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Dual-Band Hexagonal Microstrip Patch Antenna For 5g Applications

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Hexagonal shape, radiation pattern, microstrip patch antenna, dual-band.

ABSTRACT:

The field of microstrip antenna has seen creative work lately. A smaller size performance antenna is required for applications with a wider frequency range, such as Bluetooth, WiFi, wireless networks, etc. due to the everincreasing need for mobile communication and the emergence of new technologies. Here in this paper, a compact hexagonal-shaped microstrip antenna fed by a microstrip line for dual-band operations with center frequencies at 25 GHz and 38 GHz is proposed and investigated. The proposed antenna operates in two different frequency bands from 24.1 to 26.3 GHz with a center frequency of 25 GHz and from 37.3 to 39.4
GHz with a center frequency of 38 GHz, 9.3 dB as Gain, 9.17 dB as Directivity and respectively 1.16 dB and 1.39 dB as VSWR (Voltage Standing Wave Ratio). The proposed antenna was simulated using Roger RT/ Duroid 5880 material for the substrate and its efficiency is 98.6% suitable for 5G applications. The software that has been used for this work is HFSS 15 (HighFrequency Simulation Structure).

I. INTRODUCTION

There are different types of microstrip antennas in wireless communications, the most common being the microstrip patch antenna. A microstrip antenna consists of very small conductive plates built on a ground plane and separated by dielectric substrates. The idea of patch antennas was first proposed in the early 1950s, but it wasn't until the late 1970s that the antenna community began to notice this type of antenna [1,2].

Microstrip patch antennas have the advantages of low profile, ease of fabrication, and compatibility with integrated circuit technology. It can be designed to operate over a wide frequency range (1-40 GHz) and can be easily combined into linear or planar arrays [3]. It can generate linear polarization, double polarization, and circular polarization. Microstrip antennas have different feeding techniques such as probe feed, aperture coupling, proximity feed, and insertion feed.

Conventional antennas in electronic systems are often bulky and expensive, so microstrip antennas are considered a breakthrough technology for compact communication devices and systems, especially remote applications where compactness is a highly desirable feature. It is considered. However, the traditional microstrip patch antenna has a very narrow bandwidth disadvantage. This poses a design challenge for microstrip antenna designers to meet broadband requirements. Various techniques are used to solve this problem, among which are the use of thick substrates with low dielectric constant, parasitic loading of patches on the same layer as the main patch, and stacked multilayer patches.

Microstrip patch antennas play an important role in wireless communications. It has a dielectric substrate, a ground plane, and a thin copper metal pad. The patch and the ground plane are separated from the dielectric substrate. There are many types of patch antennas, including circular, rectangular, square, oval, triangular, and dipole antennas. The most commonly used microstrip antennas are circular and rectangular in shape, but for this article, we will work on the hexagonal shape, which seems to bring a better valuation of the parameters of the antenna. These two patch antennas are used for the most demanding applications, especially in the field of 5G applications [6].

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For this design, the authors used a Roger RT/Duroid 5880 substrate with a dielectric constant of 2.2 [7]. Indeed, the substrate has a low dielectric loss and is composed of a reinforced PTFE material (ceramic or glass) suitable for high-frequency and broadband applications. Additionally, the low dielectric substrate improves efficiency and increases bandwidth. Moreover, the stray magnetic field is also increased due to the low dielectric constant of the substrate. These fringing fields at the ends of the microstrip patch antenna add in phase to produce the desired radiation. Therefore, this research focuses on providing high speed and high bandwidth with low return loss.

