Design of 2×2 Micro strip Patch Array Antenna For 5G C-Band Access Point Applications

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Abstract : In fastest growing technology microstrip patch antennas are practically used in the field of advance communication for their compact size, low cost, flexibility and efficiency. Different shapes and sizes of patch antennas are available in the market. The paper presents a design of 2×2 microstrip patch array antenna for 6GHz and analysis in terms of resonant frequency, VSWR, Return loss etc. The FR4 substrate is used to design the antenna with CST software. Simulated result achieves considerable improvement and can be used in 5G communication application.

IndexTerms **- Antenna, pattern, 5G, CST, FR4, VSWR, Return loss.**

I. Introduction

The 4th generation of mobile communication technology standards (4G) is to satisfy people's needs. The trend is move toward to the new generation. The 5th generation mobile networks (5G) are proposed and developed. The speed of 5G will be 100 times faster than that of 4G. The 5G is an attractive topic for wireless systems. The microstrip antenna has the advantages of low cost, space-saving, and easier manufacturing. However, the design of single element of microstrip antenna cannot meet the requirement of access point applications. Therefore, an antenna array with microstrip antennas is adopted in the design.

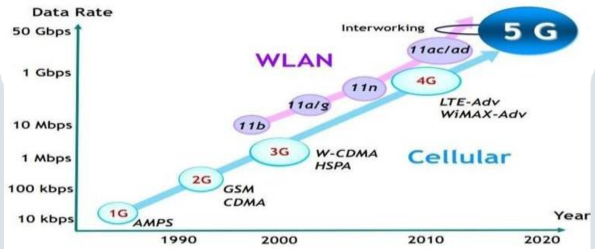

Figure 1: Evolution of Wireless Communication Technologies

Frequency range 1 (< 6 GHz)- The maximum channel bandwidth defined for FR1 is 100 MHz. Note that beginning with Release 10, LTE supports 100 MHz carrier aggregation (five x 20 MHz channels.) FR1 supports a maximum modulation format of 256-QAM while LTE has a maximum of 64-QAM, meaning 5G achieves significant throughput improvements relative to LTE in the sub-6 GHz bands. However LTE-Advanced already uses 256-QAM, eliminating the advantage of 5G in FR1.

Frequency range 2 (24–86 GHz)- The maximum channel bandwidth defined for FR2 is 400 MHz, with two-channel aggregation supported in 3GPP Release 15. The maximum phy rate potentially supported by this configuration is approximately 40 Gbit/s. In Europe, 24.25–27.5 GHz is the proposed frequencies range. An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feedpoint with asymmetric patch structures. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

II. LITERATURE OVERVIEW

Microstrip 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.

A. Ahmad, M. Zafrullah, M. A. Ashraf [2] To fulfill the extensive increase in the capacity and quality of multiple users, 5G next generation cellular network system is expected to be in the form of heterogeneous radio access networks (Het-RAN) [1]. It is expected to encompass small cells, known as macro, pico or femto cells. For such dense deployment, network operators have preferably deduced the mechanism of cloud networks called C-RAN due to their highly optimized operational efficiency and cost effectiveness. A centralized operating system which can easily be integrated with existing 4G/LTE networks is main aim of mobile phone operators. This approach reduces remarkably front haul overheads in C-RANs [2]. To expand the architecture of C-RAN, large number of antennas at access end majorly contributes to increase the network capacity either by improving the spectrum bandwidth or by increasing the number of active users at a specific time. Future 5G wireless and mobile communication operating systems require high transmission data rates and large channel bandwidth. Therefore, they can adopt millimeter-wave (MMW) band (30-300 GHz) as main operating frequencies to fulfill the requirements. In this paper, we focused on 60 GHz MMW frequency band. The potential benefits are, it is license free, large bandwidth ~2 GHz, high oxygen attenuation that supports high frequency reuse and large number of components integration on small area (Massive MIMO). Moreover, we designed, simulated and optimized novel antennas suitable for implementing in the wireless devices of CRAN networks. In addition to compact, low cost, light weight, and ease of integration, the proposed antennas exhibit wide bandwidth above 4 GHz with an average gain values more than 12.5 dBi.

