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CPW FED Square Patch Antenna for 5G Applications

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Abstract: - In this paper, we proposed a novel compact square patch radiator and coplanar wave guide fed antenna for 5G communication application. The proposed antenna has comact size of 22x22x1.6mm^3 and it operate from 3.5 and 4.5 GHz. The resonant frequency having maximum return loss value of -22dB across the operating frequency and VSWR <2dB for 5G communication. This proposed antenna has been studied using Finite Element Method numerical techniques. The proposed structure is a high gain, low cost, low weight antenna. The characterstic analysis such as return loss, VSWR, radiation pattern of this antenna has been investigated numerically. Simulated results are carried out using HFSS software.

Keywords: *5G communication, CPW, Double square patch, antenna parameters.*

1. Introduction

One of the most widely used types of antennas these days, for the most part, integrated with the sampled count of operating frequency under the discretised approximation of 1-8 GHz existed with the microstrip patch antenna. This type of antenna development began seriously in the 1970s when communication networks became firmly established at frequencies whose size and design was beneficial. In the meantime, it was attractive for mobile and rocket applications because of its light mass within the approach of mid-level outline compared to reflections in the parabolic shape that has been categorised in developing the antennas. These precise characteristics, combined with further size reduction using materials under consistency rate maximum for the patch structured antennas within handsets, receivers and transmitters, developed GPS methods including various additionally centred products commonplaces recently. Basic information on the design and use of patch antennas is anticipated to be provided by this study. We can better understand the simulation of a square patch antenna with the help of the data in this research. Fundamental elements of any wireless communication system are antennas. Several antennae designed with the periodic classification fed for the antenna waving to travel within the strip establishment that further generates in the reflection work designs a tiny strip antenna operating at 2.25 GHz. Microstrip antennas are increasing in value due to their ability to be explicitly printed onto a circuit board. The mobile phone industry makes significant and conspicuous use of microstrip antennas. The cost of microstrip antennas is low, they are safe, and they need little work to do.

Patch antennas have many uses since they are easy to manufacture using printed circuit technology, compact, and conform to surface variations. Development through the patch design holding the dimension length; l with reach in value at a lower rate than g/2 (where g represents the substrate's guiding wavelength). Higher efficiency and more enormous data transfer are made possible by thicker substrates with lower dielectric constants but at the expense of larger component sizes. Thin, more dielectric-constant substrates cause smaller element sizes, minimise coupling, have lower proficiency and generally show a relatively fast bandwidth. Several circularly polarised applications have increased their use of microstrip patch antennas due to their safety position and advantageous radiation characteristics. The development of modern wireless systems in the last few decades has sparked extensive research on tiny strip radiators, focusing on improving performance and shrinking. For communication systems to deliver assurance of unwavering quality, versatility, and high production qualities, superior gain value, compactness, and structural design can be generated within the antennas are required. It represents a different approach to the development of application-oriented wireless transfer because of the growth in the creation of thinner, lighter, less expensive, low-profile, and more reliable antennas for wireless devices. The planar architecture within the side of the substrate can be radiated through the patch designed in the antenna. The main benefits include low profile, planar and nonplanar surface conformability, lightweight, and ease of fabrication. The antenna's low profile and conformal design make it suited for high-speed vehicles, aeroplanes, spacecraft, and missiles **[1], [2], [3]**.

The dielectric Superstrate enhances antenna performance while shielding the patch from weather and environmental risks **[7]**. Impedance can be mapped within the patchwork shaped in various formats structured through the superstrate development in a circular configuration designed within the examination of researchers **[3], [4], [5],** and **[6]**. (radome). Numerous scholars study the various circular and square patch microstrip antennas. The examination can be impacted for dielectric medium designed in approaching the antenna developed pitch stripped was published by K.M. Luk et al. in **[8]**. The patch's bandwidth is slightly changed while its resonance frequency is reduced. Hussain has studied the performance of microstrip antennas coated in a dielectric layer. An et al. **[9]**. He discovered the findings of his simulations, which demonstrate that while the gain decreases with increasing dielectric layer thickness, the antenna resonance frequency increases. According to R.K. Yadav et al. **[10]**, the dielectric constant of the Superstrates causes loss returned for enhancement of VSWR. At the same time, the frequency can be directed in dropping with the resistive rate for shifting beyond the decremental transparency in modelling to the distance created gain conditioned facilitated to the determination varied in the layer developed in covering the thickness according to Hussein Attia et al. **[11]**. The resonance conditions necessary to produce the highest gain are determined using the transmission line analogy and the cavity model. Layers in which the design can be superstrated to the base structure of improved thickness in the model approach can be deployed as studied by Samer Dev, Gupta, et al. **[12]** and significantly impact gain and efficiency. Gain increases significantly when the substrate and superstrate layer thicknesses are appropriately chosen.

