# Mutual Coupling Reduction between Closely Spaced Micros trip Patch Antenna Using Modified Triangular 2x2 MIMO with Stub

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*Abstract:* An important challenge in wireless communication is the reduction in size of devices. Also array size reduction has attracted increasing interest in recent years. Placing elements of an antenna close to each other is one way to reduce the total size of an antenna. However, one of the factor called mutual coupling depends on inter element separation and relative orientation. Mutual coupling is the major limiting factor of MIMO systems which arises mainly due to the smaller spacing between multiple antennas. Thus, within a compact structure of an antenna, reduction in mutual coupling in microstrip antennas is a major challenge.

This paper presents simulation and design of a compact tapered triangular 2x2 multi input multi output patch antenna for reducing mutual coupling. This proposed system is applicable in the area of WLAN (2.4 GHz–2.5 GHz/5.2 GHz–5.8 GHz) and WiMAX (2.3 GHz–2.6 GHz/3.3GHz–3.8 GHz/5.7 GHz–5.85 GHz). Good agreement has been achieved between measured and simulated results.

**Index Terms-Mutual Coupling MIMO Antenna.**

## I. INTRODUCTION

Over the past few years, a significant development in indoor and outdoor wireless communication enhanced the multiple input multiple output (MIMO) antenna technology. MIMO technology is a good in non-line of sight (NLOS) communication to provide better quality of services. The idea of MIMO was started with the capacity theorem.

The close proximity of radiating elements in MIMO has size reduction but at the cost of performance degradation. This degrading effect is known as mutual coupling, which severely affects radiation characteristics. The interference between the antennas is assessed by the parameter mutual coupling and the challenge of MIMO system is reduction in mutual coupling. This is the main objective of any MIMO design. Various diversity techniques like space diversity, polarization diversity, and pattern diversity can be used to control the degrading effects of mutual coupling.

In this paper, a thorough investigation of mutual coupling reduction techniques is studied and 2x2 modified triangular multi input multi output antenna is designed for mutual coupling reduction .A stub is inserted between the radiating elements for better isolation. It is found that a significant increase in isolation can be obtained between a pair of microstrip antennas with slits and addition of stub element. The proposed design can be used for reducing mutual coupling value of closely placed patch antenna effectively.

## 2. TECHNIQUES TO REDUCE MUTUAL COUPLING

Mutual coupling among closed spaced antennas is essential for the performance of microstrip antenna systems due to fact that induced currents, input impedance and radiation patterns are affected when antenna elements are correlated which in turn reduces capacity of MIMO system [4] and simple solution to reduce correlation is through physically separating radiating elements by greater distance. But this solution is impractical due to space limitation constraints. There are Methods to reduce mutual coupling between radiating elements in MIMO system and antenna array systems discussed in following sections. Some commonly used techniques include: parasitic element (PE) technique [10], electromagnetic band-gap (EBG) structures [11], decoupling and matching networks [12], and neutralizing line [13]. Also, some techniques have been presented for UWB applications recently, including stubs [14], slots introduced on the ground plane [15],the orthogonal placement of radiating elements with respect to each other [16], etc

### 2.1 USING ELECTROMAGNETIC BAND GAP (EBG) STRUCTURES

Basically Electromagnetic band gap (EBG) structures are realized by periodic arrangement of dielectric materials .It shows characteristics of band-pass or band stop [5] for isolation between components [6]. Coupling between the microstrip antenna arrays is the essential problem that always exists. To solve the problem, metamaterial is used in a rectangular patch antenna array substrate in order to reduce coupling between array antennas [7]-[9].

### 2.2 USING SPLIT RING RESONATOR (SRR) STRUCTURE

In [11] and [12], electromagnetic band-gap (EBG) structures using the mushroom like topology were used. However, the structures involved plated through vias, which are not attractive from the electric loss and manufacturing perspective. In [12], planar EBG structures were used, eliminating the need for vias, however incurring the complexity and cost of using two dielectric layers. In [13], a spiral resonator was embedded within the dielectric substrate, requires long fabrication process and increased losses in the antenna system. Complementary split-ring resonator (CSRR) structures were used for harmonic rejection and filtering [14].

In [15] a novel structure based on complementary split-ring resonators (SRRs) is introduced to reduce the mutual coupling between two coplanar microstrip antennas which radiates in the same frequency band.

### 2.3 USING EBG AND SRR

In paper [24] One-dimensional electromagnetic bandgap (1-D EBG) and split ring resonator (SRR) structures were inserted between two closely located monopole antennas to suppress mutual coupling. The 1-D EBG and SRR structures in these planar multiple antennas function as a reflector and wave trap, respectively. With the effect of these two structures, the mutual coupling between the two antennas is reduced by more than 42 dB and the back lobes are reduced by 6 dB.

