# Design & Analysis of MIMO Microstrip Antenna with Improved Mutual Coupling

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**Abstract—:** *This work presents a defected ground structure (DGS) for a dual component multiple input multiple output (MIMO) antenna with improved mutual coupling. Defected ground structure is accepted as an arising approach for enhancing the different parameters of microwave circuits, which are narrow bandwidth, low gain and isolation. The two-element MIMO antenna operates at 3.3 GHz. The designed mimo antenna has a compress size of 26 mm × 40 mm suitable for practical design of an antenna. The antenna can be applicable for WLAN, Wi-Max, Wi-Fi which covers a patch operating at a frequency range 2.7 GHz to 5.1GHz. The antenna attains peak gain of 1.17 dB. Efficiency of the antenna is 94%.*

***Keywords* —** MIMO, Defected Ground Structure, Isolation.

## 1. Introduction

MIMO (multiple input multiple output) is an antenna technology for wireless communications in which multiple antennas are used at both the origin (transmitter) and the target (receiver). The antennas at both end of the broadcasting circuit are combined to reduce errors and optimize data speed. MIMO technology uses Multipath to boost wireless performance. MIMO technology takes a single data stream and breaks it down into some discrete data streams and sends it out over multiple antennas. MIMO becomes an essential segment of wireless communication excellence which involves WLAN/WPAN, WiFi, WiPro and WiMAX.

The antenna consists of two planar monopoles. Planar monopoles are placed such as to obtain good isolation. Two long ground stubs and short ground strip are exerted to enhance the isolation [1]. Two novel bend slit on ground behind antenna element is used for the reduction in mutual coupling. The slits are tilts by 90º, to reduce the effect of slits on impedance bandwidth [2]. Dumbbell shaped structure is used for the reduction in mutual coupling [3]. A dual slot patch along with parasitic elements is used for isolation enhancement. For the improvement in isolation, two elements are responsible which are parasitic monopole element and symmetric slot element [4]. Novel miniaturized two layer Electromagnetic Band Gap structure is introduced For the reduction in electromagnetic coupling. There is reduction in mutual coupling by using EBG structure [5]. To enhance the isolation and for the design and implementation of antenna modified serpentine structure is used. Modified serpentine structure acts like a band-reject filter, so that the mutual coupling of the antenna is reduced [6]. There is another technique for mutual coupling reduction that is by using metamaterials. This technique attained a -14 dB reduction in mutual coupling at 2.45 GHz and -13 dB at 5.2 GHz [7]. The technique slotted meander-line resonator (SMLR) is used to enhance the isolation in microstrip patch antenna arrays. This structure particularly designed for band-notch function. The proposed design provides an improvement in isolation by -16 dB [8]. Planar electromagnetic band gap (EBG) structure based on a truncated frequency selective surface is used. The reduction in the number of elements and isolation has been examined. By using this technique mutual coupling is reduced by more than -10 dB [9]. Photonic band-gap (PBG) structure is a new structure introduced to improve the isolation of antennas array. The presented technique is using spurline structure in the ground plane between antennas array which effectively suppresses mutual coupling [10].

Here in this paper we are designing a multiple input multiple output (MIMO) microstrip antenna with improved mutual coupling. For the reduction of mutual coupling there are various techniques like Decoupling Networks, Parasitic Elements, Neutralization Lines and Metamaterials. In this paper our aim is to reduce mutual coupling and improve the isolation. For this purpose we are using defected ground ease of use structure technique. The compact geometrical slots embedded on the ground plane of microwave circuits are referred to as Defected Ground Structure (DGS). A single defect (unit cell) or multiple periodic and aperiodic defects configurations may be comprised in DGS. In wireless communication system there is high demand for high data rates and channel bandwidth. It is very necessary in modern wireless system to shift towards multiple input multiple output from single input single output and single input multiple output. MIMO antenna is interesting and attractive topic as it has so many challenges to achieve. Some of the challenges are to improve channel capacity, bandwidth, gain, polarization diversity and reduce coupling between inter elements. As these are the multiple input multiple output antennas i.e. multiple element antennas there is high demand for size minimization so that they can fit in the compact and robust equipment.

## 2. Methodology

### 2.1. Methods

For the design of the antenna we have used Ansoft HFSS software. HFSS stands for high-frequency structure simulator. It is one of several commercial tools used for antenna design, and the design of filters, transmission lines, and packaging.

The designed antenna is fabricated on FR-4 substrate having thickness of 1.6 mm and is fed by 50 Ω microstrip line on ground plane. There are some formulae that should be used while designing an antenna.