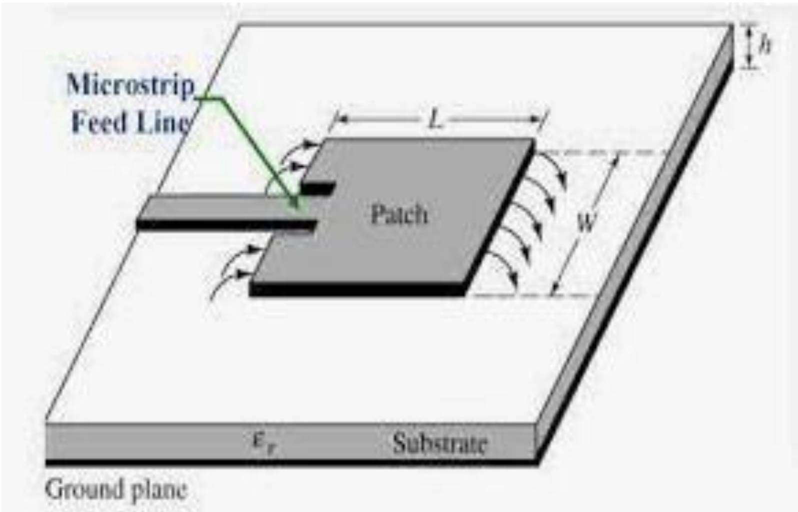

Figure 1. Rectangular microstrip patch antenna

However, the online teaching process requires high data rates and large bandwidths to improve the quality of online teaching, especially super-highquality video streaming, which is superior to existing 4G wireless systems. Existing 4G data rates are not suitable for 4K/8K Ultra High displays. Therefore, considering the above situation, we have developed a hexagonal microstrip patch antenna with high bandwidth, high gain, good reflection coefficient, and excellent antenna radiation efficiency. It uses the 5G millimeter wave band with a resonant frequency of 26 GHz and achieves high performance with high multiple input and output frequencies. Its 5G radio frequency spectrum specification in India is the millimeter wave band in the 24.5-29.5 GHz range.

II. DESIGN OF THE HEXAGONAL MICROSTRIP PATCH ANTENNA

5th generation applications require antennas with higher gain and directional beams that can be aimed in specific directions. Achieving such a high gain with a single antenna can be difficult. However, many designs can be made to achieve such high gains. For this case, we worked on designing a compact hexagonal antenna with substrate dimensions equal to 24 mm x 17 mm x 1.6 mm. The side dimension (A) of the antenna is 5 mm. The patches are printed on a Roger RT/Duroid 5880 substrate with a thickness of 1.6 mm and a dielectric constant of 2.2, and the ground plan is printed on the back of the substrate. The simulation of this project has been done with HFSS 15 (High-Frequency Simulator Structure).

To find the dimensions of the hexagonal microstrip patch antenna, we had to use the known equations [3] below using an operating frequency of 25 GHz.

To calculate the side of the hexagonal patch antenna (A):

$$A = \frac{c}{23.1033 * f\sqrt{\varepsilon_r}} \quad (1)$$

To calculate the radius of the hexagonal patch antenna (R):

$$R = A * \sqrt{\frac{2.598}{\pi}} \quad (2)$$

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To calculate the dimensions of substrate:

Ls=6h+λ (3)

Ws=6h+λ (4)

$$\lambda = \frac{C}{f * \sqrt{\varepsilon_r}} \quad (5)$$

Where C is the speed of light with C = 3*10^8 m.s^{-1} and f is the operating frequency of the antenna.

TABLE 1. DIMENSIONS OF THE SIMPLE HEXAGONAL PATCH ANTENNA

Configurations	**Parameters**		**Values (mm)**
Substrate	Ls		24
	Ws		17
	h		1.6
Patch	A		5
	R		4.75
	B		10.67
	C		2
Ground	Lg		24
	Wg		17

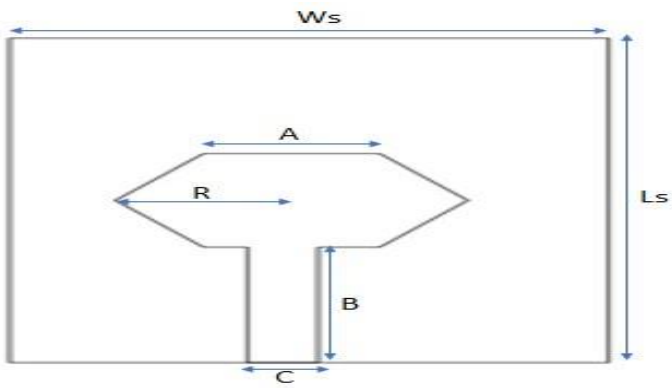

Figure 2. Design of hexagonal microstrip patch antenna

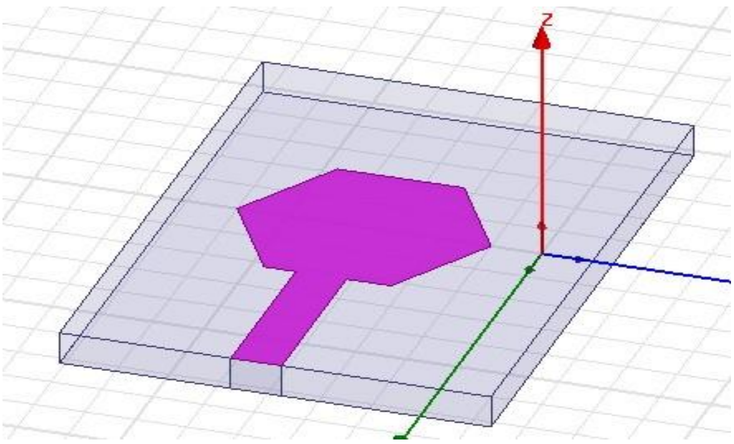

Figure 3. Design of hexagonal microstrip patch antenna in HFSS 15

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III. RESULTS AND ANALYSIS

In our study, we will focus more on the four parameters of the antenna, such as Bandwidth, gain, VSWR, and return loss (S_{11}).

