INSET FEED COMPACT MILLIMETER WAVE MICROSTRIP PATCH ANTENNA AT 28GHz FOR FUTURE 5G APPLICATIONS

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Abstract – *The main objective of this paper is to design and simulate the microstrip patch antenna which operates at 28GHz for advanced 5G communication. The designed antenna achieves a high gain of 8.00dB at a centre frequency of 27.91 GHz, a very wide bandwidth of 582MHz with a maximum reflection coefficient of -34.05dB. The feeding technique for the transmission line used is Inset feed. In this the substrate used is Rogers RT Duroid 5880 which has a low dielectric constant of 2.2 and a height of 0.254 mm. The proposed antenna dimensions were calculated and simulated results have been displayed and analyzed using High Frequency Structure Simulator (HFSS).*

Key Words: **Microstrip, 5G, Millimetre-wave, 28GHz, HFSS, VSWR, Reflection coefficient, Antenna Gain, Inset feed.**

1. INTRODUCTION

The importance of technology in our daily lives is undeniable. This is due to the fact that in today's dynamic world, life without a technology is worthless. As seen now-a-days, the telecommunication industry is booming. More and more users are getting their devices connected to the network causing the need of enormous capacity and faster speed in the upcoming years. As technology continues to advance with the competence of 5G, a lot of industries will be enhanced such as smart cities, smart transportation. The small cell technology of 5G can be integrated into the existence macro cells of 4G. The 5G technology uses a high frequency band at 28GHz which provides large broadcasting of data in Gbps. The high data rate and low latency of 5G are envisioned as opening up new applications in the near future. One is practical virtual reality and augmented reality. Another is fast machine-to-machine interaction in the internet of things. For example, computers in vehicles on a road could continuously communicate with each other and with the road by 5G.

1.1 Microstrip Patch Antenna

Microstrip patch antennas attracted considerable amount of attention of researchers due to demand of its large variety of applications and are considered as most common types of antennas due to their obvious advantages of light weight, low cost, low profile, planar configuration, ease for fabrication, suitable for arrays and easy integration with microwave monolithic integrate circuits (MMIC). The applications in present day mobile communication systems usually require smaller antenna size in order to meet the miniaturization requirements of mobile units. The typical range for dielectric constant of the substrate is $2.2 \leq \varepsilon_r < 12$. These antennas are simple to design, easy to modify according to needs. Microstrip patch antenna having finite ground plane. Microstrip antennas are often used where thickness and conformability to the host surfaces are the key requirements. Since patch antennas can be directly printed onto a circuit board, these are becoming popular in the mobile market.

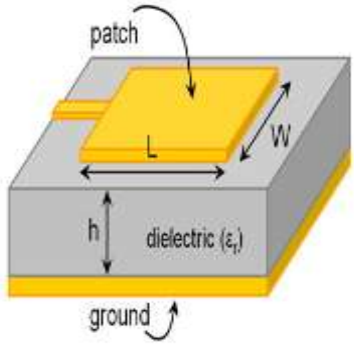

Fig- 1: Structure of Microstrip Patch antenna

In this paper, the proposed antenna uses a single radiating patch element which is designed to resonate at 28GHz. The patch is designed using the Rogers RT Duroid 5880 substrate has a thickness of 0.254 mm with a low dielectric constant ε_r = 2.2. The overall dimension of the proposed antenna is 14.71 mm x 7.9 mm x 0.254

mm. To excite the antenna a lumped port is used having an input characteristic impedance of 50Ω.

2. DESIGNING PROCEDURE

To design the proposed single patch radiating element HFSS simulation software is used. This Antenna design consists of three layers where the first layer is the ground plane at the bottom which is made up of copper, the second layer is the Rogers RT Duroid substrate, a thickness of 0.254 mm and the top layer is the radiating patch. By using RT Duroid substrate gives 80% efficiency with a bandwidth of 15% increase. The reason for the increase in bandwidth is due to the low dielectric constant. By increasing the thickness of the substrate the bandwidth increases which gives better radiation. The detailed characteristics about the designed Microstrip patch antenna and various simulation results are discussed in the next section.

