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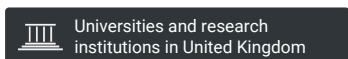
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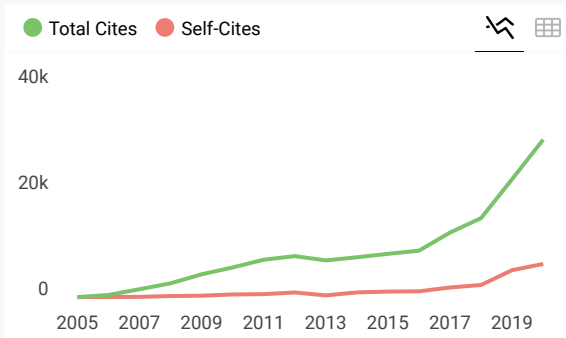
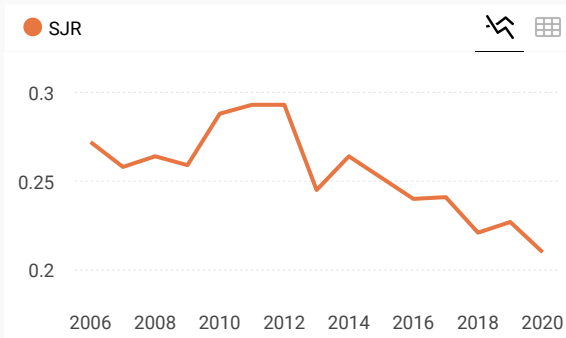
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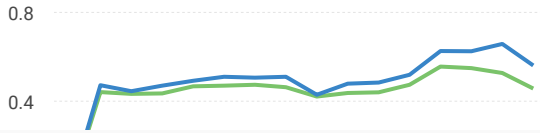
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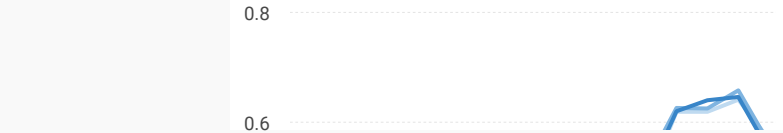
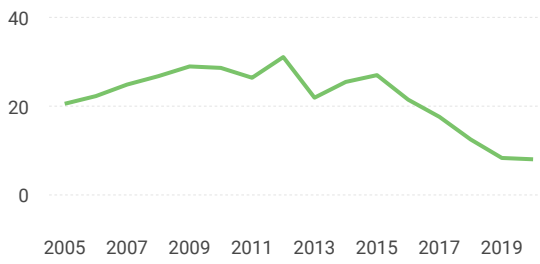


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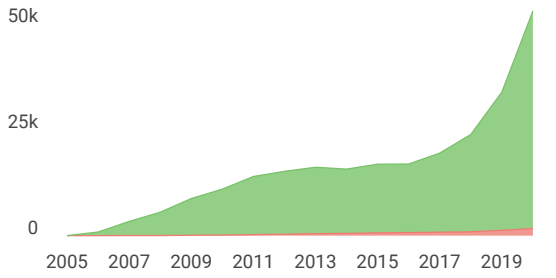




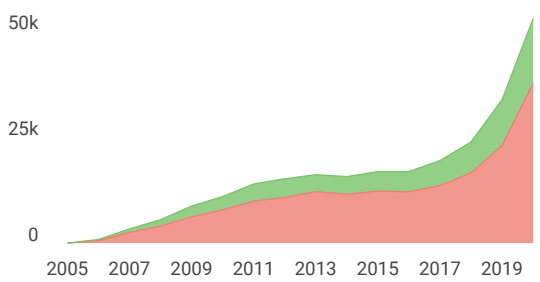
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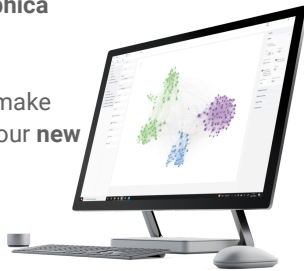
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Design and simulation of a rectangular patch microstrip antenna for the frequency of 28 GHz in 5G technology

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Abstract. The development and application of the fifth generation mobile communication system (5G) requires and provides high-speed and high-capacity wireless communication services. This paper describes the design of small antennas using microstrip technology as a wireless communication device operating at a frequency of 28 GHz. The technique method used for antenna design is inset feed technique with a shift to the length of the transmission line on the side of the patch gap. Antenna design is used method of moment or simulation using CST software application. To support antenna design in the simulation process using the type of material substrates used was Taconic TLY-5 type. The results of simulations the obtained, such as: bandwidth of return loss ≤ -10 dB is 454 MHz, VSWR (2:1) is 1.03, beam width is 74.4 degrees and gain is 6.72dB. An antenna design obtained through simulation shows a simple and compact antenna shape with the expected parameter value. The design is a basic element of research for antenna sub arrays for increasing radiation power.