M. Li et al [3] A dual-polarized hybrid eight-antenna array operating in the 2.6-GHz band (2550-2650 MHz) for 5G communication multi-input multi-output (MIMO) operation in the smartphone is presented. The proposed hybrid antenna array elements are symmetrically placed along the long edges of the smartphone, and they are composed of two different four-antenna array types (C-shaped coupled-fed and L-shaped monopole slot) that exhibit orthogonal polarization. Therefore, coupling between the two antenna array types can be reduced, and the MIMO system performances are enhanced. A prototype of the proposed eight-antenna array is manufactured and measured. A good impedance matching (10 dB return loss or better), desirable cross-polarization discrimination (better than 15 dB), and an acceptable isolation (better than 12.5 dB) are obtained. Envelope correlation coefficient and channel capacity are also calculated to evaluate the MIMO performances of the proposed antenna array.

S. Faleh and J. B. Tahar [4] In this work a new structure patch antenna for multiple-input multiple-output (MIMO) and fifth generation (5G) applications has been introduced. Simulation results are presented in this paper. The proposed design of the single antenna is based on rectangular structured slots in order to operate at multiple frequency bands. The slots are designed on the rectangular patch and fed by a microstrip feeder line. The single antenna has a very compact size of 3× 2 mm 2 with operating frequency equal to 20.67 GHz, it covers a large band (19-36.6 GHz). The desired antenna is designed on a substrate with a relative dielectric permittivity of 4.4 and its thickness is of 0.4 mm. It provides a wide bandwidth, a directional radiation pattern, a high gain and its reflection coefficient (S11) is less than -10 dB in the frequency range of 19-36.6 GHz that is one of the candidate bands for future 5G communications. The antenna array consists of eight elements with rectangular patch. It has a compact size of 35.52×28.79 mm 2 . Simulation results indicate that the antenna not only has a very small power return loss but also exhibits a low mutual coupling highlighting the ability of the proposed design to operate in multiple-input multiple-output (MIMO) applications.

Y. Li, C. Sim, Y. Luo and G. Yang [5] A 12-port antenna array operating in the long term evolution (LTE) band 42 (3400-3600 MHz), LTE band 43 (3600-3800 MHz), and LTE band 46 (5150-5925 MHz) for 5G massive multiple-input multiple-output (MIMO) applications in mobile handsets is presented. The proposed MIMO antenna is composed of three different antenna element types, namely, inverted π-shaped antenna, longer inverted L-shaped open slot antenna, and shorter inverted L-shaped open slot antenna. In total, eight antenna elements are used for the 8×8 MIMO in LTE bands 42/43, and six antenna elements are designed for the 6×6 MIMO in LTE band 46. The proposed antenna was simulated, and a prototype was fabricated and tested. The measured results show that the LTE bands 42/43/46 are satisfied with reflection coefficient better than -6 dB, isolation lower than -12 dB, and total efficiencies of higher than 40%. In addition to that, the proposed antenna array has also shown good MIMO performances with an envelope correlation coefficient lower than 0.15, and ergodic channel capacities higher than 34 and 26.5 b/s/Hz in the LTE bands 42/43 and LTE band 46, respectively. The hand phantom effects are also investigated, and the results show that the proposed antenna array can still exhibit good radiation and MIMO performances when operating under data mode and read mode conditions.

Table 1: Summary of Literature Review

Sr No.	Author Name	Year of Publication	Frequency Range	Objective
1	Y. Li et al.,	June 2018	3.4-5.9 GHz	Eight-element multiple-input multiple-output (MIMO) antenna
2	Y. Li C sim et al	Oct 2018	3.4-5.9 GHz	Proposed MIMO antenna is composed of three different antenna element types
3	W. Chen et al	Mar 2018	3.4–3.6 GHz	2×2 microstrip patch array antenna for 5G
4	A. Ahmad et al	Nov 2017	3-4 GHz	Antennas exhibit wide bandwidth above 4 GHz with an average gain values more than 12.5 dBi.
5	M. Li et al	Sep 2016	2.6-GHz	Hybrid antenna array elements are symmetrically placed along the long edges

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.