The improvement reached in the investigation developed in the case of a rectangular-shaped antenna format under a specific frequency range sampled among 1 THz, including the cover layer of the substrate of material suggested through the work projected by Mohammed Youness et al. in **[13-17]**. They have achieved the desired matching bandwidth and maximum radiation gain; however, they haven't looked closely at how Superstrates' effects on patch antennas are caused by changing thickness and dielectric constants. We created a rectangle and square patch microstrip antenna based on the transmission line model. The material of the substrate and Superstrate has the same dielectric constant. Investigations have been done into the Superstrates' dielectric constant impact, causing a rise in the resonance frequency. Additionally, it has been noted that as the dielectric constant of the Superstrates increases, bandwidth besides gain fall during return loss and VSWR increase. The thickness of the Superstrate causes an increase in input impedance.

This study proposes a downsized dual band antenna design for wireless applications using a double square patch antenna with an asymmetric CPW feed. We have contrasted the outcomes of simulations with those of a literature review.

2. Design of the Antenna Developed

The proposed antenna structure is shown in Figure. 1which is printed on and FR-4 susbtrate (dielectric constant 4.4 and loss tangent tan $\delta = 0.002$) the antenna simply consists of low dielectric loss substrate, CPW feeding line. The geometry of the antennas in this section was decided by the parametric study of each element in the software. The proposed antenna consists of substrate, ground, radiating patch and feed. The patch is connected to a feed line. The thickness of substrate is 1.6mm and used as the substrate material. It has the high permittivity and low dielectric loss substrate material.

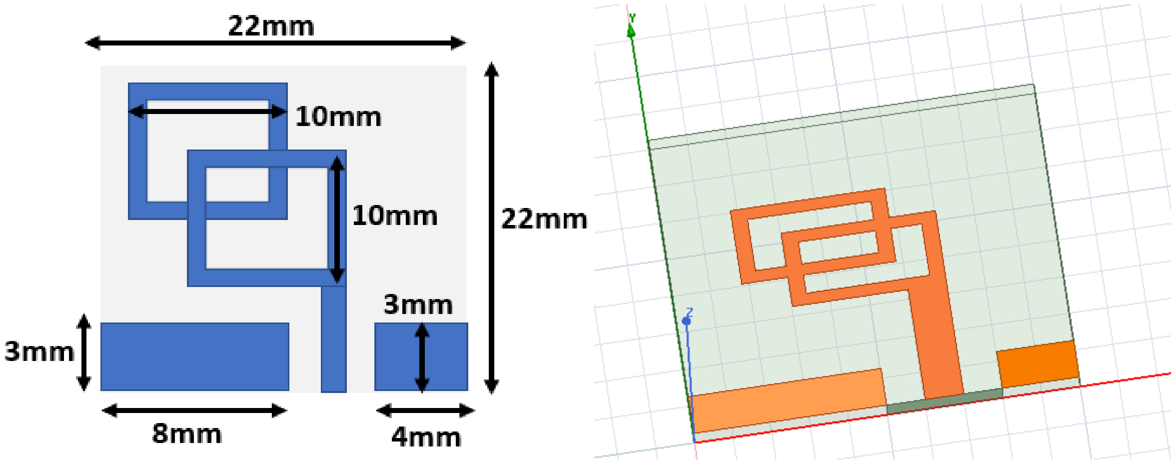


Fig.1. Representation view for antenna featured as double square patch conjunction to asymmetric CPW feed

Figure 1 illustrates the proposed patch antenna double square patch with asymmetric CPW feed within the geometry of the antenna is small and straightforward. This antenna comprises a double square patch with asymmetric CPW feed.

