return loss.

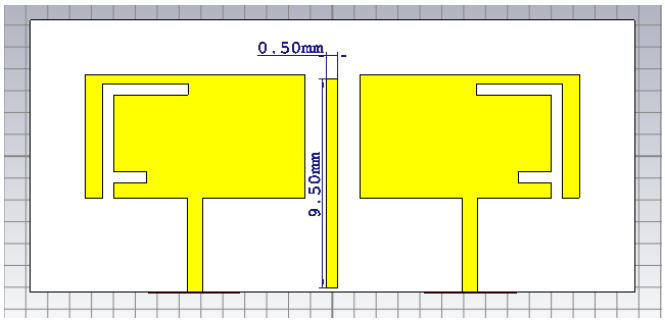


(a) Proposed MIMO antenna without decoupling element

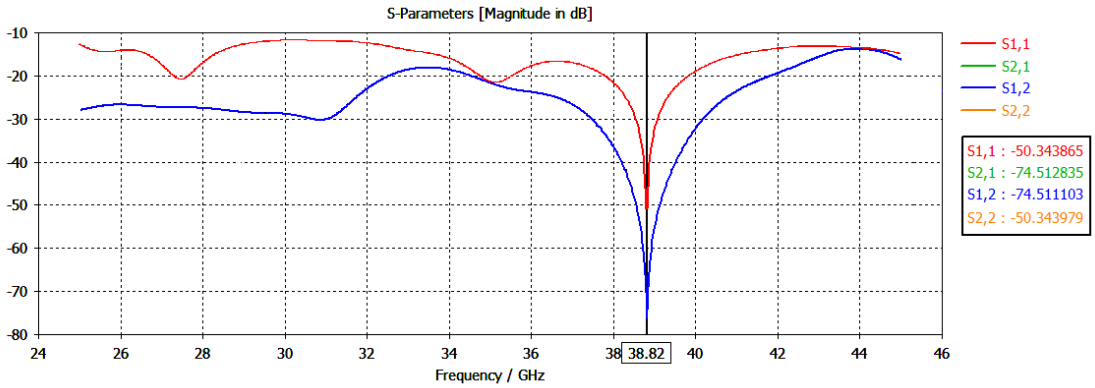


(b) Return loss of Proposed MIMO antenna without decoupling element

Fig. 4 Proposed antenna design (without decoupling element) and return loss



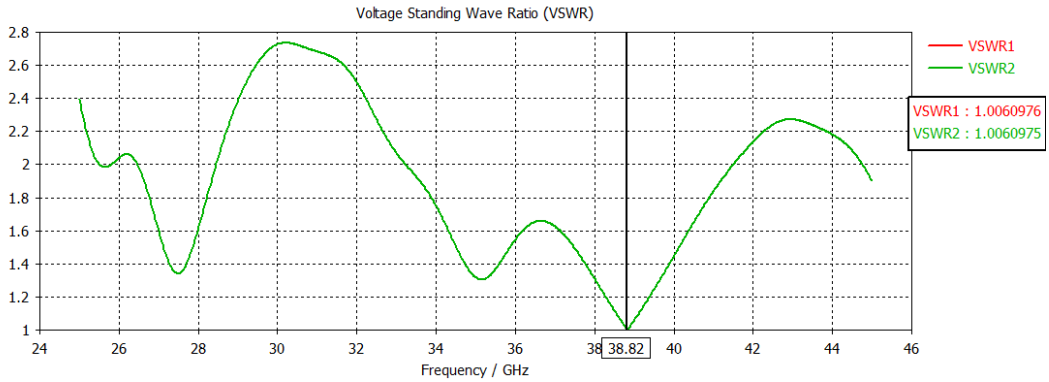
(a) Proposed MIMO antenna with decoupling element



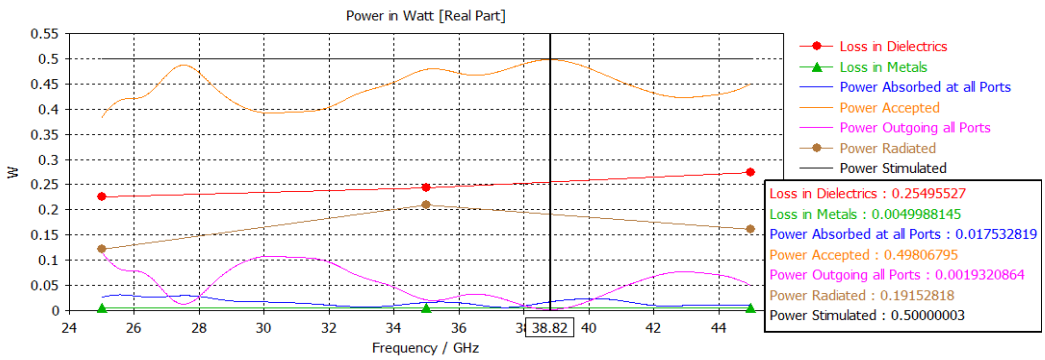
(b) Return loss of Proposed MIMO antenna with decoupling element

