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Design and Experimental Microstrip MIMO Antenna for WLAN Applications

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Abstract: In this article we presented simulated and fabricated MIMO (Multiple Input Multiple Output) antenna for WLAN applications. The designed MIMO antenna consist of four element microstrip patch antenna by using FR-4 substrate and proposed size of the four element MIMO antenna is 62.8X60X1.6mm^3. The antenna is fabricated and tested. Fabricated measured results are good in agreement with simulation results. The designed antenna resonated at 5.9GHz frequency and its isolation -21.3dB with overall bandwidth 204MHz and it supported data rate of 5Gbps with maximum correlation coefficient is less than 0.03 and VSWR is 1.2. The result of this proposed MIMO antenna system shows a good isolation, bandwidth, VSWR, and correlation coefficient, hence proposed antenna suited for WLAN applications.

Keywords: Microstrip patch antenna, MIMO, WLAN.

I. INTRODUCTION

The demand for higher data rates in wireless communications due to extensive use of multimedia applications and video streaming is always on the rise. With the limited spectrum and power levels available for current wireless standards, the multiple-input-multiple-output (MIMO) technology was adopted to provide a significant increase in such data rates via the use of multiple antennas on the user and base station terminals. The design of MIMO antenna systems on the user handset has many challenges due to the limited size and complexity. These challenges become even more profound when antenna systems are to cover lower frequency bands supported by the latest LTE standards with multi-band coverage. Wireless local area network (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) have been widely used in mobile devices such as handheld computers, laptops and intelligent phones [1-3]. This antenna has been widely considered as a cost-effective, reliable and high-speed data connectivity which enables user mobility.

For this reason, plenty of MIMO antennas for mobile communications have been investigated recent years [5-8]. However, most of the proposed MIMO antennas have narrow impedance bandwidth and low isolation. In this work we proposed high isolation and wide bandwidth of four element rectangular microstrip patch MIMO antenna to resonate 5.9GHz for WLAN applications. Microstrip patch antenna preferable due to its easy fabrication low cost, small size low weight, integrate ability compatibility with standard manufacturing process and the smallest edge-to-edge separation of the four symmetrical patch antennas is $\lambda/4$ (where λ is the free space wavelength), because if the antenna are placed close to each other, resulting in high correlation between the antenna elements, and therefore poor diversity. Hence the proposed four element MIMO antenna exhibiting the wide bandwidth of 204MHz with supporting data rate 5Gbps and proposed antenna results shows that it well suited for WLAN applications and finally we discussed some of the better solutions to overcome the critical issues of MIMO antenna design problems.

II. MIMO ANTENNA DESIGN PROCEDURE

The single antenna element, the geometry of an antenna element is optimized and is shown in Figure 1. The FR-4 (ε_r=4.4) single substrate is used with 1.6mm thickness. Rectangular shape patch antenna is use to provide the WLAN applications and the single antenna dimension are shown in table1. Figure.2 shows that the reflection coefficient S11 is -21.3dB at 5.9GHz. Reflection coefficient is a measurement of how much power the antenna accepts from the transmission line the impedance of the antenna must match the impedance of the transmission line for maximum power transfer. Hence the single antenna has shown good isolation with a frequency bandwidth of 204MHz (WLAN frequency band). Figure.3 shows the meandering of the surface current on the radiating rectangular patch, Figure.4 shows that the gain is better than 4dBi with antenna efficiency of 93.43% at 5.9GHz. The results of single rectangular patch antenna are summarized in table 2.

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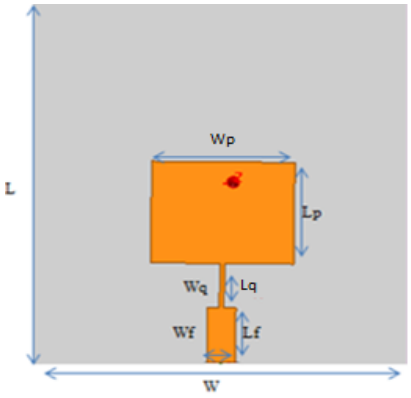

Figure1: Geometry of Single Antenna

Parameters	Dimensions (mm)
Width of the Patch Wp	11.35
Length of the Patch Lp	15.25
Width of the Quarter wave transformer Wq	3.05
Length of the Quarter wave transformer Lq	6.15
Width of the feed line Wf	0.5
Length of the feed line Lf	4.9