Width of the patch

$$\frac{C}{2f_0}\sqrt{\frac{2}{\varepsilon_r+1}}$$

λ is wavelength
C is Velocity of light (3 * 108 m/s)
f0 is Operating/ Resonant frequency (in GHz)

(1)

Length of the patch

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{\left[\frac{-1}{2}\right]}$$

(2)

Where, εr is the relative permittivity of the substrate h is the thickness of the substrate and is given by

$$h = \frac{0.0606\lambda}{\sqrt{\varepsilon_r}}\ h = \frac{0.0606\lambda}{\sqrt{\varepsilon_r}}$$

(3)

The incremental length of the patch along its length has now been extended on each end by a distance ΔL and is given by empirical formula

$$\Delta L = 0.412h * \frac{(\varepsilon_{eff}+0.3)*\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)*\left(\frac{W}{h}+0.8\right)}$$

(4)

The effective length is

$$L_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{eff}}}$$

(5)

The length of the patch is finally given as

$$L = L_{eff} - 2\Delta L \tag{6}$$

The fed location design The position of the fed can be obtained by using

$$X_f = \frac{L}{\sqrt{\varepsilon_{reff}}} \tag{7}$$

Where Xf is the desire input impedance to match the fed and reff ε is the effective dielectric constant.

$$Y_f = \frac{W}{2} \tag{8}$$

3. Results and Discussions

Various types of printed monopole antennas are investigated for wireless applications, including circular, square, elliptical, hexagonal, pentagonal, octagonal, and so on. Such shapes have been associated with asymmetric CPW feed with a double square patch for the consideration of analysis within the design developed.

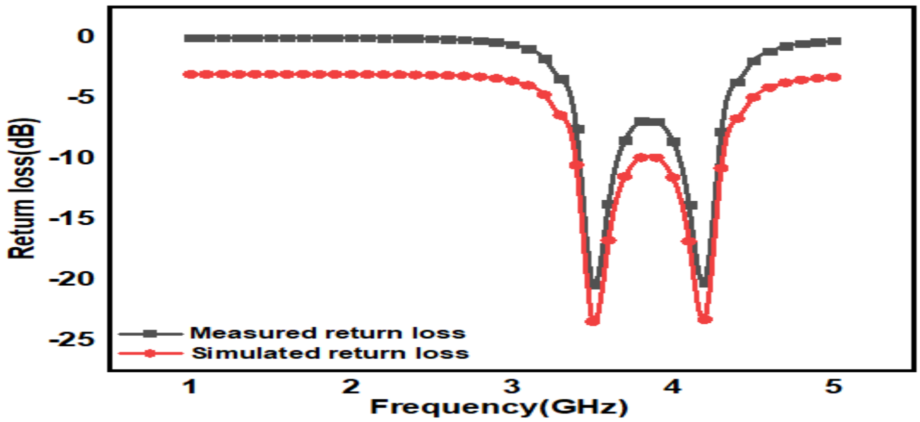


Fig.2 Return loss value

Figure 2 states the loss range returned for the antenna proposed over several ranges of frequency employed, and it is observed that the return loss value is -22dB across the operating frequency of 3.5GHz, similarly across the operating frequency of 4.2 GHz, the antenna stating the return loss value of -22dB. The implementation of the double square patch with asymmetric CPW feed of the proposed antenna shows high-performance values in the antenna parameter in figure 2.

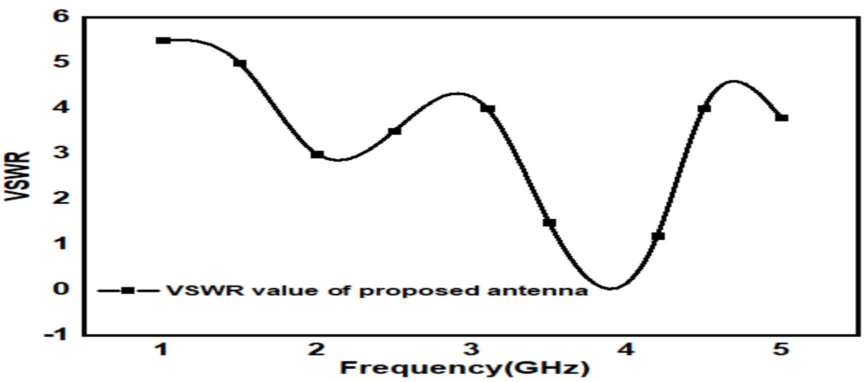


Fig.3 VSWR value of the proposed antenna

Figure 3 depicts the value of VSWR, which denotes the impedance mapped to the structure built with the antenna incorporating the signal passed in the line across the operating frequency. The proposed antenna has the VSWR value of 1.5 across the operating frequency of 3.5GHz, similarly across 4.2 GHz frequency functioning, stating the VSWR value at 1.5 and 1, which are in the acceptable range. The implementation of the double square patch with asymmetric CPW feed of the proposed antenna shows high-performance values in terms of the antenna parameter in the system model.

