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MIMO Antenna for 5G Systems using Complimentery Split Ring Resonantors

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Abstract— **In this paper a MIMO antenna is proposed for 5G applications. Every antenna is minted on the top layer of substrate in the form of rectangular patch. Each antenna is fed through transmission line and the transmission line is connected with quarter wave transformer for impedance matching. The substrate used in our design is "Rogers RT/duroid 5880 (tm)". Circular split ring resonators are designed on the ground plane to increase the bandwidth and the efficiency of our antenna. The antenna resonates on the frequency of 28 GHz. The gain secured by the antenna is above 8 dB with a bandwidth of 2.82 GHz. The simulation results have substantiated a good performance of the MIMO antennas thus making them suitable for many 5G devices**.

Keywords— **CCSR, 4G, 5G, MIMO, high bandwidth**

I. INTRODUCTION

Wireless communication plays a vital role in our daily routine life. Recently scientists are working on 5G systems which will give us high data rates and increased bandwidth. Higher bandwidth also gives us more numbers of users as the frequency channels are increased. 5G has less interface and better efficiency than pervious wireless technologies. It also has lower latency and greater capacity of remote execution. In order to achieve better bandwidth and high gain antennas are very crucial. The amplifier also enhances overall gain of the system but complex in circuitry so instead of using amplifier use the antennas which give us better performance on simple optimizing techniques.

Recently many researchers have modified patch antennas to increase bandwidth. A single element microstrip patch antenna is proposed in [1], feeding with a transmission line at operating frequency of 28 GHz. The inset fed point value is 0.2mm and bandwidth of 1.29 GHz. In [2] the microstrip antenna is operated on four different frequencies (3.05, 3.75, 4.55 and 4.9) GHz three elliptical slots are etched to expose the feeding strip for impedance matching with maximum bandwidth of 2.33 GHz. A two dimensional compact slotted antenna consisting of 8 elements array was proposed for 5G applications in [3] with the bandwidth of 1.38 GHz and a gain of 9dB. Although the gain of array antenna is high but its bandwidth is not much higher. In [4] a compact dual band microstrip patch antenna is proposed for 5G applications. The antenna is operating on 10 GHz and 28 GHz with a gain of 5.51 dB and 8.03 dB. The bandwidth of the antenna is 0.278 GHz and 1 GHz at frequency of 10 GHz and 28 GHz respectively. In [5] a PIFA antenna is designed for 5G with the gain of 4.5 dBi. Feeding and shorting of the antenna is done using metallic strips. The bandwidth of antenna is 1.55 GHz. A dual band circular patch array antenna is designed in [6]. The antenna is operated at 28 GHz and 45 GHz with the bandwidth of 1.3 GHz and 1 GHz. Although antennas proposed in [1-6] proved to be good candidates of 5G systems, however, their bandwidth was limited, which results in less number of users and data rates. MIMO antennas use multiple signal paths to gain the knowledge of communication channel. By using spatial dimensions MIMO antennas achieve significantly higher data rate than a single element and an array antenna.

In this paper we proposed the four element MIMO antennas with complementary split ring resonators (CSRR) having a bandwidth of 2.82 GHz. The antenna is operated at 28 GHz with the gain of 8.29 dBi. The design of our MIMO antenna is discussed in section **II,** while section **III** is about parametric analysis**,** results and conclusions are in sections **IV** and **V** respectively.