Bandwidth (B) is the frequency range over which the antenna can operate and is given by the formula:

$$B = F_h - F_l \qquad (6)$$

where F_h represents higher frequencies and F_l represents lower frequencies [8].

Gain (G) is the maximum power a transmitter will transmit to a particular target. S_{11} is defined by the value of the power reflected by the antenna. The VSWR helps determine the efficiency of the transmit power [9].

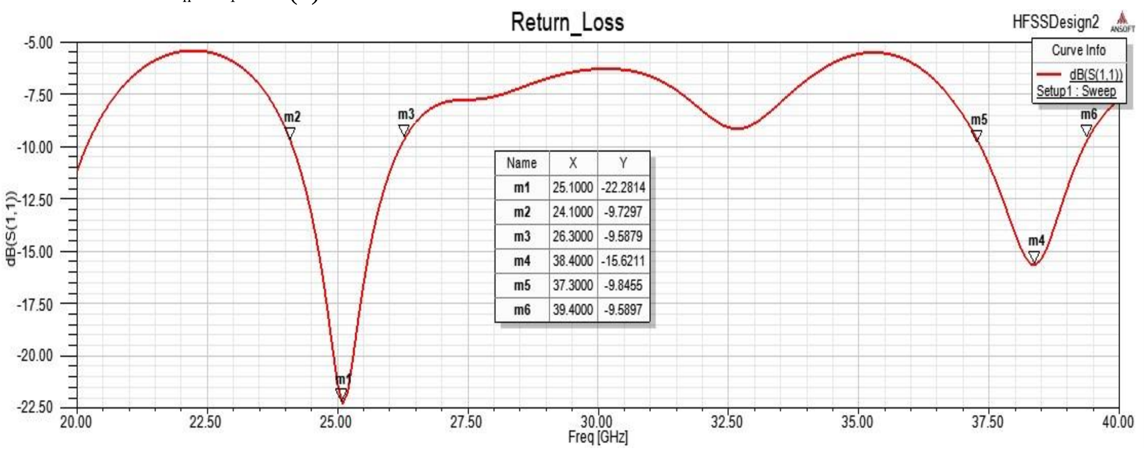

Figure 4. Return Loss of hexagonal microstrip patch antenna

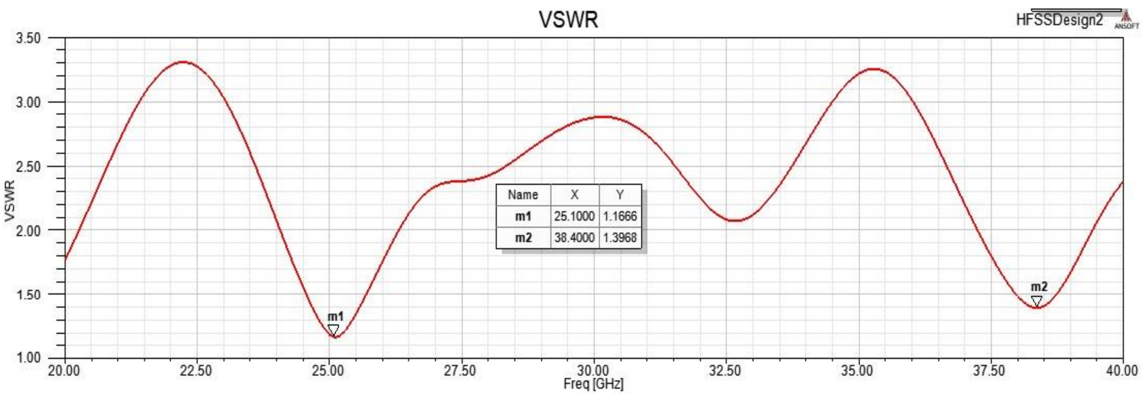

Figure 5. VSWR of hexagonal microstrip patch antenna

Figure 4 shows that the proposed antenna gave a reflection coefficient of -22.28 dB at 25 GHz and 15.62 dB at 28 GHz. This means that 0.006 W of the transmitted power is retransmitted in the back lobe at 25 Ghz and 0.027 W at 38 GHz. VSWR can be used to determine how much power is transmitted from a radio transmitter to a receiver and whether the signal transmission path is properly matched to the antenna. An antenna can easily be defined as a well-matched antenna if the VSWR is between 1 and 2 [9]. The VSWR can be seen in figure 5 and its values are 1.16 dB at 25 GHz and 1.39 at 38 GHz.

