Design and Analysis of 2×2 Micro strip Patch Antenna Array for 5G C-Band Wireless Communication

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Abstract : For the next generation wireless technology microstrip patch antenna array are practically used in the field of advance communication for their compact size, low cost, flexibility and good efficiency. Various designs and sizes of patch antenna array are available in the market. This paper presents a design of 2×2 microstrip patch antenna array for C-band and analysis in terms of bandwidth, resonant frequency, VSWR, Return loss etc. The FR4 Epoxy substrate is used to design the antenna. CST software is used for design and simulation of proposed antenna array pattern. Simulated result shows that bandwidth achieved 172.11MHz, return loss is -46.61db and resonant frequencies are 4.915GHz and 6.018GHz.

Index Terms – Array, Patch, Antenna, 5G, CST, FR4, VSWR, Return loss.

I. INTRODUCTION

The fourth era of versatile correspondence innovation models (4G) is to fulfill individuals' needs. The pattern is advance toward to the new age. The fifth era portable systems (5G) are proposed and created. The speed of 5G will be multiple times quicker than that of 4G. The 5G is an appealing point for remote frameworks. The microstrip antenna has the upsides of minimal effort, space-sparing, and simpler assembling. In any case, the structure of single component of microstrip antenna can't meet the prerequisite of passage applications. In this manner, an antenna array with microstrip antennas is embraced in the plan.

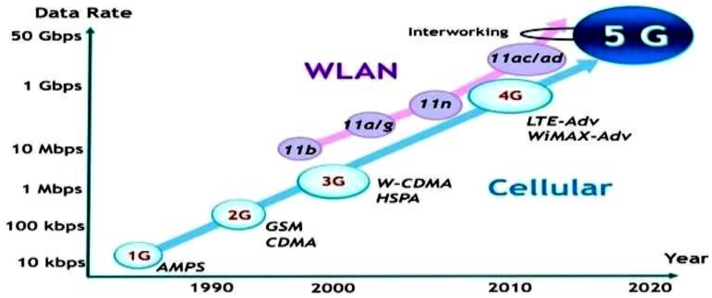


Figure 1: Evolution of Wireless Communication Technologies

Lower Frequency range of 5G (< 6 GHz)- The most extreme channel transfer speed characterized for FR1 is 100 MHz. Note that start with Discharge 10, LTE bolsters 100 MHz bearer accumulation (five x 20 MHz channels.) FR1 underpins a greatest regulation configuration of 256- QAM while LTE has a limit of 64-QAM, which means 5G accomplishes huge throughput upgrades in respect to LTE in the sub-6 GHz groups. Anyway LTE-Propelled as of now utilizes 256-QAM, disposing of the benefit of 5G in FR1.

Upper Frequency Range of 5G (24– 86 GHz)- The most extreme channel data transmission characterized for FR2 is 400 MHz, with two-divert total upheld in 3GPP Discharge. The most extreme phy rate conceivably upheld by this arrangement is roughly 40 Gbit/s. In Europe, 24.25– 27.5 GHz is the proposed frequencies go. A preferred position inalienable to patch antennas is the capacity to have polarization decent variety. Patch antennas can without much of a stretch be intended to have vertical, level, right hand round (RHCP) or left hand roundabout (LHCP) polarizations, utilizing numerous feed focuses, or a solitary feedpoint with uneven patch structures. This special property permits patch antennas to be utilized in numerous kinds of interchanges interfaces that may have shifted requirements.

