# Design and Analysis of High Isolation MIMO Antenna For Wireless Applications

**Miss.Gauri Krushnat Jadhav[1], Prof. S.B Abhang[2]**
Department of E & TC
[1, 2] JSPM ,Narhe,Pune, India

***Abstract***-*The ever increasing demand for high data rates drives the wireless communication standards towards incorporation of multi input multi output (MIMO) technology. For such systems, the designed antenna must be compact with low profile configuration, good impedance bandwidth and low mutual coupling. In this paper, a compact two-element double E shaped microstrip antenna operating at dual band 2.45 GHz & 1.57GHz is proposed specially used for multiple-input–multiple- output (MIMO) communications. First, the miniaturization is investigated by using double E shaped patch antenna structure. Next adding corrugated stub structure (CSS) between two patches for to enhance isolation in microstrip antenna arrays. The proposed CSS acts like a band-reject filter to reduce the coupling between the radiators in the antenna array. The Proposed antenna has been designed on FR4 substrate dielectric constant 4.4 and thickness h=1.53 mm & its dimension is 64.0 mm × 100.0 mm × 1.6 mm. The low frequency band covered is 1.56-1.59 GHz, and the high frequency band covered is 2.43-2.48 GHz. The isolation between the two elements was -51.0dB & -30.0 dB respectively after using a corrugated stub structure (CSS) between the two antenna elements. The gain of proposed antenna is around 2.45dBi. Experimental results show an high mutually coupling for an array with reduced edge-to-edge spacing of 15 mm.*

***Keywords***-Envelope correlation coefficient (ECC), double E shape band, multiple-input–multiple-output (MIMO), Antenna miniaturization, mutual coupling reduction

## I. INTRODUCTION

Antenna arrays play an important role in multiple-input–multiple-output (MIMO) systems, which are one form of smart antenna technology. MIMO technology offers significant increase in data throughput and link range without additional bandwidth or increased transmit power. MIMO system improves spectrum efficiency and transmission quality of wireless communication systems by utilizing the spatial degree of freedom of wireless multipath channel as citedin [1]. It also finds application in LTE [2], which is one of the most progressive 4G mobile communication standards. In these applications where spacing is a strong limitation, we need to use compact antenna elements with proper isolation between adjacent antenna elements. Defected ground plane structures can be used to resolve the isolation problem [3]. Electromagnetic band-gap (EBG) structures help in suppressing the surface current as in [4] and [5]. Mushroom-like EBG structure along with choke structure is used to improve the transmit-receive isolation to X-band large antenna arrays [6] providing an isolation improvement of 30 dB. Since the EBGs occupy large space, the need for a compact decoupling unit arises. Coupled feed structure can also be used for compactness as in [7]. This letter is aimed to achieve isolation enhancement in antenna arrays with closely spaced antenna elements using compact decoupling units as given in [8]. In [8], the use of a compact slotted meander-line resonator configuration is proposed to be the decoupling unit. To address the needs of recent technological advancements, the antenna array for MIMO applications has been considered for simultaneous transmit and receive operation. The performance validation of this structure for MIMO applications.

The corrugated stub structure (CSS) along with resonators helps in reducing the mutual coupling between the antenna elements operating at a frequency of 1.57GHz & 2.45 GHz. The surface currents from the radiating antenna are captured by the intermediate resonators along with corrugated structures, thus providing an enhanced isolation.The proposed corrugated stub structure (CSS) occupies only 2 mm spacing between the antenna elements. This compactness brings the suitability of the structure at high frequencies. The S21 value is -51.0dB at 1.57GHz and -30.0dB at 2.45GHz isolation has been achieved with an edge-to-edge spacing of between the radiators.

## II. ANTENNA DESIGN

The dielectric chosen is FR4-epoxy substrate having relative permittivity of 4.4 and the thickness of 1.53mm. The resonant frequency of the rectangular patch antenna, of length L and width W can be calculated using the following formula.

