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# FOUR ELEMENT OPEN SLOTTED MIMO ANTENNA FOR WIRELESS APPLICATIONS

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## ABSTRACT

In this research work the four elements slotted MIMO antenna has proposed for wireless applications. The proposed antenna covers the 5.8 GHz to 6.1 GHz band which also used in Wi-Fi applications. The antenna is resonates at 5.9 GHz having return loss of -17 dB and isolation coefficients are at -11dB, -12 dB and -21 dB achieved with the help of open slotted cut. The open slot geometry shifts the frequency to the lower side and also enhances the isolation between antenna elements. In this study all s-parameter are evaluated and discussed. The surface current distribution of proposed antenna shows the better isolation characteristics. The gain, directivity, radiation pattern, envelops correlation coefficient, voltage standing wave ration, and bandwidth of proposed antenna is evaluated and discussed in the research work. The size of single element is 32 X 33 mm$^2$. The first element is designed then it transformed in four element antennas.

**Keywords:** Isolation, ECC, VSWR, AR, CST, WLAN.

## I. INTRODUCTION

There are six isolation techniques have been described using decoupling networks, meta-material structures, parasitic elements, neutralization lines and defected ground. Improved isolation is observed from the measured s-parameter curves over a band of 14 MHz A compact wideband indoor base station antenna, loaded with artificial magnetic conductor (AMC) is proposed for MIMO antenna system covering 5.2/5.8 GHz WLAN and 5.5 GHz WiMAX band [2]. A compact high-isolation ultra-wideband (UWB) multi-input-multi-output (MIMO) antenna loaded with L-shaped branches is proposed. This design provides high isolation at 2.4 GHz WLAN and 3.1-10.6 GHz UWB bands [3]. In the design of antenna, Hilbert curve is adopted, because printed Hilbert antenna meets both the requirements of multi-frequency and of small size [4]. In this study, a design of circularly polarized antenna based on Koch fractal geometry is presented. The circular polarization is achieved by placing two asymmetric Koch fractal geometries on x- and y-planes of the single-probe-feed square radiator [5]. For an indoor MIMO wireless communication system, the dual polarized antenna with wide impedance bandwidth and high isolation is presented by the author [6]. The purpose of this paper is to develop a LTE MIMO antenna having four elements, which has compact volume for small-cell base stations covering the frequency ranging from 698 to 960 MHz [7]. The proposed antenna is a single-radiator card-type tag antenna is constructed using series Hilbert-curve loop and matched stub for HF/UHF dual-band RFID applications. This is achieved by merging the series Hilbert-curve for implementing the square loop structure and HF coil antenna for implementing the UHF antenna to form a single RFID tag radiator [8]. The measured ECC of the MIMO antenna system was about 0.05 at the target 5 GHz band [9]. The measured isolation between two GradiAnts with the proposed ground-coupled loop-type isolator is above 17 dB in the WLAN operating band with a peak of 37 dB at 2.42 GHz and that without the proposed isolator is approximate 10 dB. The measured radiation efficiency ranges from 62 to 76% over the whole frequency range, which is suitable for MIMO applications. In mobile communications, the ECC of the MIMO system should be lower than 0.5, which is acceptable for diversity considerations [10]. The author has introduced an 800 MHz 2×1 compact MIMO antenna system for Long Term Evolution (LTE) handsets [11]. The author has introduced antenna by using a fractal mushroom-like EBG structure to provide high isolation. The isolation for frequencies between 2100 to

2830 MHz has been increased 2 dB to 21 dB. The paper covers WLAN and WiMax bands [12]. The antenna is based on meandering monopoles. A high isolation is achieved by etching a slot at the centre of the ground. The ultra-wideband MIMO antenna provides high isolation at 2.4 GHz WLAN. The proposed antenna provides reflection coefficient less than -10 dB [13]. In this paper, a parasitic tape is introduced on each micro strip patch element to reduce the mutual coupling between two micro strip patch antenna elements [14]. The paper has investigated the latest issues and challenges of the current generation MIMO antenna [15]. In this paper, the author proposed a compact multiband handset antenna including MIMO antenna operation for LTE 13 band applications. The proposed antenna achieved isolation of higher than 14 dB, envelop correlation coefficient (ECC) of less than 0.25 and total efficiency of greater than 40% [16] The author proposed an excellent technique to improve the port-to-port isolation of two closely spaced dual-band radiating elements in the WLAN 5.15-5.825 GHz and 2.4-2.5 GHz frequency band. This design achieved isolation level higher than 15 dB, in the lower band and higher than 22 dB, in the 5 GHz band [17].