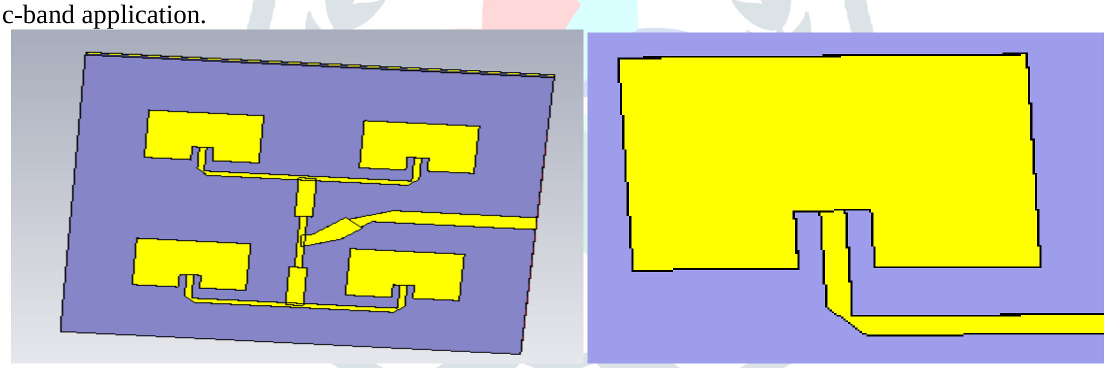
II. LITERATURE OVERVIEW

Y. Li et. al., the proposed reception apparatus exhibit underpins 4 × 4 MIMO in the LTE groups 42/43/46 (3400- 3600 MHz, 3600-3800 MHz, and 5150-5925 MHz)[1].A. Ahmad, et. al., It is required to include little cells, known as large scale, pico or femto cells. For such thick sending, organize administrators have ideally concluded the instrument of cloud systems called C-Kept running due to their profoundly improved operational proficiency and cost adequacy[2].M. Li et. al., proposed half and half reception apparatus cluster components are symmetrically set along the long edges of the cell phone, and they are made out of two distinctive four-antenna cluster types (C-formed coupled-bolstered and L-molded monopole opening) that show symmetrical polarization[3]. S. Faleh et. al., the proposed plan of the single antenna depends on rectangular organized spaces so as to work at numerous frequency groups[4].Y. Li, et. al.,the proposed MIMO antenna is made out of three diverse antenna component types, to be specific, upset π-formed antenna, longer modified L- molded open space antenna, and shorter altered L-formed open space antenna[5].M. Li et. al., the proposed antenna exhibit is made out of four sets of uniform antenna components that are symmetrically put at the four corners of the principle board, and every antenna combine incorporates a mutual square circle and two autonomously coupled sustaining strips[6]. B. Yang, et. al., A 64-channel gigantic different info various yield (MIMO) handset with a completely computerized beam forming (DBF) design for fifth-generation millimeter-wave interchanges[7]. Y. Rahayu et. al., In this exploration, rectangular micro strip patch antenna with 56 radiation components and 2 × 2 MIMO micro strip antenna with 112 radiation components utilizing micro strip line sustaining are intended for 5G remote interchanges organize[8].W. A. W. Muhamad et. al., the proposed micro strip matrix exhibit antenna effectively improved the antenna gain up to 11.32 dBi contrasted with existing silicon dioxide antenna, 2.99 dBi and 10.35 dBi for existing stacked patch antenna clusters[9].K. Laafif, et. al., In this work a reconfigurable radiation design antenna displayed to use for point-to-point correspondence base station frameworks. The outcomes are approved for the 5.6GHz frequency that can be in for 5G remote correspondences innovation[10]. A. Alieldin et al[11] This work proposes another plan of a triple-band double enraptured indoor base station antenna for mobile correspondence frameworks serving the 2G, 3G, 4G, and the new sub-6 GHz 5G applications. The plan likewise offers stable radiation designs inside the ideal frequency groups, high polarization immaculateness and, a straightforward encouraging structure with a minimized size and low profile which make this new plan a perfect contender for indoor mobile base stations serving the 2G, 3G, 4G, and the new sub-6GHz 5G applications[11]. Y. Li, et. al.,the proposed antenna cluster shows great impedance coordinating and disconnection, with return losses more noteworthy than 10 dB and detachments bigger than 15 dB. The aggregate proficiency of the antenna exhibit is higher than 70% in the ideal operation groups. The envelope relationship coefficient (ECC) and ergodic channel limit are determined to check the MIMO execution[12]. Y. Li, H. Zou, M. Wang, M. Peng [1] An eight-element multiple-input multiple-output (MIMO) antenna applied for 5G and sub-6GHz indoor wireless access points is studied in this paper. The proposed antenna array supports 4 × 4 MIMO in the LTE bands 42/43/46 (3400-3600 MHz, 3600-3800 MHz, and 5150-5925 MHz). Four fork-like electric dipoles disposed at the corners of the system circuit board cover the LTE bands 42/43, while four inverted L-shaped open slots placed along the edges support the LTE band 46. The proposed antenna array exhibits good impedance matching and isolation, with return losses greater than 10 dB and isolations larger than 15 dB. The total efficiency of the antenna array is higher than 70% in the desired operation bands. The envelope correlation coefficient (ECC) and ergodic channel capacity are calculated to verify the MIMO performance.