A. Geometry

Step 1: Calculation of Lambda ($\lambda 0$)-
Lambda ($\lambda 0$)=c/f=3x10^8/2.45x10^9
($\lambda 0$)=60mm at 2.45 GHz

The center frequency will be approximately given by:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}}$$

$$L = \frac{C}{2fc\sqrt{\varepsilon_r}} \quad \text{------------ (1)}$$

Where fc=is centre freq=2.45GHz
are=4.4 and c=3x10^8
**L=29.83mm**

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad \text{------------- (2)}$$

For c=3*10^8 m/s2, *fr*=2.45GHz,ε *r*=4.4
We get **W=38.22 mm.**
Feed width calculate by using

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \ln\left(8\left(\frac{H}{W_f}\right) + 0.25\left(\frac{W_f}{H}\right)\right) \quad \text{--------- (3)}$$

We get **Wf=2.84mm**
Step 5: Calculation of Feed length (Fl)-
Feed length (Fl)=lam/4*sqrt (4.4)
**Fl=14.5mm**
Calculation of Substrate dimension-
**Ls=L+2*6h=29+2*6*1.6=49mm**
**Ws=W+2*6h=38+2*6*1.6=58mm**

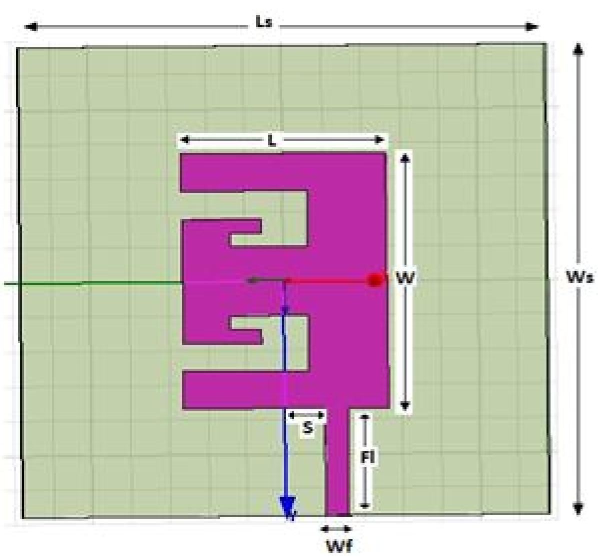


Fig.1 Geometry of the proposed Single double E shape patch antenna

Figure 1 shows the design of both rectangular patch antennas and its dimension. As shown in the Figure, the patches are fed The proposed antenna array is a double E-shape patches as shown in Fig. 1. It consists of a microstrip feed line and E shape patch. double E-shape patch antennas are used to produce dual band of microstrip antennas In the proposed design, double E-shape patch is connected into one antenna and is placed closer to another identical antenna. Both these antennas are separated by vertical patch Corrugated stub structure to reduce mutual coupling. The proposed antenna design achieves dual band because of double E shape structure that are generated in radiating patch.

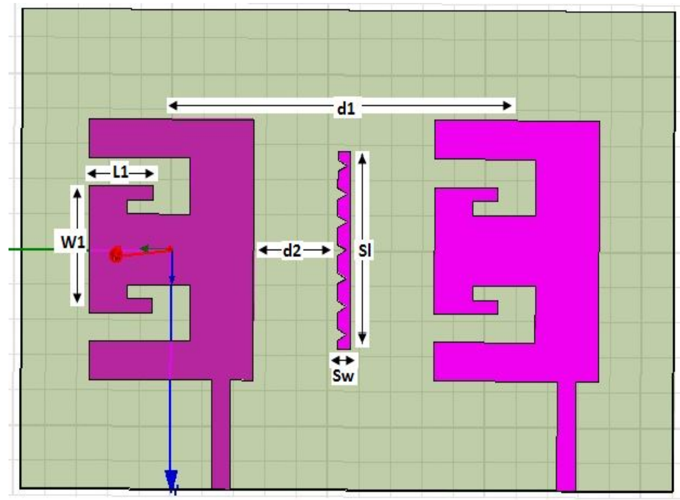


Figure 3. Proposed two-element antenna array with CSS decoupling unit.