1. Introduction

The emerging 5G technology is demanding antennas with features previously unseen on a user terminal, such as the beamforming capability of the radiation pattern to perform spatial scanning. This requirement raises numerous design challenges to achieve a reasonable trade-off between technological design issues and commercial criteria - low cost, small size, radiation efficiency, antenna gain, broadband performance, and so on – mainly at millimetric wave bands [1,2]. The Microstrip antenna is an option that can be developed to support this technology. A coplanar microstrip antenna design uses a rectangular patch as a network feeding and feeding element is made to be able to operate at a frequency of 28 GHz which is part of the 5G application [3,4]. This antenna is designed for 5G communication network applications for Mobile Backhaul Transceiver on 5G technology [5]. Some previous studies of antenna designs were made using duroid type material. The difference in material types, especially material thickness, will affect the results of the dimensions of the antenna.

In this paper, the proposed single patch antenna is designed to resonate at 28 GHz for the local multipoint distribution service band. An antenna is designed with a rectangular patch and the inset feed technique as a transmission line uses material from TLY-5 type. The substrate of Taconic TLY-5 type has a thickness of 0.12 mm, a dielectric constant (ϵ_r) is 2.2 and loss tangent ($\tan \delta$) is 0, 0009 [6]. For simulation of antenna design used CST microwave studio software. The overall dimension of the path antenna proposed antenna is 8.52 mm x 7.14 mm x 0.12 mm. For bandwidth of return loss at frequency 28 GHz is 463MHz.



2. Antenna design

2.1. Rectangular patch

For the design a rectangular radiator patch can be done through calculation analysis of the dimensions of length and width. Conceptually to determine the size of the patch dimension, it is necessary to know the working frequency value of the antenna to be designed first. Furthermore, also need to know the data about the specifications of the type of material. In this design the working frequency used is 28 GHz and the type of material used is Taconic TLY-5 which has a dielectric constant (ϵ_r) is 2.2, thickness (h) is 0.12 mm and loss tangent ($\tan \delta$) is 0, 0009 [7-9].

$$W = \frac{c}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

Where, C is the speed of light (3×10^8 m.s⁻¹), the dielectric constant and f_r are resonant frequencies. The length of a rectangular patch can be obtained through the effective length equation (L_{eff}) by first calculating the length value (L) and the effect fringing difference (ΔL). The length of a rectangular patch is obtained through equation 2 [9,10].

$$L = L_{eff} - \Delta L \quad (2)$$

Further to analyze the L_{eff} value can be calculated by equation 3 [10,11].

$$L_{eff} = \frac{c}{2f_r \sqrt{\epsilon_{reff}}} \quad (3)$$

While for the ΔL value can be calculated with equation 4 and 5.

$$L_{eff} = \frac{c}{2f_r \sqrt{\epsilon_{reff}}} \quad (4)$$

And,

$$\epsilon_{reff} = \frac{\epsilon_{reff} + 1}{2} + \frac{\epsilon_{reff} - 1}{2} \left[\left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}} \right] \quad (5)$$

2.2. Transmission line

The transmission line is a power supply that supports antenna performance. The microstrip transmission line is designed with a characteristic impedance of 50 Ohm. Conceptually the transmission line design is determined by the width of the transmission line on a substrate material patch. To determine the width of the transmission line can be done by calculation through equation 6 [8-10].

$$Z_0(\Omega) = \frac{[120\pi(\epsilon_{eff})^{-1/2}]}{w/h + 1,393 + 0,667 \ln(1,444 + w/h)} \quad (6)$$

This equation only applies to when a substrate has a $w/h \geq 1$. Where, Z_0 is characteristic impedance in Ohm, w is width of line in mm and h is thickness of substrate.

