

# AN INCREASED BANDWIDTH OF A MICROSTRIP PATCH ANTENNA AT 28GHz FOR FUTURE 5G APPLICATIONS

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## ABSTRACT

*Narrow bandwidth discovered in many antenna designs as well as in 1G, 2G, 3G, and 4G technologies could be enhanced by using 5G technology. The problem of limited bandwidth is solved using 5G technology by employing different techniques such as introducing a slit on the patch, ground slot technique, etc. This work proposes an increased bandwidth of a microstrip patch antenna resonating at 28GHz frequency for future 5G applications. The design was carried out using CST Microwave Studio and used RT Duroid 5880 substrate with a dielectric constant of  $E_r = 2.2$  and loss tangent of 0.0009. The increased bandwidth of 3.6373 GHz was achieved by introducing a slit at the top side of the antenna. This future antenna has a size of 3.8mm X 2.12mm geometrically in length and width and used a microstrip feed line with 50 $\Omega$  matching. Hence, it is recommended that this milli-meter wave antenna can be a good candidate for future 5G applications.*

**Keywords:** Computer Simulation Technology, Milli Meter Waves.

## 1 INTRODUCTION

An antenna is an electrical device that systematically converts radio frequency or electromagnetic fields into alternating currents and vice versa. However, a high data rate requires an antenna that can support wider bandwidth for fifth-generation or (5G) wireless communication networks [1]. This can be achieved by employing many techniques, such as microstrip patch technology. It offers less cost of fabrication, simplicity, and ease of designing in different shapes such as rectangular, square, and triangular. Even though, microstrip patch technology or design has a very narrow bandwidth that needs to be improved, increased, or enhanced by employing different feeding techniques, ground plane cuts, slit on the patch, and dielectric materials [2]. Several kinds of research in antenna design have suggested the wider bandwidth, high gain, and effect of coupling reductions for fifth-generation communications. The choice of 28GHz is based on the suitable results obtained at this band in terms of gain and bandwidth. However, other bands that support milli-meter waves are 28GHz, 38GHz, 52GHz, and 64 -71 GHz [3]. Higher bandwidth can easily be obtained in a milli-meter antenna with an estimated minimum value of 1GHz [3]. Ashwin proposes the title “performance enhancement of millimeter wave antenna with integrated inter-digital capacitor structure” which used an operating frequency of 30GHz to support 5G technology and it

provides a bandwidth of 1GHz [4]. Similarly, Qian, Ning, LingLi, Saifuddin, and Jinping in their paper “5G MIMO conformal Microstrip Antenna Design” used a 35GHz operating frequency with a bandwidth of 1GHz [5]. In research proposed by Muhammad and Majeed in the paper titled “Millimeter-Wave Pattern Reconfigurable Antenna” at a frequency of 79GHz and still obtained a bandwidth of 1GHz [6]. An almost equivalent result was obtained by Igor, Shual, and Pedersen in works titled “Dual-Polarized Dual-band Mobile 5G Antenna Array” which operated on a frequency of 33.5GHz [7]. However, this proposed antenna would provide very high bandwidth at an operating frequency of 28GHz using a microstrip patch technology. The bandwidth obtained is about 3.6373GHz which is a massive boost to what is obtained in the previous literature.

## 2 ANTENNA DESIGN

It was discovered by many researchers as well as antenna design engineers that microstrip patch antenna has three key parameters to be firstly known before starting the design viz operating frequency, dielectric constant, loss tangent, and the height of the substrate. Moreover, the desired bandwidth, gain, and radiation coefficient can be obtained by computing the width (W) as well as the Length (L) of the patch as discussed in [2, 3, 8, 9, 10, 11, 12, 13, 14] as shown on Figure 1.

