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A FOUR PORT, DUAL BAND ANTENNA FOR FIFTH GENERATION MOBILE COMMUNICATION AND WLAN SERVICES

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Abstract: This paper presents a dual-band four port antenna system for Fifth Generation devices and WLAN services. This antenna works on sub-6 GHz frequency bands with center frequencies as 3.6 GHz and 5.5 GHz. It is designed on FR-4 substrate of thickness of 1.6 mm. The simulations are performed on CST for 4 port configuration of the proposed antenna. It offers gain more than 3dB and radiation efficiency more than 60% for both bands of operation. Both operating bands can be controlled independently.
Keywords: 5G, WLAN, MIMO, Sub-6 GHz, Dual-band

INTRODUCTION

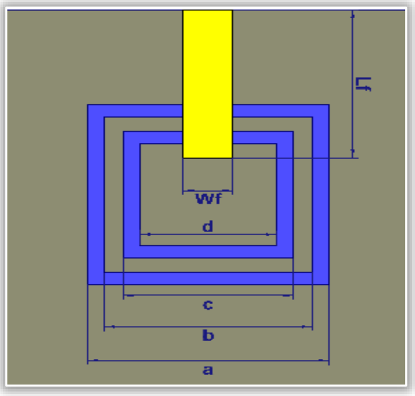
Multiple input, multiple output (MIMO) technology has been used to increase the data rate in fourth generation mobile device and will also be deployed in Fifth Generation (5G) user equipments with even higher data rate. In advanced wireless communication devices, MIMO, massive MIMO and multi-beam systems have been extensively deployed. [1] To get the superior data capacity, MIMO is almost certain to be used in 5G systems. [2] MIMO antenna systems have been proposed with different number of antennas. Two to four elements MIMO antennas are proposed in literature by various researchers. [3]-[4] MIMO with 8 elements is discussed in numerous research articles. [5]-[6] More than eight elements MIMO is also discussed by few researchers.[7]

Various types of antennas have been proposed for 5G devices by various researchers. Slot antenna have been proposed in [8], [9] Multi-band antenna is proposed by the author for GPS/2G/3G/4G and 5G NR Applications. [10] A compact ultra-wide band antenna with MIMO system for sub-6 GHz 5G services is also proposed with fractional bandwidth of 143%. [11] Parasitic layer-based pattern reconfigurable antenna is discussed by the author for 5G communication devices. [12] A '9' shaped patch antenna for 3.5 GHz band of 5G applications, designed on FR-4 substrate is presented by the author. [13] An eight antenna MIMO array with balanced open slot antenna operating at 3.5 GHz band with total efficiency greater than 62% and low ECC is presented. [14]

In this paper a dual-band 4 port MIMO antennas system is proposed on FR-4 substrate that operates on the sub 6 GHz frequencies allotted for fifth generation services. It is designed on a square substrate. The two operating bands are results of the two square loops etched on the ground plane. The antenna design and the simulation results in terms of S-parameter, gain, efficiencies and the surface current distribution pattern is discussed in the next section of the paper.

ANTENNA DESIGN

Figure 1 show a four port antenna designed on the FR-4 epoxy substrate with thickness 1.6 mm and the copper thickness of 0.035 mm. The overall dimensions of the antenna are 60mm x 60mm x 1.6mm. The proposed antenna has four identical antennas each designed in 30mm x 30mm area and packed together as shown in figure.