Table1: Single Antenna Dimensions

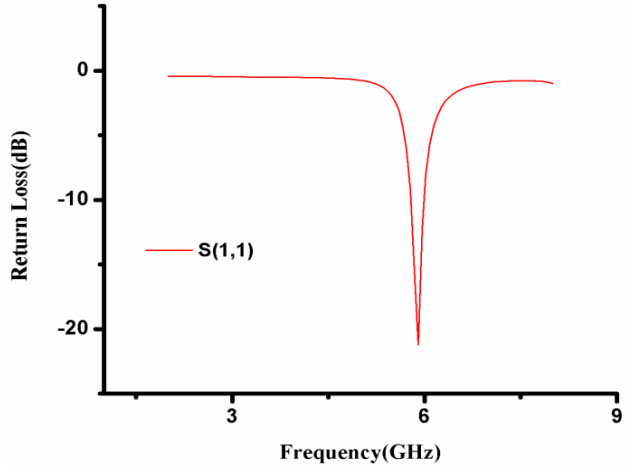

Figure2: Reflection Coefficient of Single Antenna

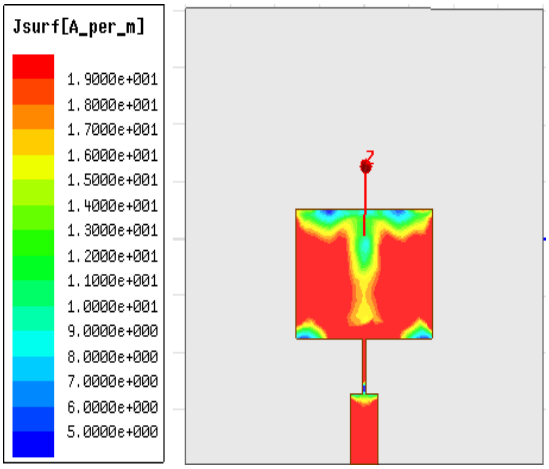

Figure3: Surface current of Single Antenna

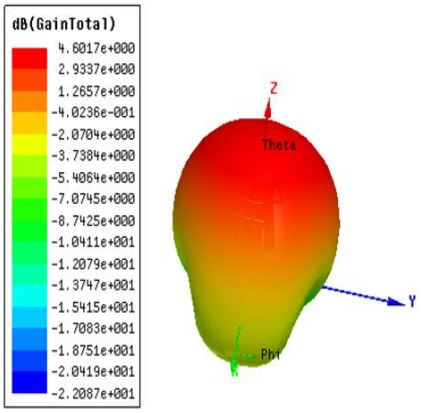

Figure 4: Gain of Single Antenna

Parameters	Results
Return Loss	-21.3dB
Surface Current	1.9
Gain	4.60dB
Efficiency	93.43%
Bandwidth	204MHz

Table 2: Summarized Single Antenna Results

For the 2x2 MIMO antenna dimension parameters and geometry are shown in table 3 and Figure 5 respectively. The 2x2 MIMO antennas with edge to edge separation of λ/4 (where λ is the free space wavelength) maintained because if the antennas are placed close to each other, resulting in high correlation between the antenna elements, and therefore poor diversity and separate feeding ports for all individual antennas.

Figure.6 shows the reflection coefficients S11, S22 S33, and S44 is -21.3dB at 5.9GHz with a frequency bandwidth of 204MHz (WLAN frequency band). Hence the proposed 2X2 MIMO antenna without increasing bandwidth it supported data rate is 5Gbps as per the Shannon channel capacity. Figure.7 shows that the gain is better than 5.69dBi with antenna efficiency of 98.03% at 5.9GHz. Figure 8 shows that the coupling between ports 1and 2 is better than -20.9dB at 5.9GHz. Figure.9 shows the meandering of the surface current on the proposed MIMO antenna.

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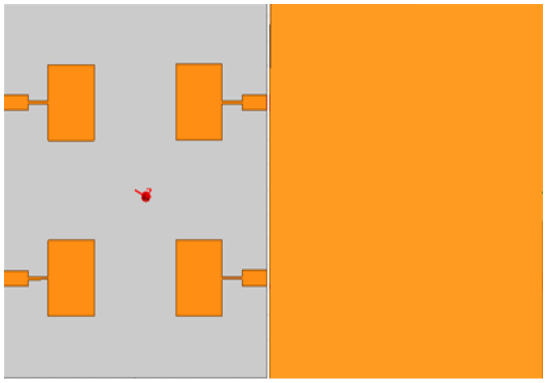

Figure5: Geometry of 2X2 MIMO Antenna

Parameters	Dimensions(mm)
Length of the substrate	62.8
Width of the substrate	60
Antenna between edge separation	λ/4
Height of the substrate	1.6