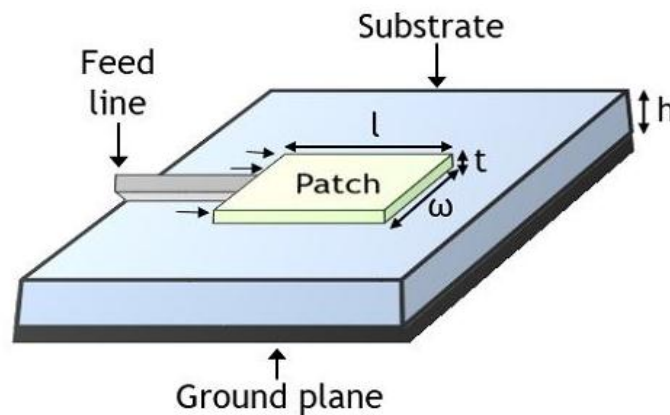


Figure 1. Microstrip Patch Antenna Schematic Diagram

The height or thickness of the substrate is 1.6mm, the dielectric constant  $\epsilon_r = 2.2$  and the operating frequency is 28GHz. The length and width can be obtained using the microstrip patch antenna formulas in [2, 3, 4, 5, 6, 7, 8, 9]. By applying these formulas, the length and width obtained are 3.32mm and 5.12mm respectively. After parametric sweep and optimization, the length and width values changed to 2.11mm and 4.12mm respectively for an optimal value of reflection coefficient, gain as well as bandwidth. The bandwidth, reflection coefficient, gain, directivity, and other parameters were monitored and observed. The schematic diagram and dimensions of the proposed antenna before and after introducing a slit are shown in Figures 2a and 2b below.

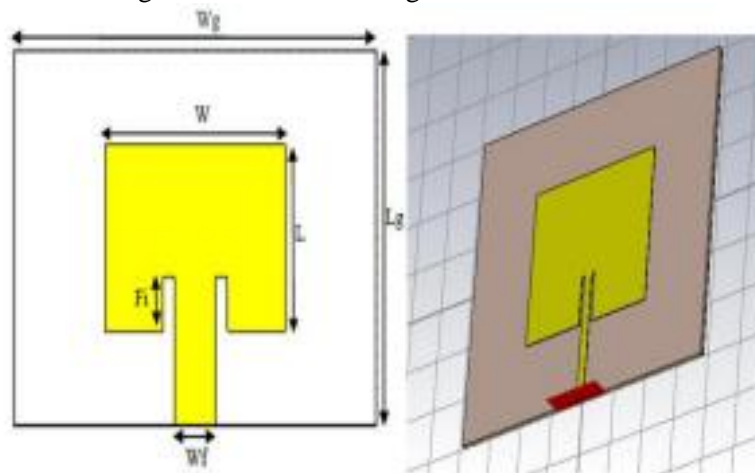


Figure 2a. Proposed Antenna Milli Meter wave Microstrip Patch Antenna Before introducing a slit.

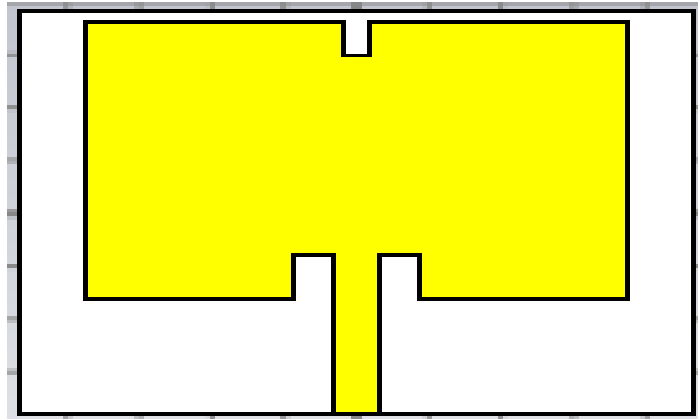


Figure 2b. Proposed Antenna Milli Meter wave Microstrip Patch Antenna After introducing a slit.

The figure above shows a complete dimension of the proposed milli meter wave microstrip patch antenna operating at 28GHz and is tabulated in Table 1 below.

Table 1. Design Specifications and Parameters of a Proposed Antenna

Description	Parameter	Value (mm)
Patch width	Wp	4.12
Patch length	Lp	2.11
Substrate width	Ws	8.4
Substrate length	Ls	7.2
Feeding length	Lf	1.32
Feeding width	Wf	0.46
Slit Length	Ls	0.8
Slit Width	Ws	0.21

### 3 RESULTS AND DISCUSSION

The simulation results of the proposed milli meter wave microstrip patch antenna operating at 28 GHz for future 5G applications in terms of antenna performances are presented.

#### 3.1 Reflection Coefficient or Return Loss

The reflection coefficient is obtained in the early stage of the design, but it was discovered that it is not at the optimal value as in the other cited works. A parametric sweep on different dimensions was run and the optimal value was obtained at -24.33 dB, it shows a better result compared with the cited works. Figure 3 shows a reflection coefficient output or return loss for the simulated result of the milli-meter microstrip patch antenna operating at 28GHz frequency. it observed that the antenna resonates at exactly 28.088GHz with  $|S_{11}|$  below -24.33 dB.