3. Method

In this paper will be described about designing for a microstrip antenna that operates at a frequency of 28 GHz supporting the 5G technology wireless communication [12,13]. So, for the rectangular patch design analysis used calculation to width and length of patch [14]. For design used Taconic TLY- 5 substrate type for media PCB (portable circuit board) specification. Calculation analysis of a patch width can be done through equation 1. For resonance frequency of 28 GHz, dielectric constant is 2.2 and c is speed light, then the patch of the width is 4.32 mm. Furthermore, to calculate the length of a patch can

be done using equation 2. Previously it is necessary to calculate the effective length and shifting fringing effect. For effective length can be obtained through calculation using equation 3. The result of calculation for width effective is 3.68 mm. The fringing effect can be calculation with substitution equation 5 into equation 4. The result of calculation obtained for fringing effect is 0.068 mm. For feed line between patch and supply power in antenna design used transmission line microstrip has characteristic impedance 50Ω . The characteristic impedance can be done calculate to width of feed line. The result of the calculation uses equation 6 and then the width of the transmission line is 0.4 mm. To find out the results of an antenna design, the simulation method is then performed to see the antenna design performance against several parameters.

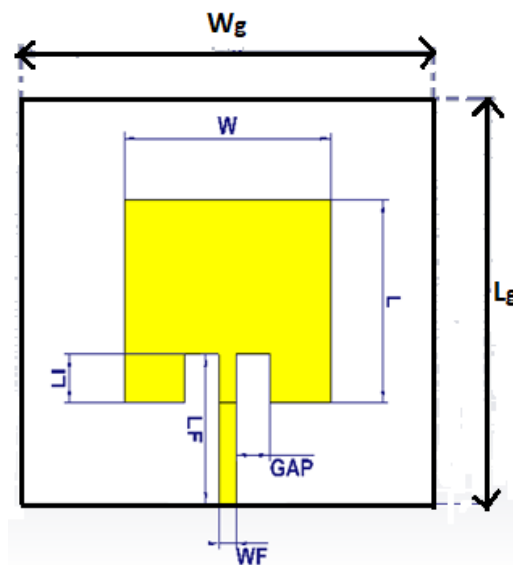


Figure 1. Antenna design.

Table 1. Dimension of antena design.

Dimension	Symbol	Size (mm)
Width ground of substrate	W_g	8.52
Length ground of substrate	L_g	7.14
Width of patch	W	4.26
Length of patch	L	3.57
Length of inset feed	L_I	0.85
Width gap	GAP	0.7
Length of feedline	L_F	2.64
Width of transmission line	W_F	0.35

Simulation process for antenna design conducted with CST software. In Figure 2 shows an antenna design in the CST software application. An antenna design is limited to the air boundary space. Antenna modeling begins with the selection of the type of substrate material and continues with making patch structures and transmission lines.

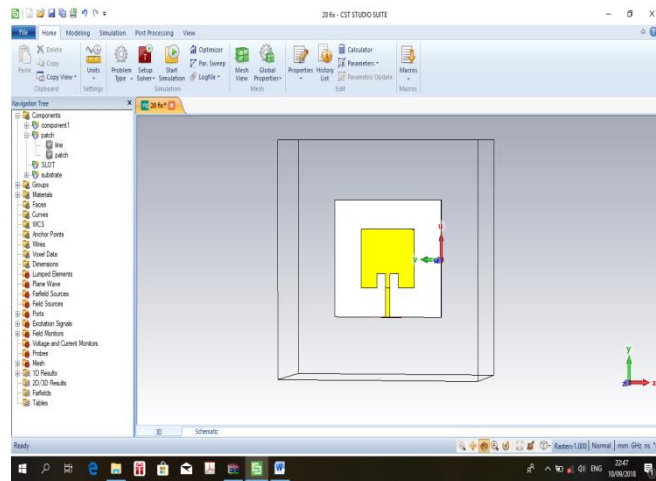


Figure 2. Design of antenna CST software.

Table 2. Bandwidth parameters of simulation results.

Width of gap (mm)	Resonance Frequency (GHz)	Return loss (dB)	Bandwidth (MHz)
0.5	27.793	-22.7	483.1
0.6	27.82	-21.25	495
0.7	28.06	-27.7	463
0.8	28,183	-21.7	423
0.9	28.339	-18.304	548

Figure 3 and table 2 shown an experiment conducted on the effect of changes in gap width. From this experiment, the effect of the gap width on the effective value obtained for the resonance frequency of 28 GHz is 0.7 mm. To obtain the target antenna parameters such as resonant frequency of 5G bandwidth the antenna design is strongly influenced by the width of the gap on the patch and the length of the transmission line. The simulation was carried out with three experiments on changes in gap width with the target resonance frequency at 28 GHz.

