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Fractal antenna for Multiple C band application

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Abstract
The article puts forth an Octagonal SRR-based Fractal geometry. The Conventional Octagonal patch serves as the main antenna. To create the suggested structure in the first iteration, 0.5 scaling is done and in the second, by 0.25. The antenna is only 60mm x 64mm x 1.6mm in size. Operating frequencies for the proposed structure are 5, 6.7, and 7. GHz. In all of the operating bands, the gain and directivity are greater than 3.25 dBi and 4 dBi. Surface current and return loss are used to analyze the fractal's impact. According to the outcomes of simulations of various parameters of the antenna. the suggested antenna is a strong choice for C-band wireless applications.
Keyword: Octagonal SRR, Fractal, Metamaterial, Microstrip feed, Tri-band

Introduction:

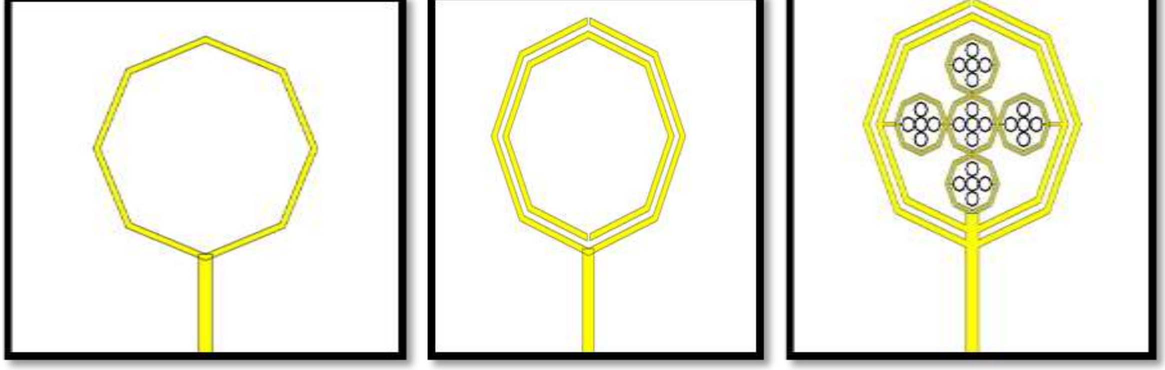
A crucial consideration in the design of a wireless antenna is its physical compactness, or size reduction with good radiation characteristics. The other two crucial criteria taken into account in modern wireless antenna design are multiband and wideband properties [1,2]. Due to its versatility in fabrication and inexpensive cost, microstrip patch antenna is frequently used for such antenna. Due to its limited bandwidth, low gain, and low radiation efficiency, the microstrip patch antenna performs poorly and has a low profile. With the aid of a patch, a number of applications [3,4] are made possible, from wearable to wireless communication.

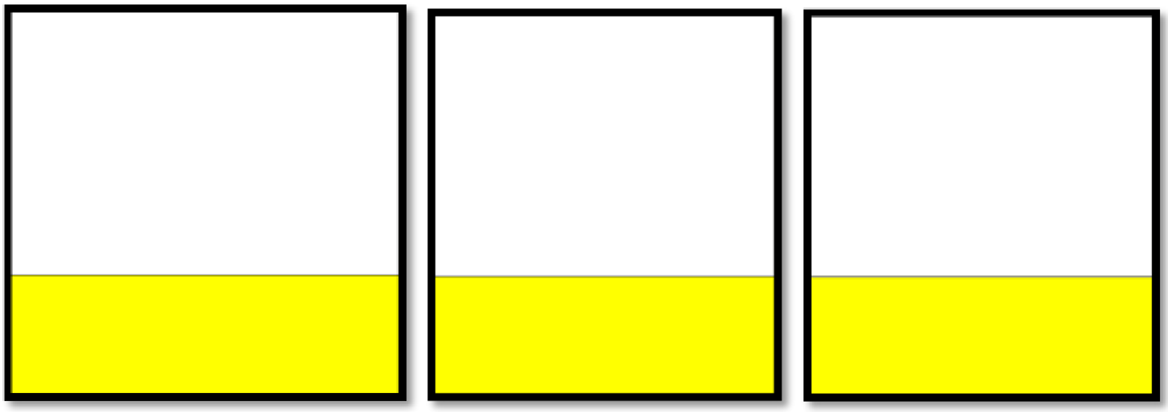
Different types of approaches [9-11] include defective ground structure, the addition of slots to the ground, slotted patch, meandering, and metamaterials have been used to boost the microstrip patch's functionality [5-8]. Researchers are particularly interested in the metamaterial [4-7] because of its peculiarly negative constitutive characteristics. Negative permeability, permittivity, and refractive index are examples of anomalous properties that are related to the structure of the substance rather than its chemical components. A variety of metamaterial structures have been produced in the literature, of which the split ring, complementary split ring, omega shed, S, and eight shaped resonators are used. The EM energy is efficiently radiated is enhanced by the taking up space and being similar to oneself characteristics of fractal geometry., including multi-band features [12,13] and bandwidth enhancement. In order to accomplish miniaturisation by extending the effective length, a number of fractal geometries, including the Sierpinski, Koch, and Minkowski geometries, have been presented in the literature. They are also used to increase gains, but their main disadvantage is that they are complex in nature and difficult to fabricate because of their space-filling characteristics.

