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DESIGN MICROSTRIP ANTENNA FOR Ka BAND

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ABSTRACT

The Micro-strip patch antenna has become very famous and has attracted much attention towards research because of its light weight, compactness, inexpensiveness, and ability to maintain high performance over a wide range of frequencies. In this paper, the rectangular patch is designed with different parameters like return loss, Voltage Standing Wave Ratio (VSWR), directivity, and radiation pattern in 3-D, and impedance matching is simulated using CST Microwave Studio simulation software.
This project presents the design and simulation of a Micro-strip patch antenna operating at 38 GHz for 5G communication. The antenna operates a centre frequency of 38 GHz with a maximum reflection coefficient of -31.305 dB, and a very wide bandwidth of 0.978 GHz. The transmission line of the antenna used is an inset feed. The substrate used is Roger RT5880, which has a dielectric constant of 2.2 and a height of 0.2 mm. The antenna dimensions were calculated and simulated results have been displayed and analyzed using CST Microwave Studio.

1.0 Introduction

The fifth Generation Mobile Network or simply 5G is the forthcoming revolution of mobile technology. The features and usability are much beyond the expectations of a normal human being. With its ultra-high speed, it is potential enough to change the meaning of cell phone usability, with a huge array of innovative features, your smart phone would be more parallel to the laptop. You can use broadband internet connection; other significant features that fascinate people are more gaming options, wider multimedia options, connectivity everywhere, zero latency, faster response time, and high-quality sound and HD video can be transferred on other cell phone without compromising with the quality of audio and video, the topic covered in this work will be the Design of a Microstrip Antenna for 5G Networks. Simply, the "G" stands for "GENERATION". While you are connected to the internet, the speed of your internet depends upon the signal strength that has been shown in alphabets like 2G, 3G, and 4G etc. right next to the signal bar on your home screen. Each Generation is defined as a set of telephone network standards, which detail the technological implementation of a particular mobile phone system. The speed increases and the technology used to achieve that speed also changes. For eg, 1G offers 2.4 kbps, 2G offers 64 Kbps and is based on GSM, 3G offers 144 kbps-2 mbps whereas 4G offers 100 Mbps - 1 Gbps and is based on LTE technology. Table 1 Comparative of mobile technology [1].

2.0 Problem Statement

Decreasing the data transfer time, known as network latency, will make the difference between 4G and 5G. You can download files quickly and easily without worrying about any downtime or downtime of your network or mobile phone. when you finish downloading the files, the Internet will respond more quickly, and you will be able to watch 4k videos, you should not experience any interruption during watching or lag when restarting. Also, 5G networks will solve bandwidth problems. At present, many devices are working on 3G or 4G networks even though they do not have the infrastructure to address these problems efficiently. While 5G will be able to deal with current devices as well as future technology, such as self-driving cars and household items connected to the Internet. The lag factors will disappear when waiting for the network's response, as its rates will drop to 1/1000 of a second, which cannot be felt by a human, and the 5G network will be fast enough to provide a detailed 3D mapping service for cars without drivers, such as the one owned by Google.

1. Design Antenna

The design parameters can be performed mathematically based on the given frequency 28GHz, and the other physical dimensions accordingly by using equations to determine the length, and width of the patch and substrate taking into account that c=3x108 m/s. After The parametric study is performed the final design of the antennas is simulated based on the dimensions shown in Table 2 [1], The length and width of the micro-strip patch antenna can be modeled by the resonant frequency using the following equations (1) - (4).[3]

$$W = \frac{C}{2F}\sqrt{\frac{\epsilon r + 1}{2}} \qquad (1)$$

$$L = \frac{C}{2F\sqrt{\epsilon r}} - 2\Delta L \qquad (2)$$

$$\varepsilon e = \frac{1}{2}\,(\epsilon r + 1) + \frac{1}{2}\,(\epsilon r - 1)\sqrt{1 + \frac{10h}{W}} \qquad (3)$$

$$\Delta L = 0.412h\,\frac{(\varepsilon e + 0.3)[\frac{W}{h} + 0.8]}{(\varepsilon e - 0.258)[\frac{W}{h} + 0.8]} \qquad (4)$$

3.1 Tables

Table. 1 represents the parameters of the first design of the proposed antenna.