II. ANTENNA DESIGN

The top view of the MIMO antennas are shown in fig. 1.There are four microstrips patch antennas all are placed just little away from the edges with a distance of 0.328λ. The horizontal and vertical distance between the two antennas is 0.404λ and 0.931λ respectively. "Rogers RT/duroid 5880 (tm)" is used as a substrate having =2.2 and tanδ=0.0009.The thickness of the substrate is 0.073λ. All the antennas are composed of patch, transmission line and quarter wave transformer. The patch is connected with the quarter wave transformer and quarter wave transformer is further attached with the transmission line through which our antennas are fed. Quarter wave transformer is used for impedance matching between the patch and transmission line. The patch (P2) length is 0.262λ and its width is 0.396λ. The length and width of transmission line (T2) is 0.25λ and 0.033λ respectively. The dimension of quarter wave transformer (Q2) is 0.366λ and 0.226λ. The bottom layer is composed of CSRR. The purpose to use this is to increase the bandwidth of the antenna. As you see in fig. 2 there are two CSRR exactly on the back side of all the four patches of antennas, the center point of both CSRR are same but their radius are different. The radius of CSRR 1 (C1) is 0.093λ mm and CSRR 2 (C2) is 0.112λ. When we draft the circular rings on the ground plane the antenna could not operate on our desired frequency because impedance is not properly matched. We resolve this problem by flattening the patch edges of all the antennas as shown in fig. 3. The radius of flattening edges (FR) is 0.112λ.

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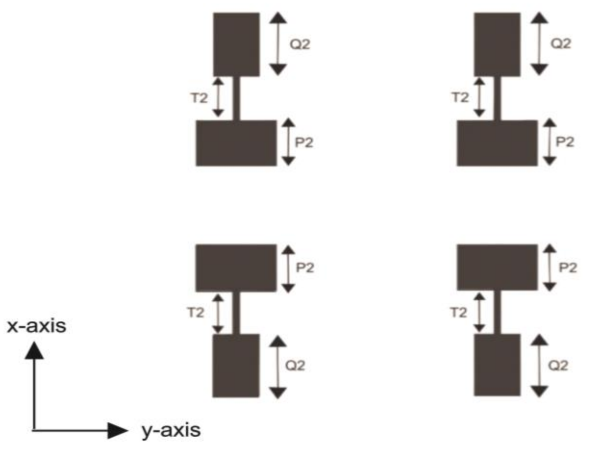

Fig 1. MIMO antenna (Top Layer)

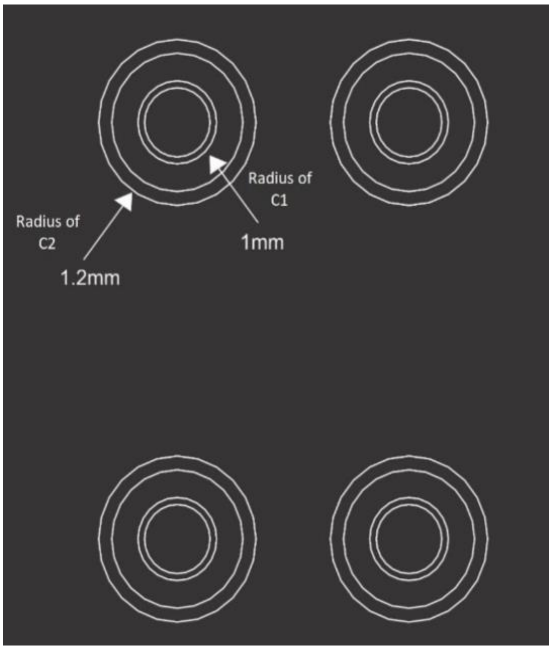

Fig 2. MIMO antenna (Bottom Layer)

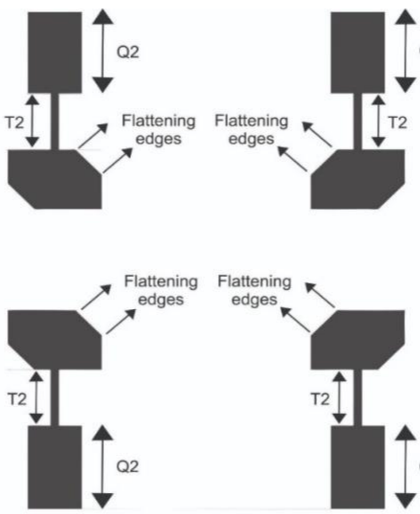

Fig 3. MIMO antenna (Top Layer)