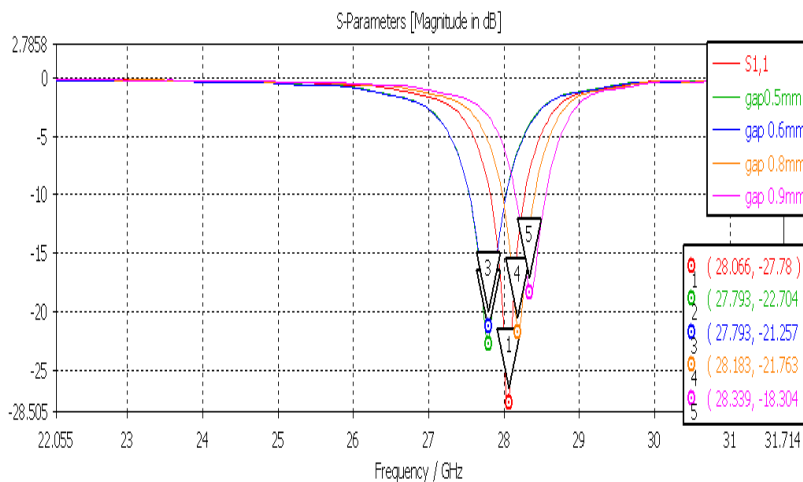


Figure 3. Graph of frequency versus return loss of gap inset feed.

4. Results and discussion

This paper discusses some of the simulation results for antenna parameter values, such as: bandwidth, VSWR, radiation pattern, beam width and polarization. Bandwidth is the frequency range of a frequency spectrum region that shows the low to high frequency limits. Figure 3 shows the results of the bandwidth obtained from experiments on changes in gap width. The experimental results that were effective in operating resonance frequency of 28 GHz were at 0.70 mm gap (table 2). For this gap distance the bandwidth of return loss below 10 dB obtained is 463MHz. Figure 4 shows a graph of the frequency value of the SWR. For resonance frequencies at 28 GHz, the minimum VSWR value is 1.08. (2: 1).

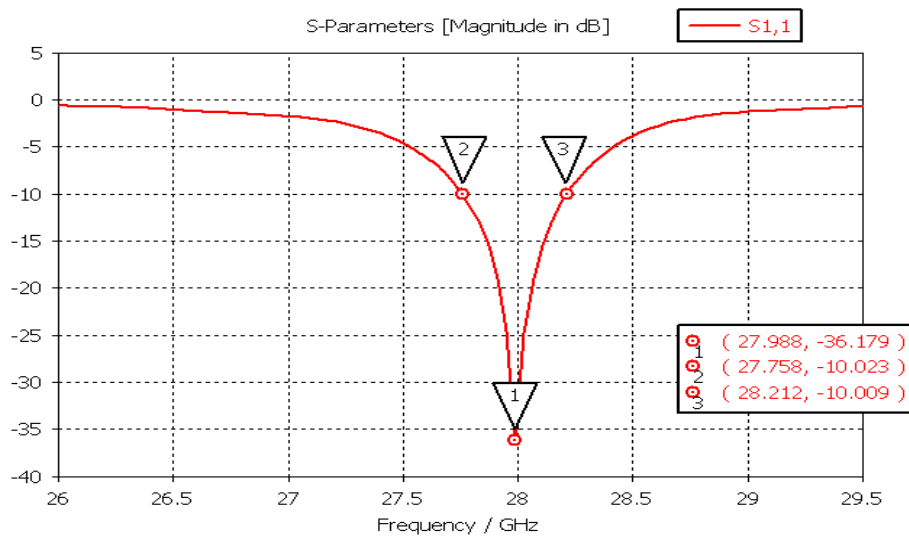


Figure 4. Graph frequency versus return loss of simulation result.