(a)

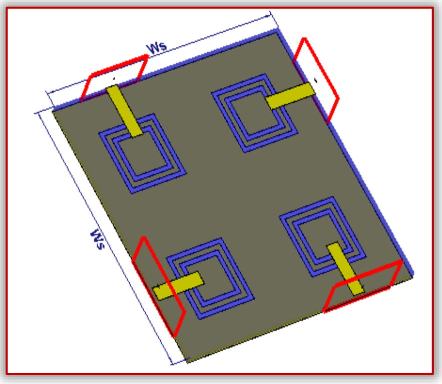


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Figure 1: The proposed slot antenna configuration, (a) Front and Back View (b) Side-View

Each antenna has a feed element is fed by 50-Ω microstrip transmission line and two squared ring slots cut into the ground plane. The dimensions of feed element and of the slots are given the figure. Two slots are responsible for two resonating frequencies of the antenna, outer slot for lower frequency and the inner slot for higher one. The length of the slots is responsible for the resonating frequency and the resonating frequency is inversely proportional to the length of the slot.

Table 1: The Values of Design Parameters

Parameter	Value (mm)
a	14.6
b	12.6
c	10.3
d	8.3
Wf	3
Lf	12
Ws	60
h	1.6

RESULTS AND DISCUSSION

The S-parameter results of the proposed antenna are shown in the figure 2. All the four antennas have almost identical S-parameter results with resonating frequencies at 3.6 GHz and 5.5 GHz. The band with 6 dB as the benchmarks is 450 MHz in 3.6 GHz band and more than 800 MHz in 5.5 GHz band.

The value of voltage standing wave ratio (VSWR) remains close to 2 as visible in figure 3 and it also verify the same about the operating frequencies of the antenna. The antenna is also having good isolation i.e. very less mutual coupling, more than 17 dB isolation from the neighboring antennas, verified from the figure 4.