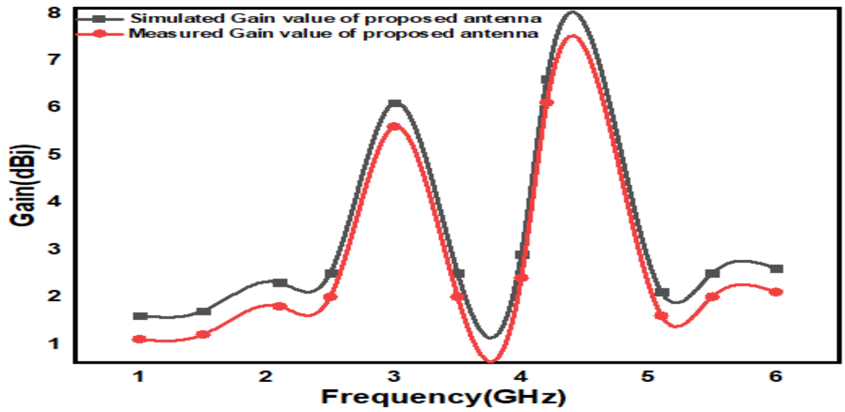


Fig.4 Gain value of the proposed antenna

Figure 4 shows the proposed antenna stating the gain value of >2.5dbi across the operating frequency of 3.5, and 4.2, which are used in wireless band applications.

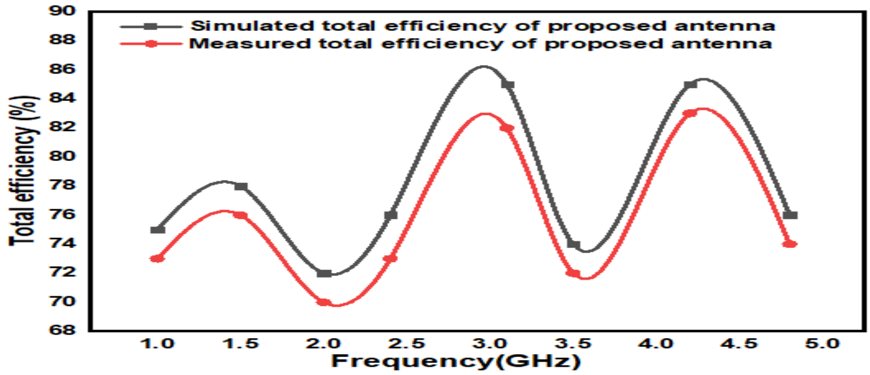
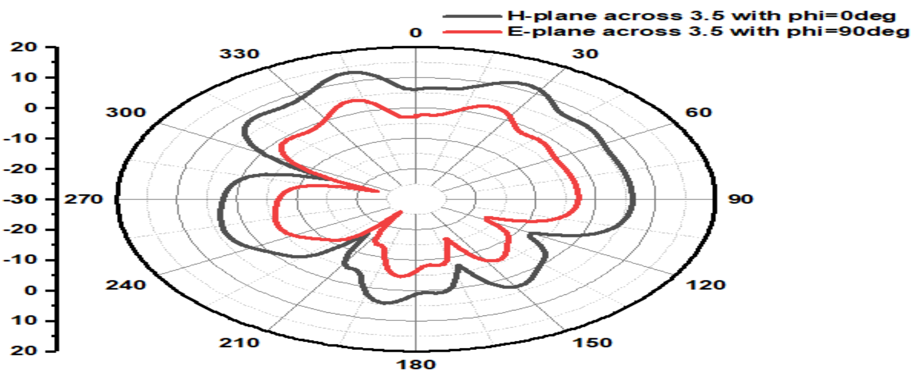
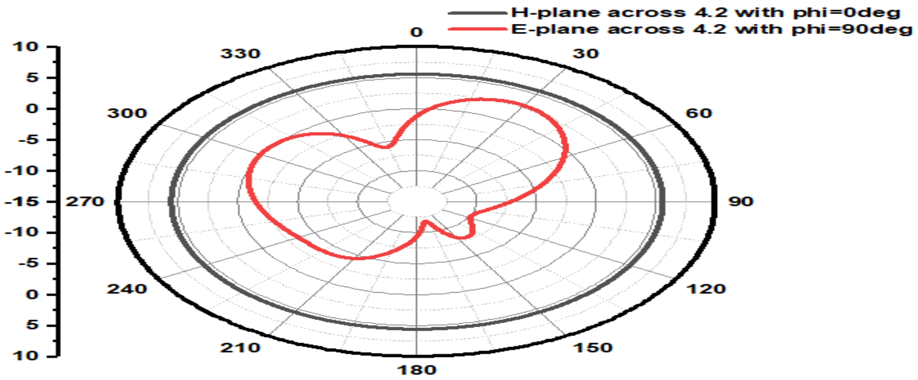


