Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

Simple High Gain Array Antenna for 5G Applications

Ali Ahsan Hasnain
Electrical. HITEC University
HITEC University, Taxila Cantt
Taxila, Pakistan

Muhammad Nauman, Muddasir Abbas,
Muhammad Asad Anwar, Iftikhar Ahmed,
Muhammad Talha Asghar
Electrical. HITEC University Taxila, Pakistan
Taxila, Pakistan

***Abstract*—A 1×4 microstrip patch antenna array operated at 28 GHz covering 5G frequency band is proposed in the design. The Rogers RT/duroid 5880 (tm) with a relative permittivity of 2.2, dielectric loss tangent 0.0009 is used as a substrate in the design with a thickness of h = 0.787mm. The single element patch antenna has a gain of 8.43 dBi and a bandwidth of 2.54 GHz at 27.94 GHz. The array of this single element has a gain of 12.986 dBi and a bandwidth of 3.07 GHz at 27.99 GHz. The maximum gain achieved by the antenna array is 13.04 dBi at 27.8 GHz.**

Keywords—Patch Antenna Array, 5G applications, Gain Enhancement

I. INTRODUCTION

In the era of modern communication, users need high data rate, smarter and efficient transmission of data in cellular industry. To achieve higher data rates and faster communication for the end users the idea of 5th generation 5G came into being. It has several frequency bands to transmit and receive electromagnetic waves for 5G applications. The 5G network is faster in speed which is 10 times the bit rate available today and its coverage area is 1000 times greater than the 4G network [1]. The increasing numbers of users bring in a bandwidth scarcity and to accommodate large end users there is a need of increasing bandwidth that increases the overall data rates of the system. The high data rate provides the end users with the faster and smarter communication.

Many microstrip patch antenna arrays have been designed and investigated in recent years. A millimeter-wave filtering monopulse antenna array based on substrate integrated waveguide (SIW) technology is proposed in [2] covering Ka band operated at 29.25 GHz with gain of 8.1 dBi and bandwidth of 0.351 GHz. A 2×2 microstrip patch array antenna for 5G C-band access point applications with two vertical slots is designed [3] which is operated over (3.4-3.6 GHz) with gain of 5.37 dBi and bandwidth of 0.2 GHz. A dual band millimeter wave microstrip patch antenna array is designed in [4]. The antenna is operated at 28 GHz and 24.9 GHz with a gain of 8.42 dBi, 5.375 dBi and bandwidth of 0.9 GHz, 0.3 GHz respectively having applications in future 5G smart phones. A compact 4 element slotted antenna array is designed in [5] for 5G applications with a length of slot 4.01mm having a maximum gain of 9.25 dB at 26.9 GHz and bandwidth of 1.27 GHz. A microstrip patch antenna array is designed using tapered line feeding in [6] for 5G mobile communications. The antenna resonates at four different frequencies 23.2 GHz, 27.09 GHz, 31 GHz and 42.5 GHz with bandwidth of 1.18 GHz, 1.63 GHz, 2.185 GHz, 2.43 GHz and gain of 12.3 dBi, 13.1 dBi, 9.4 dBi and 8 dBi respectively. All the antennas reviewed so far are designed for the 5G communications however these antennas have low value of gain and they have limited bandwidth. The proposed antenna has an array of 4 elements with a high impedance matching feeding network operated at 28 GHz that increases the gain and bandwidth.

In this paper, a simple 1×4 microstrip patch antenna array is demonstrated which fulfills the basic needs of 5G communication system. The design of our antenna is discussed in section **II**. The results and parametric analysis are discussed in section **III** and section **IV**. In section **V**, the conclusion of the paper is discussed.

II. ANTENNA DESIGN

The 1×4 microstrip patch antenna array of single patch element is designed in Fig. 1. The designed antenna is covering the 5G band of communication and is operated at the 28 GHz. The prototype is designed on Rogers RT/duroid 5880 (tm) substrate with relative permittivity of 2.2, dielectric loss tangent 0.0009 with height of 0.787mm. The overall length of the proposed design is 20mm and the overall width of the design is 57.4mm.