The designed Microstrip patch antenna with substrate containing low dielectric constant of 2.2 operating at 28GHz for future 5G by using Inset feeding technique is shown in Fig-2.

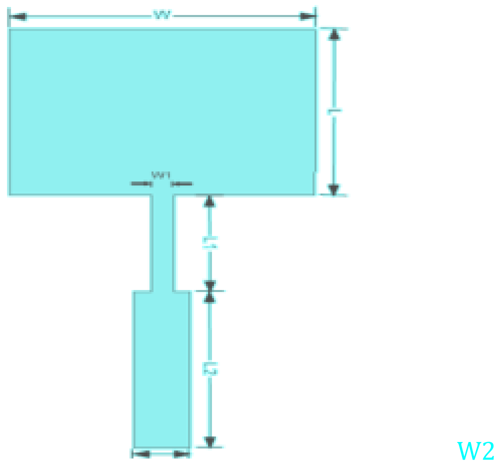

Fig-2: Microstrip Patch Antenna

The dimensions of the single patch antenna shown in the above figure are designed by using the analytical calculations.

$$W = \frac{C}{2f_r\sqrt{\frac{\varepsilon_r}{2}}} \quad (1)$$

Where W is width of the patch, C is the velocity of light, f_r is the operating frequency and ε_r is the dielectric constant of the substrate.

$$Length = \frac{C}{2f\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (2)$$

Where,

Ɛr = Dielectric constant = 2.2

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\frac{h}{w}\right)^{-1/2}$$

ΔL **=** length of extension

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\epsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)}$$

From equation 2, the length of the patch L can be determined after obtaining the value of the effective length of the patch (L_{eff}) and the length of extension (ΔL). The designed antenna is connected with a microstrip line of 50Ω having a width of W2= 0.783 mm. If frequency of the antenna increases the size of the patch will be decreased. The thick substrate with low dielectric constant provides better efficiency and larger bandwidth. The dimensions of the antenna are tabulated below in Table 1.

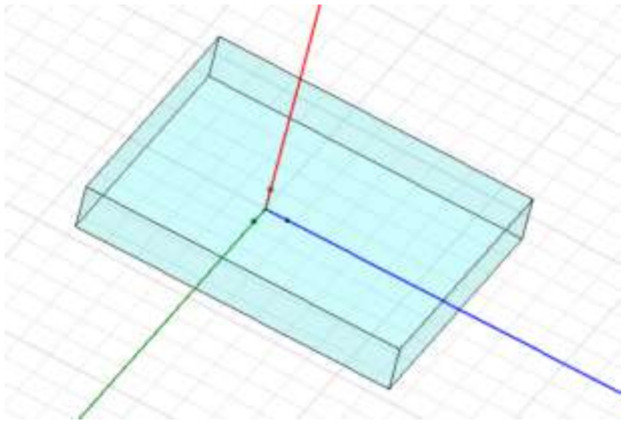

Fig-3(a): Substrate

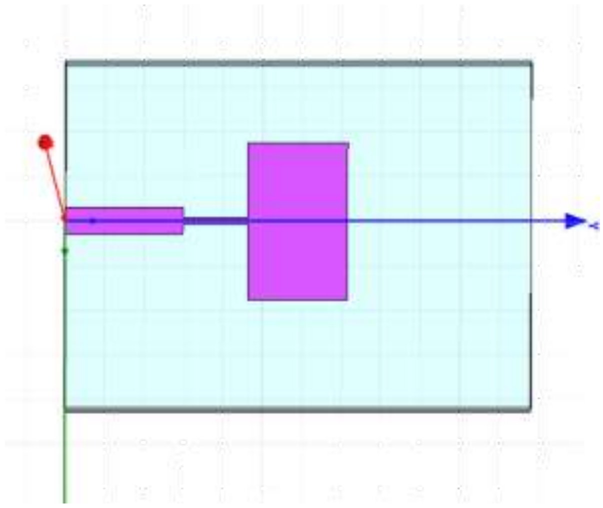

FIG-3 (b) Single Radiating Patch element

Table-1: Dimensions of designed antenna

SL.NO	ANTENNA PARAMETERS	VALUES (mm)
1.	Length of the Patch (L)	3.348
2.	Width of the Patch (W)	4.232
3.	Length of the Feedline (L1)	2.006
4.	Width of the Feedline (W1)	0.304
5.	Length of the Edge feed (L2)	0.268
6.	Width of the Edge feed (W2)	1.524
7.	Thickness of the substrate (h)	0.254

