

45 degree arrangement of compact array antenna for MIMO application

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ABSTRACT

A study on the compact array microstrip patch antenna for multiple-input multiple-output (MIMO) communication system based on the antenna arrangement is performed. The 2.45 GHz rectangular array are arranged in 45 degree slanted inward and outward for each other to reduce the mutual coupling effect between the patches. The antenna properties are analyzed and compact antenna design is determined based on the simulation results. The results show the antennas can very compact while maintaining low mutual coupling. The gain of the MIMO antenna is 11.3 dBi. The simulated and tested return losses, together with the radiation patterns, are presented and discussed.

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1. INTRODUCTION

In telecommunication system, the data rate is a key aspect for the performance analysis. In a condition which the modulation and the frequencies can't be altered, the data rate still can be increased by multiplying the data path. MIMO offers higher data capacity than the capacity of the single-input-single-output (SISO) antenna system [1]. The single antenna configuration normally has a wider antenna radiation pattern while the multiple antenna has more directive radiation. MIMO antenna was robust against channel fading and interferences. The MIMO allowing a faster data rate through the antenna by allowing the data to travel in multiple path through spatial multiplexing [2]. Without using the multiplexing technique, the additional antenna would not increase the data speed as the additional antennas only increase the diversity order but do not provide independent communication channels [3]. There are several research conducted on MIMO antenna [4-10].

This project focused on the antenna technology development using a low cost patch antenna design. The antenna would be used in point to point communication. In rising need for fast internet access for an organization, the point to point communication seems to be the best possible solution to connect the user with the data server. Point to point communication is based on line of sight communication over a certain distance depending on the frequency band. Any obstacle in its wave propagation path would create a disturbance which degrades its performance. As it only involves single receiver and single transmitter antenna, it usually utilizes an antenna with high gain as it would provide a narrow radiation pattern beam [11-13].

As the content getting more interactive and increase in resolution, the data size sent over in the data link getting larger. Together with high number of user, these would create a slow data traffic for the normal antenna with low bandwidth. Antenna with Multiple Input Multiple Output (MIMO) offer a high bandwidth and at the same time providing a high speed connection [14-15]. However antenna using the MIMO architecture usually large in size has a greater wind resistance once it mounted in high rise building. However the multiple antenna array design produce a mutual coupling effect that reduce the antenna performance.

2. ANTENNA DESIGN

Figure 1 and Table 1 shows the proposed antenna dimensions The antenna was designed using FR4 substrate board with thickness of 1.6mm, dielectric constant of 4.5 and tangential loss of 0.019. The FR4 board has low water absorption making it suitable for outdoor usage. The low coefficient of thermal expansion of the FR4 allow the antenna to be manufactured using the wet etching technique with thermal as catalyst.

The antenna patch size, “C” and “D” decrease slightly each time the number of antenna element increase. The decreased of antenna size is done to counter balance the effect of the antenna on the effective radiation. The frequency of the antenna increases each time the number of the antenna increased. This causing the antenna S11 and S21 to shift toward the higher frequency. To maintain the effective frequency of 2.4GHz, the antenna patch size was decreased.

The value “K” was predetermine using a parametric studies. The V-shape antenna placement has a gap of 0.8mm, away from the other antennas. The antenna “E” value was determine using the parametric study conducted for the “K” value. The gap “E” was slightly larger to for allow space for the antenna transmission lines marked in “F”. The thickness of “H” is calculated for equal distribution of the transmitted power to the antenna patch. The transmission lines marked by “H” is the power divider of the antenna. The antenna port is raised towards the antenna element marked by “J” to allow two antennas SMA jack port to be soldered and connected to the RF cable.