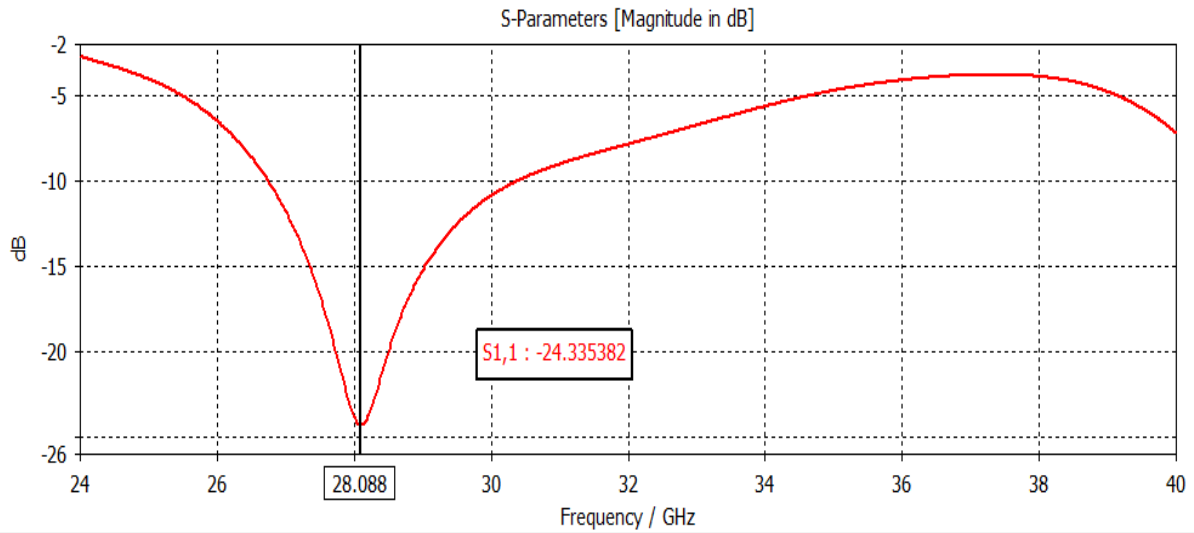


Figure 3. Reflection Coefficient Results for Milli Meter Wave Microstrip Patch Antenna

### 3.2 Antenna Bandwidth

Figure 4 below shows the antenna bandwidth at a standard of -10 dB impedance bandwidth, the simulation result for the proposed milli meter microstrip patch antenna operating at 28GHz shows an antenna bandwidth of 3.673GHz at the resonance frequency of 28.088GHz. However, the main target of this work is to increase or enhance the bandwidth of the millimeter wave antenna, the result shows that 3.673GHz bandwidth is 2.673GHz greater than cited works above, as most of the antennas above have not more 1GHz bandwidth.

