# Octagonal Split Ring H Shape DGS Based MIMO Antenna for Wireless Applications

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***Abstract***— In this paper octagonal split ring H shape DGS (Defected Ground Structure) based microstrip patch MIMO (Multiple Input Multiple Output) antenna is presented. The proposed MIMO antenna consists of four ports rectangular patch and electrically small size 62.8x60x1.6mm3, with inexpensive FR4 substrate of a dielectric constant of 4.4. The ground plane is a defected ground structure (DGS) having a number of complimentary octagonal split ring DGS (COSRDGS) windows are arranged in H shape under the patch. The proposed MIMO antenna resonate at 5.9GHz frequency and for its isolation -17.9dB, with overall bandwidth 369MHz and it supported data rate of 18.14Gbps with maximum ECC (Envelope Correlation Coefficient) is less than 0.03 and VSWR is 1.31. The result of this proposed MIMO antenna system shows a good isolation, bandwidth and high data rate with low envelop correlation coefficient which is promising for wireless application systems.

***Keywords***-*MIMO; COSRDGS; VSWR;ECC ;*

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## I. INTRODUCTION

Gbps (Giga bits per second) represents a significant increase in the peak rate, which is five times or more than the 150 Mbps peak rate currently provided by 4G. Today's 4G networks can support high definition (HD) video and audio, web browsing, social media, and similar services. However, it won't be long before higher peak rates are required to support 2K/4K video, virtual reality, enhanced reality, telemedicine, and other new services. For example, virtual reality requires 1Gbps to ensure user experience, which can only be available on a 4.5G network.

Gbps increases the average capacity of a single 4.5G site to 600Mbps, which is six times that of a single 4G site. The high penetration rate of smart phones drives the rapid growth of video traffic on platforms such as YouTube. Video traffic accounts for over 50% of total traffic on many 4G networks. Each subscriber consumes on average more than 30GB of traffic per month, increasing by 60% each year. Network capacities must be expanded to accommodate more video service connections. This ensures an uninterrupted user experience at the cell edge when watching HD videos or performing other latency-sensitive services [1, 2].

Gbps is implemented through MIMO, DGS, 3D beam forming, 4CC/5CC CA, 256 QAM, and other technologies.

MIMO technique has been widely used in all portable wireless devices to increase high data rate and improve signal quality during fading environment. MIMO technique uses multiple antennas at both transmitter and receiver, and they operate in same frequency bands. However such MIMO antenna design adds many challenges such as size constraints, and mutual coupling between the individual antennas, and required MIMO specification such as pattern, gain, efficiency, bandwidth, VSWR, and polarization should be achieved. These constraints should be achieved simultaneously to design a good MIMO antenna. Such a task represents the actual challenge facing the antenna designers. This work complimentary octagon split ring DGS (COSRDGS) in H shape structure loaded on its ground plane of the four port microstrip patch MIMO antennas are designed, analyzed, fabricated and measured[9]. Section 2 presents a detailed design and description of the conventional and proposed MIMO antenna respectively. Simulation results are presented and discussed in section 3. The fabricated MIMO antenna results are presented and discussed in section 4. Finally the paper is concluded in the last section.

## II. DESIGN AND DESCRIPTION OF MIMO ANTENNA

The microstrip MIMO antenna as an initial conventional design is composed of a four microstrip patch antenna. These patch antennas are mounted on a FR4 substrate ($\varepsilon r$ = 4.4, tangent loss $\delta$ = 0.025, conductor and height $h$ = 1.6mm). Patch and substrate dimensions ($Lp$ =11.35mm, $Wp$ = 15.25mm, $Lf$=6.15mm, $Wf$=3.05mm, $Lq$=4.90mm, $Wq$=0.50mm & $Ls$=62.8mm, $Ws$=60.0mm).The smallest edge-to-edge separation of the four symmetrical elements is $\lambda/4$ (where $\lambda$ is the free space wavelength) as shown in figure1.

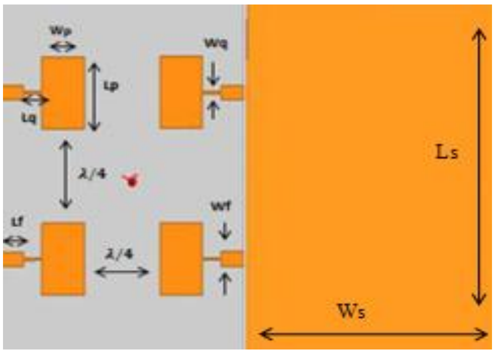


Figure 1 A simulated conventional MIMO Antennas top and bottom view

The proposed DGS microstrip patch MIMO antenna a modified conventional microstrip patch MIMO antenna.