## II. ANTENNA DESIGN

Microstrip Patch Antenna Design is having a open slotted patch with inset feed line style power supply. The structure is simple and easy to design. Antenna is designed for frequency range 5.8- 6.1 GHz, Wi-Fi used in this frequency. Antennas are placed on the dielectric layer and base ground structure made up of copper.

The parameters will be clear from the table 1 shown below:

**Table-1:** Parameters

| | |
|---|---|
| Operating Frequency | 5.9 GHz |
| Dielectric constant of the dielectric layer (εr): | 4.3 (FR4 substrate) |
| Dielectric layer thickness (h): | 1.523mm |
| Thickness of patch and ground plane | 0.07 mm |

**I) Design of Ground-**

For the design of the ground, copper (pure) material is used, having dimensions as follows-

Ground length (gl) = 30 mm

Ground width (gw) = 32 mm

Ground height (gh) = 0.07 mm

**II) Design of Substrate-**

For the design of the substrate, FR-4(lossy) substrate is used, having dimensions as follows-

Substrate length (sl) = 33 mm

Substrate width (sw) = 32 mm

Substrate height (sh) = 1.524 mm

**III) Design of Feed-**

For the design of the feed, PEC material is used, having dimensions as follows-Feed length (fl) = 8.9 mm

Feed width (fw) = 2.52 mm

Feed height (fh) = 0.07 mm

**IV) Design Of Patch-**

For the design of the patch, PEC material is used, having dimensions as follows-

Patch length (pl) = 20.8 mm

Patch width (pw) = 14.51 mm

Patch height (ph) = 0.07mm

## III. MIMO ANTENNA DESIGN

The Figure 1 shows the design of open slotted microstrip patch antenna. In this figure there are four patches are mounted on a single substrate. The open slotted shaped structure provides the optimum isolation below -11 dB for the entire frequency range. The four port MIMO antenna are arranged in such manner that isolation can maintained. There are 16 s-parameters for four element MIMO antenna which discussed in the research. The figure 2 shown the back view or ground plane of proposed antenna.

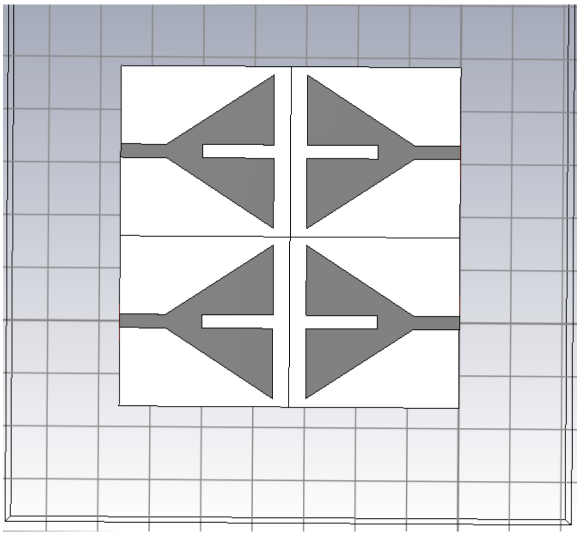

**Figure-1:** Front view of designed antenna

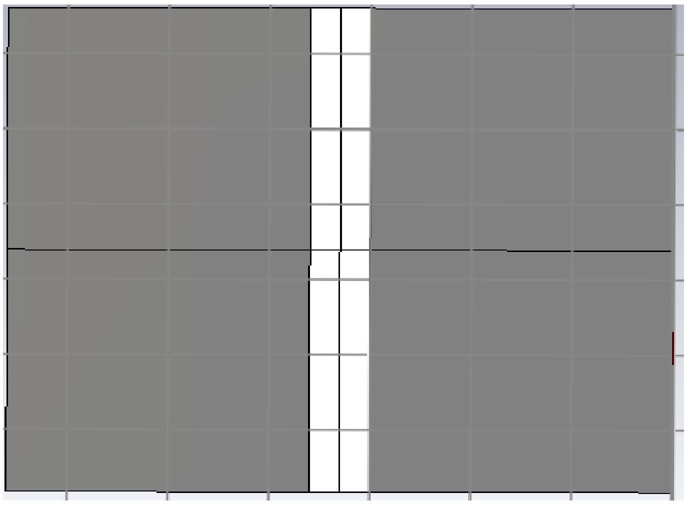

**Figure-2:** Back View of Antenna

## IV. RESULT AND DISCUSSION

S-parameters are the most important factor to decide the isolation and reflection coefficient. The simulated results of S-parameters and bandwidth are obtained at the resonant frequency 5.9 GHz and analyzed for isolation and bandwidth. Figure 3 discussed the S-parameters results. The return loss is S11=S22 =-17 dB and S33=S44= -20 dB while the isolation coefficient value is S12=-11 dB, S13= -21, and S14= -12 dB. Rest parameter follow the same data, so that not discussed in detail here.