The optimized dimensions of the proposed antenna along with other design parameters are in Fig 1. And fig.2. They are given below.

The proposed two element MIMO antenna array is developed on FR4 substrate with a relative dielectric constant εr= 4.4 , loss tangent of 0.02 and having a thickness of h =1.53 mm.

Table.1.Optimized Dimension table

| Sr.No | Parameters | Dimensions(mm) |
|---|---|---|
| 1. | L | 29.8 |
| 2. | W | 38.2 |
| 3. | Ls | 49.0 |
| 4. | Ws | 58.0 |
| 5. | FL | 14.5 |
| 6. | Wf | 2.85 |
| 7. | S | 6.0 |
| 8 | L1 | 10.0 |
| 9. | W1 | 18.0 |
| 10. | d1 | 50.0 |
| 11. | d2 | 13.0 |
| 12. | Sl | 28.0 |
| 13. | Sw | 2.0 |

## III. RESULTS AND DISCUSSIONS

The Simulation results are obtained by using HFSS software. Fig. 2 shows the simulated results of return loss for the proposed antenna Proposed two-element antenna array with CSS.

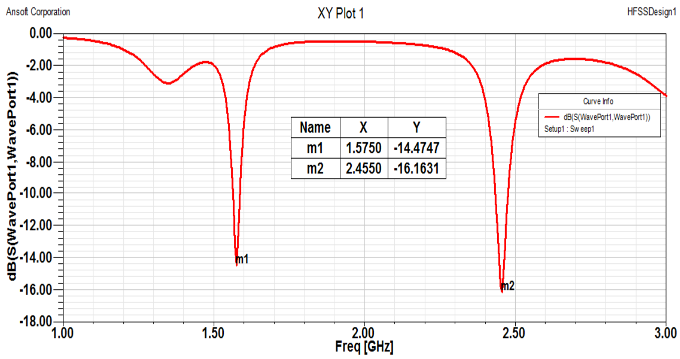


Figure 3. Return loss of proposed patch antenna

As shown in figure 3 the value of Return loss is -16.16dB at 2.45GHz.

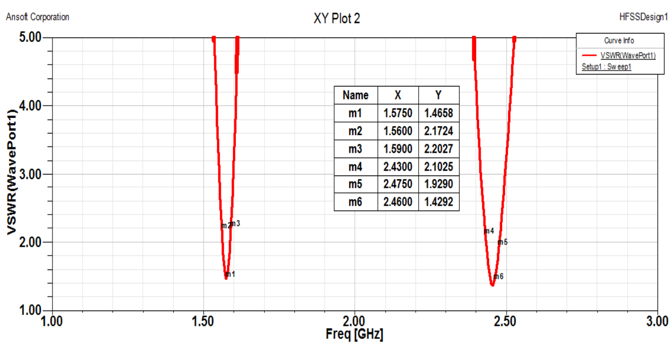


Figure 4 : VSWR of proposed patch antenna

From the Fig.4 we can be seen that the VSWR lies below the value 2 for 1.57 GHz & 2.45 GHz frequency band.

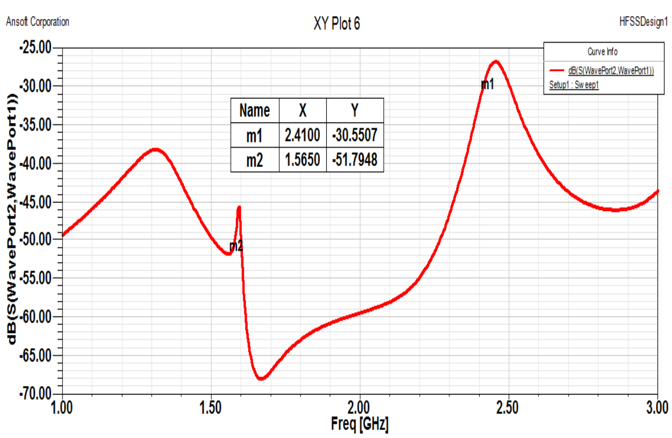


Figure 6: Isolation characteristics ( S21 ) of the two-element antenna array with and without CSS.