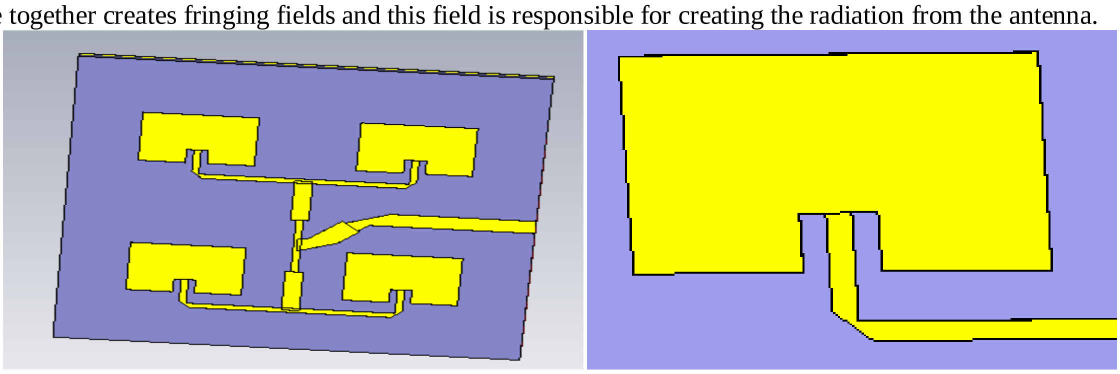

Figure 2: Top view and basic design of proposed Array microstrip antenna

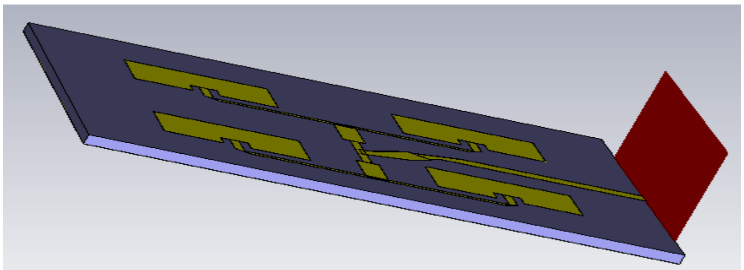

Figure 3: Side view of proposed antenna

IV. SIMULATION AND RESULT

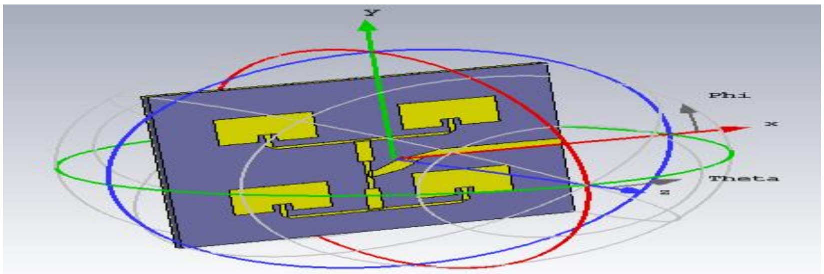

Figure 4: Simulation and fields of proposed antenna

Table 1: Design parameters for proposed Antenna

Frequency(f_r)	7 GHz
Dielectric constant(ε_r)	4.4 / FR4
Substrate Height(h)	1.6 mm
Line Impedance	50 Ω
Ground Plane	Upto 35 each mm^2
Tangent Loss	0.06

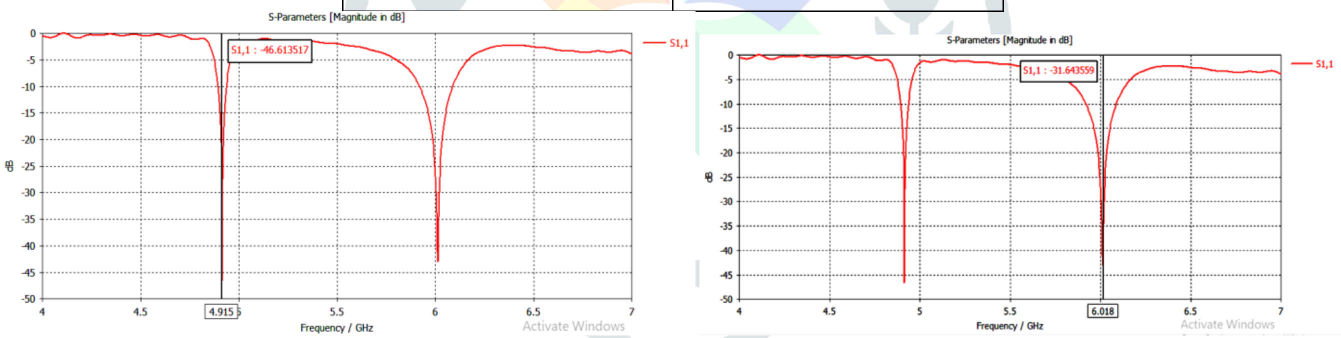

Figure 5: S parameter and Return loss

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.