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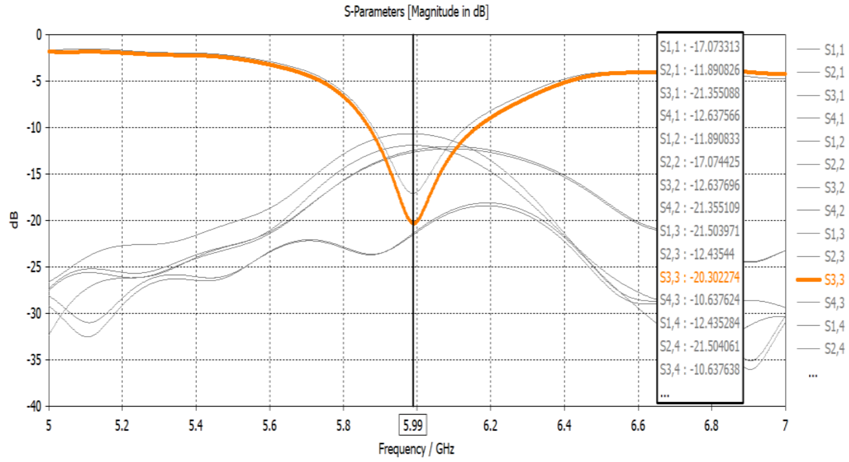


**Figure-3:** S parameters at frequency 5.9 GHz

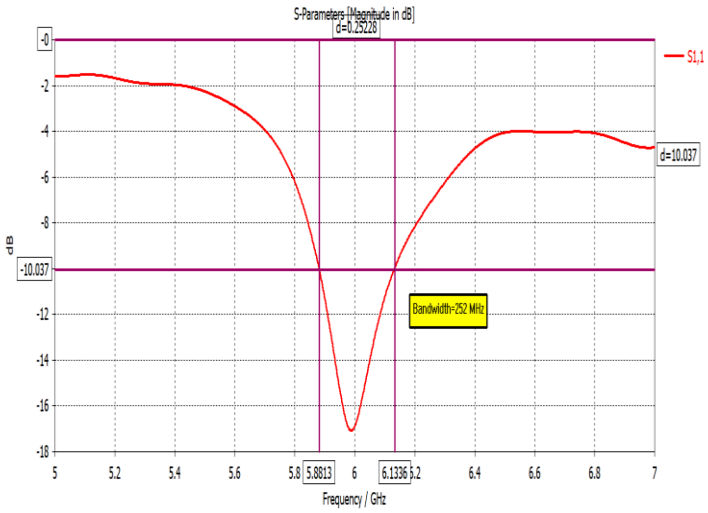


**Figure 4:** Bandwidth of MIMO antenna

According to S-parameter results, upper frequency and lower frequency are calculated at -10 dB of S11 or S33. According to the simulated results, the bandwidth found to be

From the plots it is clear that structures have good ECC values. Figure 5 , discussed ECC at port 1,2. The ECC is less than 0.08 at port 1,2.

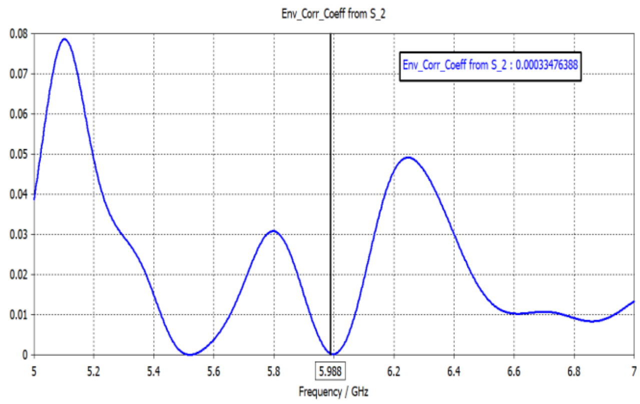


**Figure 5.**6 Figure 5: ECC 1-2 for antenna

The E-field radiation pattern at frequency 5.9 GHz is presented in figure 6. The H-field pattern of MIMO antenna at frequency 5.9 GHz is presented in figure 7. The main lobe direction of E-field is at 60 degree

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with magnitude 14.6 dBV/m. The main lobe direction of H-field is at 120 degree with magnitude 41 dBA/m.

