# Design and Analysis of 2x2 MIMO Antenna using Reshape Hexagonal Geometry for Wideband Wireless Application

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## Abstract:

In this study, an antenna with four port is designed and analyzed by utilizing latest multiple input multiple output techniques for 3.3 to 6.0 GHz frequency band and Wi-Fi applications. The designed antenna covers wi-fi applications at 3.6 GHz, and 5 GHz band. The low-profile microstrip patch antenna was used in the design of the antenna (MPA).The MPA is the antenna which can place in any metallic surface. In the initial work of the thesis single antenna is discussed and optimized using CST-Microwave Suit software, then it converted in four element antenna and optimized. The antenna is developed with Wi-Fi applications in mind. The various results are calculated like gain, efficiency, envelop correlation coefficient, far field parameters etc. The resonating frequency is 5.1 GHz and return loss coefficient (S11) is -31 dB and isolation coefficient (S12, S13, S14, S21, S31, S41, S23, S24, S42, S32 etc.) is below -11 dB. A 5.14 db gain is at resonant frequency while the directivity is 5.94 dB at resonant. The antenna has a radiation efficiency of higher than 80%.The approximate bandwidth of the reshaped hexagonal four ports multiple inputs multiple output antenna is 2.6 GHz. All other antenna parameters are evaluated and discussed.

**Keywords**: Antenna, Efficiency, MPA, Surface current Distribution, gain

## 1. INTRODUCTION

Antenna plays very vital role in the field of communication. An electrical device known as an antenna or aerial transforms electrical energy into radio waves and vice versa. An Antenna can be used as transmitter and as a receiver. An antenna converts information in the form of voltage and current into the electromagnetic signal, which is then transmitted into air. As the name implies, electromagnetic waves are made up of magnetic and electric fields of varying strengths. E and H are parallel to one another, and they are also parallel to the direction in which waves propagate. The definition of an antenna provided by Stutzman and Thiele for the official IEEE [1], follows the concept: “Antenna is the part of a transmitting or receiving system that is designed to either receive or radiate the electromagnetic waves in a specific direction with define polarization”.

It is very important to have knowledge about the existing research work in the field of microstrip antenna have been done by researcher and existing project of the same. A lot of sources are there by which we can get full fledge knowledge such as internet, antenna related books, old IEEE papers and many other sources. There has been a tonne of research done in the topic of mutual coupling reduction, size reduction of antenna, improvement of isolation between various antenna elements; improve the bandwidth utilization, directivity and gain of antenna. Laurent Desclos et al. describe a quarter-wavelength diversity patch setup for the 2.4 GHz ISM band PC card application in [2-4]. The framework is composed of two patches having the length is equal to quarter of wavelength which is separated by a distance to achieve the single side space diversity on a substrate. It has a high cross polarization factor and offers superior impedance matching.

Small Printed Antennas are designed and performed by M. Agarwal et al. [5]. This study looks closely at electrically tiny microstrip patches with shorting posts. These antennas are appropriate for mobile communication systems that call for a small antenna size. Performance patterns are identified, and methods to increase these antennas' bandwidth are offered. These trends provide important information about the ideal design, which consists of a wide bandwidth, a small size, and ease of production. Mark et al. conduct an experimental study of a single layer wideband electromagnetic linked microstrip patch antenna in [6]. A dual wideband antenna printed in a substrate is proposed which is designed especially for WLAN (wide local area network) and WI-MAX services. It uses a microstrip feeder line which excites the antenna and a trapezoidal conductor utilized [7-9] for band widening that is positioned in the back plane. The measured 10 dB bandwidth for return loss spans the 2.4/5.2/5.8 GHz WLAN bands and the 2.5/3.5/5.5 GHz WI-MAX bands, and it is between 2.01 and 4.27 GHz and 5.06 and 6.79 GHz, respectively. A technique for creating a microstrip patch antenna array with linear polarization utilizing a microstrip line feed has been developed by Baskar. With the help of quarter wave transformer the array of microstrip patch antenna designed. This array [10-15] works on 8000 MHz to 12GHz frequency range. This band is used to receive unsupervised signal in radio communication and transmit this to the host. The resonant frequency for each element is quite different than other and each antenna element operates on their own resonant frequency.