In order to address the C band wireless applications like WLAN, RADAR, and satellite communication at 5,6.7, and 7.1 GHz, a self-similar Octagonal Dual ring SRR is proposed in this paper. This article suggests a self-repeating fractal structure for an Octagonal Split Ring Resonator. The suggested pattern has a straightforward, less intricate self-repeating structure. To create multi-band properties, metamaterial and fractal are combined. The suggested antenna's design process is given in section II. The proposed antenna's results are reported in section III, and the conclusion is presented in section IV.

2 Octagonal SRR Fractal Antenna Design:

The three phases of development for the proposed Ant 1, 2, and 3. Ant 3 is the suggested fractal antenna, while antennas A and B are straightforward Octagonal single rings. The suggested antenna is constructed on a FR4 substrate and measures 60mm x 64mm x 1.6mm in dimension. Figure 1 shows the progression of the suggested structure. The suggested structure and parameters are shown in Figure 2, and the parameter values are shown in Table 1..





Ant 1 Ant 2 Ant 3

Figure 1 Evolution of Antenna

Table 1 Parameter value in mm

L	W	A	B	C	d
64	60	17	0.5	14	7
U	v	W1	Wf	Lf	h
0.5	0.5	4	2	16	1.6

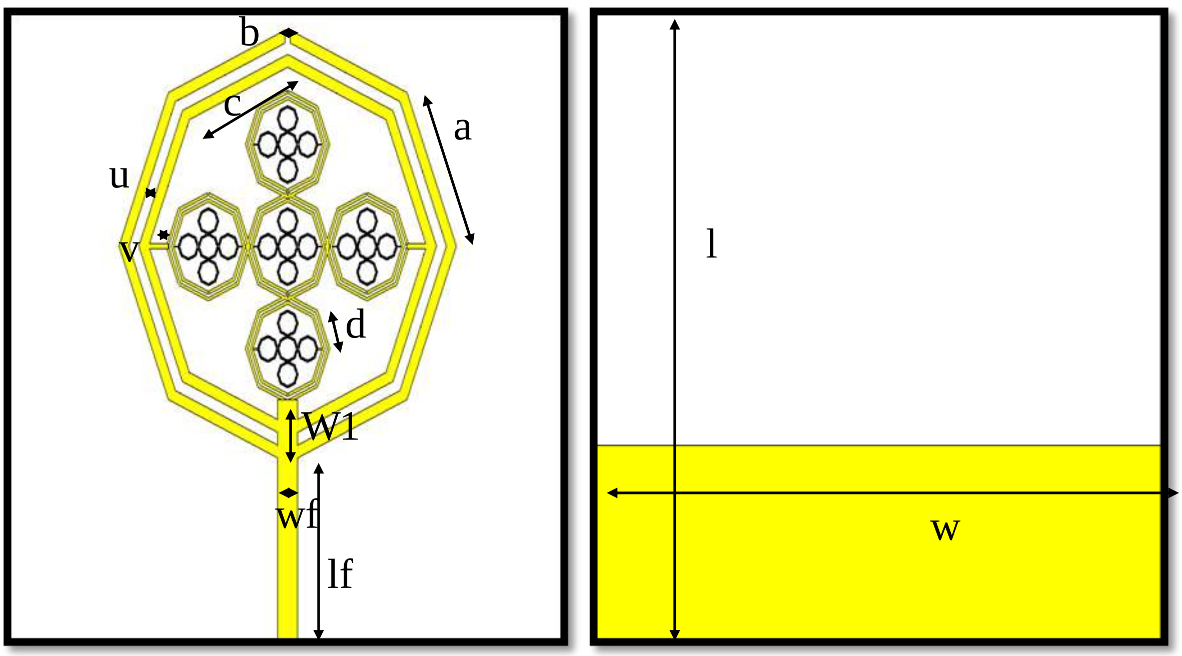


Figure 3 Proposed Structure

The Ant 1 is a straightforward octagonal antenna with a 50-ohm microstrip feed.. The defective ground structure is all that remains of the ground. 5 GHz is the intended frequency range for the Ant 1. Figure 4 shows the simulated return loss outcome. The antenna works between 4.2 and 5.3 GHz and has a return loss of -20.08 dB. Plotting the VSWR versus frequency in Figure 4 makes it abundantly evident that the value is less than 2 in the frequency range of 4.2 to 5.3 GHz.