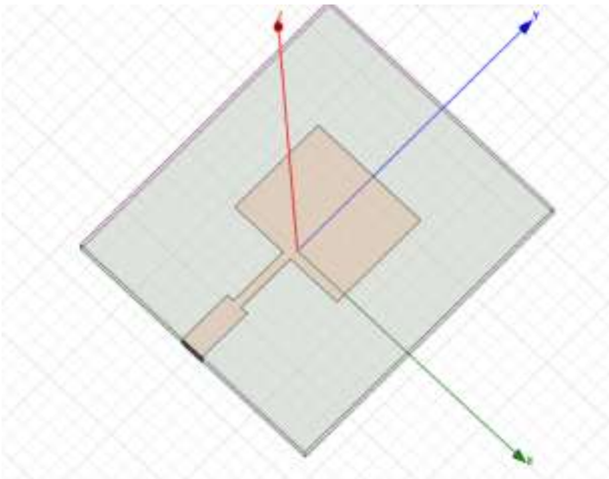

Fig-3(c): Designed Microstrip Patch Antenna

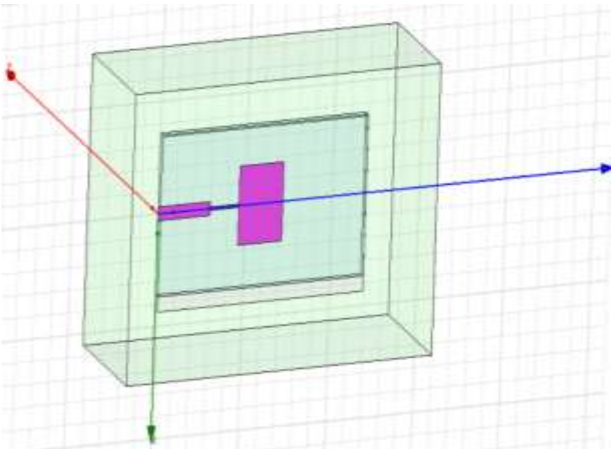

Fig-4: Simulated Antenna

3. SIMULATION RESULTS

The design and simulation of the antenna is done using HFSS software. The operating frequency of this antenna is 28GHz. The S11 parameters were obtained by using the lumped port configuration. From fig-5 the high gain of 8.21dB is obtained which is considered excellent in terms of a compact microstrip patch antenna. From fig-6 VSWR of 1.75 is seen which is acceptable for wireless applications i.e. less than 2. The fig-7 indicates a plot of reflection coefficient (S11) of -34.05dB. The radiation pattern at phi=0^0, 360^0 is represented in fig-8. An omnidirectional pattern of the designed antenna is seen with a small back lobe.