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The ground plane is a defected ground structure (DGS) having a number of complimentary octagon split ring DGS (COSRDGS) windows are arranged in H shape under the patch. The unit cell of the complimentary octagon split ring DGS (COSRDGS) and proposed MIMO antenna are shown in figure 2, figure 3 respectively.

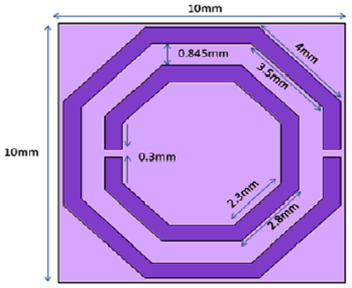


Figure2: The unit cell COSRDGS structure

The proposed COSRDGS structure dimensions ($S1$= 4mm, $S2$=3.5mm, $S3$=2.8mm, $S4$=2.3mm, $g$=0.30mm, $d$=0.845mm & $W$=0.6mm, $L$=10mm, $W$=10mm).

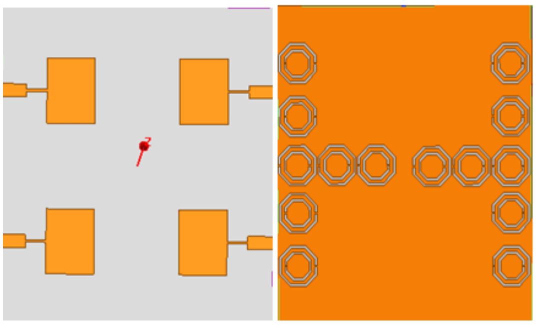

Figure 3 A simulated proposed MIMO Antennas top and bottom view

## III. RESULTS AND DISCUSSION

### *A. CONVENTIONAL MIMO ANTENNA*

Simulated return loss of the conventional MIMO antennas is presented in figure 4. In the case of the conventional MIMO antenna it is clear that, it shows the reflection coefficients S11, S22 S33, and S44 is -21.3dB at 5.9GHz with a frequency bandwidth of 204MHz (WLAN frequency band) and it supported data rate is 10.02Gbps as per the Shannon channel capacity.

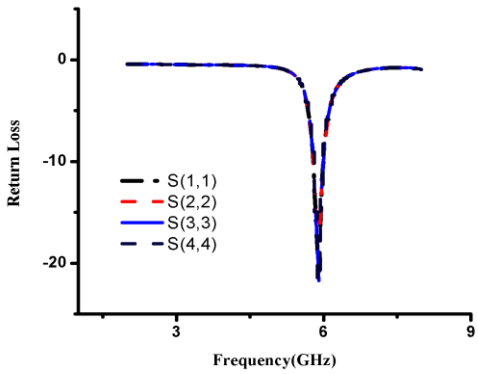


Figure 4: Return loss of conventional MIMO antenna

Figure.5 shows that the peak gain of the conventional MIMO antenna gives 5.69dBi with antenna efficiency of 98.03% at 5.9GHz..

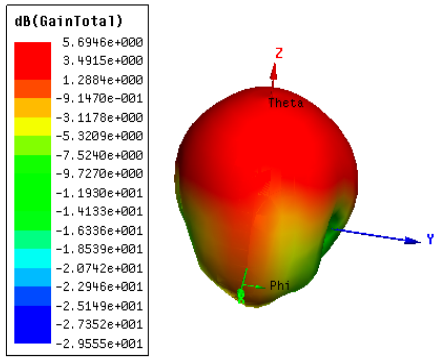


Figure 5: Gain of conventional MIMO antenna

The diversity performance of four element MIMO antennas is directly related to the minimum coupling between individual antenna elements. While designing such MIMO antenna mutual coupling is the major factor to be consider because it degrade the performance of the system. Hence conventional MIMO antenna it gives mutual coupling between ports 1and 2 is -20.9dB at 5.9GHz as shown in figure 6.

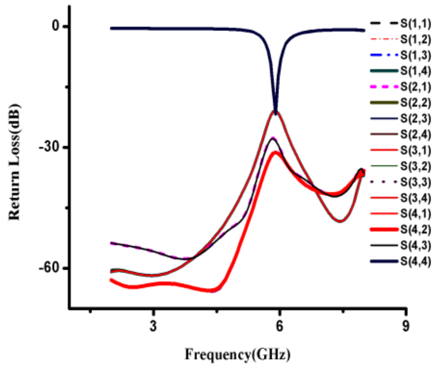


Figure 6: Mutual Coupling of conventional MIMO antenna

Figure.7 shows the meandering of the surface current on the conventional MIMO antenna.