Using a patch [16-18] with slots in it, Atser A. described a method for boosting microstrip patch antenna bandwidth. A rectangular patch that is 32 mm wide and 24 mm long generates the three alternate geometry forms U, E, and H. Simulation of such antenna was done [19-22] by Sonnet software tool and result of software compared with conservative rectangular microstrip patch antenna. One can find several applications wherein proposed research work may be implemented [23-29.] The comparison of these two antenna It is evident that placing an E, U, or H-patch over the substrate will increase the bandwidth of a standard patch antenna by 28.89% (630 MHz), 4.81% (100 MHz) to 28.71% (610 MHz), and 9.13% (110 MHz), respectively. Present work intend to design and analyze a four port antenna by utilizing latest multiple input multiple output techniques for 3.3 to 6.0 GHz frequency band and Wi-Fi applications. The designed antenna covers wi-fi applications at 3.6 GHz, and 5 GHz band [30-37].

## 2. ANTENNA DESIGNING PARAMETER

In the microstrip patch antenna design, the rectangular patch contains a built-in feed line power source. The antenna in present work has a modified hexagonal configuration and resonates at 5.1 GHz. Antennas are mounted atop a copper common ground plane and an electrically insulating dielectric layer. The table 1 will make the criteria clear.

Table 1 Design parameters for Microstrip Patch Antenna

| Description | Size | Material |
|---|---|---|
| Substrate width (SW) | 50 mm | FR-4 |
| Substrate Length (SL) | 50 mm | FR-4 |
| Substrate height (SH) | 1.524 mm | FR-4 |
| Ground Width (GW) | 50 mm | Copper |
| Ground Length (GL) | 13 mm | Copper |
| Ground Height (GH) | 0.07 mm | Copper |
| Feed width (FW) | 2.9 mm | Copper |
| Feed length | 2.74 mm | Copper |
| Feed width-2 | 0.99 mm | Copper |
| Feed length-2 | 20 mm | Copper |
| Radius of patch | 14.7 mm | Copper |
| Patch height (PH) | 0.07 mm | Copper |

## 3. ANTENNA DESIGN

The design of reshaped hexagonal geometry based microstrip patch antenna is shown in figure 1. In which four patches are mounted on a single substrate. Figure 2 shows the proposed antenna's back view. In the initial level of design, single element of complete hexagonal shaped patch is designed thereafter one cut is produced in the hexagonal geometry results in reshaped hexagonal geometry.

The proposed antenna's ground is depicted in the diagram. Four identical ground with equal length and width are there. The single ground length and width is 50 x 13 $mm^2$.

## 4. RESULTS AND DISCUSSION

**4.1 S- Parameter Calculation**

The simulation results of above microstrip patch antenna structure GHz is shown in graphs below. It has a return loss coefficient below -30 dB and an isolation coefficient below -11 dB, and it resonates at 5.1 GHz. The front view shows the four element antenna which has hexagon modified geometry. Single feed line is there with two different feed widths. The isolation coefficient like S12, S13, S14 are discussed in figure 3, the S12 is below -11 dB in the complete frequency band. In the proposed band the isolation coefficient S13 is below -18 dB and the isolation coefficient S14 is below -16 dB. All other parameters like S23, S24 etc. are not discussed just because of symmetry in the geometry.

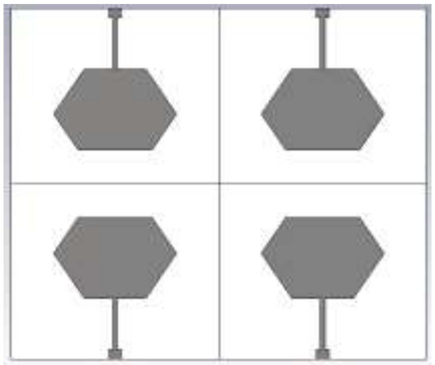

Figure 1 Front aspect of a microstrip patch antenna

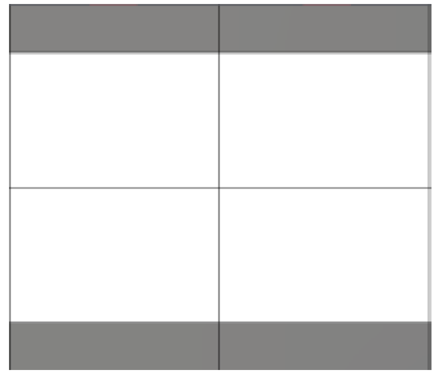

Figure 2 Design of Patch Antenna back view

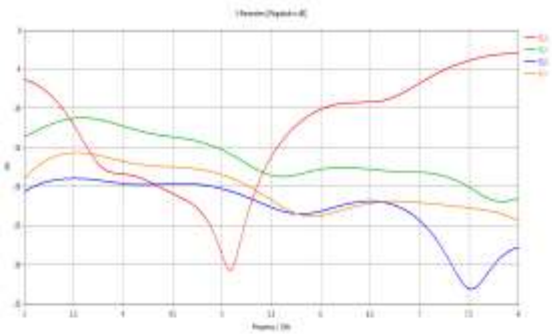

Figure 3: S- Parameter of proposed antenna.