Table 2: 2X2 MIMO Antenna Dimension

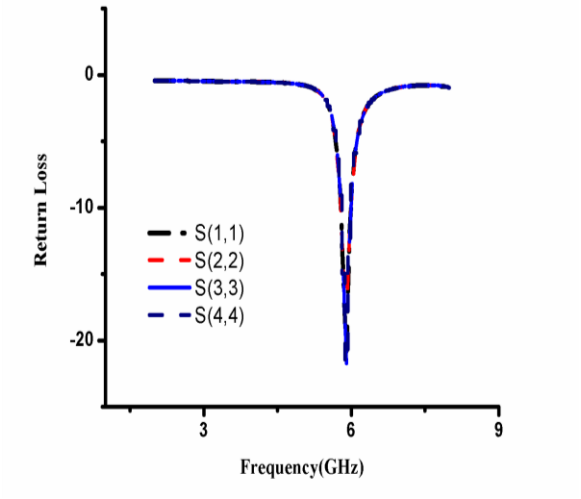

Figure 6: Return loss of MIMO antenna

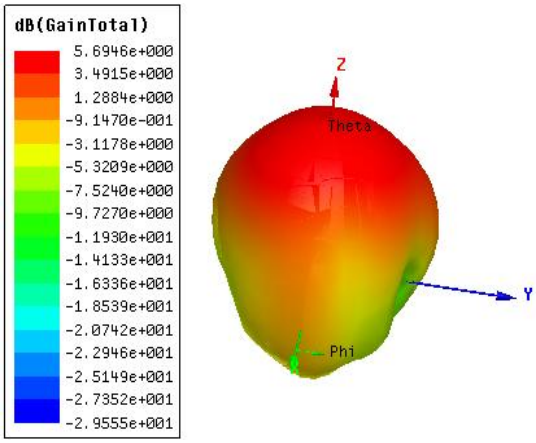

Figure 7: Gain of MIMO antenna

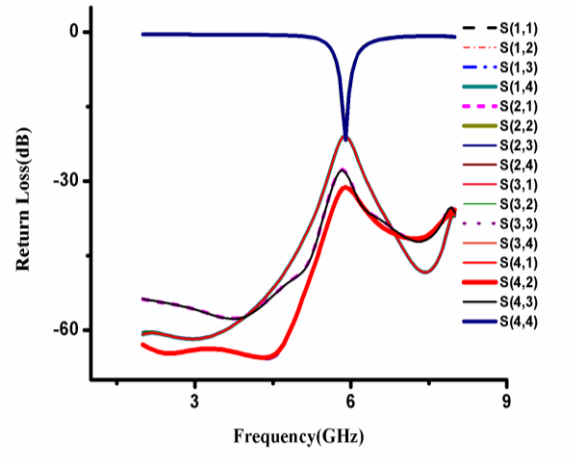

Figure 8: Mutual Coupling of MIMO antenna

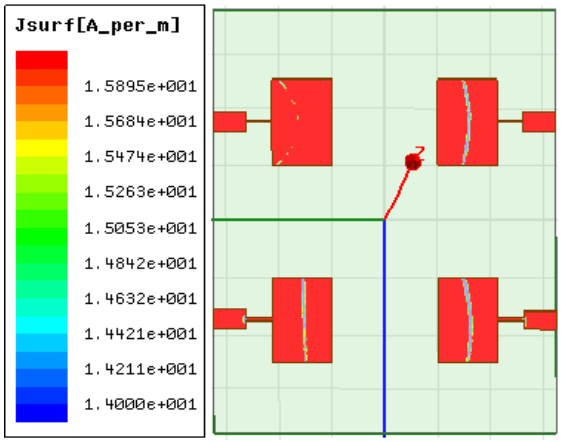

Figure 9: Surface Current of MIMO antenna

III.FABRICATED AND MEASURMENT MIMO ANTENNA

Figure10 and Figure 11 show the fabricated single element and 2X2 MIMO antennas respectively. Figure 12 shows that the single antenna measured reflection coefficient S11 is equal to -21.3dB at 5.9GHZ with a band width of 204MHz hence good agreement achieved between the measured and the simulated results for the single element. Figure 13 shows that the 2X2 MIMO antennas measured reflection coefficients of S11, S22 S33, and S44 are -21.3dB at 5.9GHz with a frequency bandwidth of 204MHz (WLAN frequency band). Hence good agreement achieved between the measured and simulated results for the 2X2 MIMO antenna.