The feeding network is made up of multiple lines having the impedances of 50ohm, 70ohm and 100ohm that connect the individual antennas into a network. In this design, the patch has an input of 100Ω and must be matched to a transmission line of 50Ω. There is a quarter wave transformer of 70ohm in between 50ohm line and patch used for impedance matching and it also reduces the power losses. The dimensions for the feeding network are shown in table I.

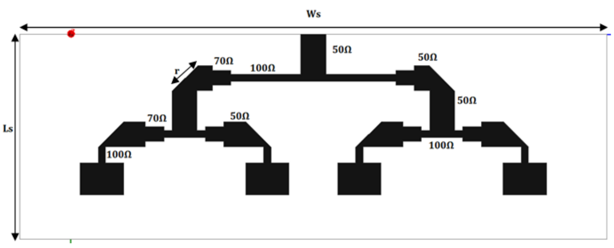

Fig. 1. Top View of the proposed prototype

TABLE I . PARAMETERS OF FEEDING NETWORK

Transmission line	Width(mm)	Length(mm)
50ohm	2.4248	3.9162
70ohm	1.4158	1.805
100ohm	0.7053	4.0401

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

The technique that is used to feed an antenna is power divide technique in which the input is equally divided among all the patches. In Fig. 1 the r=2.5 mm is truncating the 50ohm line and is used for better impedance matching. Fig. 2 shows the 100ohm transmission line and patch that is connected to each other. The dimensions for the width and length of patches and transmission lines are shown in table II.

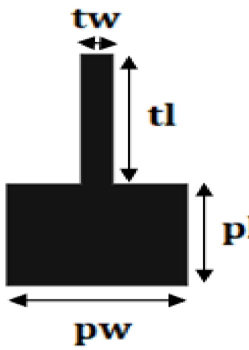

Fig. 2. Patch and Transmission line of the Antenna

TABLE II . PARAMETER OF PATCH AND TRANSMISSION LINE

Parameters	Values(mm)	Details
pl	3.0645	Length of patch
pw	4.2351	Width of patch
tl	4.0401	Length of transmission line
tw	0.7053	Width of tranmission line

III. PARAMETRIC ANALYSIS

In order to have a better understanding of antenna, we performed a detailed parametric analysis. Performance analysis of the antenna array was performed by changing the width of the transmission line from 0.7053 mm to 1.9053 mm is shown is Fig. 3, and other parameters were kept constant. By varying the width of transmission line better impedance matching can be achieved. The maximum bandwidth and return loss of the proposed antenna is achieved at the tw=0.7053mm.

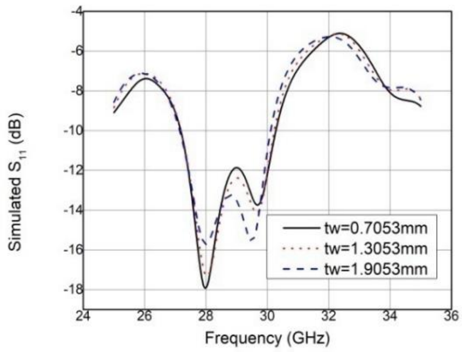

Fig. 3. Simulated S parameter at different width of Transmission line

Truncation of 50 ohm line was performed for better impedance matching and its performance analysis is shown in Fig. 4. By increasing value of r radius of truncation, as shown in fig. 2 resonance frequency shifts towards higher frequencies. At r=2.5mm the antenna resonates at desired frequency of 27.99 GHz.