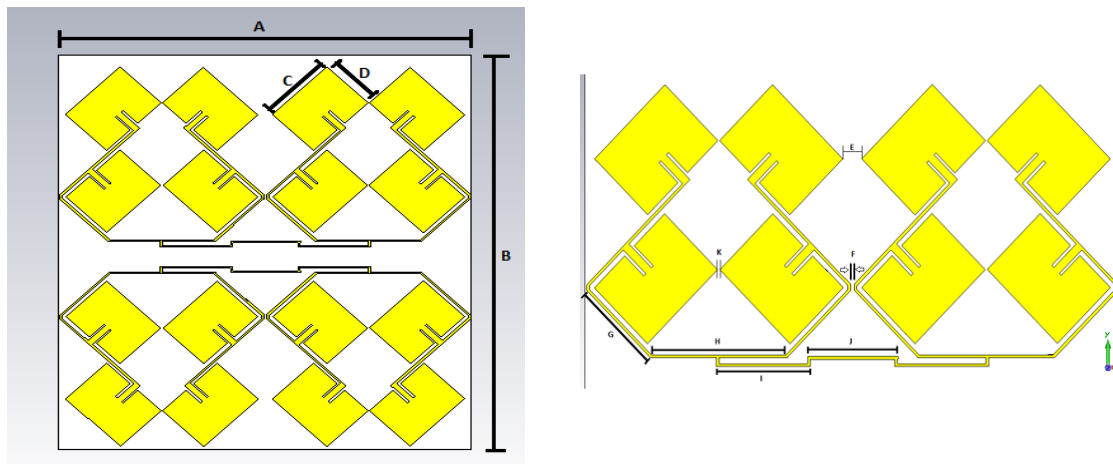


Figure 1. General dimension of the antenna

Table 1. The geometry specifications of the proposed antenna

Variable	Dimension (mm)
A	198
B	210
C	37
D	28
E	7.00
F	1.36
G	33.4
H	50.00
I	35.00
J	33.70
K	0.80

3. RESULTS AND ANALYSIS

The fabricated antenna as shown in Figure 2 has undergone a simulation and testing using CST simulation and tested inside the anechoic chamber. The S-parameter of the antenna was plotted in a single graph shown in Figure 3. The tested antenna has the lowest antenna return loss S11, at 2.45GHz with the value of -35.32dB and a mutual coupling is at the at 2.45GHz with the value of -46.81dB. For simulation result, the antenna has the highest radiating efficiency at the 2.45GHz with antenna return loss, S11 has the value of -15.15dB and antenna mutual coupling, S21 is at -28.34dB.

Simulated antenna has narrow bandwidth for 2.4GHz channel. It has S11 value ranges from -7.1dB to -5.8dB at frequency from 2.4GHz to 2.5GHz with its highest value at 2.45GHz. The tested antenna bandwidth 2.4GHz to 2.5GHz with the S11 value at 2.4GHz is -11.6dB. At 2.5GHz, the antenna S11 value is at -14.21dB. For the S21 value, the antenna has the value of -37.46 dB at 2.4GHz and value of -24.10 dB at 2.5GHz.