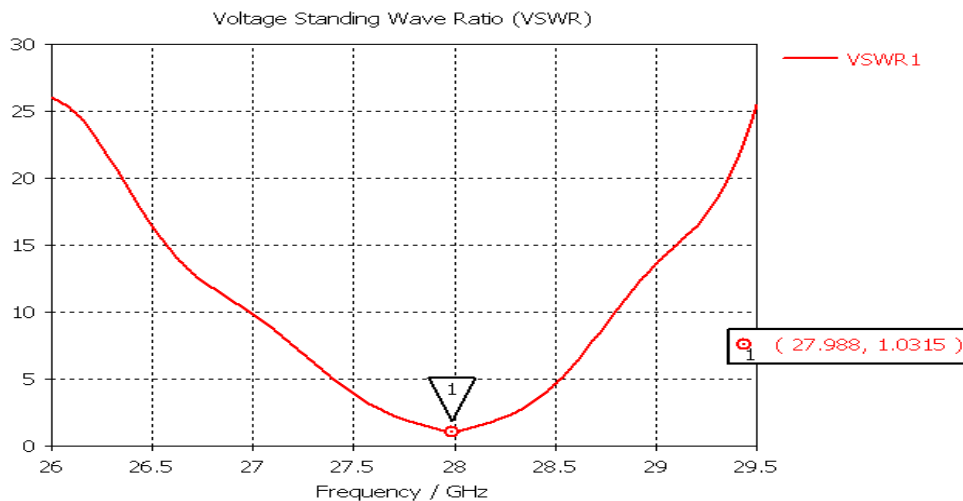


Figure 5. Graph frequency versus VSWR of simulation result.

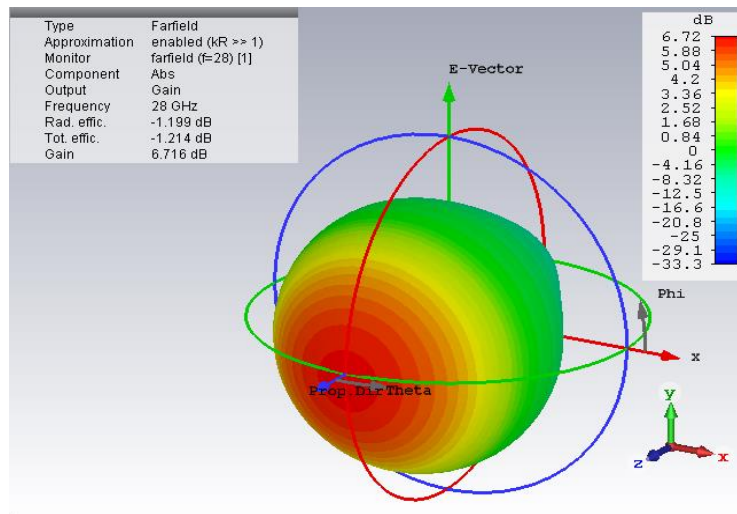


Figure 6. Radiation pattern 3D at 28GHz simulation result.

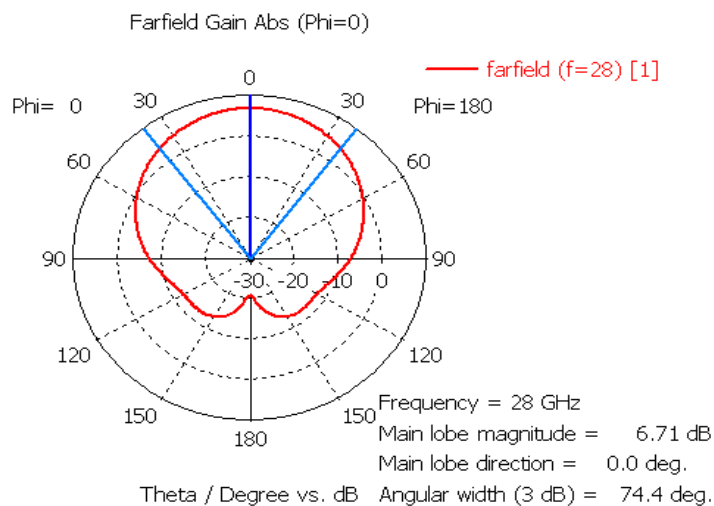


Figure 7. Radiation pattern 2D at 28GHz simulation result.

Figures 6 and 7 show the shape of the radiation pattern produced at a frequency of 28 GHz. In 3 dimensions the measured far field radiation maximum radiation strength (gain) is 6.716dB. As a monopole antenna beam width, the measured at the 3B limit is 74.4 degrees.

5. Conclusion

Simulation results from the antenna design show a device that is small and compact. The shape of the antenna model is a monopole planar type having one direction with wide beam width. For the performance of the antenna parameters operate at a frequency of 28 GHz with a bandwidth of 463 MHz (VSWR minimum is 1.22). As the monopole antenna the radiation performance obtained shows that the gain parameter is 6.72dB at maximum directivity and the beam width is 74.4 degrees of the radiation pattern. As a form of design of the antenna model and the performance obtained is very supportive for 5G wireless communication technology. Furthermore, to realize this design, prototypes will be made through manufacturing and testing in the laboratory.

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