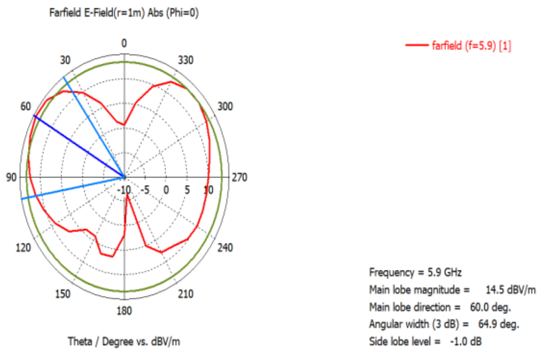


**Figure 6:** E-field pattern

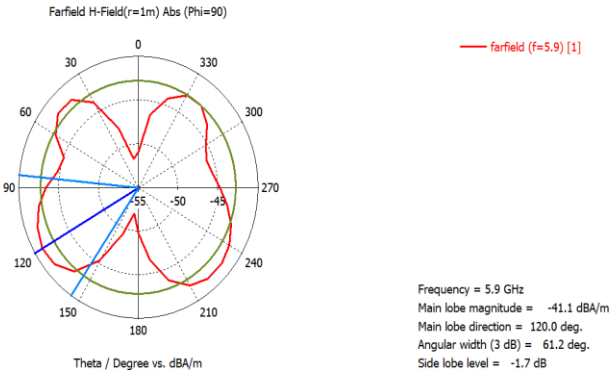


**Figure 7:** H-Fields at 5.9 GHZ

The gain of proposed MIMO antenna at port 1 is discussed in graph 8. The directivity of proposed MIMO antenna at port 1 is given in figure 9.

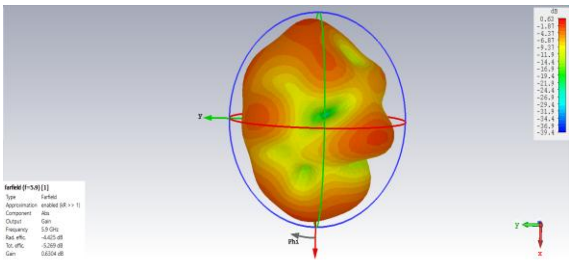

**Figure 8:** Gain of antenna

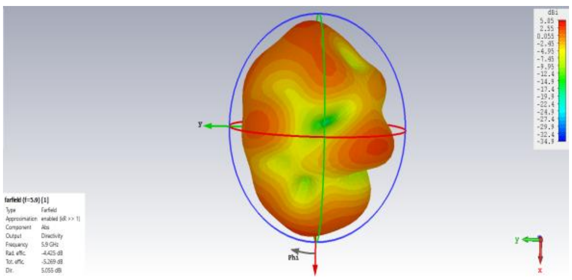

**Figure 9:** Directivity of MIMO antenna

To see the effect of surface current distribution on the proposed MIMO antenna, any one of the ports is excited, and remaining ports are terminated by 50Ω. The simulate results showed that the antenna surface current distributed mainly on the edge of the metal patch and at the intersection surface of microstrip line and patch. The figure 5.16 -5.19 shown the surface current of proposed antenna at port 1-4.

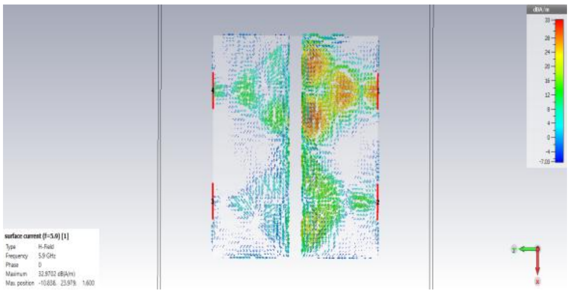

**Figure 10:** Surface current distributions for antenna at port 1

## V. Conclusions

An open slotted 4 element MIMO antenna is designed and simulated using CST Microwave tools. The antenna is designed for frequency 5.9 GHz frequency (5.8-6.1 GHZ) with FR4 substrate ($\varepsilon_r$=4.3), h=1.523 mm, tan$\delta$=0.02. The designed antenna produced very low value of ECC between port 1, 2 less than 0.08, ECC between port 1,3 is less than 0.04 and ECC between port 1,4 is less than 0.08. The antenna produces the isolation S12 is below -11 dB, Isolation coefficient S13 is below -21 dB and S14 is below -12 dB isolation in the proposed frequency band. The 4X1 MIMO antenna has VSWR of 1.3. The main advantage of proposed design is the shape of design which produces low correlation without using any isolation structure between antennas.

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