Table I Design parameters of MIMO antenna

Name	Symbol	Value (mm)
Patch length	P2	2.80
Patch width	P2	4.23
Quarter wave transformer length	Q2	2.67
Quarter wave transformer length	Q2	0.36
Transmission line length	T2	3.91
Transmission line width	T2	2.42
Flattening radius	FR	1.2
Radius of CSRR 1	C1	1
Radius of CSRR 2	C2	1.2

III. PARAMETRIC ANALYSIS

Parametric analysis is carried out on our MIMO antenna to achieve the best results and for better understanding of our design. Parametric analysis is performed on the patch width and on the edges. The parametric analysis on the width is shown in fig. 4.we performed parametric analysis on width to obtain the best result of S_{11}. As it is clear from fig. 4 that when we increase width of patch the S_{11} graph moves towards lower frequencies. For better impedance matching truncation on edges of patches is performed, and its parametric analysis is shown in fig. 5. As it is seen from fig. 5 that when we increase truncation area the S_{11} graph moves towards higher frequencies.

IV. RESULTS

The S_{11} comparison of MIMO antenna with and without CSRR is shown in fig. 6. As it is clear from the figure that the MIMO antenna operates on our desire resonating frequency. with addition of CSRR impedance matching is increased, without effecting the operating bandwidth. It operates in the range of 26.70 GHz to 29.52 GHz having a bandwidth of 2.82 GHz. Gain is directly proportional to the directivity of the antenna so if the antenna has high gain than its more directive. The gain of our MIMO antenna with CSRR is shown in fig. 7 and we see the directivity of our antenna in radiation pattern which is shown in fig. 8. As we see from the fig. 7 that our gain is high which is 8.29 dBi then accordingly our antenna is more directive, we see that in fig. 8 as well. The mutual coupling between each antenna is shown in fig. 9. As we see from the figure that the mutual coupling between each antenna is below from -20 dB therefore it can be claimed that these radiating elements have very less coupling between all the them.

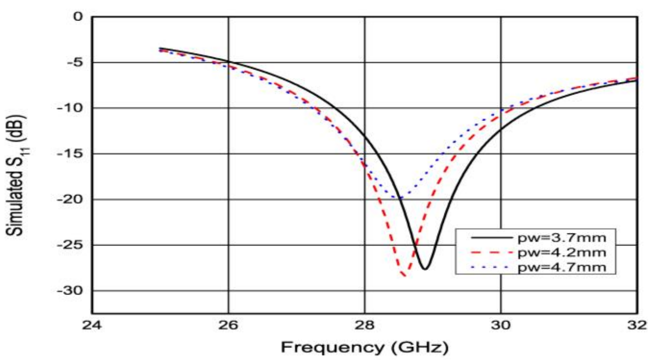

Fig 4. Simulated S parameter at different width of patch

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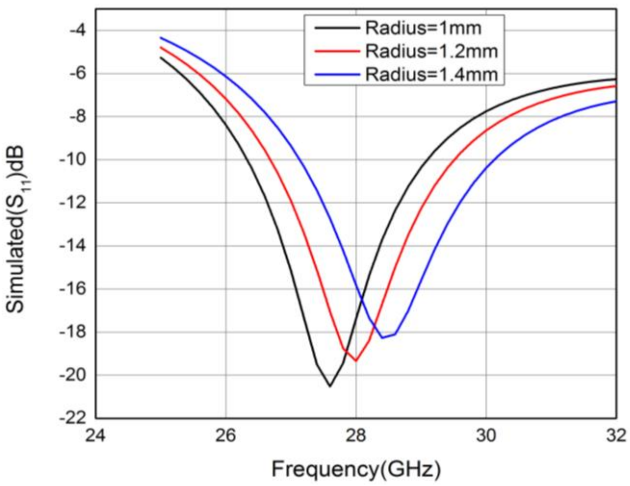