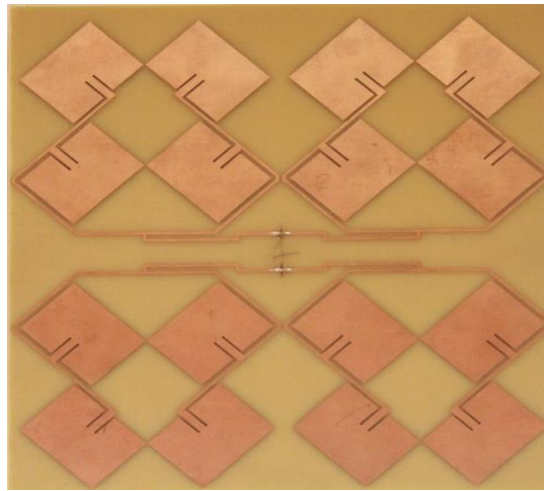


Figure 2. Fabricated antenna

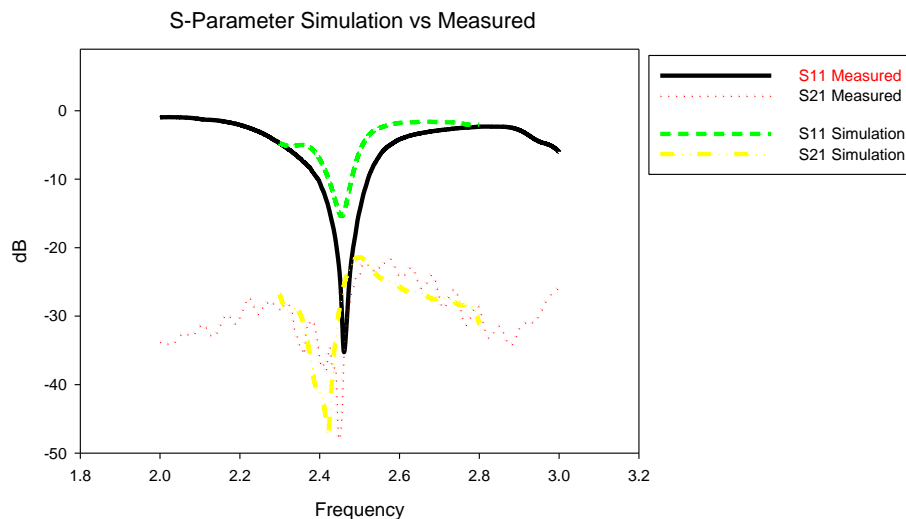


Figure 3. Measured and simulated S-parameter of proposed antenna

Antenna radiation pattern shows the antenna has a directive radiation pattern with the antenna gain of 11.3dB in the simulation shown in Figure 4. The tested antenna has the radiation pattern has the radiation pattern on 7.19dB. The radiation was almost at 0 degree at plane. The antenna has the gain of 4.69dB when place at 45 degree angle as the antenna is polarize. The 3-dimensional radiation pattern are shown in

Figure 5. It has narrow radiation pattern with almost no side lobe. The antenna has a 7.19dB gain measured because the physical shape of the antenna has change. During manufacturing, the antenna has flex toward the radiation port. The concave shape of the antenna has diverge the antenna array lowering the antenna gain.