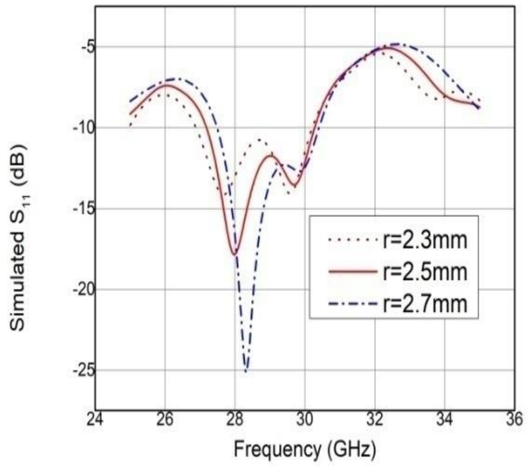

Fig. 4. Simulated S parameter at different values of r

IV. RESULTS

The simulated return loss (S_{11}) of single patch element and its array is shown in Fig. 5. The operational frequency of the single element is at 27.94 GHz having bandwidth of 2.54 GHz covering the frequencies in the range of (26.76 GHz-29.3 GHz). The operational frequency of antenna array is at 27.99 GHz having bandwidth of 3.07 GHz covering the frequencies in the range of (27.19 GHz-30.26 GHz).

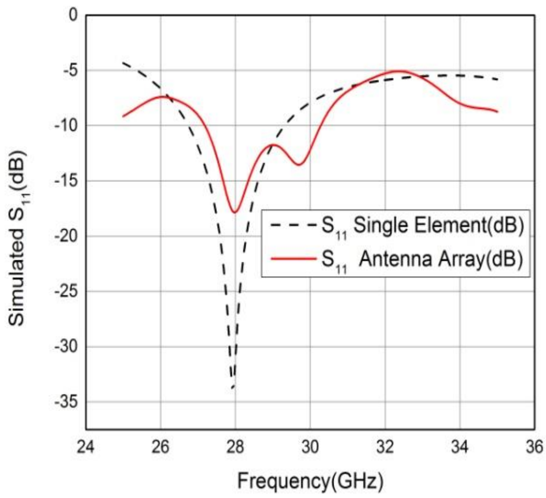

Fig. 5. Simulated S_{11} of the Single element & Antenna Array

It can be seen from Fig. 5 that the bandwidth of antenna array is greater than single element. The antenna array is used to increase overall gain as well as it increases bandwidth of the system.
The gain of the proposed antenna array is 12.986 dBi at 28 GHz as shown in Fig. 6. At 27.8 GHz the maximum gain of the antenna array is achieved i.e. 13.04 dBi. The gain of the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 09, September-2020

single patch antenna is 8.43 dBi. The array of the single patch element is used to increase the overall gain of the antenna that has several applications in cellular industries.

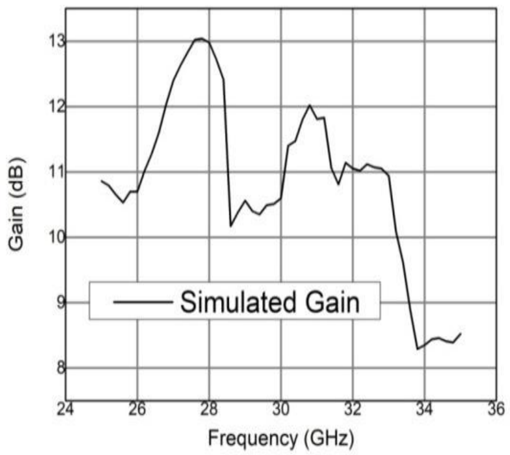

Fig. 6. Gain of the proposed Antenna

The radiation pattern of antenna array at 28 GHz is shown in Fig. 7. It specifies the strength of the wave in the specific direction. The direction of wave along XZ Plane and YZ Plane is also mentioned in the Fig. 7.