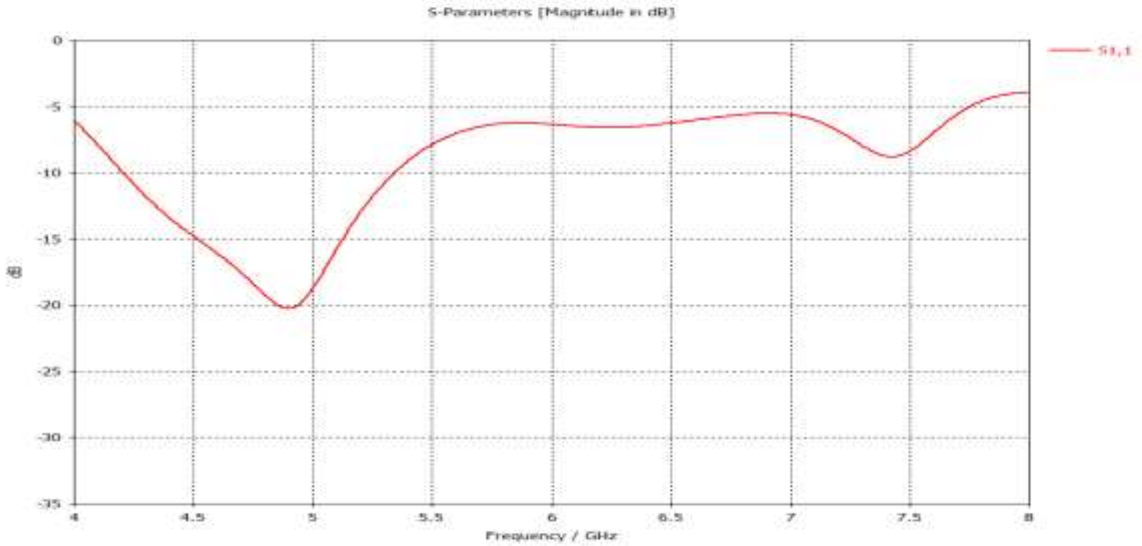


Figure 4 Return loss Ant 1

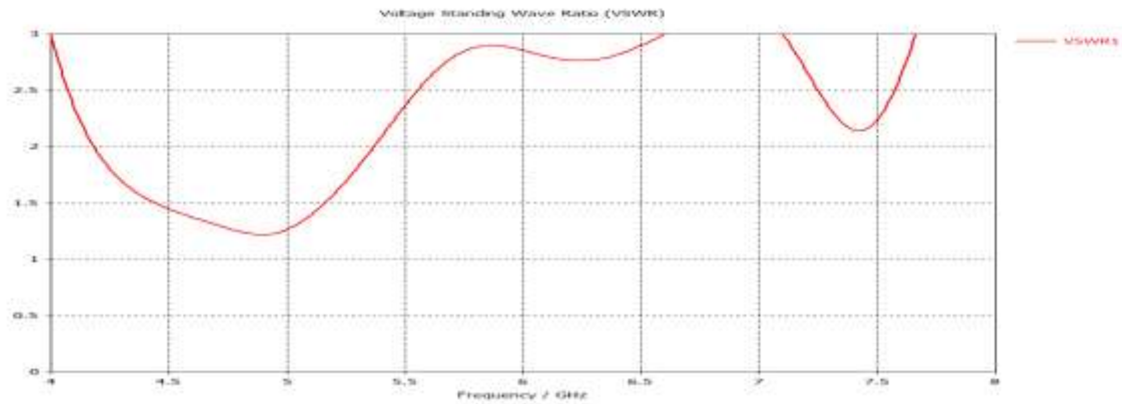


Figure 5 Ant 1 VSWR

Then, another octagonal ring with slits on the opposite side is incorporated into the Ant 2's design. The proposed octagonal SRR has a dual band resonant frequency of 6.4 GHz and 5 GHz. The planned Ant 2's operational range is from 4.61 GHz to 5.31 GH. However, the impedance matching has decreased since SRR was introduced.