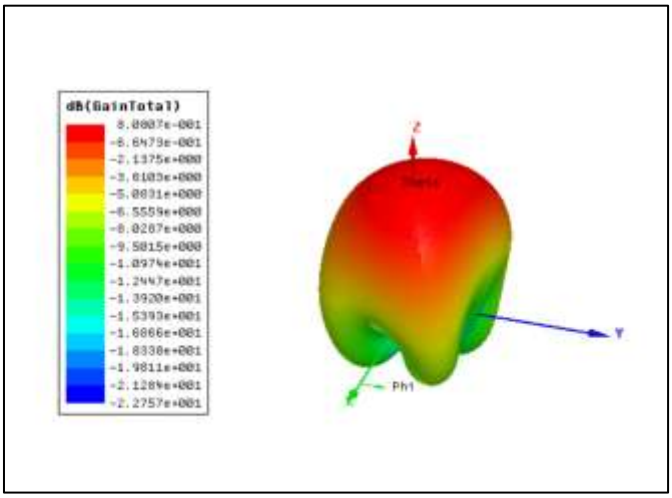

Fig-5: Antenna Gain 8.00dB

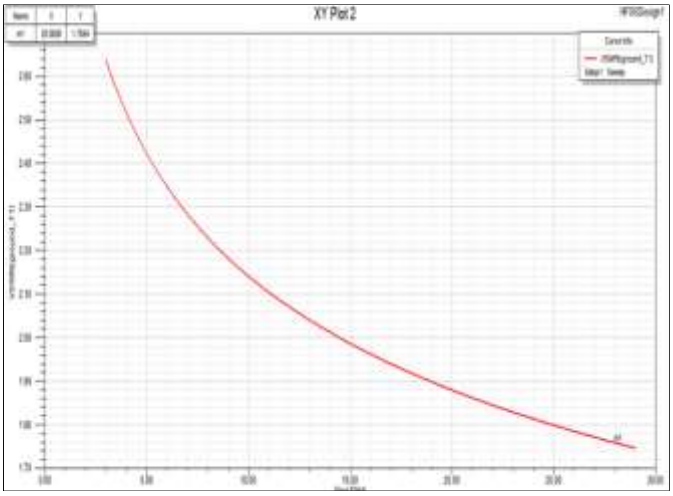

Fig-6: VSWR 1.75

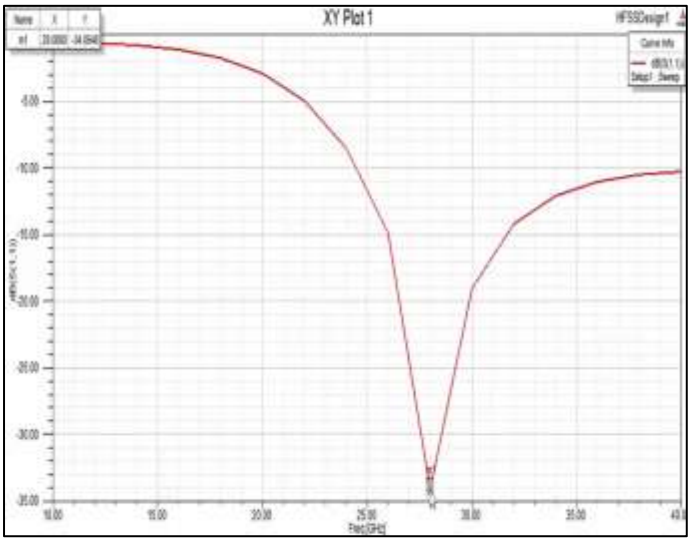

Fig-7 Return Loss -34.05dB

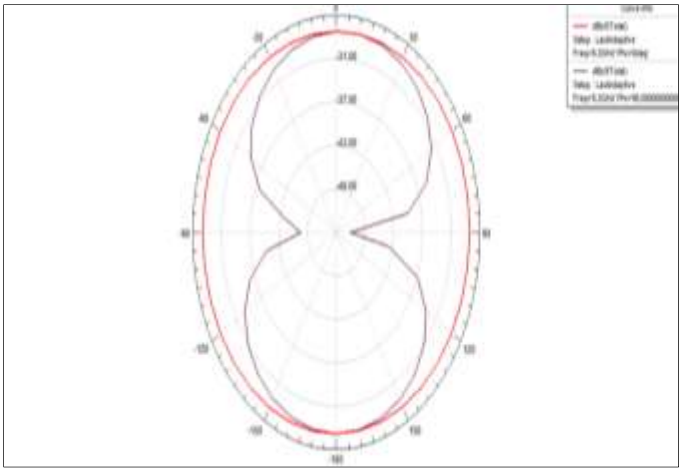

Fig-8: Radiation pattern which is omnidirectional at 360^0.