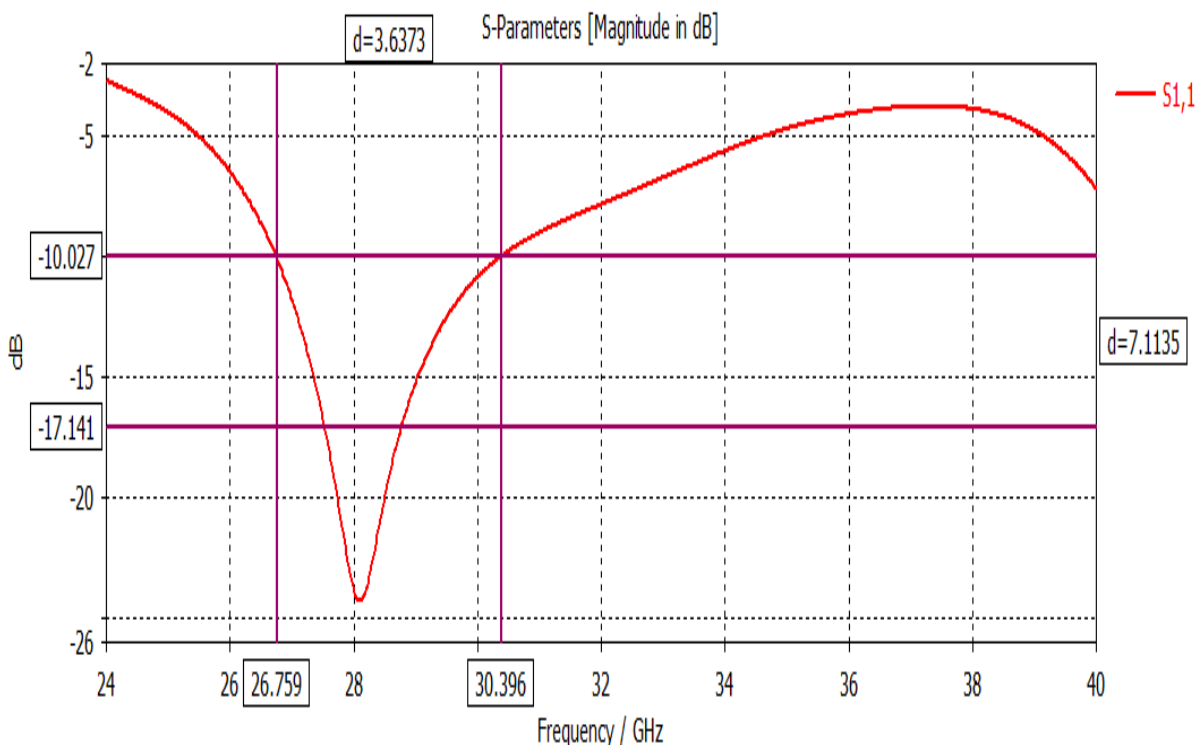


Figure 4. Bandwidth Result of Milli Meter Wave Antenna

### 3.3 Gain, Directivity, and Radiation Pattern

The gain, directivity, and radiation pattern of the proposed milli-meter wave microstrip patch antenna are discussed. It could be seen from the diagram that the radiation pattern is more directional

with a directivity and gain of 5.43 dBi and 3.97 dB which can be improved by employing array or MIMO techniques or any other technique for improving gain and directivity. It can be observed that this proposed antenna has a very good gain or directivity which is similar to the cited works, even though the gain could be increased or improved using an array or MIMO techniques. Figure 4 shows the radiation pattern in polar cartesian.

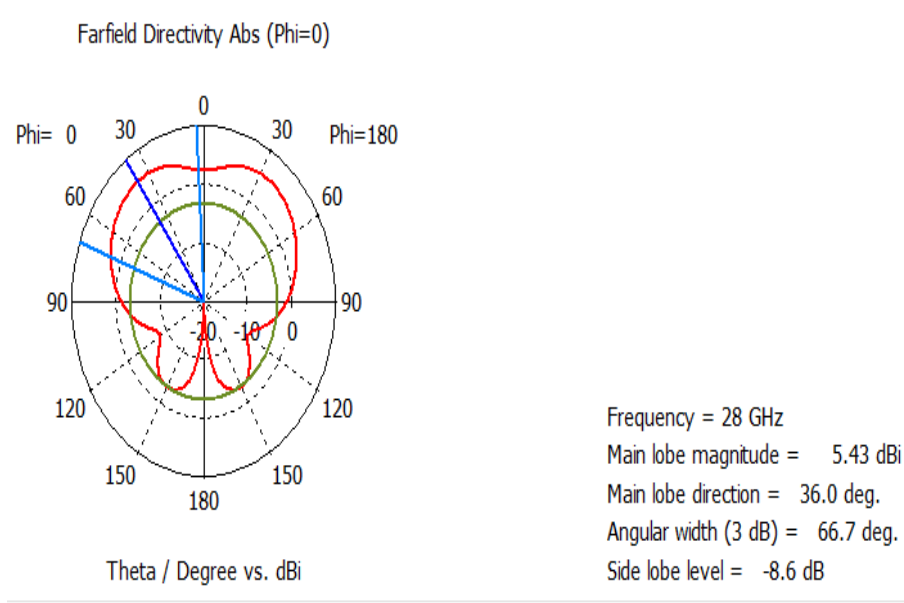


Figure 4. Simulated Polar Plot of Milli Meter Wave Antenna

#### 4 CONCLUSIONS

Milli meter wave microstrip patch antenna operating at 28GHz was designed and implemented. The antenna was designed using RT Duroid 5880 substrate with the dielectric constant of  $E_r = 2.2$ , loss tangent of 0.0009 and with the thickness of substrate 1.6mm. The -10 dB impedance bandwidth achieved has been observed and recorded as 3.6373GHz, the return loss or reflection coefficient of -24.33 dB as well as the Directivity of 5.43 dBi (need improvement using an array or MIMO techniques). Hence, the antenna can be a good candidate for future 5G applications. However, in future work, the gain of this antenna can be improved by employing an array, MIMO, or any available techniques.