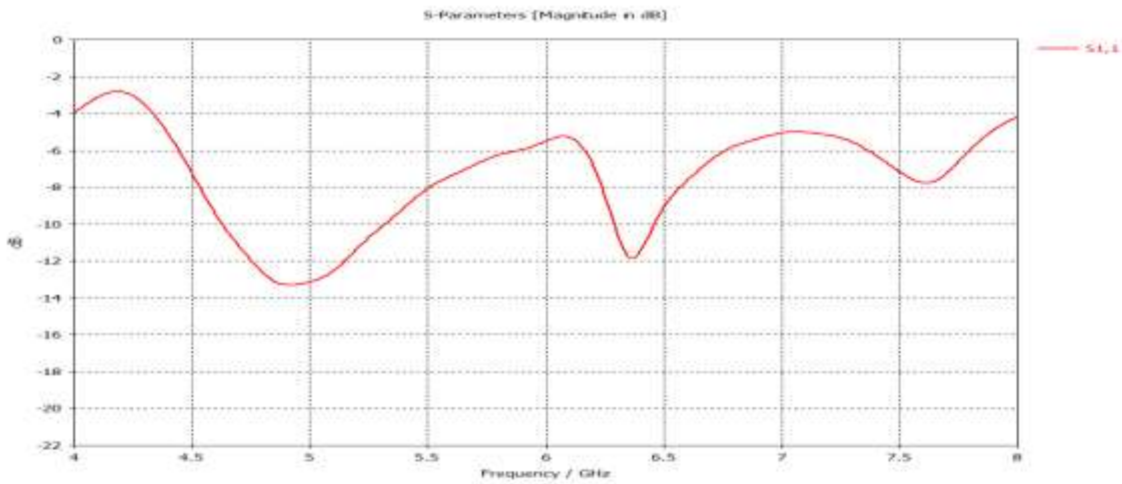


Figure 6 Return loss Ant 2

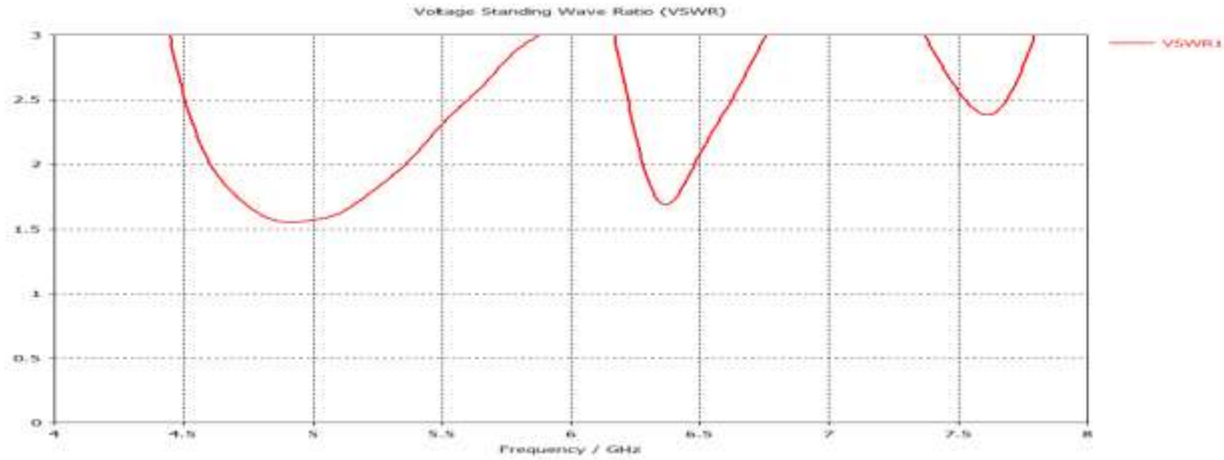


Figure 7 Ant 2 VSWR

The proposed antenna is then designed using the fractal structure. In two steps, the fractal shape is introduced. In the first phase, the octagonal SRR is scaled by 0.5 and organised in a plus-shaped pattern. The second iterated shape is scaled by 0.25 in the second phase. The surface current is modified when the effective electrical length increases when fractal structures are used. The impedance is matched as a result of the change in surface current. The suggested structure operates in dual bands from 4.65 GHz to 5.29 GHz, resonating at 5 GHz, and from 6.52 GHz to 7.36 GHz, resonating at 6.7 GHz and 7.1 GHz. Figure 8 depicts the proposed antenna's return loss, and Figure 9 depicts the VSWR of the proposed Ant 2, which shows VSWR less than 2 in the operating band.

