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Triple Band Multi-Input-Multi-Output Antenna for Wireless Applications

Ahmed Shaker, Hossam Helaly, Ahmed Khaled

Abstract : This paper presents a design of multi-input-multi-output (MIMO) microstrip antenna using E-shape model . The MIMO antenna consists of four patch elements that operate at WIFI application (2.4GHz) , LTE application (2.6 GHz) and WIMAX application (3.5 GHz) .

Orthogonal polarization and electromagnetic band gap structure methods are used to reduce the mutual coupling effect between the elements to increase the MIMO system performance . The return loss results are below -10 dB which are accepted results . Also, the mutual coupling coefficients of the four elements are below -20 dB which are accepted results .

Key words: MIMO , microstrip , WIFI , LTE ,WIMAX , orthogonal polarization , Electromagnetic band gap , mutual coupling

1. INTRODUCTION

MIMO plays an important role in 3G and 4G wireless communication systems .It improves the data rates with high speed and increases the performance of the wireless system . Also, MIMO is a method used to increase the channel capacity by designing an array of antennas at the transmitter and receiver sides [1] .

The main challenge that faces the MIMO antenna is the mutual coupling effect . The mutual coupling effect is resulted due to the surface waves propagation between the antenna elements . These surface waves are electromagnetic waves interact with each other forming a high correlation which degrades the performance of the wireless system [1] .

The mutual coupling is primarily depends on the spacing between the antennas . If the spacing between the antennas is increased , the mutual coupling is decreased . But if we apply MIMO antenna for some applications like MODEMS , smartphones , routers , access points and so on, the spacing between the antennas must be minimized as possible.

There are several methods used to reduce the mutual coupling effect in the MIMO antenna such as applying parasitic elements as in [2] , applying concave rectangular patches as in [3] and applying triangular lattice structures as in [4] .

In this paper , orthogonal polarization and EBG structure methods will be discussed in our MIMO antenna design .

2 . MICROSTRIP ANTENNA

The microstrip antenna configuration is conducting on the substrate side and ground plane on the other side as shown in Fig. 1 . microstrip antenna is one of the most famous antennas for the wireless systems . It is characterized as compact size antenna , easy to fabricate , it has a low cost fabrication and it can be integrated with microwave circuits easily . Also, microstrip antennas have disadvantages such as low efficiency , narrow bandwidth , low gain and surface wave excitations [5] .

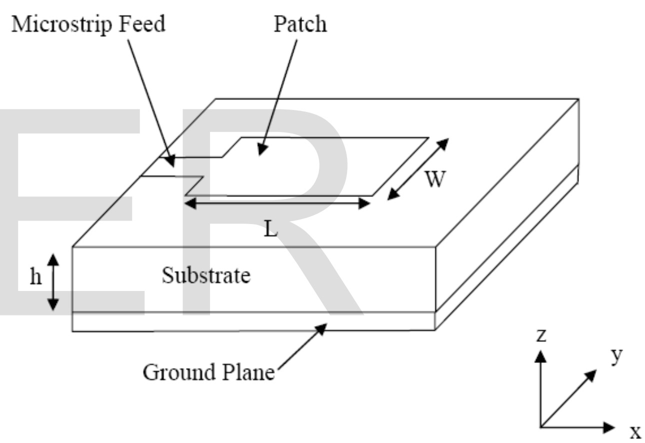

Fig. 1. Microstrip antenna configuration

3. ANTENNA DESIGN

Fig.2 shows E-shaped microstrip antenna designed on air substrate of permittivity equals 1. The thickness of the substrate is 3.2 mm [6] . Fig. 3 shows the modified E-shaped microstrip antenna . The modified antenna is designed on FR-4 substrate permittivity equals 4.5 and of substrate thickness 1.5 mm .