III. PROPOSED ANTENNA VIEW

In figure 2, showing top view of proposed Array microstrip patch antenna, one side of a dielectric substrate acts as a radiating patch and other side of substrate acts as ground plane. Top view of a rectangular patch antenna with coaxial feed has. Patch and ground plane together creates fringing fields and this field is responsible for creating the radiation from the antenna.

We proposed 2 X 2 antenna array design due to small size and reference work. If array size enhance like 2X3, 3X3, 4X4 etc. then overall antenna size is also enhance. But miniaturization of antenna is also very important factor in antenna research. Resonant frequency of proposed antenna is 4.9 and 6.01GHz that means it operate under C-band. Therefore proposed antenna should be useful for all c-band application.



(a) (b)

Figure 2: (a)Top view (b) basic design of proposed microstrip antenna array

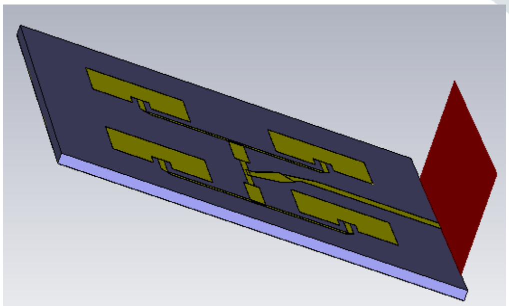


Figure 3: Side view of proposed antenna

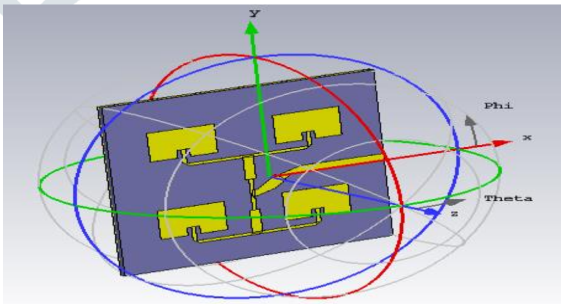


Figure 4: Simulation and fields of proposed antenna

IV. SIMULATION AND RESULT

The geometry of the proposed design of 2×2 microstrip patch array for C-band applications is shown in Fig. 2. The overall size of the design is 65mm × 65mm × 1.64mm (L × W × H) and printed on Flame Retardant 4(FR4), with a relative permittivity of 4.4, and a loss tangent of 0.024. Table I lists the dimension of the antenna array. The antenna is fed by 50-Ω and 0.5W. The antenna array uses the rectangular microstrip structure with two slots for 5G C-Band applications.

Table 1: Design parameters for proposed Antenna

Sr No.	Parameter	Value
1	Lower Frequency(f_L)	4 GHz
2	Higher Frequency(f_H)	7 GHz
3	Dielectric constant(ε_r)	4.4 / FR4
4	Ground (LxW)	65mmX65mm
5	Ground height	0.0.35mm
6	Substrate(LxW)	65mmX65mm
7	Substrate Height(h)	1.57 mm
8	Single Patch (LxW)	16mmX11mm
9	Top full design patch(LxW)	46mmX41mm
10	Line Impedance	50 Ω
11	Tangent Loss	0.06
12	Input watt	0.5W