The two-port planar antenna with1-D EBG and SRR structure was operated at 2.46 GHz .The spacing between the two monopole elements was fixed at 24 mm ($0.19\lambda0$) antennas were fed via coaxial cables. The reference antenna and the antenna with the 1-D EBG structures were fabricated to operate at the same frequency to investigate the effects of the 1-D EBG and SRR structures.

### 2.4 Using Slots

When slots are added to the ground plane, RF current in the antenna's orthogonal antenna ports is significantly reduced. Hence, the introduction of ground plane slots improves isolation to the point where each port behaves as an independent antenna. Due to the common element structure, a ground-plane slot structure is introduced to reduce the mutual coupling between the elements. Therefore, the parameters in terms of isolation better than 15 dB is achieved at the expected frequency band.

### 2.5 Isolation enhancement by adding a feed network

The isolation between the closely spaced antennas can also be improved through external microwave feed networks. Chen et al. (2008) proposed a four-port decoupling network, with two output ports connected to the antennas, for reducing the coupling between the two resultant new input ports. Each input port is in turn connected to a matching network for improving the input impedance. The transmission coefficient without the stub is more than -25 dB which reduces to -35 dB when the technique is applied.

## 3. Antenna design and analysis

In this paper, a 2x2 modified triangular multi input multi output antenna is constructed and its results are discussed. For reducing mutual coupling, external feed network i.e. stub is added.

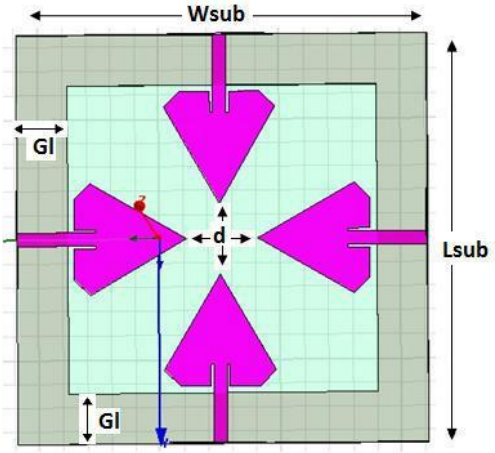



**figure1: proposed 2 x2 tapered triangular mimo patch antenna**

Figure 1 shows the 2x2 tapered triangular MIMO patch antenna. The planned two element array is designed on FR4 material with dielectric constant εr=4.4, loss tangent of 0.02 and having thickness =1.53 mm. After testing the results, for better performance slits were added. Addition of slits gives better results.

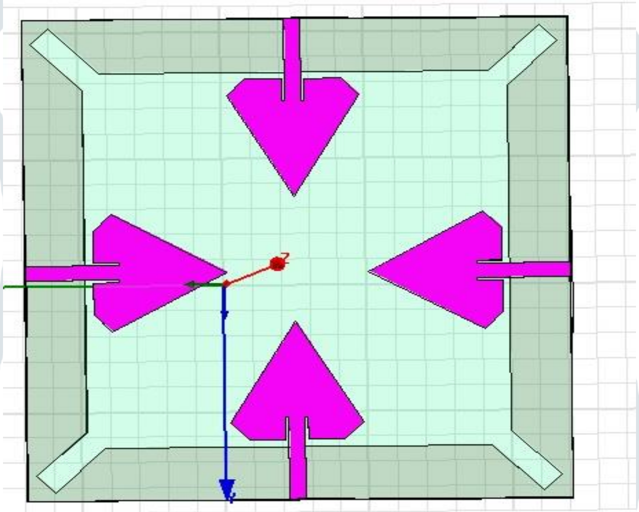


**figure 2: a 2x2 mimo antenna with slits**

Figure 2 shows the antenna design with slits. The results of the two antennas are shown in comparison table.

## Comparison Table

| Sr.No. | Shape of MSA | Freq (GHz) | Return Loss (dB) | Isolation (dB) | VSWR | BW (GHz) | Gain (dB) |
|---|---|---|---|---|---|---|---|
| 1. | 2x2 MIMO (without slits) | 2.46 | -20.85 | -13.61 | 1.21 | 2.38 | 3.30 |
| 2. | 2x2 MIMO (With slits) | 2.46 | -19.85 | -17.00 | 1.23 | 1.84 | 3.80 |

After studying the comparison table 2, it is seen that better results are obtained using antenna with slits. For even better performance, especially for reduction in mutual coupling, stub is added. This forms the final design of the antenna. It is shown in figure 3.