Figure.5 Efficiency value of the proposed antenna

Figure 5 demonstrates the proposed antenna stating an efficiency value of >85% across the operating frequency of 3.5GHz. Next, across the operating frequency of 4.2 GHz, the proposed antenna shows an efficiency value of >85%.



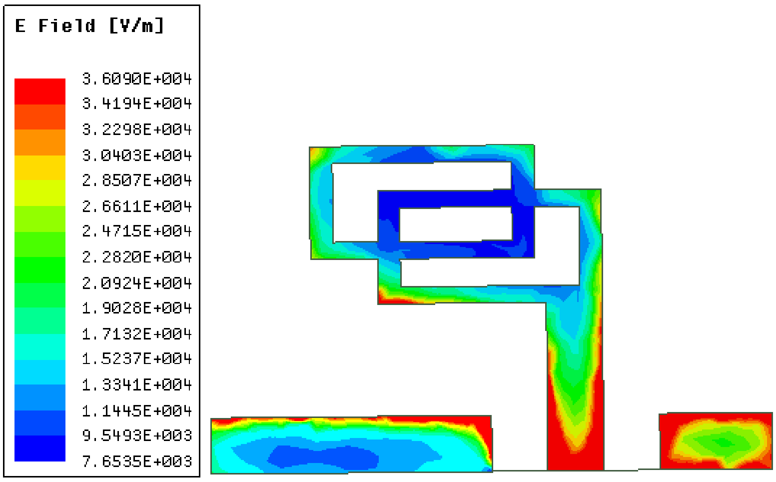
(a)



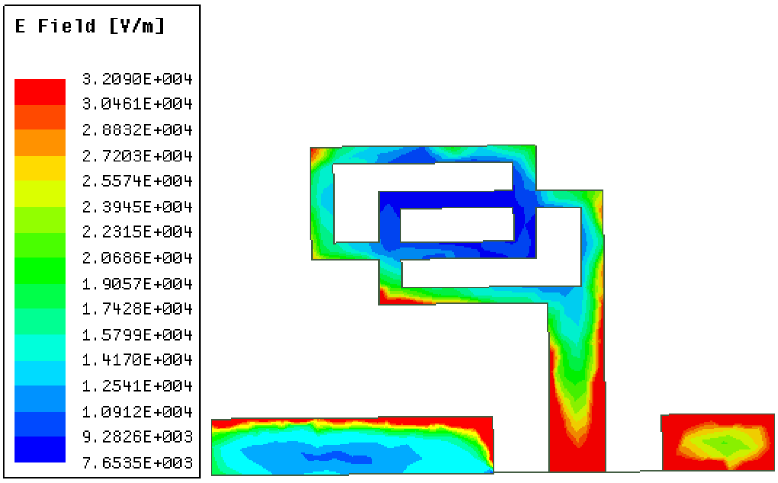
(b)

Fig.6. Radiation patterns analysed across the operating frequency

Figure 6 gives the analysis of the proposed antenna stating the radiation pattern across the operating frequency 3.5GHz, and 4.2 GHz. The antenna shows the Omni direction in the h-plane and singles and butterfly shape in E-plane.