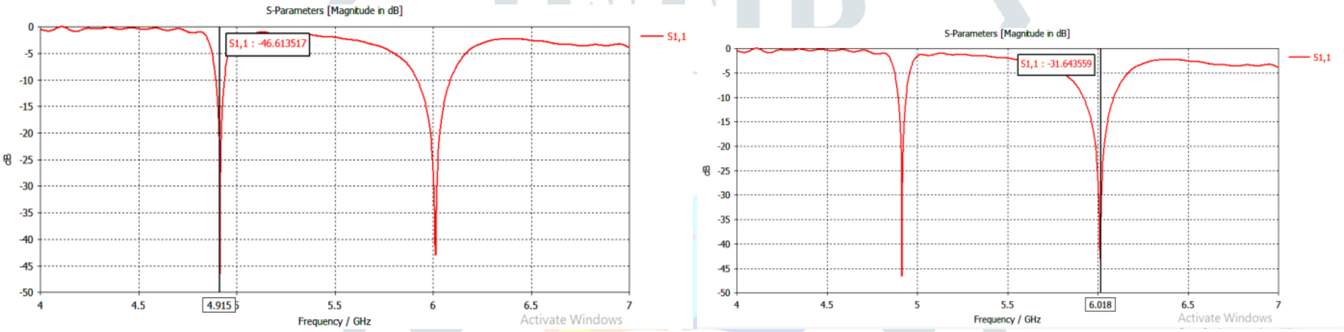


Figure 5: Return loss

A. Bandwidth

The bandwidth of an antenna is defined as "the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard." For broadband antennas, the bandwidth is usually expressed as the ratio of the upper-to-lower frequencies of acceptable operation.

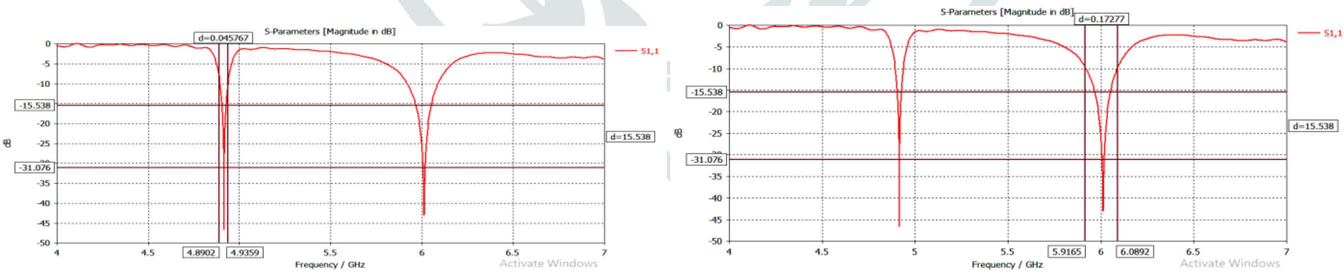


Figure 6: Bandwidth calculation

For broadband antennas, the bandwidth is expressed as a percentage of the frequency difference (upper minus lower) over the center frequency of the bandwidth.

The bandwidth of proposed antenna is 45.7 MHz, (4.9359GHz-4.8902GHz), for first band and 172.77 MHz, (6.0892GHz-5.9165GHz), for second band

B. Voltage Standing Wave Ratio (VSWR)

The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible. When an antenna and feed line do not have matching impedances, some of the electrical energy cannot be transferred from the feed line to the antenna. Energy not transferred to the antenna is reflected back towards the transmitter. It is the interaction of these reflected waves with forward waves which causes standing wave patterns.