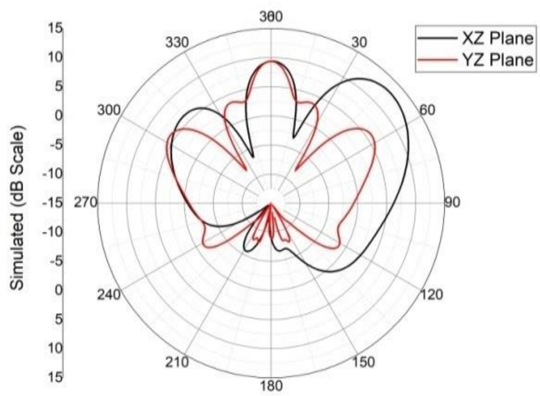

Fig. 7. Radiation Pattern of the proposed Antenna

The table III shows the comparison of our proposed work with reviewed papers. This work has better and greater bandwidth than [2-6] which allows this proposed antenna to cater more frequencies than the antennas designed before and has greater gain in comparison to [2-5].

TABLE III . SUMMARY OF RELATED REVIWED WORKS AND OUR PROPOSED

Reference	Number of Elements	Bandwidth (GHz)	Frequency (GHz)	Gain(dBi)
[2]	4	0.351	29.25	8.1
[3]	4	0.2	3.4	5.37
[4]	13	0.9,0.3	28,24.9	8.42,5.375
[5]	4	1.27	26.9	9.25
[6]	4	1.18,1.63,2.185,2.43	23.2,27.09,31,42.5	12.3,13.1,9.4,8
Proposed Work	4	3.07 GHz	27.99 GHz	12.986 dBi

V. CONCLUSION

A 1×4 antenna array for 5G applications is designed having a high gain of 12.986 dBi. This high gain antenna radiates in the specific direction having many applications in cellular industry and is covering the 5G band (27.19 GHz-30.26 GHz). The bandwidth of the proposed antenna is 3.07 GHz with a return loss of -17.85 dB at 27.99 GHz. The array of single patch increases the overall gain of the antenna that makes it viable for cellular and wireless communication.

REFERENCES

[1] I. Gharbi, R. Barrak, M. Menif and H. Ragad, "Design of patch array antennas for future 5G applications," 2017 18th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA), Monastir, 2017, pp. 674-678.

[2] H. Chu, J. Chen, S. Luo and Y. Guo, "A Millimeter-Wave Filtering Monopulse Antenna Array Based on Substrate Integrated Waveguide Technology," in IEEE Transactions on Antennas and Propagation, vol. 64, no. 1, pp. 316-321, Jan. 2016, doi: 10.1109/TAP.2015.2497351.

[3] W. Chen and Y. Lin, "Design of 2×2 Microstrip Patch Array Antenna for 5G C-Band Access Point Applications," 2018 IEEE International Workshop on Electromagnetics: Applications and Student Innovation Competition (iWEM), Nagoya, 2018, pp. 1-2.

[4] C. K. Ali and M. H. Arif, "Dual-band Millimeter-Wave Microstrip Patch Array Antenna for 5G Smartphones," 2019 International Conference on Advanced Science and Engineering (ICOASE), Zakho - Duhok, Iraq, 2019, pp. 181-185.

[5] A. Kakkar, Nirdosh, M. R. Tripathy and A. K. Singh, "Design and analysis of slotted antenna array for 5G application," 2017 Progress in Electromagnetics Research Symposium - Fall (PIERS - FALL), Singapore, 2017, pp. 459-463.

[6] K. Bangash, M. M. Ali, H. Maab and H. Ahmed, "Design of a Millimeter Wave Microstrip Patch Antenna and Its Array for 5G Applications," 2019 International Conference on Electrical, Communication, and Computer Engineering (ICECCE), Swat, Pakistan, 2019, pp. 1-6.

[7] C. A. Balanis, Antenna Theory: Analysis and Design, 3rd ed., John Wiley and Sons, 2005.

[8] Rogers Corporation,'RT/duroid®5870 /5880 High Frequency Laminates',datasheet, 2016,[Revised avril 2017]