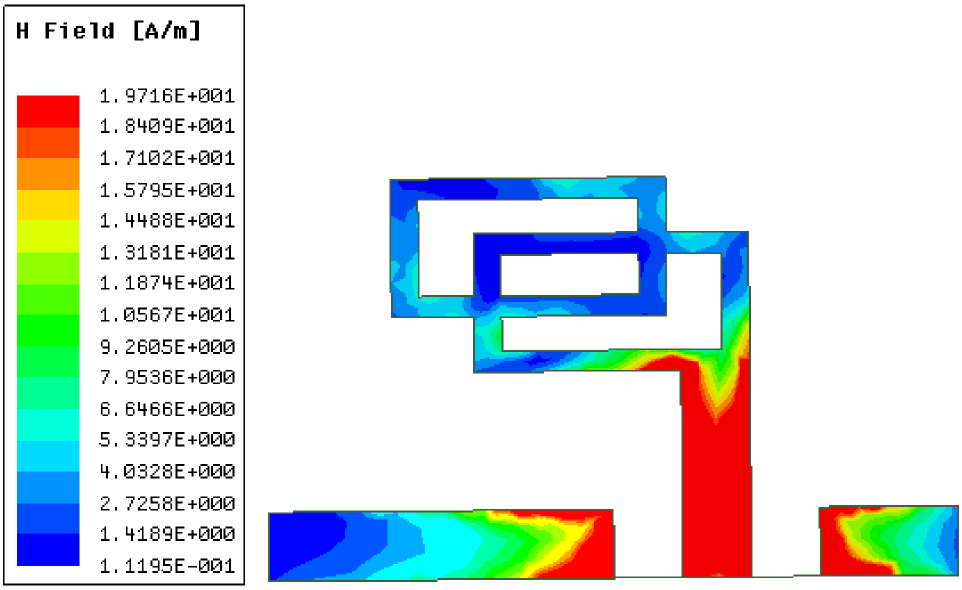
(a)



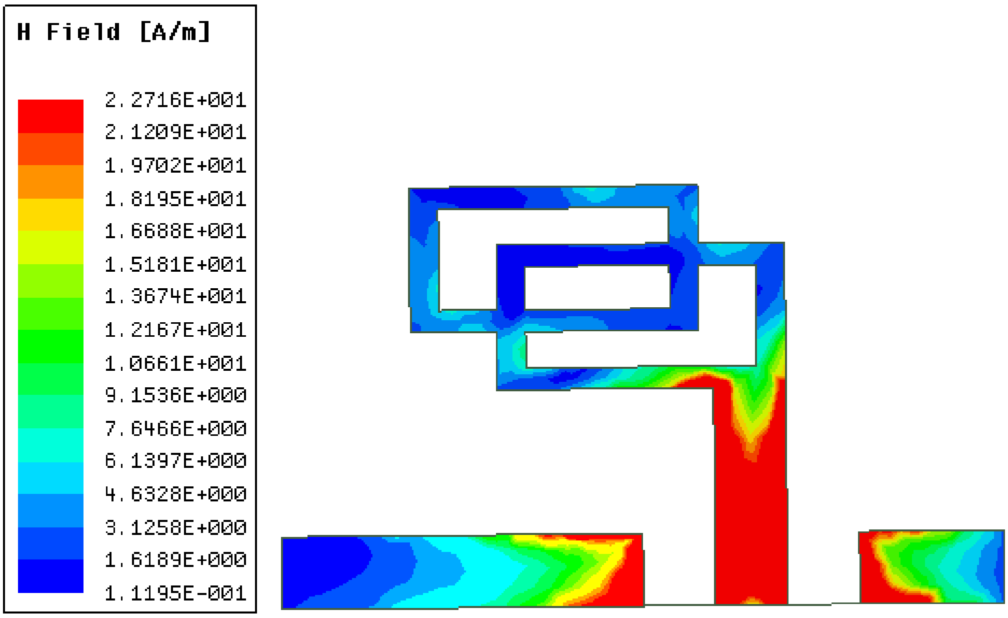
(b)

Fig.7 Electric field distribution of proposed antenna

Figure 7 states the electric field distribution of the proposed antenna across the operating frequency 3.5 and 4.2 GHz with the value of 3.6 and 3.2e^4 V/m as the frequency shifts from left to right. The red colour indicates the maximum radiation and blue colour indicate minimum radiation and similarly green colour indicates the average distribution of the electric field.