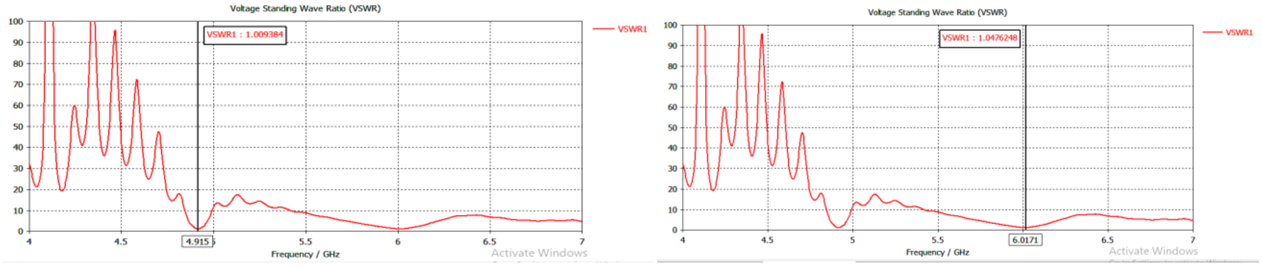


Figure 7: Voltage Standing Wave Ratios

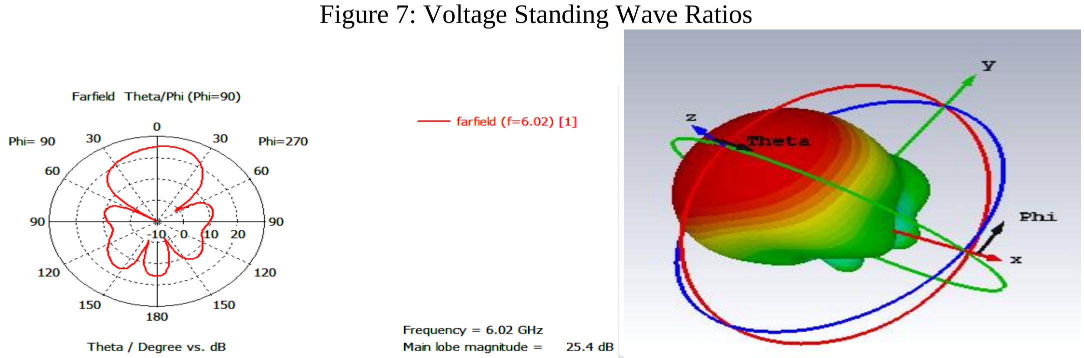


Figure 8: Radiation pattern

C. Antenna Hardware

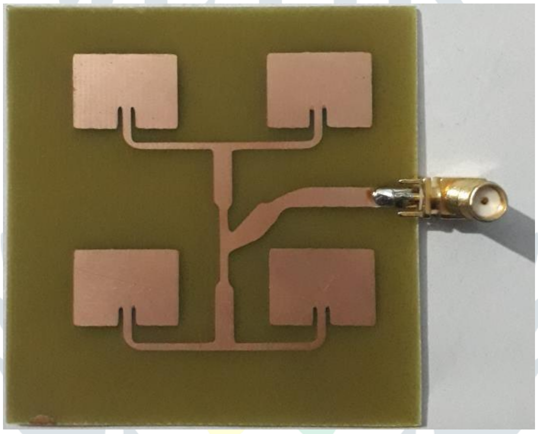


Figure 9: Proposed Antenna Hardware

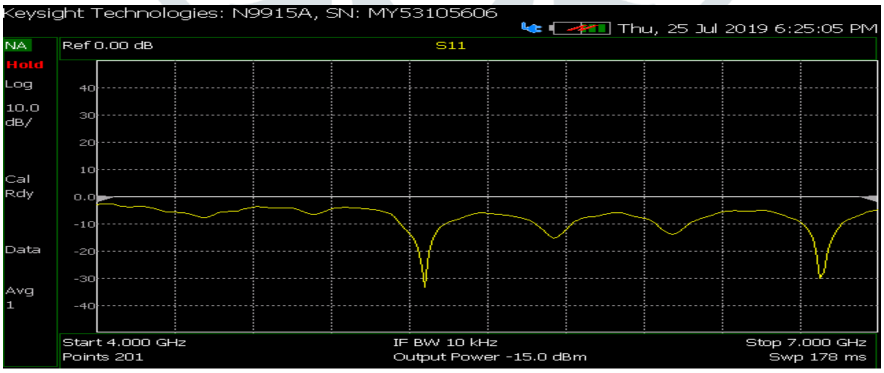


Figure 10: Experimental Result

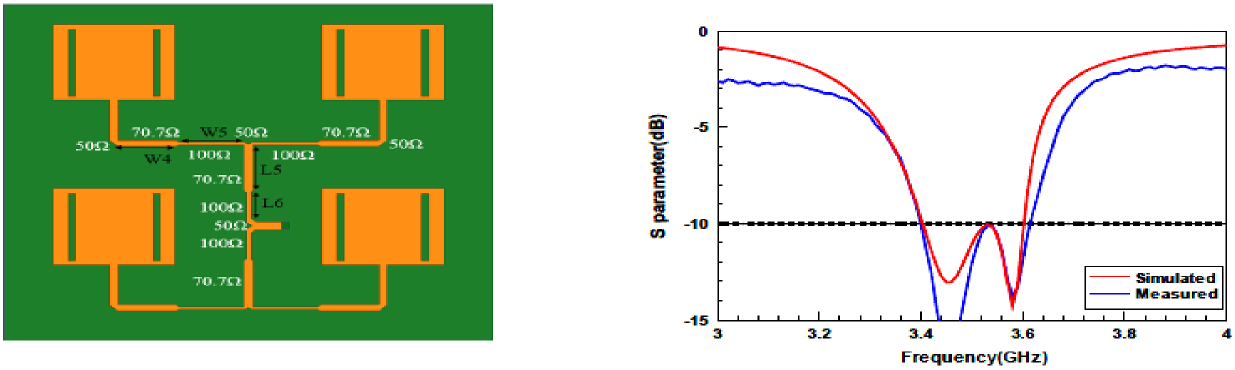


Figure 11: Base paper proposed design and result graph

Figure 11 is showing proposed design of existing work; this design is also 2X2 antenna array pattern. Figure also showing return loss and bandwidth result of existing work, it can be seen that return loss is achieved -15db and bandwidth is achieved 80MHz (3.48GHz- 3.4GHz).

Table 2. Comparison of proposed design result with previous design result.

Parameter	**Previous work**	**Proposed Work (Simulated)**	**Proposed Work (Practical)**
Antenna Array	2X2	2X2	2X2
Bandwidth	80MHz	45.7,172.11 MHz	165,120MHz
Return Loss	-15db	-46.61, -31.64dB	-33.50, -15.40dB
Resonant Frequency	3.45GHz & 3.57GHz	4.915GHz & 6.018GHz	5.26GHz & 5.755GHz
VSWR	>1	1.009	1.002
No of Band	Multi	Multi	Multi
Application	Wireless communication	Wireless communication	Wireless communication