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Figure 10: Fabricated Single Antenna

Figure 11: Fabricated 2X2 MIMO Antenna

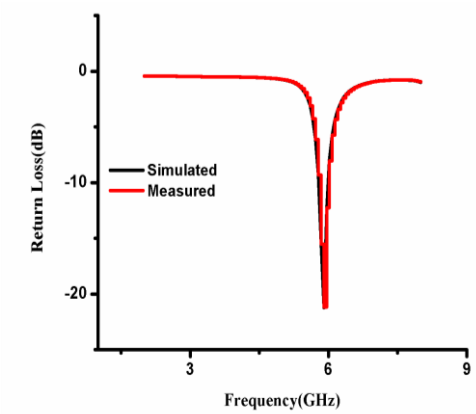

Figure11: Return loss of fabricated single Antenna

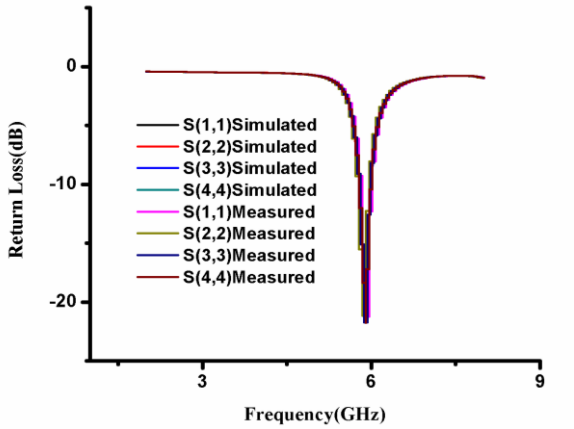

Figure 12: Return loss of fabricated 2X2 MIMO Antenna

Figure 13 shows VSWR of 2X2 MIMO antenna is less than 1.2 hence it shown good amount of power transfer along the antennas. Figure 14 shows correlation coefficient is less than 0.001 hence we concluded that very small channel capacity loss in the rich environment of multipath.

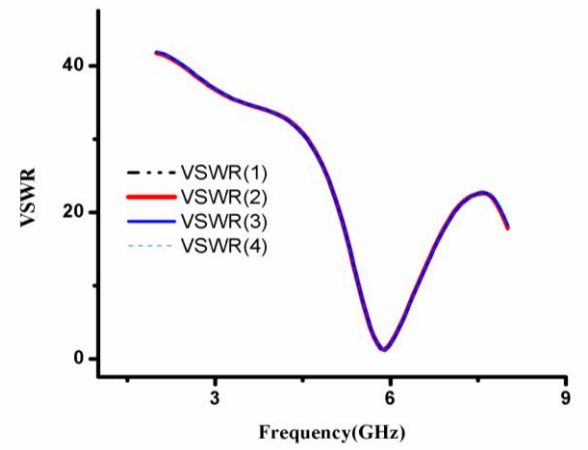

Figure13: VSWR of 2X2 MIMO antenna

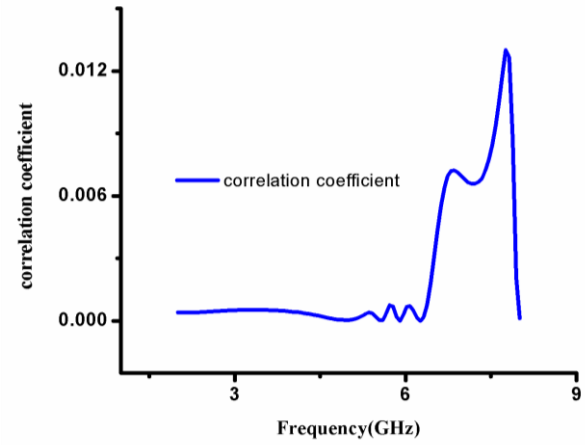

Figure 14: Correlation Coefficients of 2X2 MIMO Antenna

IV. CONCLUSION

A proposed rectangular microstrip patch array antenna that is suitable for the MIMO 4G and 5G WLAN has been developed. Single element and 2X2 MIMO antennas prototype are fabricated and measured. Good agreement between the measured and simulated results is achieved. The achieved results satisfy the requirements of both the MIMO 4G and 5G WLAN systems.

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BIOGRAPHIES

Shiddanagouda.F.B received his BE and M.Tech from PES College of Engineering Mandya and IIT Kharagpur in the year 2009 and 2012 respectively. He has published more than 10 papers in national and international journals. Currently he is pursuing his Ph.D. in the field of Microwave Antennas from the department of Applied Electronics, Gulbarga University Gulbarga. India.

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