Compare the various properties of Circular and Rectangular Microstrip Patch Antennas for 5G application

Anand Kumar Gupta[1], Prof. Rajendra Kumar[2*], Prof Ashutosh Singh[3]
[1] Research Scholar, Department of ECE, FET, RAMA University, Kanpur
[2] Professor Department of Physics, FET, RAMA University, Kanpur
[3] Professor Department of Electronics Engineering, HBTU, Kanpur

***Abstract*- There is an increasing demand of high speed, large bandwidth and compact devices for the fifth-generation systems. So, micros trip patch antennas have been introduced to resolve this issue. We have taken rectangular and circular micros trip patch antennas for comparison at the frequency of 27 GHz for 5G applications. The antenna parameters used for the comparison are return loss, reflection coefficient, VSWR and far field radiation pattern. The substrate material used for designing of the antenna is Roger RT 5880 which has dielectric constant of 2.2 and has a height of 0.797 mm. The software Computer Simulation Technology Microwave Studio (CST MW Studio) is used here for designing and analyzing the different shapes of microstrip patch antennas. In this work, we evaluated the changes in the properties of antenna due to variation in the geometric shape of patch while the material used as substrate is same. The antenna proposed in this paper resonates at the frequency of 27 GHz.**

Keywords: Return loss, far field radiation pattern, VSWR, Reflection coefficient, CST MW Studio.

I. INTRODUCTION

The new era is of 5G network as it provides high communication capacity and 100 times high data rate than 4G communication systems. It arises new issues related to network requirements, antenna design to fulfil desired capacity and data rate [1, 2].

Microstrip Patch Antennas are considered suitable to match up with the requirements of wireless 5G network system The Microstrip patch antennas consist of three parts mainly: Patch at the top, ground (conducting metal) at the bottom and substrate in between. They are light weight, compact size, easily installable and easily compatible with microwave monolithic integrated circuits. But they have limitations of producing narrow bandwidth and lower gain which can be overcome by using various methods such as probe fed technique, patch antenna with thick substrate, and slotted patch antennas [3]. Generally, Microstrip Patch Antennas can be of various shapes like Square, Rectangular, Circular, Triangular, Dipole, Circular ring and Disc sector etc. Microstrip patch antenna's structure is shown in fig.1 [4].

Circular and rectangular microstrip patch antennas are designed and compared at frequency of 27 GHz in this work for 5G applications. Both the design has its own

$$Leff = \frac{c}{2fo\sqrt{\varepsilon reff}}$$

merits and demerits. The feeding method used here for excitation is microstrip line feed technique (Direct contact method). RF power is directly fed to the patch in direct contact method, the microstrip line fed antenna is very easy to model and match.But, in this method as the substrate thickness increases, bandwidth is limited due to the surface wave and spurious feed radiation.

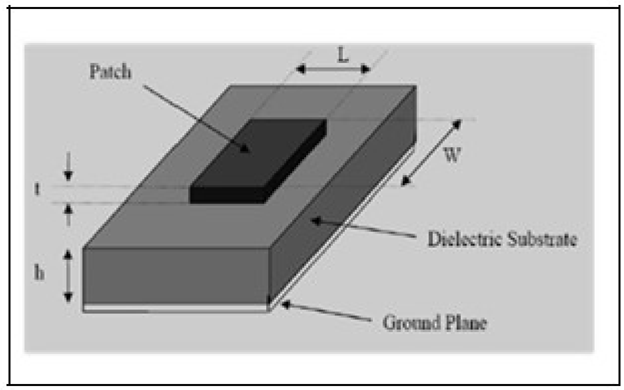


Figure 1: The structure of microstrip patch antenna

In this paper, we study the change in the crucial parameters of the antenna like VSWR, Reflection coefficient, Return loss and Far field radiation pattern due to variation in the geometric shapes of the antenna at the same frequency ie.27 GHz.