#### REFERENCES

1. Johari, S., Jalil, M.A., Ibrahim, S.I., Mohammad, M.N., Hassan, N. (2018). 28 GHz microstrip patch antennas for future 5G. *Journal of Engineering and Science Research*, vo. 2, no. 4, pp. 1-6.
2. Salisu, A., Hussaini, A., Elfergani, I., Mohammed, B. and Anuhu, W. (2020). *Dual Band Microstrip Patch Array Antenna for LTE Applications in Malaysia*. Paper presented at the Proceedings of the 1st International Multi-Disciplinary Conference Theme: Sustainable Development and Smart Planning, IMDC-SDSP 2020, Cyperspace, pp. 28-30.
3. Anuhu, W., Husaini, A., Elfergani, I., Mohammed, B., Salisu, A., Alashhb, M.I. and Rodriguez, J. (2020). *Design of a Millimeter Wave Microstrip Patch Antenna using 52GHz for Mobile Communication*. Paper presented at the IMDC-SDSP 2020: Proceedings of the 1st International Multi-Disciplinary Conference Theme: Sustainable Development and Smart Planning, IMDC-SDSP 2020, Cyperspace, pp. 28-30.
4. Peshwe, P. and Kothari, A. (2018). Performance enhancement of millimeter wave antenna with integrated inter-digital capacitor structure. *Radioengineering*, vol. 27, no. 3, pp. 654-661.
5. Wang, Q., Mu, N., Wang, L., Safavi-Naeini, S. and Liu, J. (2017). 5G MIMO conformal microstrip antenna design. *Wireless Communications and Mobile Computing*, pp. 35-38.

6. Saleem, M.K. and Alkanhal, M.A. (2018). Millimeter-Wave Pattern Reconfigurable Antenna. In *Antenna Fundamentals for Legacy Mobile Applications and Beyond*, Springer, pp. 265-282.
7. Syrytsin, I.A., Zhang, S. and Pedersen, G.F. (2018). *Dual-polarized Dual-band Mobile 5G Antenna Array*. Paper presented at the Proceedings of the 15th International Joint Conference on e-Business and Telecommunications (ICETE), pp. 309-315.
8. Goyal, R. K., & Modani, U. S. (2018). *A compact microstrip patch antenna at 28 GHz for 5G wireless applications*. Paper presented at the 2018 3rd International Conference and Workshops on Recent Advances and Innovations in Engineering (ICRAIE), pp. 29-36.
9. Imran, D., Farooqi, M., Khattak, M., Ullah, Z., Khan, M., Khattak, M. and Dar, H. (2018). *Millimeter wave microstrip patch antenna for 5G mobile communication*. Paper presented at the 2018 international conference on engineering and emerging technologies, pp. 43-49.
10. Darboe, O., Konditi, D.B.O. and Manene, F. (2019). A 28 GHz rectangular microstrip patch antenna for 5G applications. *International Journal of Engineering Research and Technology*, vol 12, no. 6, pp. 854-857.
11. Ghazaoui, Y., El Alami, A., El Ghzaoui, M., Das, S., Barad, D. and Mohapatra, S. (2020). Millimeter wave antenna with enhanced bandwidth for 5G wireless application. *Journal of Instrumentation*, vol. 15, no. 1, pp 1-3.
12. El Shorbagy, M., Shubair, R.M., AlHajri, M.I. and Mallat, N.K. (2016). *On the design of millimetre-wave antennas for 5G*. Paper presented at the 2016 16th Mediterranean Microwave Symposium, pp. 1-4.
13. Muhammad, S., Ya'u, I., Abubakar, A. and Yaro, A.S. (2019). Design of single feed dual-band millimeter wave antenna for future 5G wireless applications. *Science World Journal*, vol. 14, no. 1, pp. 84-87.
14. Mungur, D. and Duraikannan, S. (2018). Design and Analysis of 28 GHz Millimeter Wave Antenna Array for 5G Communication Systems. *Journal of Science Technology Engineering and Management-Advanced Research & Innovation*, vol. 1, no. 3, pp. 1-10.