The antenna operates on two different frequency bands (B1 and B2), so it is important to note that based on figure 4, the first bandwidth goes from 24.1 to 26.3 GHz with a center frequency of 25 GHz and from 37.3 to 39.4 GHz with a central frequency of 38 GHz, So B1 = 2.2 GHz and B2 = 2.1 GHz.

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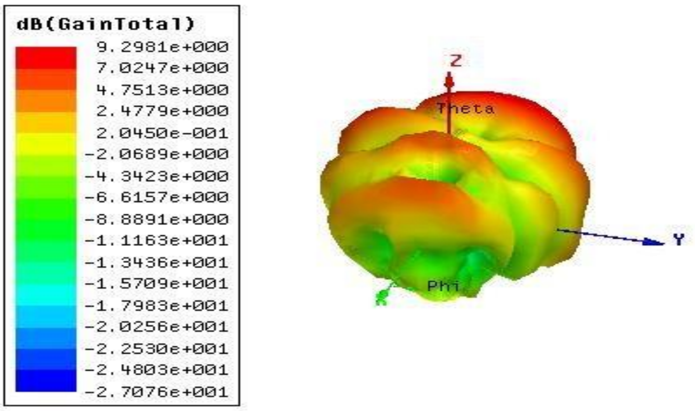

Figure 6. Gain of hexagonal microstrip patch antenna

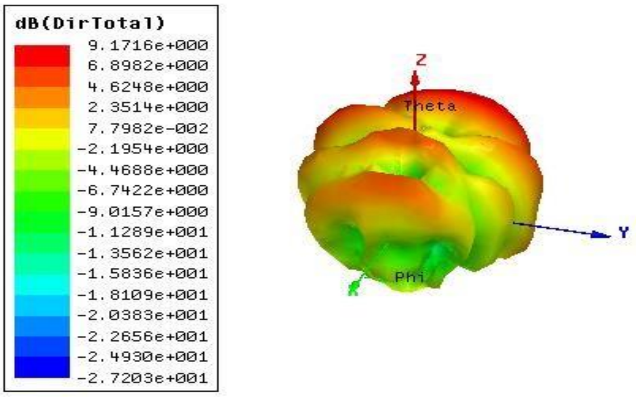

Figure 7. Directivity of hexagonal microstrip patch antenna

Our proposed antenna has a gain of 9.3 dB and is suitable for 5G applications in the frequency range of 24 GHz to 26 GHz. Basically, antenna gain is simply the amount of transmitted power concentrated in a particular direction. Directivity is sometimes thought of as antenna gain. However, it is the ratio of the intensity of radiation in a specific direction to the intensity of radiation in all directions [10, 11]. Directivity is also a special element of antenna parameters. After simulation, a directivity of 9.17 dB was obtained. Therefore, the efficiency of the antenna is approximately 98.6%.

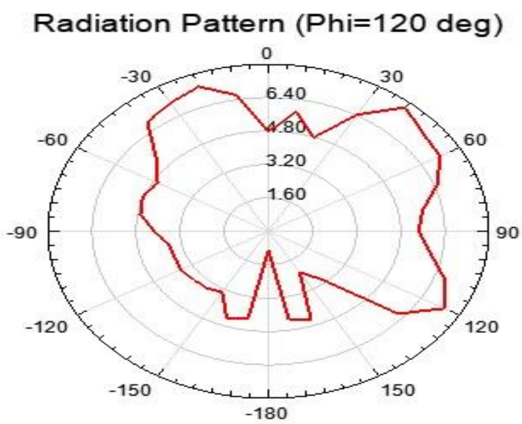

Figure 8. Radiation pattern of hexagonal microstrip patch antenna at Phi=120 deg

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TABLE 2. SUMMARY OF RESULTS

Parameters	**Values**
Operating frequency	25.1 GHz 38.4 GHZ
Bandwidth	2.2 GHZ 2.1 GHz
Directivity	9.17 dB
Gain	9.29 dB
VSWR	1.16 dB 1.39 dB
Efficiency	98.6 %

IV. CONCLUSION

The author of this article proposed a dual-band hexagonal microstrip patch antenna for 5G applications. Our proposed antenna has 2 different bands of frequency with a high gain and good values of VSWR. The summary of results in Table 2 shows that this antenna is very suitable for any application with operating frequencies from 24-26 GHz and 37 GHz to 39 GHz such as 5G technology. In the future, we should fabricate the proposed antennas and

compare the results with simulated antennas.

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