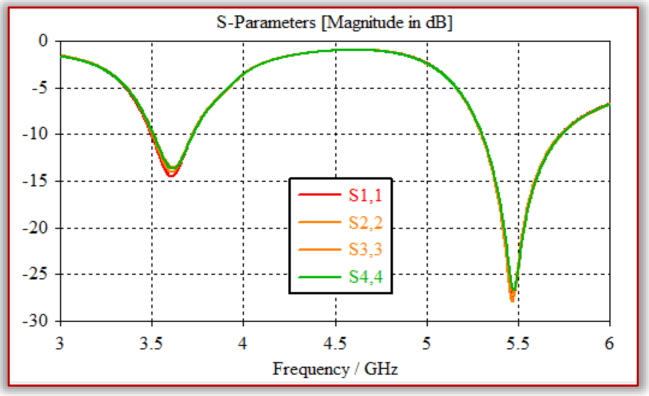


Figure 2: S-Parameter results of the proposed antenna for all four ports

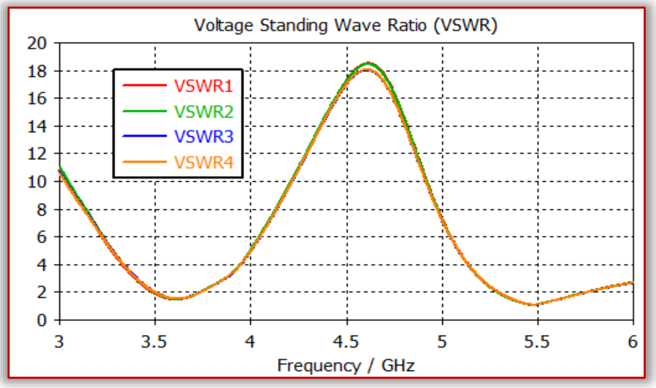


Figure 3: VSWR results of the proposed antenna for all four ports

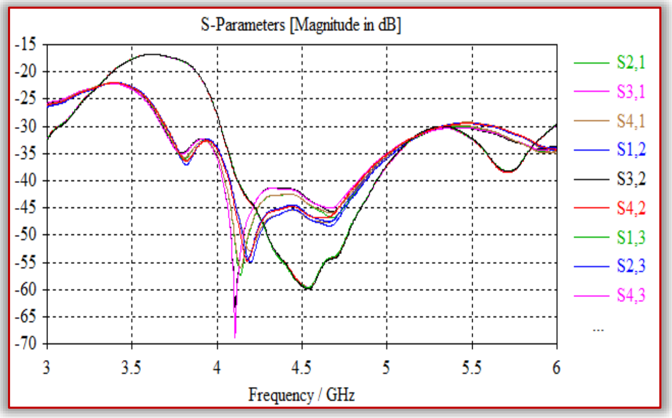


Figure 4: Mutual Coupling between the ports of antenna system

As seen in the figure 5, the plot of Radiation Efficiency v/s Frequency, the radiation efficiency of the antenna is more than 60% in the 3.6 GHz band and 55 to 74 % in the 5.5 GHz band. So, the antenna is radiating efficiently and is always more than 50%. The total efficiency of the antenna is more than 50% for both the operating bands.

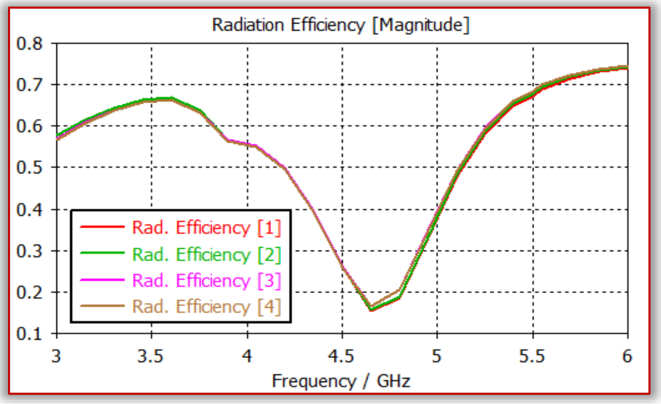


Figure 5: Radiation efficiency for all the four ports of the antenna.

Figure 6 and figure 7 shows the vector current for the both resonant frequencies of the proposed antenna. The outer slot is having high surface current density (111.3 A/m) for 3.6 GHz and the inner slot is having high surface current density (88.6 A/m) for 5.5 GHz.