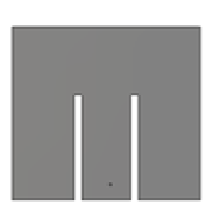

Fig.2. old design

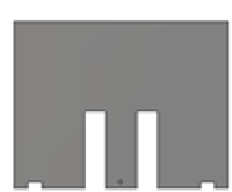

Fig.3. new design

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4. Electromagnetic Band Gap

Electromagnetic Band Gap structure is an artificial periodic or non- periodic object prevents the electromagnetic waves' propagation in a specified operating frequency band as shown in Fig. 4 .
The EBG structure is exhibiting the feature of having band gap filter which suppresses surface wave propagation at the ground plane so the mutual coupling is reduced , also EBG helps in improving antenna's performance like increasing antenna gain, and reducing back radiation [7].

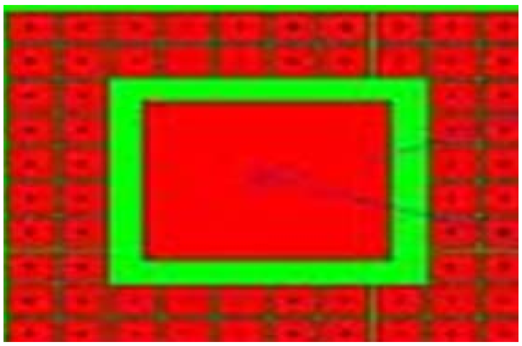

Fig.4. EBG structue

5. Orthohonal Polarization

Orthogonal polarization is another technique used to reduce the mutual coupling effect between the antenna arrays. In this technique , one antenna is shifted by a specific distance which not exceeds 0.5 lamda and then rotated by 90^0 from the previous one to produce uncorrelated signals between the array antenna to get the best isolation values [8] as shown in the fig.5.

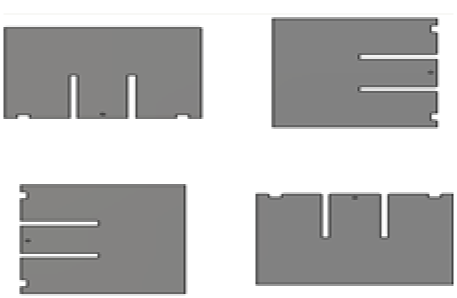

Fig.5. orthogonal polarization

6. Final Design

Orthogonal polarization and H-shape EBG structure are applied on our MIMO design as shown in fig. 6. The distance between the orthogonal antennas is 78mm from center to center. The distance between H-shaped EBG structure is 1 mm from edge to edge . Our antenna operates at WIFI (2.4 GHz) , LTE (2.6 GHz) and WIMAX (3.5 GHz) applications .