It is evident from Fig. 6 that simulated results using MIMO patch with CSS Provide high isolations -51.0 dB & -30 dB at 1.57 & 2.45 GHz, respectively.

It is evident that the mutual coupling between antenna elements in the array is well below -30 dB.

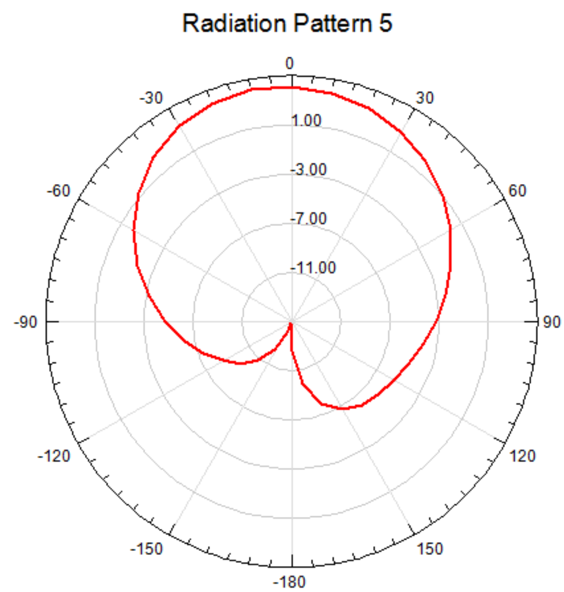


Fig.8 Radiation pattern

Fig.6 It is observed that the radiation patterns of antenna are directional in in both E-plane & H plane at freq 2.45GHZ.

It is may be inferred that this antenna array has nearly an directional radiation characteristics. It is also observed that the proposed antenna produces relatively stable pattern with resonant freq.

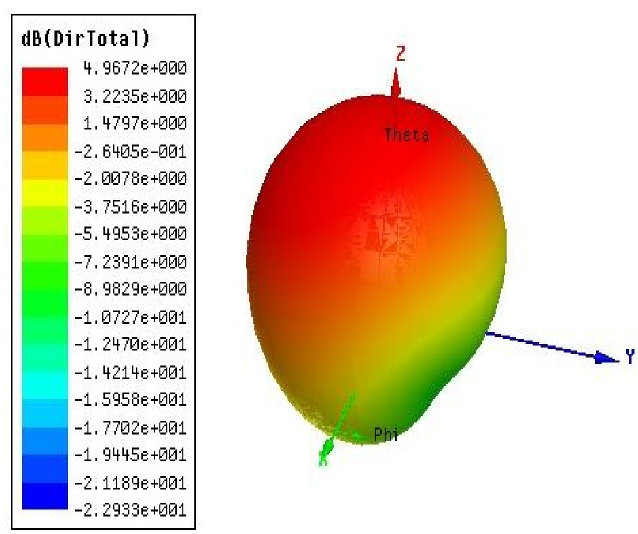


Figure 9: 3D Gain

Fig. 9 shows the simulated gain of the proposed antenna at the resonant frequency is 5.0 dBi.

Testing Measurements :

The Vector network analyzer(VNA) was used to measure the return loss, VSWR and Impedence of the fabricated antenna.for an analysis N9923A (300Khz-6GHz) technology used.

Following are the fabricated antenna results which simulated on VNA.