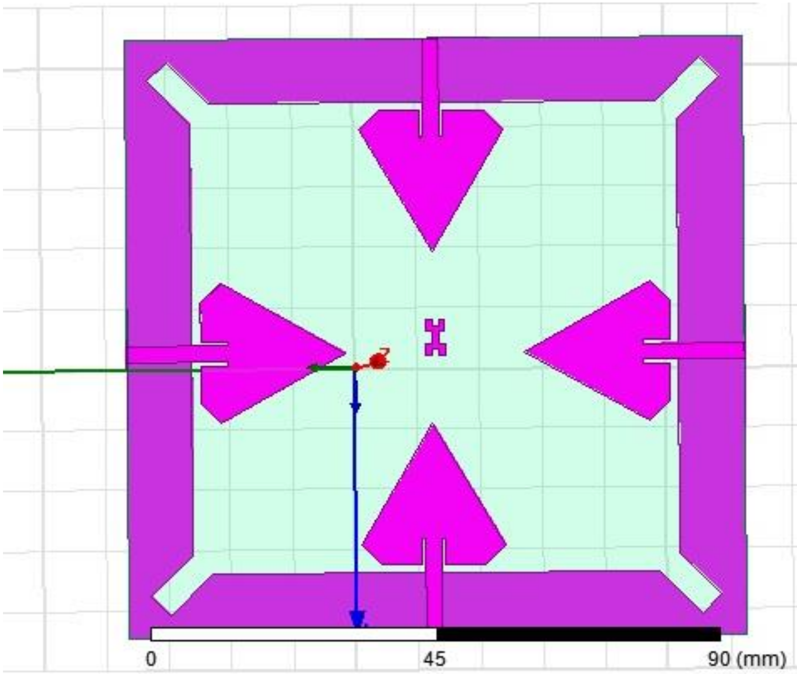



**figure 3: 2x2 mimo antenna with stub**

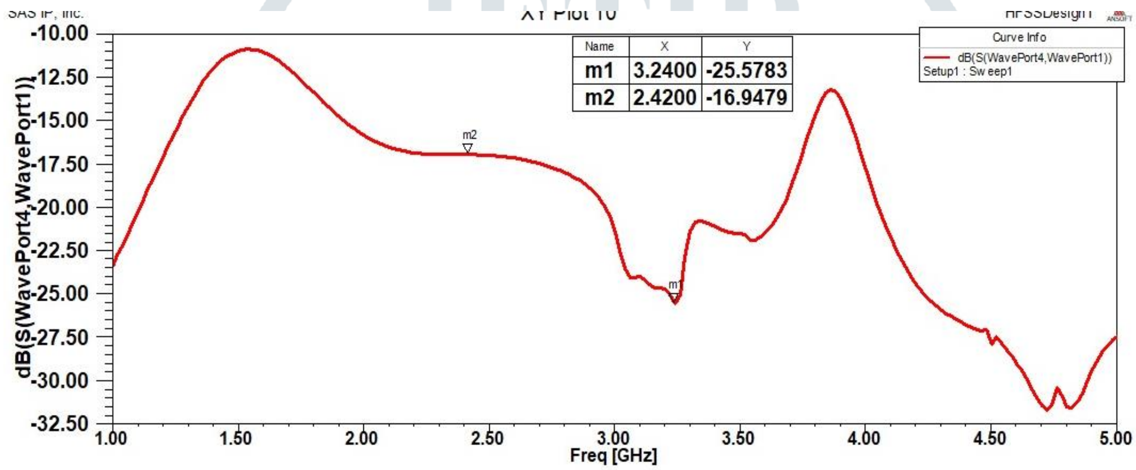
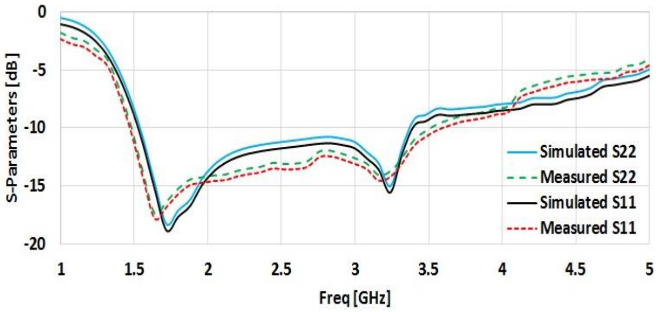
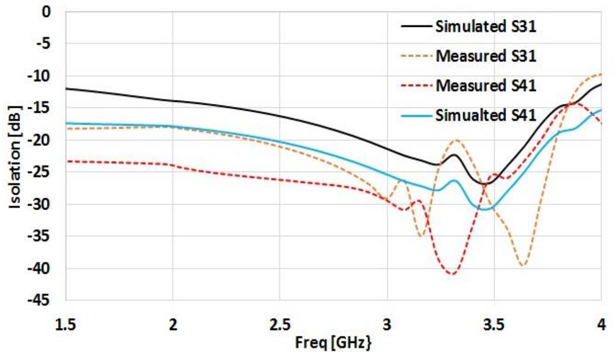