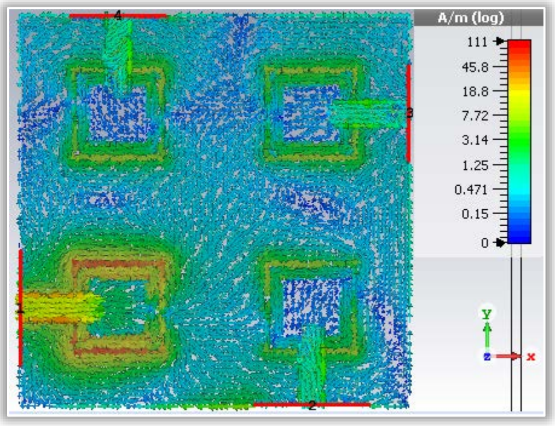


Figure 6: Surface Current at 3.6 GHz

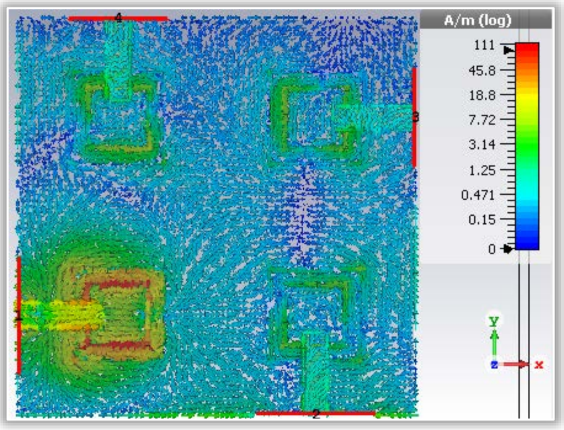
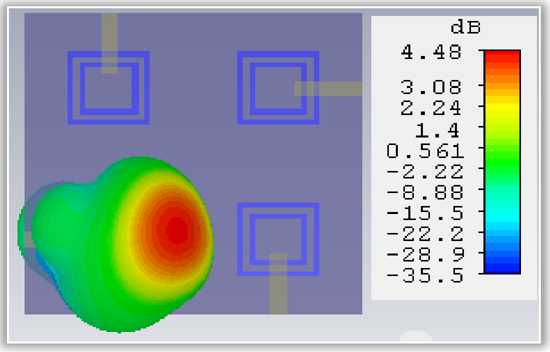
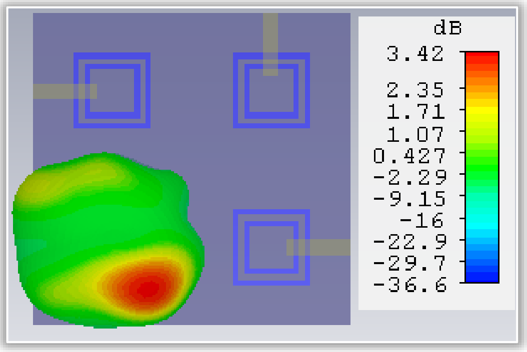


Figure 7: Surface Current at 5.5 GHz



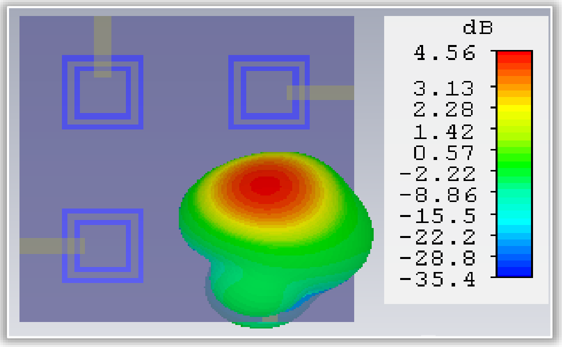
(a)



(b)

Figure 8: 3D Antenna Radiation Pattern for antenna 1 (a) At 3.6 GHz (b) At 5.5 GHz

As evident from the 3D gain plot of the proposed antenna shown in figure 8 and figure 9, the gain of the antenna at 3.6 GHz frequency is approx. 4.5 dB and for 5.5 GHz it is 3.5 dB. Further the polar plot in figure 10, show that the radiation pattern is bidirectional.



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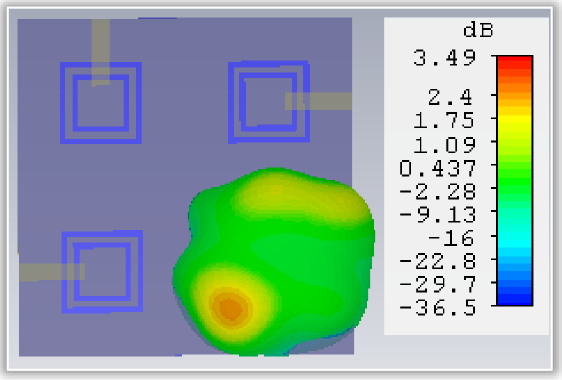

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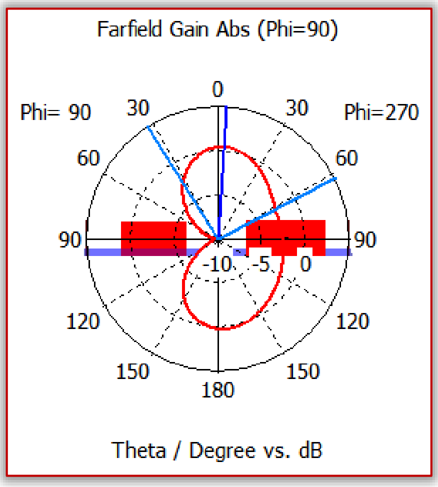
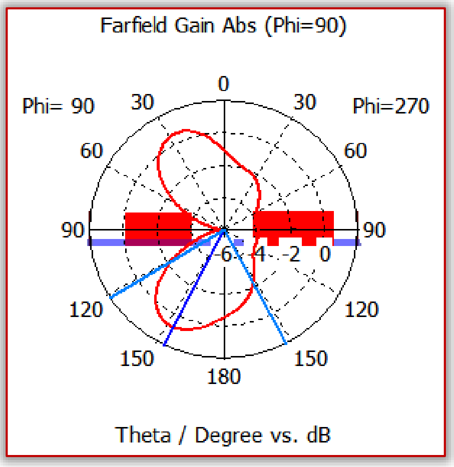
Figure 9: 3D Antenna Radiation Pattern for antenna 2 (a) At 3.6 GHz; (b) At 5.5 GHz