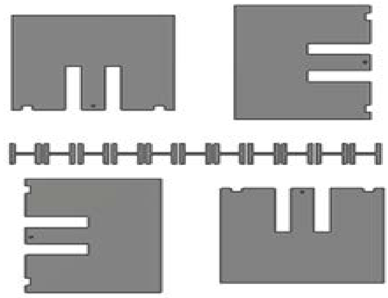

Fig .6. Final design

Fig.7. shows the MIMO antenna final results

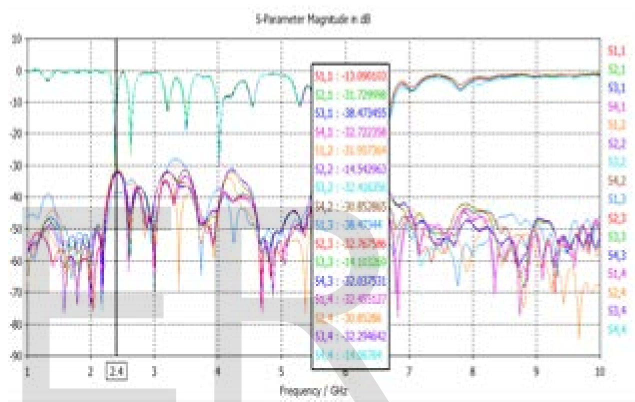

Fig.7a. WIFI application

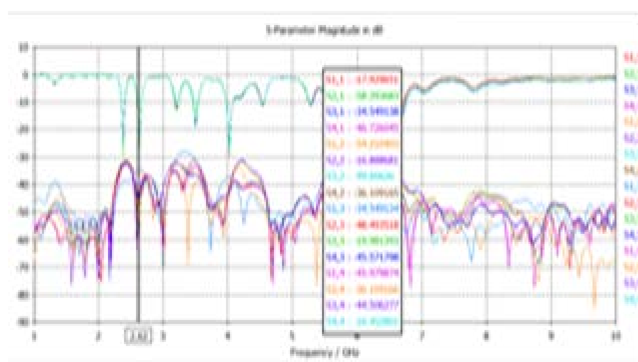

Fig.7b. LTE application

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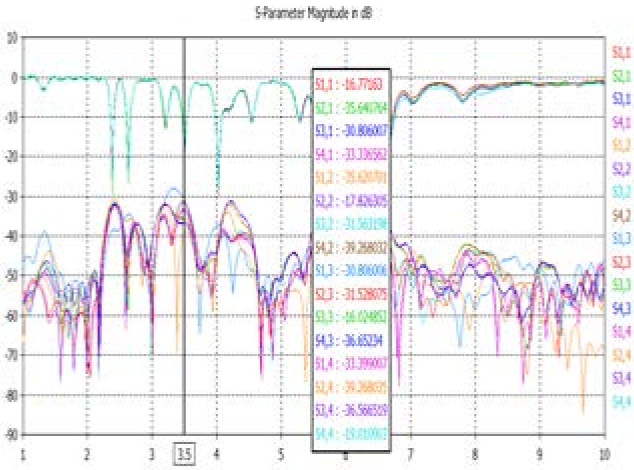

Fig.7c. WIMAX application

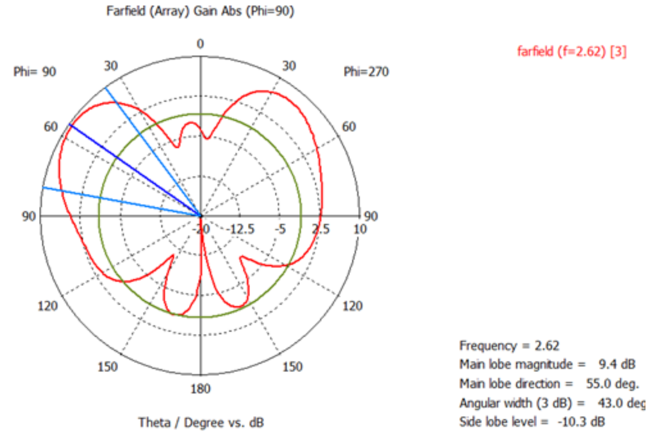

Fig.8b LTE (2.6 GHz)

From the above figures 7 (a) , 7 (b) and 7 (c) , it is observed that the return loss parameters S_{11} ,S_{22} , S_{33} and S_{44} are below -10 dB which means that the antennas operate at the mentioned frequencies with minimum amount of losses . The mutual coupling parameters $S_{21}= S_{12}$, $S_{31}= S_{13}$, $S_{41}= S_{14}$, $S_{32} = S_{23}$, $S_{42}= S_{24}$ and $S_{43}= S_{34}$ are below -20 dB which means that the interaction of the surface waves between the antennas is reduced after applying orthogonal polarization and EBG structure methods .

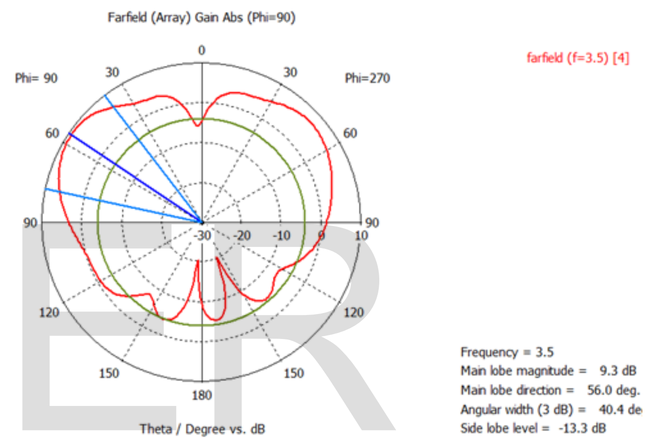

Fig.8c WIMAX (3.5 GHz)

Fig.8. shows the radiation pattern of the MIMO antenna . The radiation pateern type is omni-directional pattern at The WIFI , LTE and WIMAX applications .