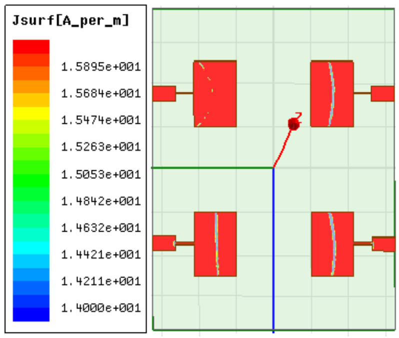


Figure 7: Surface Current of conventional MIMO antenna

### *B. PROPOSED MIMO ANTENNA*

Simulated return loss of the proposed MIMO antennas is presented in figure 8. In the case of the proposed MIMO antenna it is clear that, it shows the reflection coefficients S11, S22 S33, and S44 is -17.9dB at 5.9GHz with a frequency bandwidth of 369MHz (WLAN frequency band) and it supported data rate is 18.14Gbps as per the Shannon channel capacity. The proposed MIMO antennas have been fabricated on an FR-4 substrate, and their parameters have been measured and compared to the simulated results. Fabricated proposed MIMO antenna are shown in figure 9 and reflection coefficients of the fabricated MIMO antennas are shown in figure 10, and it shows that good agreement has been achieved between the measured and simulated results. However small deviations between the measured and simulated return losses with reasonable agreement have been noticed, in fact this due to fabrication error and soldering points of SMA connectors.

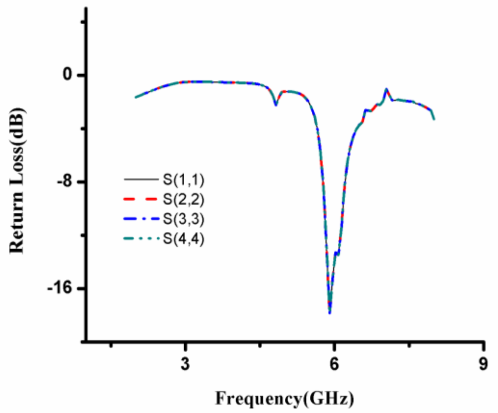


Figure 8: Simulated Return loss of proposed MIMO antenna

Figure 9 A fabricated proposed MIMO Antennas top and bottom view

Figure.11 shows that the peak gain of the proposed MIMO antenna gives 4.69dBi with antenna efficiency of 98.03% at 5.9GHz and proposed MIMO antenna gives mutual coupling between ports 1 and 2 are -23.9dB at 5.9GHz are shown in figure 12 and it shows that good mutual coupling reduction has been achieved by using DGS on ground plane as compared conventional MIMO antenna (-20.9dB). Figure.13 illustrates the current distribution of the radiating patch element of the proposed MIMO antenna at 5.9GHz. It has been revealed through observation that the distribution of current is much stronger at resonating frequency. Figure 14 shows VSWR of the proposed MIMO antenna is less than 1.2 hence it shown good amount of power transfer along the antennas. Figure 15 shows correlation coefficient is less than 0.001 hence we concluded that very small channel capacity loss in the rich environment of multipath.