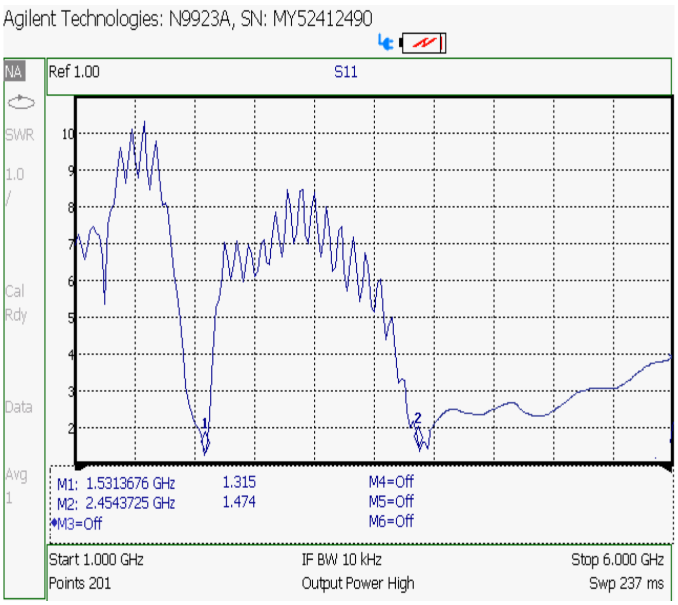


Fig 10 - VSWR of fabricated Antenna

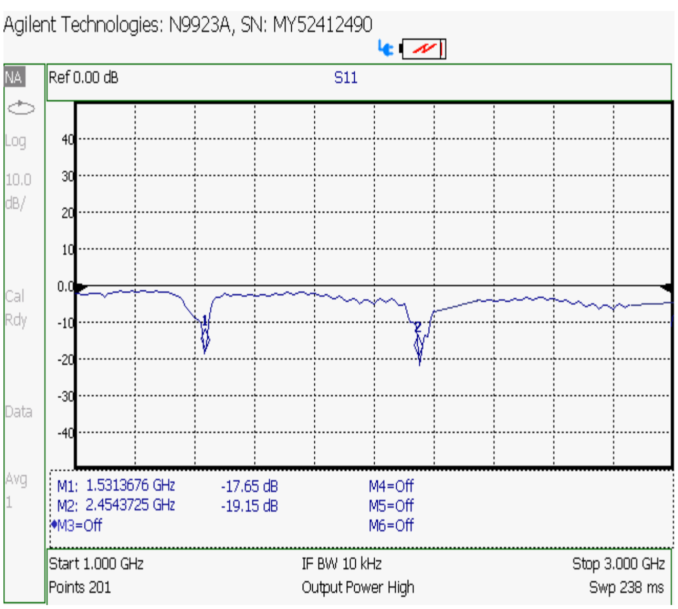


Fig 10 – Return loss of fabricated Antenna

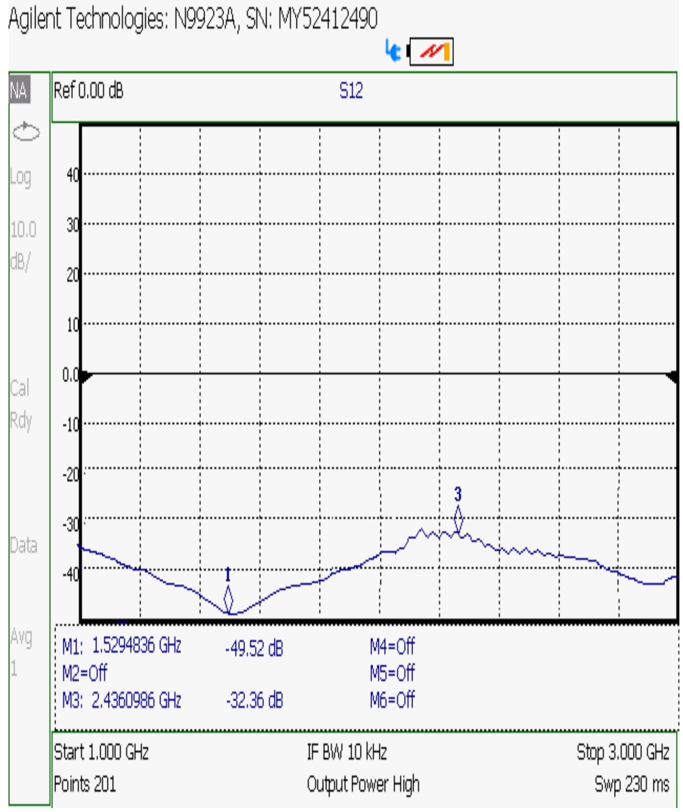


Fig 10 – S12Mutal coupling of fabricated Antenna

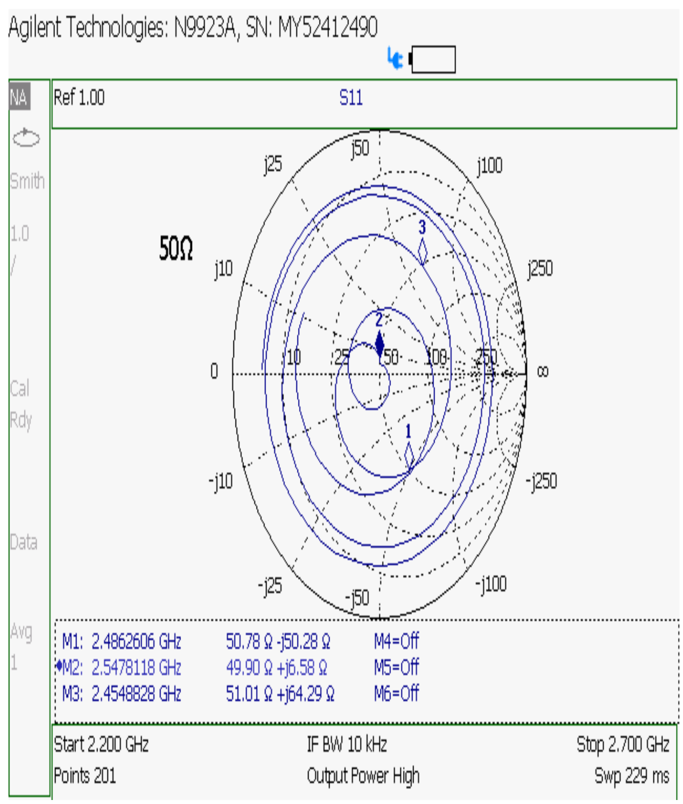


Fig 10 - Impedence of fabricated Antenna

## IV. COMPARISON TABLE

To improve isolation of this antenna, corrugated stub structure (CSS) is introduced .As seen from the table, Traditional patch antenna, and proposed patch antenna are described. It conclude that proposed patch antenna technique's both Isolation & gain of antenna are improved.

Table 2 Comparison table

| Sr. No. | MIMO Results | Freq (GHz) S11_ S22 | Return loss (dB) | Isolation S12_S21 (dB) | BW | Gain (dB) |
|---|---|---|---|---|---|---|
| 1. | Without Stub MIMO | 1.55 | -15.80 | -39.61 | 25 | 4.4 |
| | | 2.43 | -27.01 | -26.73 | 60 | |
| 2. | With Stub MIMO | 1.54 | -14.57 | -50.32 | 25 | 4.5 |
| | | 2.43 | -16.96 | -27.34 | 60 | |
| 3. | With Modified Stub MIMO | 1.55 | -14.47 | -51.80 | 30 | 5.0 |
| | | 2.43 | -16.16 | -30.00 | 60 | |

## V. CONCLUSION

In this paper, a new configuration of the corrugated stub structure (CSS) for array miniaturization with reduced mutual coupling has been introduced.A simple a compact double E-shape patch antenna array for MIMO wireless applications is presented. This MIMO antenna array resonates at 1.57GHz & 2.45GHz with an improved gain and with a reduced mutual coupling of -51 dB & -30 dB at the resonant frequency respectively. Antenna performance in terms of return loss, gain, and bandwidth, VSWR and radiation pattern are extracted for the proposed design. It has improved gain and reduced mutual coupling, hence making it suitable for many wireless applications including long rang applications.

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