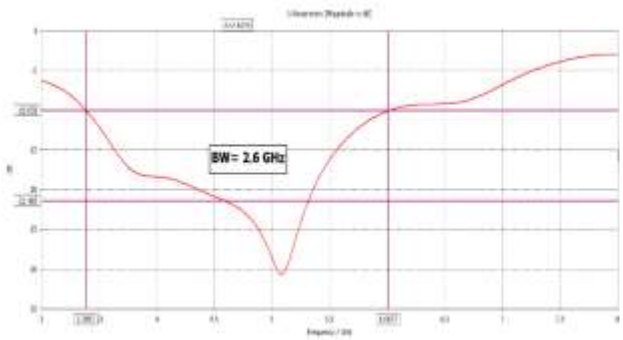


Figure 4 Bandwidth of proposed antenna.

**4.2 Bandwidth of Proposed Antenna**

The proposed antenna has a 2.6 GHz total bandwidth and operates between 3.3 and 6 GHz. Applications in the 3.6 GHz and 5.0 GHz Wi-Fi frequency bands are covered by the wideband of frequency. Figure 4 shows the antenna's bandwidth plot.

**4.3 FAR-Field**

Figure 5 and figure 6 show the E-field and H-field characteristics of proposed antenna respectively. The major lobe magnitude of E-field is 15.7 dBV/m at $217^0$. An angular width of pattern is 39 degree while the side lobe level is -0.9 dB. All the E-filed results are evaluated for resonance frequency 5.1 GHz. The major lobe magnitude of H-field is -34.3 dBA/m at $136^0$. An angular width of pattern is 42.5 degree while the side lobe level is -7.1 dB. All the H-filed results are evaluated for resonance frequency 5.1 GHz. Antenna gain is an antenna's ability to emit more or less in any direction in comparison to theoretical antenna. Figure 7 talks about the MIMO antenna's gain. Since each antenna element is the same, every port experiences the same gain. The antenna's gain at resonance frequency is 5.1 dB. The directivity results of antenna are shown in figure 8. The uniform directivity is found at resonance frequency. The directivity is 5.94 dBi at resonance frequency.

**4.4 Efficiency**

The effectiveness of the antenna is determined by the power supplied to it in comparison to the power it emits. A high efficiency antenna radiates the majority of the power that is present at the antenna's input. An antenna with low efficiency loses the bulk of the power it consumes either internally or externally due to impedance mismatch. Figure 9 shows the efficiency plot of the suggested antenna. Radiation is present in more than 80% of the graph outcomes. The surface current distribution shown in figure 10.

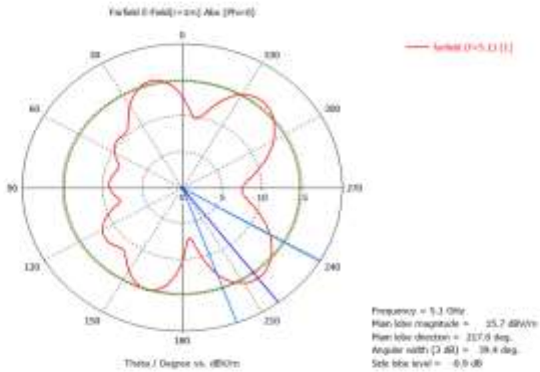

Figure 5: E field characteristics ( port 1)

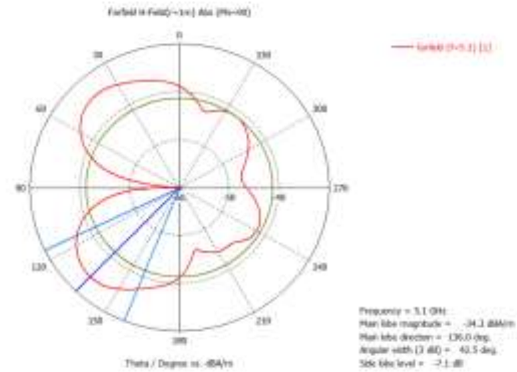

Figure 6: H field characteristics ( port 1)