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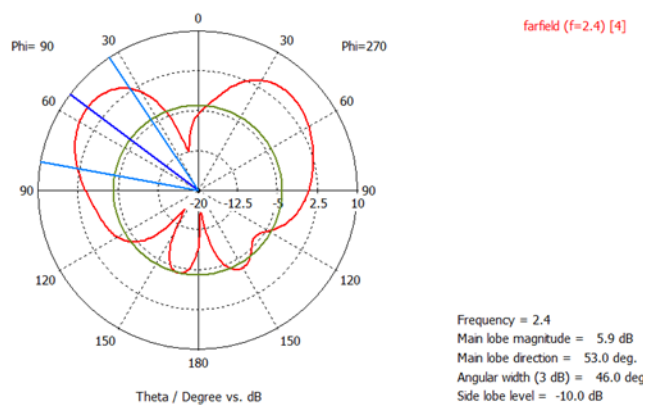

Fig.8a WIFI (2.4 GHz)

Fig.8. The radiation pattern

Fig.9. shows the prototype of the final design .

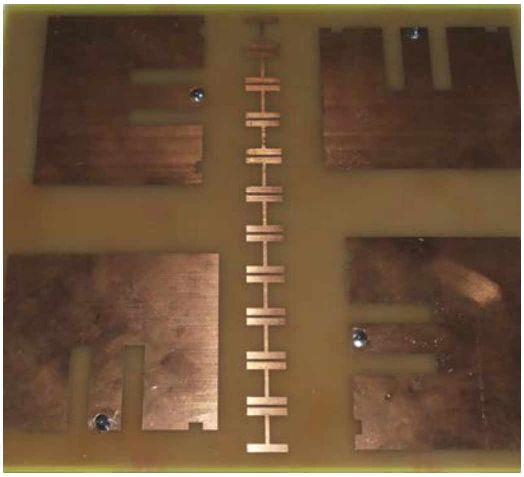

Fig.9. The prototype

Fig.10. shows the prototype results at the mentioned bands Which gives isolation values below -20 dB.

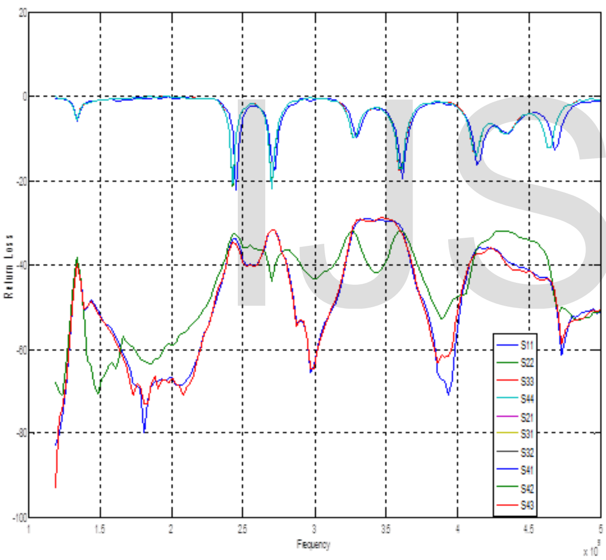

Fig.10. Prototype results

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7. Conclusion

Two by two array MIMO antenna is designed for WIFI , LTE and WIMAX applications . Orthogonal polarization and H-shaped EBG structure are used to reduce the mutual coupling . The mutual coupling results are below -20 dB which give high performance to the MIMO system .

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