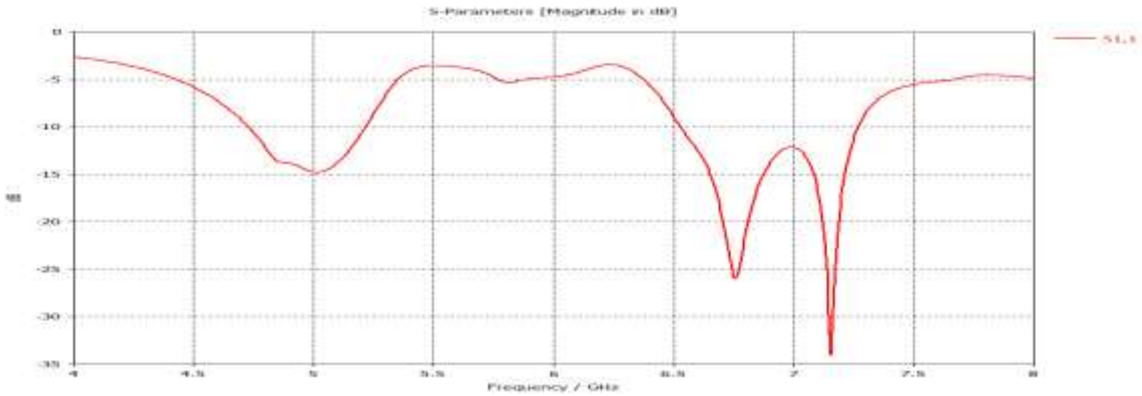


Figure 8 Return loss Ant 3

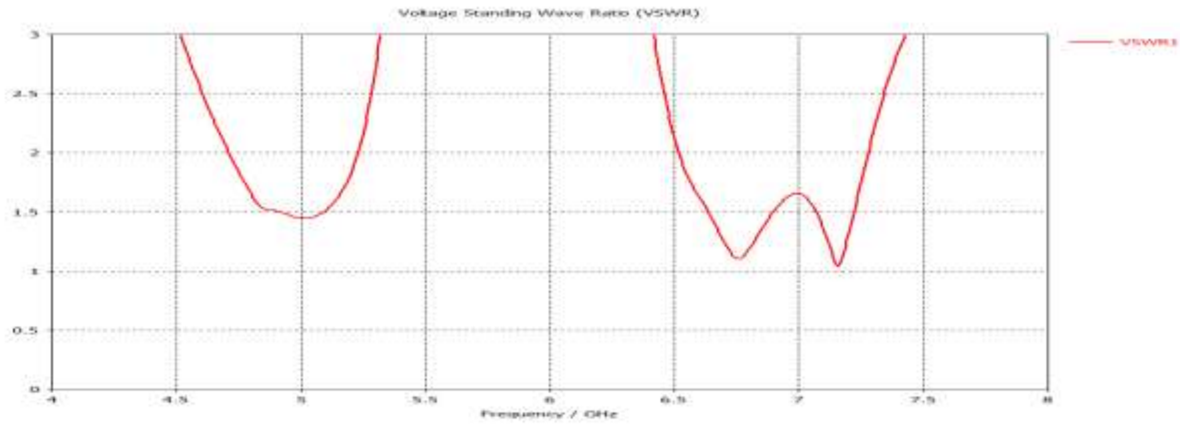


Figure 9 Ant 3 VSWR

4.Result and Discussion

The return loss of antennas A, B, and C is plotted in figure 10, which clearly shows that the inclusion of metamaterial causes the antenna to resonate at dual-band, and then the bandwidth of the higher frequency is increased following the introduction of fractal structure. The Ant 1 is a single band antenna that spans the frequency range of 4.2 to 5.3 GHz and has a bandwidth of 1130 MHz. The proposed structure has impedance bandwidths of 770 and 160 MHz and operates between 4.6 and 5.3 GHz and 6.3 and 6.4 GHz, respectively. The electrical current route is then expanded by using fractal geometry, which improves the impedance and bandwidth of the proposed