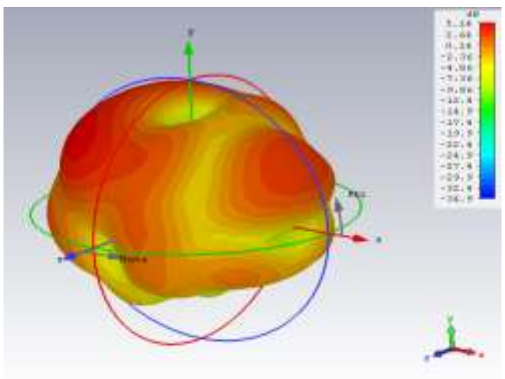

Figure 7: Gain of proposed antenna element

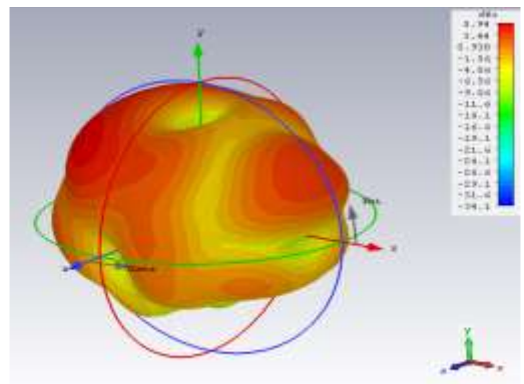

Figure 8: Directivity of proposed antenna at 5.1 GHz

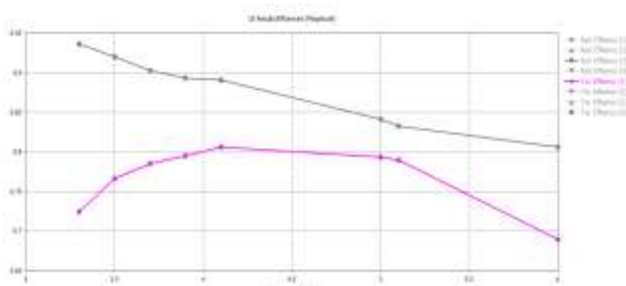

Figure 9: Efficiency of proposed antenna element

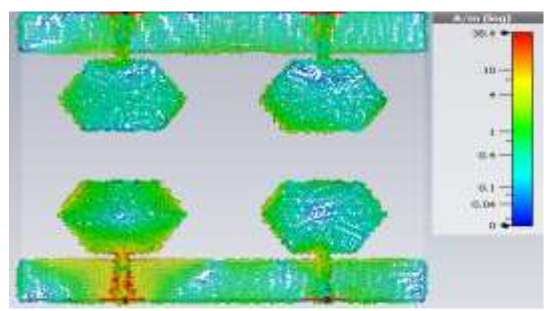

Figure 10: Surface current distributions at port 1

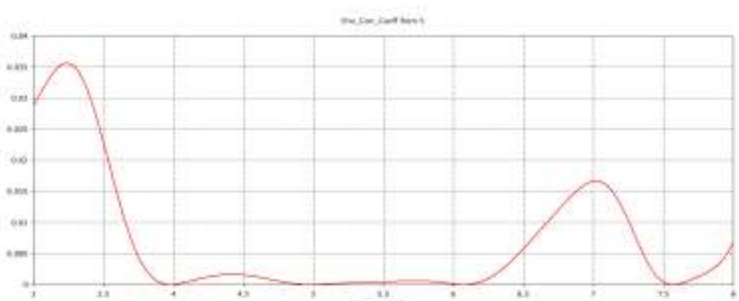

Figure 11: Envelop correlation coefficient

**4.5 ECC (Envelope Correlation Coefficient)**

The envelope correlation coefficient calculates the relationship between MIMO radiation patterns (ECC). ECC has a value between 0 and 1. It denotes that a correlation between the radiation patterns at 0 and a full correlation at 1 is indicated. From figure 11, it is concluded that ECC results are acceptable. The ECC is less than 0.03 in whole band.

## 5. CONCLUSIONS

The antenna is made of FR-4 substrate with dimensions of h = 0.078 mm, t = 0.07 mm, and frequency of 5.1 GHz. The findings show that this structure prevents a significant amount of surface current from accessing a neighboring patch antenna. The antenna has return loss coefficient (S11) is -30 dB and isolation coefficient (S12, S13, S14, S21, S31, S41, S23, S24, S42, S32 etc.) is below -11 dB. The antenna has a gain of 5.4 dB and a directivity of 5.94 dBi. The proposed antenna has a radiation efficiency of higher than 80%.The other MIMO antenna parameter are also discussed and analyzed for the proposed frequency band and it is satisfactory.

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