II. MATHEMETICALFORMULAEUSED

Following formulae is used for the calculation of design parameters necessary to design antenna: Width W of the patch:

$$W = \frac{c}{fo\sqrt{2(\varepsilon r + 1}}$$

Effective dielectric constant:

Extension length (oL):

$$\Delta L = \left(\frac{\frac{W}{h}(0.412(\ldots)+0.264)(\varepsilon reff+0.03)}{\ldots} \right)$$

Calculation of effective length (Leff):

$$\varepsilon reff = \frac{\varepsilon r + 1}{2} + \left(\frac{\varepsilon r - 1}{2}\right)\sqrt{\frac{1 + 12h}{W}}$$

Actual length of patch (L):
L = Leff - 2oL
Length of the microstrip transmission line:
TL = $\lambda/4\sqrt{\varepsilon r}$
Length and Width of the Substrate:
Ls = L+6h Ws = W+6h

$h = \frac{0.0606\lambda}{\sqrt{\varepsilon r}}$

h = height of the substrate (in cm)

III. ANTENNA GEOMETRY

The material of the substrate is RT Duroid 5880, the ground of the antenna is on pure copper which has thickness of 0.0175mm for both rectangular andcircular patch antennas. The design parameters of both the antennas are listed below in Table I, II respectively.

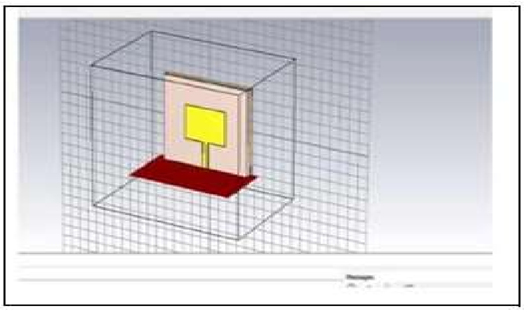


Figure 2: Designed rectangular patch antenna

Table I. Parameters for Rectangular patch micro strip antenna

Parameters	Description	Value (in mm)
H	The substrate's height	0.797
w	The Patch's width	4.392
I	The Patch's length	3.191
W_s	Width of the substrate	9.174
L_s	Length of the substrate	7.973
t	Thickness of the ground and patch	0.0175
L	Length of the feed line	3.986
W	Width of the feed line	0.5

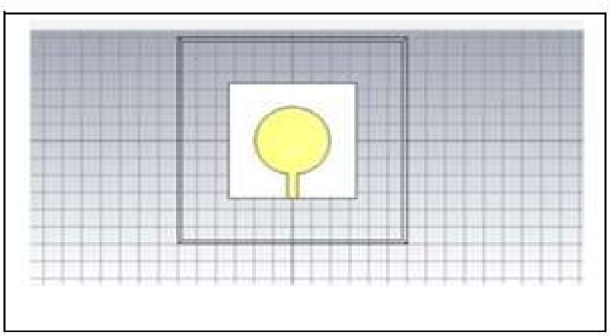


Figure 2: Circular patch antenna

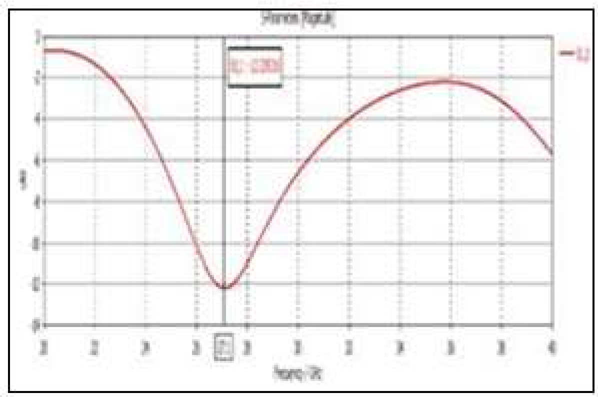
Table II. Parameters of Circular Patch Antenna