Fig 5. Simulated S parameter at different Radius on the edges of antenna

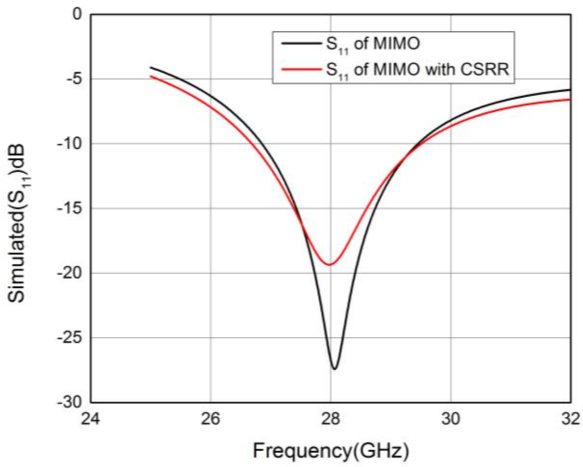

Fig 6. comparison of MIMO antenna and MIMO antenna with CSRR

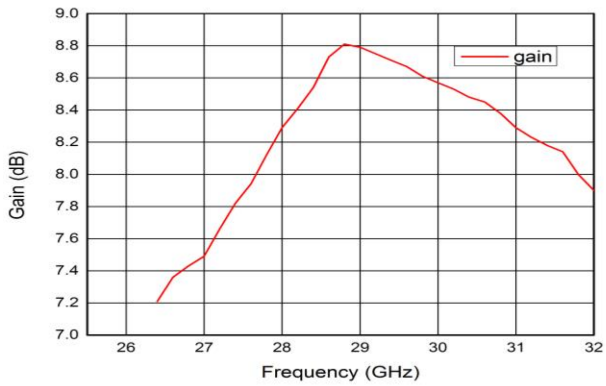

Fig 7. Gain of the proposed MIMO Antenna

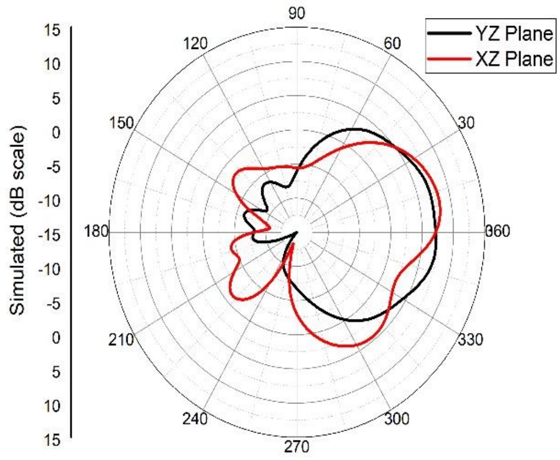

Fig 8. Radiation Pattern of MIMO antenna

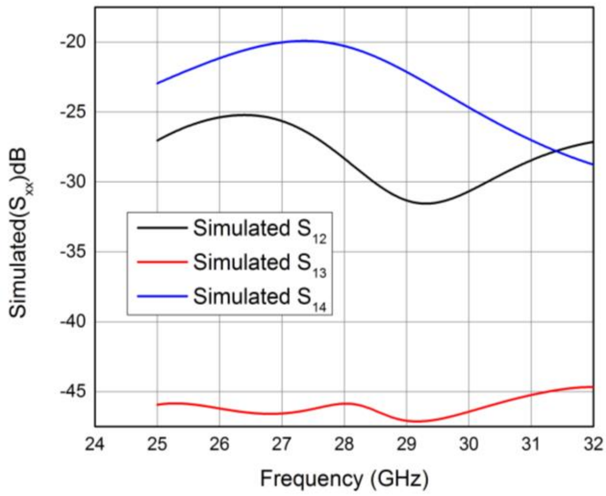

Fig 9. Simulated SXX of proposed MIMO antenna

V. CONCLUSION

A layout of 4×4 MIMO antenna is presented for 5G communication systems. The resonating frequency of the antenna is 28 GHz. The antennas indicate a compact geometry and a better bandwidth of 2.89 GHz ranging from 26.70 GHz – 29.52 GHz. Our antenna shows an acceptable return loss and radiation performance with a feasible gain of 8.29 dBi thus making it suitable for 5G utilization in the area of communication.

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