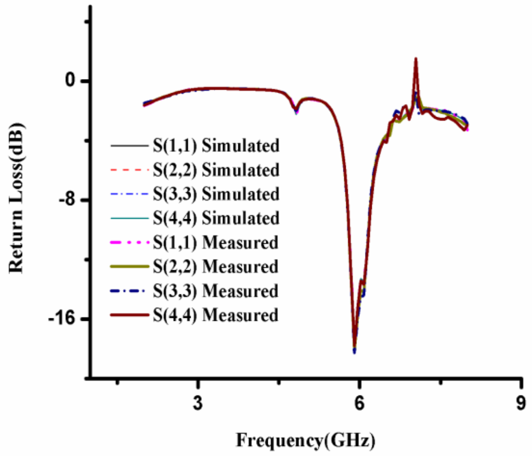


Figure 10: Measured Return loss of proposed MIMO antenna

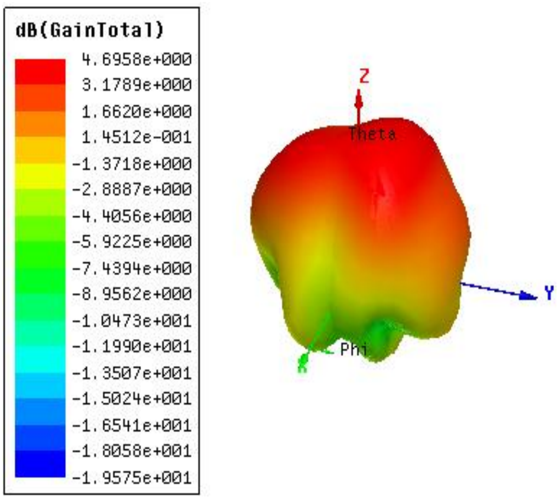


Figure 11: Gain of proposed MIMO antenna

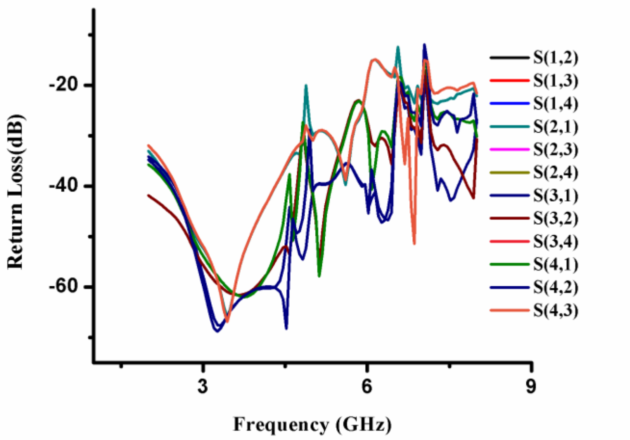


Figure 12: Mutual Coupling of proposed MIMO antenna

All the observed results are summarized results in Table1.

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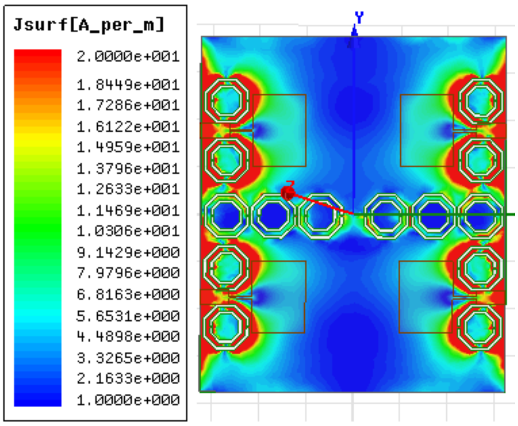


Figure 13: Surface Current of proposed MIMO antenna

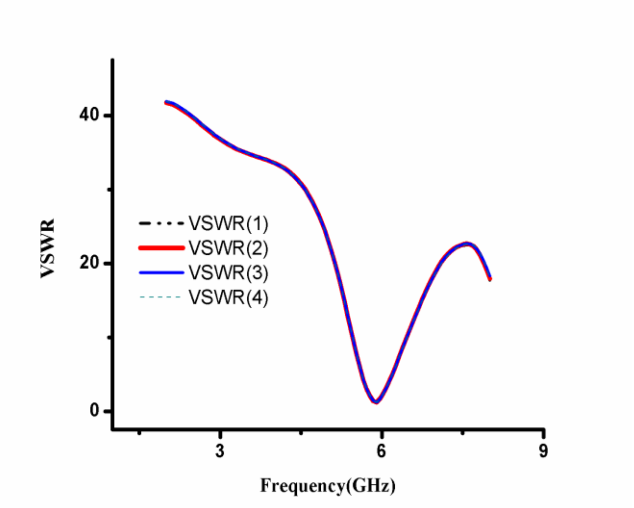


Figure 14: VSWR of proposed MIMO antenna

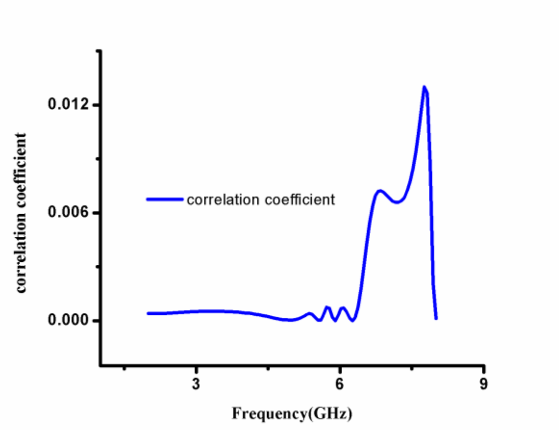


Figure 15: Correlation Coefficient of proposed MIMO antenna

## IV. CONCLUSION

Octagonal Split Ring H Shape DGS Based MIMO Antenna have been proposed and presented for wireless application. With the optimized antenna geometry, the proposed antenna offers a measured impedance bandwidth over 396MHz which is enough to cover WLAN band. The proposed MIMO antennas with COSRDGS provides good performances in terms of good return loss, bandwidth and data rate as compared to conventional MIMO antenna. It can be predicted that, the designed MIMO antennas with COSRDGS has excellent can be investigated, which is very useful for wireless communication application.

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