Table 2 showing comparison of proposed antenna results with previous design result in terms of bandwidth, return loss, resonant frequency and VSWR etc. Therefore above result shows, designed proposed antenna give significant improved result.

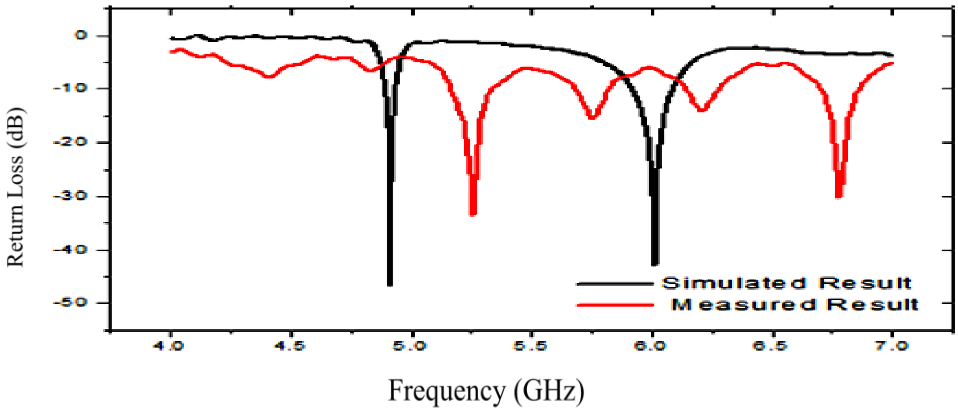


Figure12: Simulated and measured return loss and bandwidth of the proposed antenna

V. CONCLUSION

A double band, rectangular microstrip patch antenna is designed and simulated using CST simulation software. The simulation results are presented and discussed. Structure of proposed antenna is simple and compact in size of 65x65x1.64(mm)^3. The minimized size of planned antenna makes it simple to be consolidated in small gadgets. Results demonstrate that the recurrence bandwidth covers LTE band (4-7) GHz, at resonant frequencies 4.91 GHz and 6.08 GHz individually for VSWR under 2, and S11 not exactly - 10dB. In above clarified working band it indicates great impedance coordinating and bidirectional radiation patterns. These parameters spread the return loss, VSWR, E-field, H-field and increase directivity. Hence, proposed antenna is a decent candidate for remote correspondence applications in LTE band. The last outcomes fulfil every one of the parameters of a proficient antenna. The planned antenna works proficiently under all conditions with low return loss and improved bandwidth.

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