**figure 4: isolation for a 2x2 mimo antenna without stub**

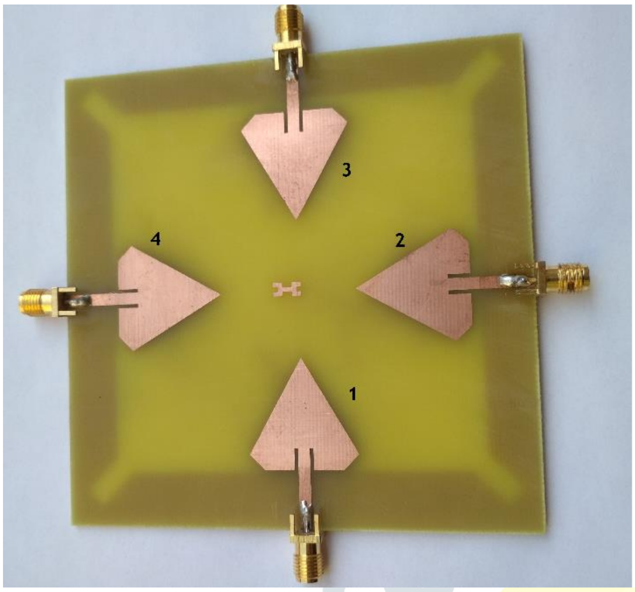
Figure 4 shows isolation value without stub. It is seen that isolation of -25.57 is obtained. To reduce the mutual coupling further, stub is added to the 2x2 MIMO antenna.The proposed Compact 2x2 MIMO antenna has been fabricated on an FR-4 substrate, and their parameters (scattering matrices and Isolation) have been measured and compared to the simulated results as presented in Fig. 5. The Proposed MIMO antenna has been tested using vector network analyzer Agilent technology N9923A series. The Measurement results of proposed 2x2 MIMO antenna gives excellent bandwidth of 2150MHz from 1.50GHz to 3.65 GHz with Isolation of less than -18dB through entire band. The simulated Vs measured S Parameter & Isolation of Proposed 2x2 MIMO antenna has been shown in fig.5(a) & (b).



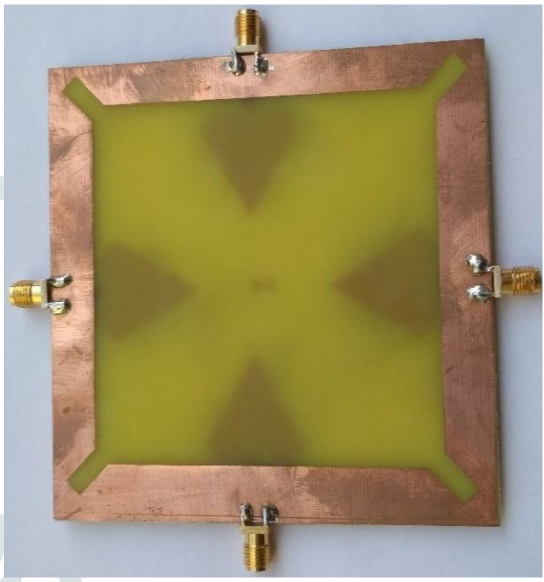

(a) s-parameters of mimo simulated vs measured




(b) isolation of mimo simulated vs measured



(c)fabricated 2 x 2 mimo – top view



(d) fabricated 2 x 2 mimo-bottom view

**Figure 5.** magnitude of simulated *s*-parameters (return loss and mutual coupling) of the proposed mimo antennas versus the measured results, and fabricated photos of mimo antennas: (a) s-parameter (b) isolation (c) fabricated top view of the proposed mimo antenna and (d ) fabricated bottom view of the proposed mimo antenna

Addition of stub reduces the mutual coupling. Isolation obtained using stub is – 40 dB, as seen in figure 5.

#### 4. CONCLUSION

In this paper, Mutual Coupling reduction techniques are studied and discussed. Also a compact 2x2 MIMO using polarization diversity for wideband is implemented and optimized to work over entire band from 1.58 to 3.96 GHz. This structure offers a maximum gain of 3.3 dB, R.L< -10 dB and isolation more than -40 dB is obtained. The radiated pattern of tapered triangular 2x2 MIMO antenna is omnidirectional in azimuth plane and bidirectional in elevation plane. A newly-designed polarization diversity multi input multi output antenna with wide bandwidth of dual slant ±45° polarization is presented here. Tapered techniques reduce size of MIMO antenna. The radiation patterns, gains and S parameters of four multi input multi output antenna elements have also been virtualized. The results obtained validate that the wideband MIMO diversity antenna which is discussed is appropriate for WLAN, Wi-Fi, 2G, 3G, LTE, UTMS, & WiMAX applications etc.

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