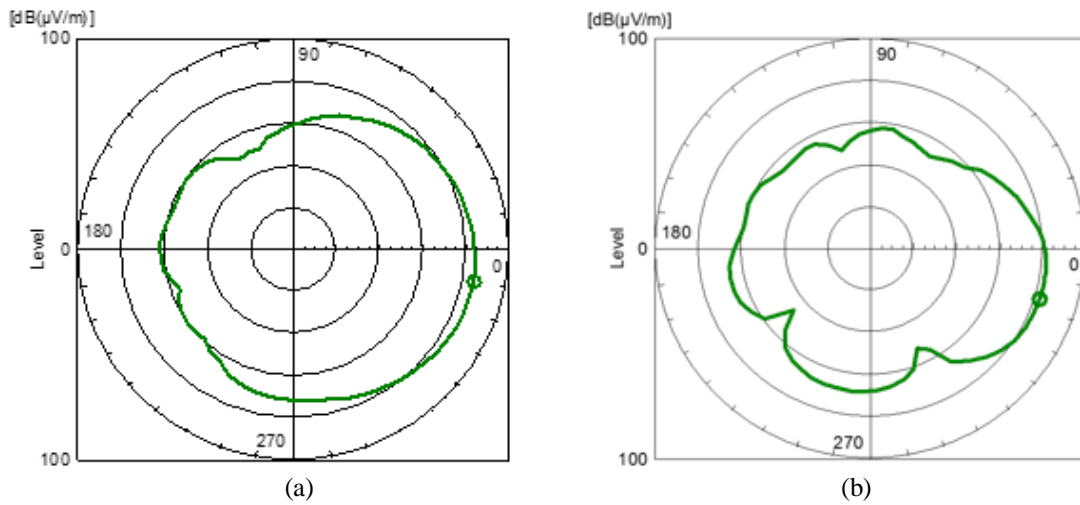


Figure 4. Radiation of the antenna at (a) H-plane, (b) E-plane

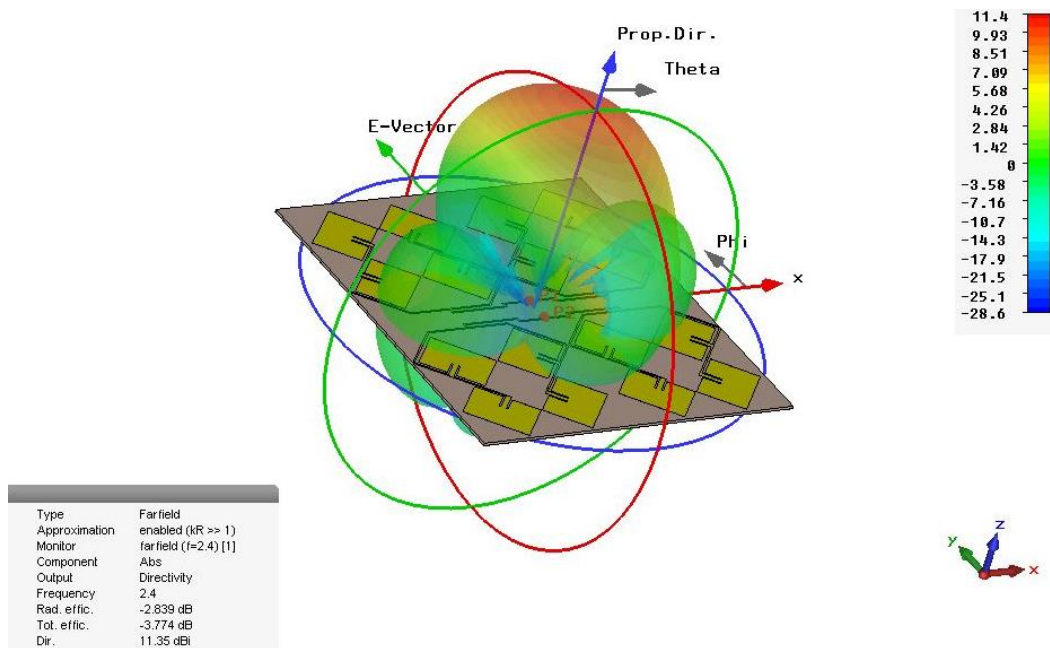


Figure 5. 3-dimensional radiation pattern

The prototype antenna has a few of its limitation. The first limitation are about the bandwidth. At bandwidth of 2.4GHz band, the antenna has the antenna return loss of -11.6dB at 2.4GHz and -14.21dB at 2.5GHz. For the antenna to operate with it maximum efficiency, the antenna must be using the frequency of 2.45GHz. The second antenna weakness, the antenna is non-dual band type antenna. This limit the antenna usage to only 2.4GHz frequency band. In some cases where the 5.8GHz frequency band is more favor, the prototype antenna cannot be utilize. The prototype antenna has limited antenna gain. The non-planar type antenna has a high antenna gain up to 30dBi. This enable the antenna to be use in long range point to point communication. At 7.19dB, the antenna range is limited for medium range communication only.

4. CONCLUSION

In this project, the microstrip patch antenna was design for point to point communication system that utilize the non-planar type antenna design system. Using the Mikrotik RouterBox BaseBox2, the antenna can transmit and received a signal wave with high data throughput. The antenna design using the MIMO principle allow the antenna to gain higher gain compare to the normal single antenna design up to 11.3dBi simulated and 7.19dB actual tested. The high antenna gain allow the antenna to has more directive radiation pattern (angular degree of 34.8 degree) and can reach further compared to low gain antenna operating using the same high frequency as the MIMO type antenna. The antenna was design to be in slanted position to polarise the antenna element so that it can be placed closed together up to 1mm. As the antenna was develop and manufactured using wet etching technique, the antenna separation need to be limit to 1mm to give the antenna etching some tolerance during manufacturing process. V shaped antenna placement for antenna has the S11 value of 12dBi and S21 value of 27dBi at 2.45GHz in simulation and -35.32dB S11 and -46.81dB S21 actual tested. Both a of the S21 and S11 value allow the antenna to be placed closer in the final design which has the S21 and S11 value of 28dBi and 15dBi. This translate into antenna gain of 11.3dBi simulated and 7.19dB actual.

For the future works, the antenna can be increase it performance and compactness by using a higher grade of material. The higher grade of material that has higher dielectric constant would further decrease the individual antenna sizes. The antenna also need a holding plate that hold the FR4 board firmly. The antenna also need to improve its bandwidth.

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