Parameters	Description	Value (mm)
H	Height of the substrate	0.797
w	Substrate/ground plane's width	6.678
l	Substrate/ground plane's length	6.678
t	Thickness of the patch	0.0175
a	Radius of the patch	1.896
L	Length of the feed line	3.339
W	Width of the feed line	0.5

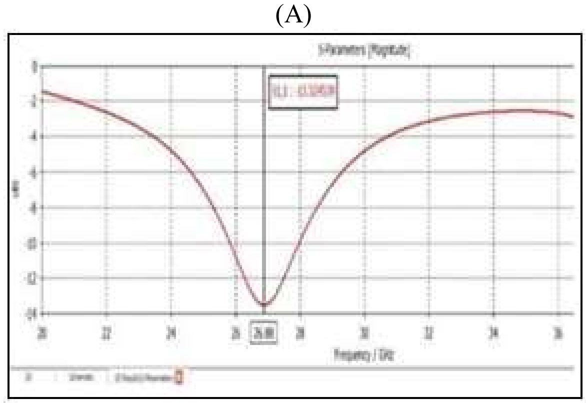
IV. COMPARISON OF ANTENNAS

A. S11 or Return loss:

The input and output relationships between the ports of an antenna is described by the S parameter. The amount of power reflected from the input terminal of the antenna is represented by S11 and hence is known as the return loss, the reflection coefficient represents the amount of wave reflected from the antenna Fig.3, shows the graph of S11 parameter of rectangular and circular micro strip patch antennas.



(A)

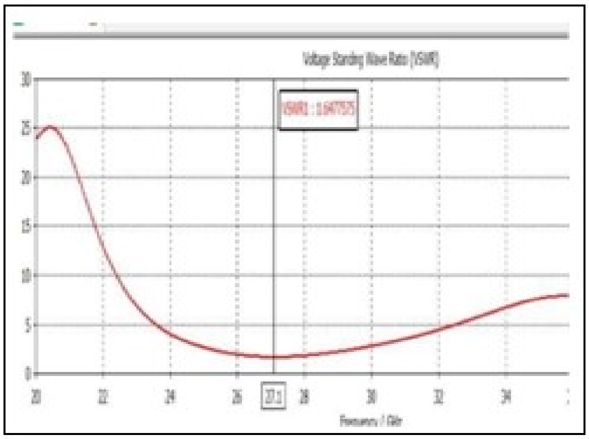


(B)

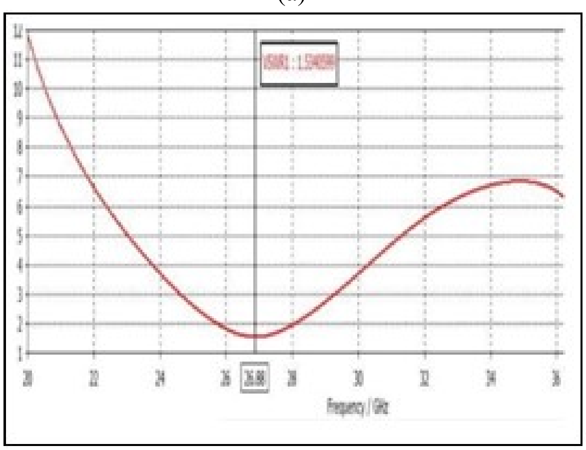
Figure 4: the s11 parameter result of both patch antennas. (a) Rectangular shaped patch antenna (b) Circular shaped patch antenna

B. VSWR Comparison:

The power reflected from the antenna due to impedance mismatching is denoted by VSWR. The ratio of the maximum amplitude of standing wave to the minimum amplitude of standing wave is denoted by VSWR. The value of VSWR should be closer to one for maximum power transfer and better impedance matching. If VSWR is closer to 1 then more power is delivered to the antenna. The figure 5 below depicts the graph of VSWR rectangular and circular micro strip patch antennas. We have analyzed after comparing that VSWR of rectangular patch antenna is smaller than that of circular patch antenna.