(a)



(b)

Figure 10: 2D Antenna Radiation Pattern for antenna 1 (a) At 3.6 GHz (b) At 5.5 GHz

Another important result to be observed is Envelope Correlation Coefficient (ECC). As visible in the figure 11, the value of ECC is below 0.02 for the complete range of frequencies from 3 GHz to 6 GHz for port 1 with other three ports. Similar results are obtained for port 2, 3 and 4.

Similarly, diversity gain is simulated for Port 1 with other three ports. The obtained diversity gain is more than 9.9 for the proposed two bands of operation of the antenna.

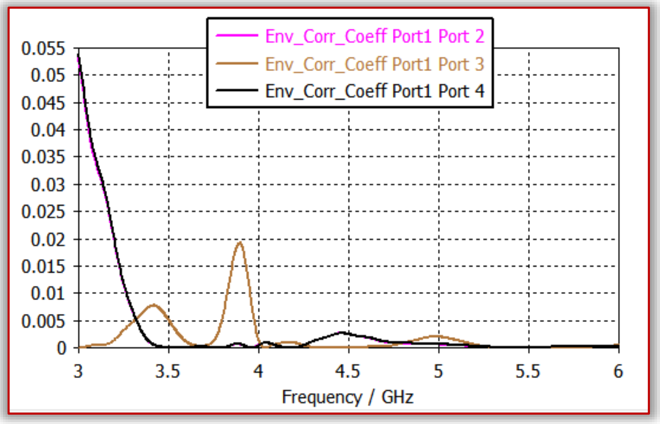


Figure 11: Envelope Correlation Coefficient for the port 1 of antenna system

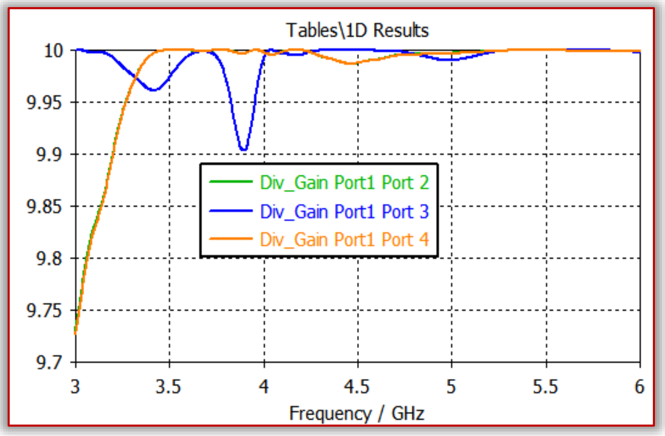


Figure 12: Diversity Gain for the port 1 of antenna system

CONCLUSIONS

In this paper, a four port dual band antenna is proposed for 5G communication systems. The proposed antenna has two concentric square slots for the two resonant frequencies at 3.6 GHz and 5.5 GHz, The proposed structure has sufficiently high gain, radiation efficiency and diversity gain with very small value of mutual coupling and Envelope Correlation Coefficient. The proposed antenna can be good candidate to be installed in future I-pads and wi-fi devices.

Acknowledgement:

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