Fig. 5 Proposed antenna design (with decoupling element) and return loss

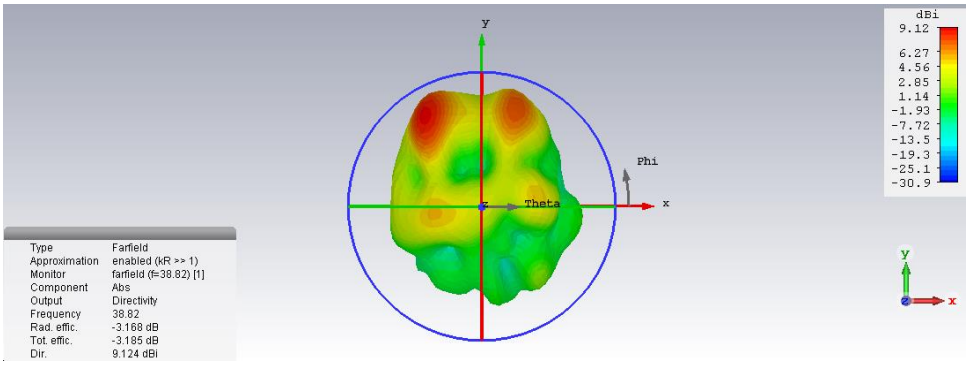
From fig. 4 it is clearly seen that (S-parameter graph) due to the problem of mutual coupling only one port is working properly but at the same time the other port is not working and hence to reduce this mutual coupling problem a decoupling element named as I shaped resonator is proposed in this paper which is placed between the closely spaced antenna channels (fig. 5). After the use of decoupling element the mutual coupling reduced by 51.6dB. other results of proposed antenna with decoupling element is shown below.



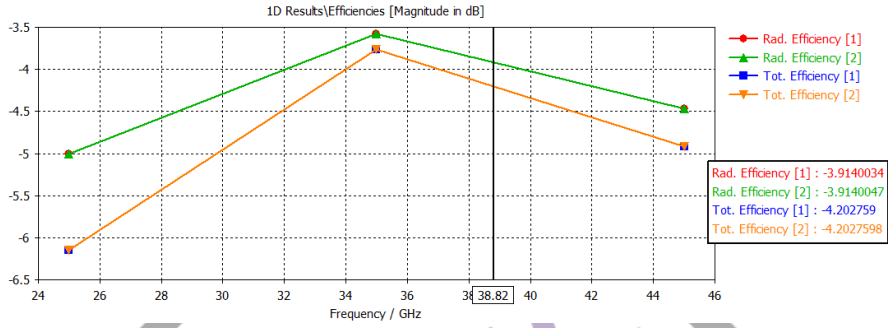
(a) VSWR



(b) Different power loss



(c) Directivity



(d) Efficiency

Fig. 6 Results of the proposed SISO antenna

Conclusion: As mentioned in the previous section the problem of mutual coupling and its reduction with the help of decoupling element is proposed which reduces the mutual coupling around 51.6dB.

References:

[1] C. A. Balanis, *Antenna Theory: Analysis and Design (second edition)*, John Wiley and Sons, Inc., New York, NY, USA, 1982.

[2] S. Nagraj and J. Xiao, "Best antenna selection for coded SIMO–OFDM," *Elsvier Signal Processing*, vol. 90, no. 1, pp 391-394, Jan. 2010.

[3] K. Ghosh and S. K. Parui, "Reduction of mutual coupling between e-shaped microstrip antennas by using a simple microstrip I-section," *Microwave and Optical Technology Letters*, Vol. 55, No. 11, Nov. 2013.

[4] S. Farsi, H. Aliakbarian, et. al., "Mutual coupling reduction between planner antennas by using a simple U- section," *IEEE antennas and wireless propagation letters*, vol. 11, 2012.

[5] J.C. Coetzee and Y. Yu, "closed form design equation for decoupling network of small array," *Electronics Letters*, Vol. 44, No. 25, Dec. 2008.

[6] A. Ghafor, A. A. Hameed and et.al., "Mutual Coupling Reduction of a (2×1) MIMO Antenna System Using Parasitic Element Structure for WLAN Applications," *Journal of Emerging Trends in Computing and Information Sciences*, Vol. 6, No. 11, Nov. 2015.

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