(a)

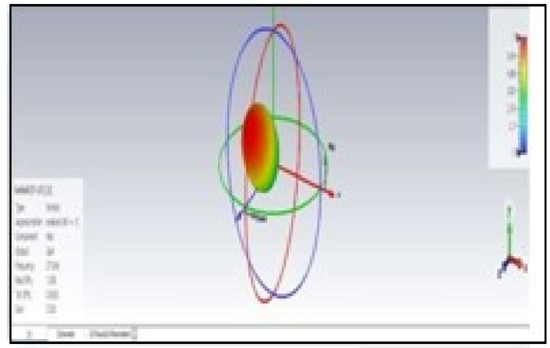


(b)

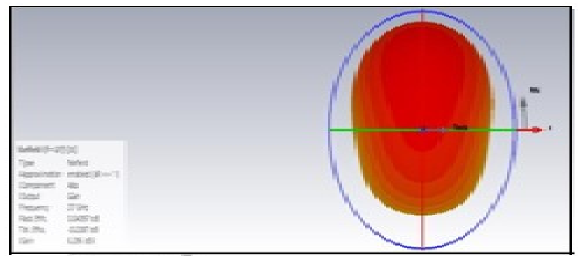
Figure 5: VSWR of both patch antennas. (a) Circular patch antenna (b) Rectangular patch antenna

C. Far Field Radiation:

The 3D result of Far Field radiation pattern of the circular and rectangular patch antennas are shown in figure 6. We have observed that rectangular shaped patch antenna has higher directivity and gain in comparison tothe circular patch antennas.



(a)



(b)

Figure 6: The far field radiation pattern of both antennas. (a) Far field pattern of gain of rectangular micros trip patch antenna (b) Far field pattern of gain of circular micros trip patch antenna

V. TABLE OF COMPARISON:

A final table of comparison of all the parameters for rectangular and circular patch antenna is given below:

Patch shape	Reflection coefficient	Return loss	VSWR	Gain
Rectangle	0.211	13.52 dB	1.534	7 dB
Circular	0.245	12.23 dB	1.649	6.3 dB

Table III. Final Comparison of Parameters

VI. CONCLUSION

In this paper, after studying, analyzing and comparing various important parameters of different types of patch antennas, we found that the change in geometry of the patch can cause significant changes in the parameters of the antenna. On the basis of our work, we found that, rectangular patch antenna is better than circular patch antenna as it has lower values of VSWR and Reflection coefficient, higher value of gain and return loss in comparison to the circular micros trip patch antenna for 5G applications at the frequency of 27 GHz.

REFERENCES

[1] Farhan Ahmad, Dr. Boutheina & Tillie Design and Analysis of Millimetre Wave Double F Slot Patch Antenna for future 5G Wireless Communications ‖ International Conference on Electrical and Computing Technologies and Applications (ICECTA), 2017

[2] Nita Kalambe, Dhruva Thakur, Shubhankar Paul, Design of Microstrip Patch Antenna for Wireless Communication Devices. International Journal of Science and Research, 2015.

[3] R. K. Prasad, D. K. Sribaspava, J.P. Saini "Design and Analysis of Extended S-shaped Microstrip Patch Antenna for Wideband Application," International Journal of Advanced Research In Computer And Communication Engineering, Vol. 2, No. 10, pp. 4164-67, Oct. 2013.

[4] K. Meena alias Jeyanthi, A.P. Kabilan, "Modeling and simulation of Microstrip patch array for smart antennas", International Journal of Engineering, vol. 3, No. 6 pp. 62-70, December 2010.

[5] Ribhu Abhusan Panda, Ranajit Sahana, Eswar Prasad Panda, Comparison between Microstrip Rectangular and Circular Patch Antenna for 5G Application", International Journal of Advanced Research in Electrical, Electronics and nstrumentation circular microstrip patch antenna Engineering, Vol. 6, Issue 9, September 2017