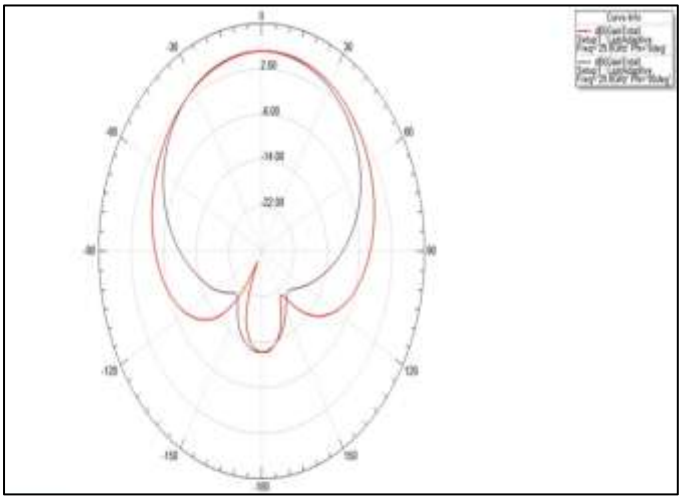

Fig-9: Radiation pattern at 0^0, 90^0

Table-2: Simulated Results at 27.91GHz

Antenna Parameters	S11 Parameter	VSWR	Gain
Specifications at 27.91GHz	-34.05dB	1.75	8.00dB

Table-3 : Different Parameters at different frequencies.

Parameters	2.4GHz	5.2GHz	24.5GHz	28GHz
Substrate	FR4	FR4	RT 3003	RT5880
Return loss	-9.76dB	-11.0dB	-12.53dB	-34.05dB
VSWR	5.98	5.01	4.15	1.75
Gain	3.93dB	5.01dB	5.51dB	8.00dB
Dielectric constant	4.8	4.3	3.0	2.2

4. CONCLUSION

In this paper, a single rectangular Microstrip patch antenna has been designed for future 5G wireless communication. When different frequencies are taken into consideration, Microstrip patch antenna at 28GHz achieves a high gain of 8.00dB. In order to get good performance of the antenna, the VSWR should be in the range of 1-2. In this paper we achieved the excellent VSWR of 1.75 and a reflection coefficient of -34.05dB which gives better performance of the antenna by using Inset feeding technique. With increasing the substrate thickness (h), the bandwidth increases to 15-30%. The obtained radiation pattern is omnidirectional at phi=0^0, and 360^0. The integration of the antenna can be done in devices where space is a major concern. This proposed antenna can be used in future 5G wireless devices.

REFERENCES

[1] Sunakshi Puri, Kiranpreet Kaur, Naveen Kumar, “A Review of Antennas for Wireless Communication Devices”, International Journal of Electronics & Electrical Engineering, vol 2, no. 3, pp. 199-201, September 2014.

[2] S. Chen and J. Zhao, "The requirements, challenges, and technologies for 5G of terrestrial mobile telecommunication," in IEEE Communications Magazine, vol. 52, no. 5, pp. 36-43, May 2014.

[3] W. Roh, 1. Y. Seol, 1. Park, B. Lee, 1. Lee, Y. Kim, 1. Cho, and K. Cheun,F. Aryanfar, Millimetre-Wave beam forming as an enabling technology for 5G cellular communications: theoretical feasibility and prototype

results," IEEE Communications Magazine, February 2014.

[4] Ka Ming Mak ; Hau Wah Lai; Kwai Man Luk; Chi Hou Chan, "Circularly Polarized Patch Antenna for Future 5G Mobile Phones," in Access, IEEE,vol.2, no., pp.1521-1529, 2014.

[5] P. Pietraski, D. Britz, A. Roy, R. Pragada, and G. Charlton, "Millimetre wave and terahertz communications: feasibility and challenges," ZTE Communications, vol. 10, no.4, pp. 3-12, December 2012.

[6] Rappaport, T.S.; Shu Sun; Mayzus, R.; Hang Zhao; Azar, Y.; Wang, K.; Wong, G.N.; Schulz, J.K.; Samimi, M.; Gutierrez.

[7] Hang Wong, Kwai-Man Luk, Chi Hou Chan, QuanXue, Kwok Kan So, Hau Wah Lai, "Small antennas in Wireless Communications", Proceedings of the IEEE Journal, vol. 100, no. 7, pp. 2109 – 2121, July 2012.

[8] Ka Ming Mak; Hau Wah Lai; Kwai Man Luk; Chi Hou Chan, "Circularly Polarized Patch Antenna for Future 5G Mobile Phones," in Access, IEEE, vol.2, no., pp.1521-1529, 2014.