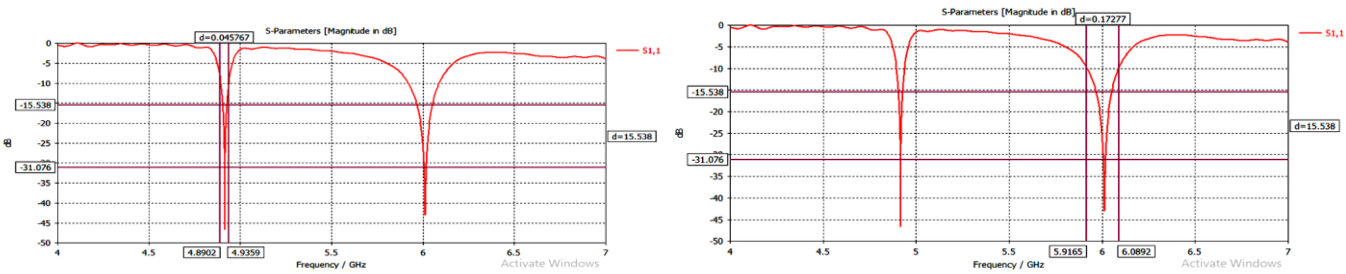

Figure 6: Bandwidth calculation

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.

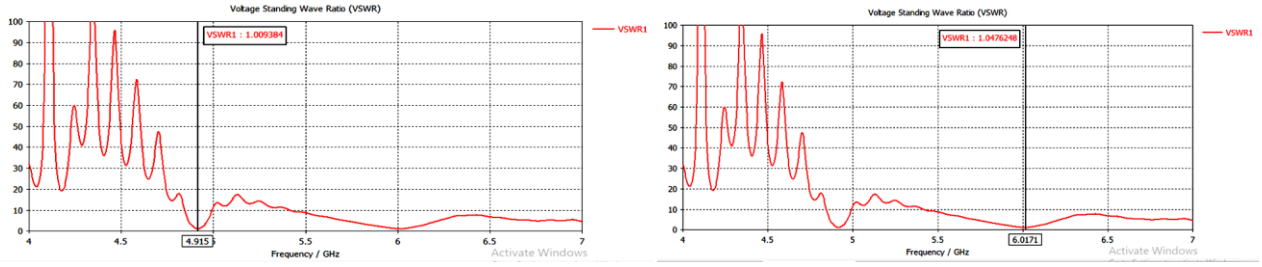

Figure 7: Voltage Standing Wave Ratios

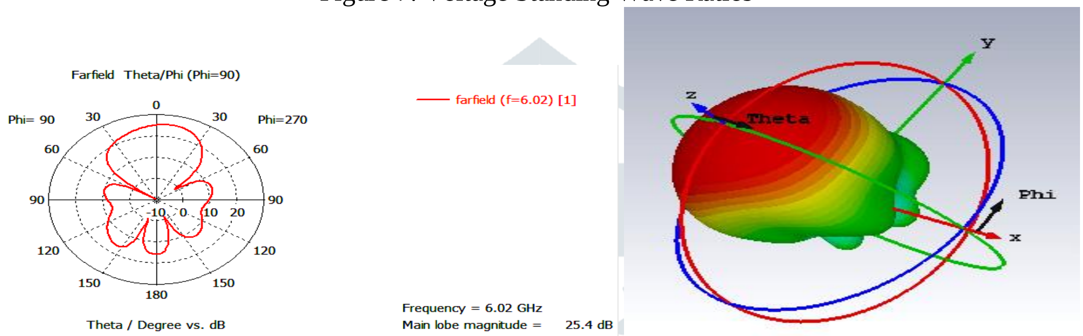

Figure 8: Radiation pattern

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

Parameter	**Previous work**	**Proposed Work**
Antenna Array	2X2	2X2
Bandwidth	80 MHz	172.77 MHz
Return Loss	-15db	-46.61db
Resonant Frequency	3.45GHz and 3.57GHz	4.915GHz 6.018GHz
VSWR	>1	1.009
No of Band	Multi	Multi
Application	Wireless communication	Wireless communication

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 approx 35×35 ×1.6 〖mm〗^3. the compact size of designed antenna makes it easy to be incorporated in small devices. Results show that the frequency bandwidth covers LTE band (4-7) GHz, at centre frequencies 4.91 GHz and 6.08 GHz respectively for VSWR less than 2, and S11 less than -10 dB. In above explained operating band it shows good impedance matching and bidirectional radiation patterns. Various parametric results of antenna are achieved and analyzed by seeing the optimized result of different parameters. These parameters cover the S- parameter, VSWR, E-field and H- field gain and directivity. Thus, proposed antenna is a good applicant for wireless communication applications in LTE band. The final results satisfy all the parameters of an efficient antenna. The designed antenna works efficiently under all conditions with low return loss and proper impedance matching.

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