### 2.2. Formulae used

Width of Patch ($W$)-

The width of the Microstrip patch antenna is calculated as

$$W = \frac{c}{2fo\sqrt{\frac{(\varepsilon r+1)}{2}}} \qquad (1)$$

where,

c = ($3 \times 10^8$m /s)

$f_o$ = operating frequency

$\mathcal{E}_r$ = dielectric permittivity of 4.4

Effective dielectric const ($\varepsilon_{reff}$)-

Fringing E-fields on the edge of the microstrip antenna add up in phase and produce the radiation of the microstrip antenna. An effective dielectric constant is introduced, since some of the waves travel in the substrate and some in air, and is given as:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{1+12\frac{h}{W}} \qquad (2)$$

$\varepsilon_{reff}$ = effective dielectric

h = thickness of the dielectric substrate

The effective length because of fringing is given as:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \qquad (3)$$

Since the fringing is there the dimension of the patch as increased by ΔL on both the sides, given by:

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \qquad (4)$$

Feed Length-

$$\text{Feed length } (fl) = \frac{\lambda}{4\sqrt{4.4}} \qquad (5)$$

λ = wavelength of antenna

Feed width-

$$Z = \frac{377}{\sqrt{\varepsilon_{reff}}+(1.393+\frac{w}{h}+\frac{2}{3}\ln(\frac{w}{h}+1.444))} \qquad (6)$$

Where,

w = width of feed line

t = thickness of dielectric constant

Z = 50ohm

Here a MIMO antenna using microstrip line feeding is constructed by placing two single antennas side by side at distance of 26 mm from feeding point to feeding point. The total size of antenna is 40 mm x 26 mm x 1.6 mm. The structure of the projected MIMO antenna is demonstrated in figure1. It is made up of two patches in rectangular shape with dimension of 10mm x 10mm. The Microstrip feed line extended from patch to feed point. The Defected Ground Structure is preferred to get better isolation. There are different shapes of DGS available like rectangular, circular, dumbbell etc. but the best results are obtained from stub DGS. Stubs are introduced on ground plane and the thickness of two stubs is 1 mm each. The dimensions of design shown in figure 2 are in millimeter. The FR4 dielectric material is used as a substrate as it is available easily. The thickness of substrate is 1.6 mm with dielectric constant 4.4.

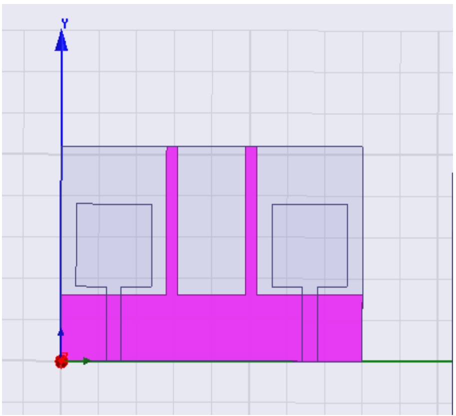

**Fig. 1:** Structure of MIMO antenna

### 2.3. Simulation Result

The antenna is simulated using HFSS (High Frequency Structure Simulator). The structure of the proposed antenna is displayed in fig.1.

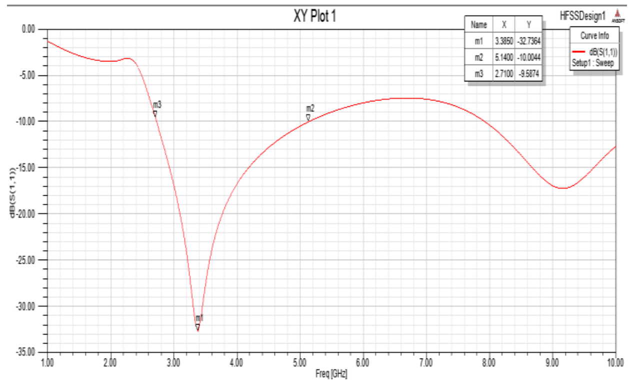


**Fig 2:** Simulated reflection coefficient characteristics of an antenna

The simulated reflection coefficient characteristics of an antenna have been depicted in Fig. 2.The characteristics shown in Fig.2 indicate that the antenna radiates at 3.38 GHz. The frequency band observed between 2.7 GHz to 5.1 GHz.

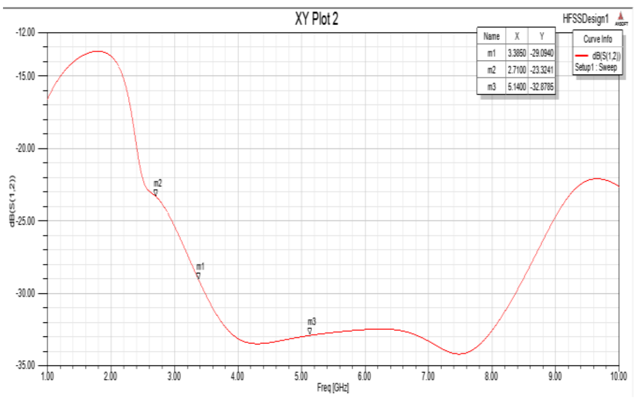


**Fig 3:** Isolation characteristics S12 of an antenna

The reflection coefficient (S11 & S22) observed at resonance 3.29 GHz is -32.73 dB and with isolation of -29.09 as shown in Fig.3.