Parameters	Value
Dielectric Constant ε_r	2.2
Dielectric Substrate	Roger RT5880
Thickness Substrate	0.2mm
Loss Tangent $tan\delta$	0.0009
Z_0	50Ω
Resonant frequency	28GHz
Feeding method	Microstrip Line Feeder
Copper thickness	$35\mu m$

For performance predictions and simplified analysis, a rectangular shaped Microstrip patch antenna operating at 38 GHz for 5G application is proposed as shown in the Figure 1 below:

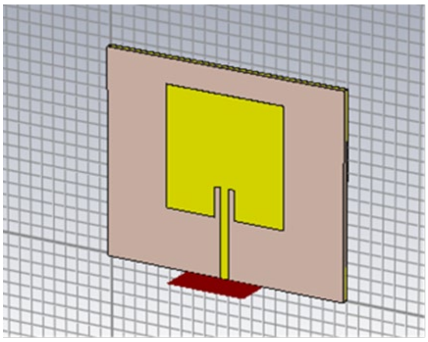

Fig. 1. Design of antenna.

Table 2 shows the values obtained from the mathematical equations and the values obtained from the simulation program.[4]

Table .2 The parameters of the proposed antenna [1]

Symbol	Design parameters	Calculated values (mm)	Optimized values (mm)
SH	Substrate Height	0.2	0.325
PW	Patch width	4.2352	5.0999
PL	Patch length	3.6123	3.393
SW	Substrate width	5.4354	6.5
SL	Substrate length	4.8123	6.5
GW	Ground width	5.4354	6.5
GL	Ground length	4.8123	6.5
LG	gap length	1.259	0.8199
WG	Gap width	0.41	0.3
LFL	Length of a feeder line	1.8059	1.5
WFL	Width of feeder line	0.8219	0.9

3.2 Results and Discussion

Figure 2 displays the return loss (S11) versus frequency for a rectangular Multi-Substrate Patch Antenna (MSPA). It indicates how effectively the antenna reflects power back to the source, with lower return loss values denoting better matching and less power reflection. The resonant frequency corresponds to the frequency at which the return loss is at its minimum. In this case, the resonant frequency exhibits a return loss of approximately -31.305 dB, indicating a well-matched antenna with minimal power reflection. The antenna's bandwidth is determined by the frequency range where the return loss remains below a specified threshold, often set at -10 dB. Figure 2 illustrates that the return loss stays below -10 dB between 36 GHz and 39 GHz, thereby defining the antenna's bandwidth.[5]

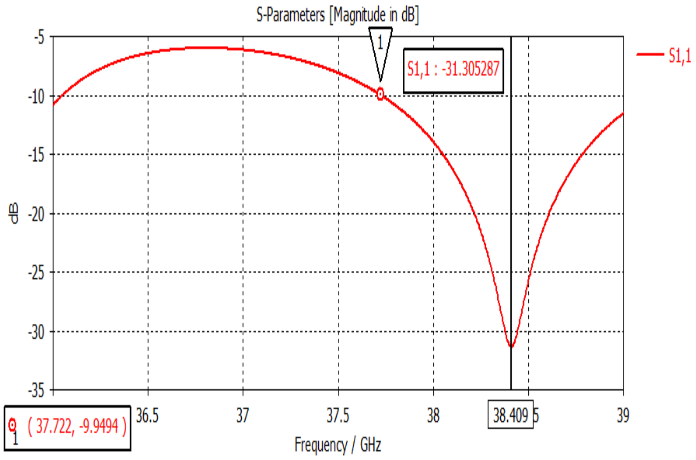

Fig. 2. S-parameters

The input power delivered from the source cannot be radiated without loss due to incorrect compensations. Some of this power is reflected at the antenna, and it is returned to the transmitter, which is quantified by VSWR. The VSWR is described as a function of the reflection coefficient, which expresses the power reflected from the antenna. The smaller the VSWR, the better the MSPA is matched to the feeder line and power distributed to the patch. Hence, for an ideal transmission line, the magnitude of VSWR is one, and for the practical scenarios, a magnitude of less than two is satisfactory if the return loss is less than -31.305 dB. [5 Figure 2 displays the return loss (S11) versus frequency for a rectangular Multi-Substrate Patch Antenna (MSPA). It indicates how effectively the antenna reflects power back to the source, with lower return loss values denoting better matching and less power reflection.