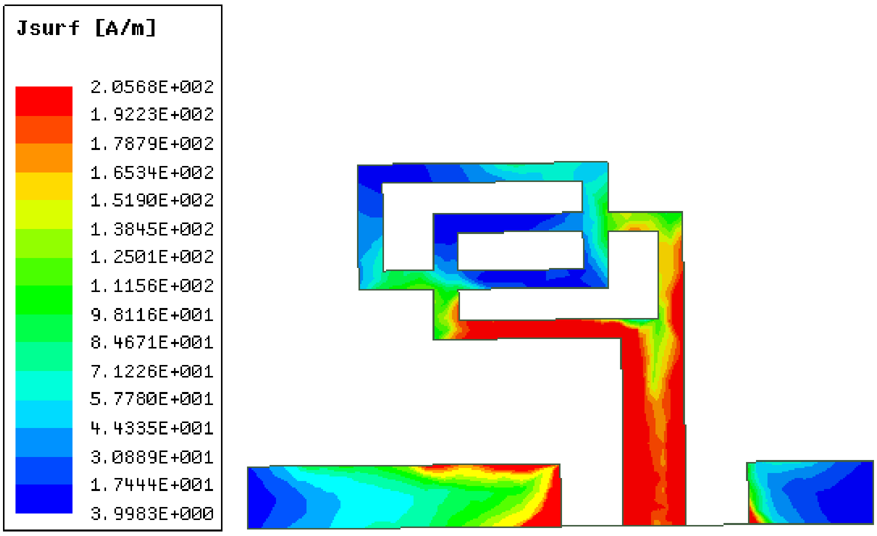
(a)



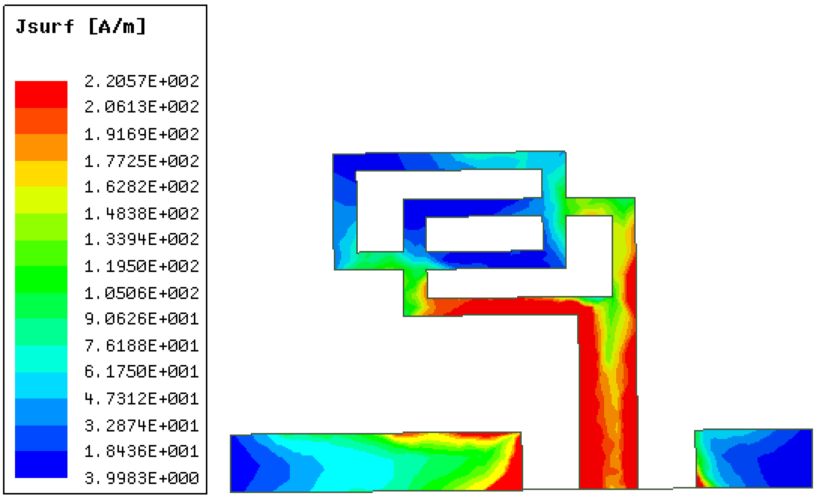
(b)

Fig.8 Magnetic field distribution of proposed antenna

Figure 8 states the magnetic field distribution of the proposed antenna across the operating frequency 3.5 and 4.2GHz with the value of 19 and 22 A/m as the frequency shifts from left to right. The red colour indicates the maximum radiation and blue colour indicate minimum radiation and similarly green colour indicates the average distribution of the magnetic field.



(a)



(b)

Fig.9 Surface current distribution of proposed antenna

Figure 9 states the Surface current distribution of the proposed antenna across the operating frequency 3.5 and 4.2 GHz with the value of 205 and 220 A/m as the frequency shifts from left to right. The red colour indicates the maximum radiation and blue colour indicate minimum radiation and similarly green colour indicates the average distribution of the surface currents.

Table.1 Comparison of work of proposed antenna with a literature survey

Ref	Dimensions(mm)	Operating frequency (GHz)	Bandwidth (B.W)	Peak Gain(dBi)
[14]	39×40 x1.6	2.6 - 12.3	0.3	2
[15]	38×25 x1.6	2.4 – 6.0	0.55	2.5
[16]	19×21 x1.6	2.78 – 12.92	0.65	1.5
[17]	18×25 x1.6	4.5-13.5	0.75	2.2
Proposed Work	22x22x1.6	3.5 and 4.2	0.8,0.6	6,7.8

Table 1 shows the comparison among the proposed and existing antenna configuration regarding their dimension, frequency in which the functioning of the network is made, bandwidth attained, and peak gain reach.

4. Conclusion

The research studied the dual-level band featuring the double square-patch architecture antenna with asymmetric CPW feed covering 5G communication applications across bands of 3.5 and 4.2 GHz under the gain reach evaluated with specific patterned structures. The Double square shaped patch antenna including asymmetric CPW feed improves performance of the proposed antenna acting the elementary component of radiation, enabling the capability in applications orienting the multiple range responsibility under wireless technology. Modelling the design through the compacted network with ease in construction, thus achieving simple fabrication using available FR-4 material.

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