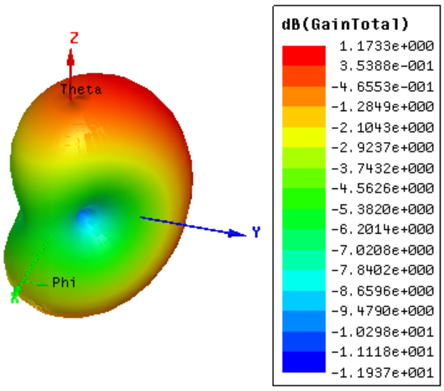


**Fig 4:** 3D Gain of the antenna

With this configuration the gain of antenna is found to be 1.17 dBi with directivity of 1.24 dBi. The directivity of an antenna is shown in Fig.5. The 2D radiation pattern of the antenna is shown in the Fig.6.

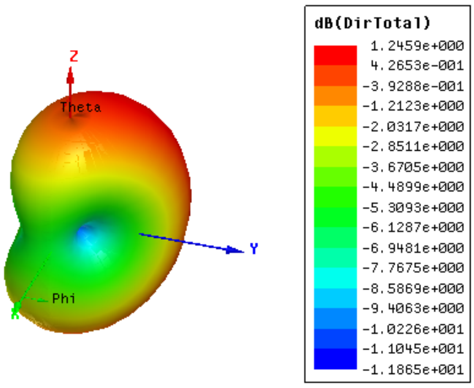


**Fig 5:** 3D Directivity of the antenna

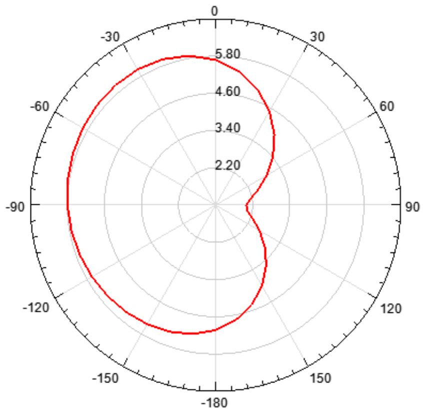


**Fig 6:** 2D Radiation Pattern

### 2.4. Measured Results

Measured Results of the proposed mimo antenna with defected ground structure have been depicted in Fig. 7 (a) and (b). Measured reflection coefficient characteristics i.e. S11 shown in Fig. 7(a) which is 3.39 GHz similar to the simulated result in HFSS.

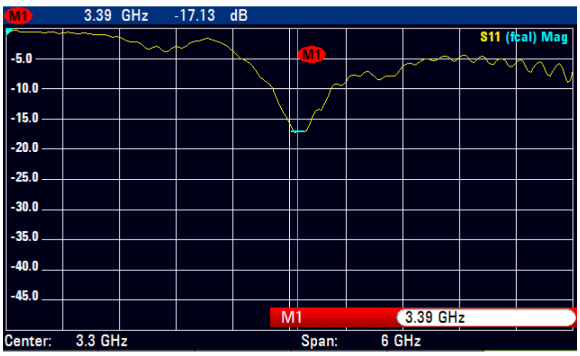


**Fig 7(a):** Measured reflection coefficient characteristics

Fig. 7(b) shows S12 parameter i.e. isolation characteristic of an antenna. It is the effectively seen that the mutual coupling between antenna elements is below -25 dB and -20 dB respectively.

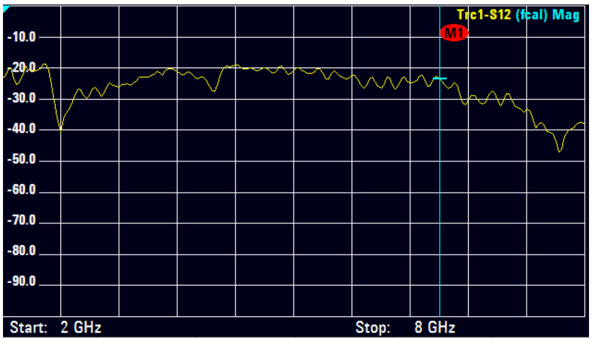


**Fig 7(b):** Measured isolation characteristics S12 of an antenna

There is a little dissimilarity in simulated and measured results. This difference may be due to the change in permittivity of substrate material between simulated and actual value or due to the losses in connector, cable and soldering.

## 3. Conclusion

A MIMO antenna is proposed for Wi-MAX, WiFi and WLAN application. It covers the frequency band of 2.7 GHz to 5.2 GHz which is useful Wi-MAX /WLAN applications. The reflection coefficient of antenna is observed below -10dB at respective resonant frequencies which is -32.73 while the transmission coefficient is found -29.09 dB which indicated better isolation. The maximum gain of achieved by an MIMO antenna is 1.17 dBi and the antenna achieved excellent efficiency up to 94 %.

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