The resonant frequency corresponds to the frequency at which the return loss is at its minimum. In this case, the resonant frequency exhibits a return loss of approximately -31.305 dB, indicating a well-matched antenna with minimal power reflection.

The antenna's bandwidth is determined by the frequency range where the return loss remains below a specified threshold, often set at -10 dB. Figure 2 illustrates that the return loss stays below -10 dB between 36 GHz and 39 GHz, thereby defining the antenna's bandwidth. Figure 2 displays the return loss (S11) versus frequency for a rectangular Multi-Substrate Patch Antenna (MSPA). It indicates how effectively the antenna reflects power back to the source, with lower return loss values denoting better matching and less power reflection.

The resonant frequency corresponds to the frequency at which the return loss is at its minimum. In this case, the resonant frequency exhibits a return loss of approximately -31.305 dB, indicating a well-matched antenna with minimal power reflection.

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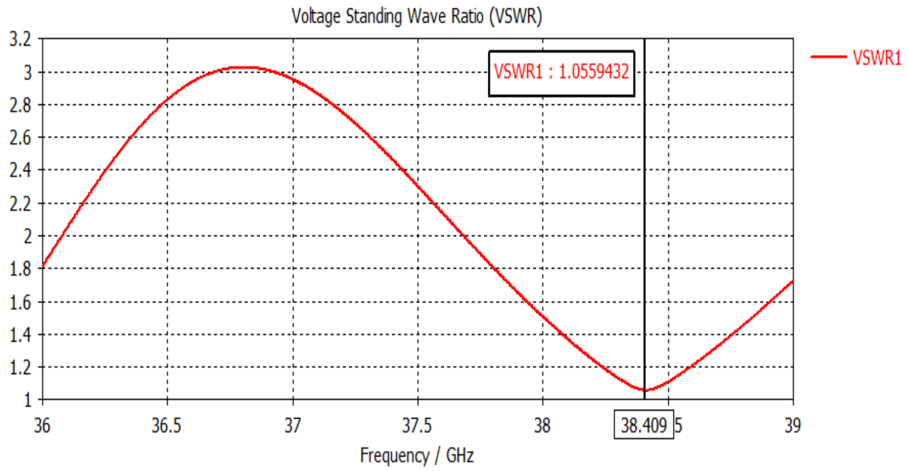

Fig. 3. VSWR of antenna

Figure 4 represents the surface current distribution with different colours. The current should be densely distributed at the edges of the slot placed on the substrate; this reflects that the edges are responsible for dominating the antenna performance.

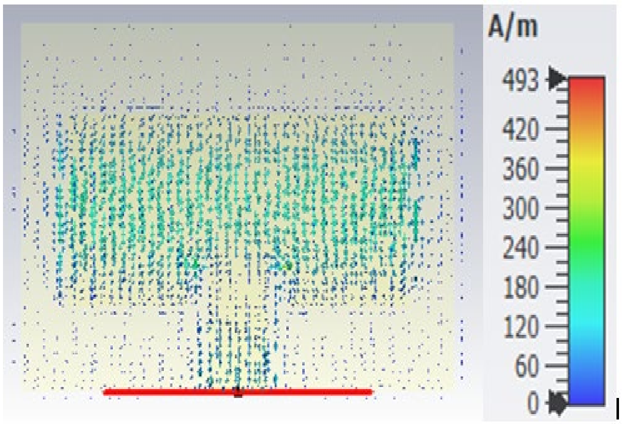

Fig . 4. represents the surface current distribution with different colors.

4.0 Conclusion

In this paper, a 38 GHz broadband rectangular MSPA has been proposed for 5G wireless applications. The conducted simulations highlight that the proposed rectangular resonates at 38 GHz having a return loss of -31.305 dB., bandwidth is 0.978 GHz, VSWR is 1.055, As compared to other similar works, the proposed rectangular MSPA has achieved significantly higher performance in terms of bandwidth, beam-gain, return loss, and radiation efficiency.

This improved performance has been achieved because the antenna parameters (physical dimensions) are optimized by considering the performance trade-off between the parameters. The proposed rectangular MSPA has a compact size; therefore, it is suitable for mobile devices with space constraints, and it Can also be considered a potential candidate to be used in an array of 5G communication systems. Also, we worked on an Array antenna to improve results as gain and return loss.

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6.0 References

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