antenna. The 640 MHz and 840 MHz impedance bandwidths of the proposed antenna operate between 4.6 and 5.2 GHz and 6.5 and 7.3 GHz, respectively.

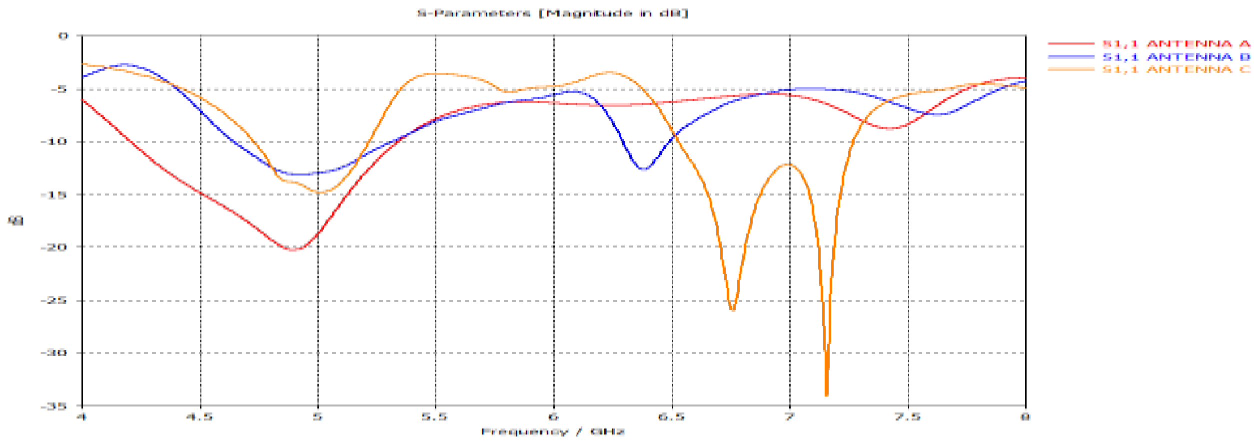
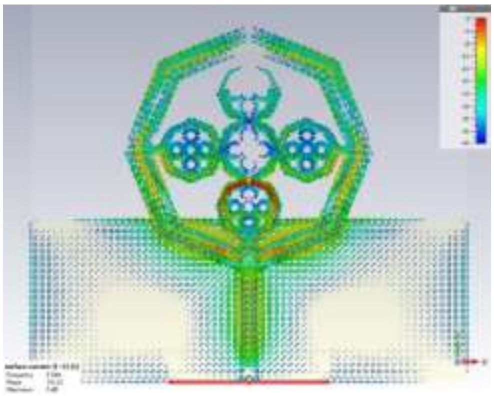
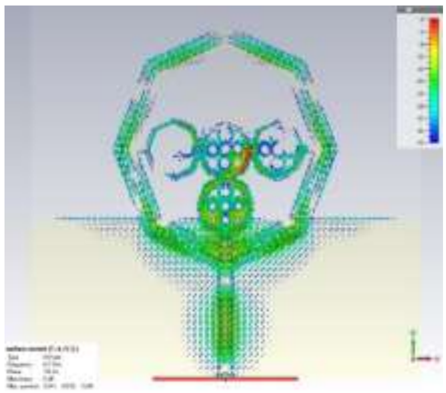


Figure 10 Ant 1,2 and 3 – Return loss comparision

The suggested antenna's surface current distribution is shown in Figure 11. The outermost portion of the octagonal ring is obviously where the surface current is focused at 5 GHz. This demonstrates unequivocally that the SRR ring controls the 5GHz frequency. As seen in figures 11 b and 11 C, the surface current is present in the fractal structure, showing that the insertion of the fractal structure is what causes the wideband with dual resonance from 6.52 GHz to 7.36 GHz.


a) 5 GHz


b) 6.7 GHz

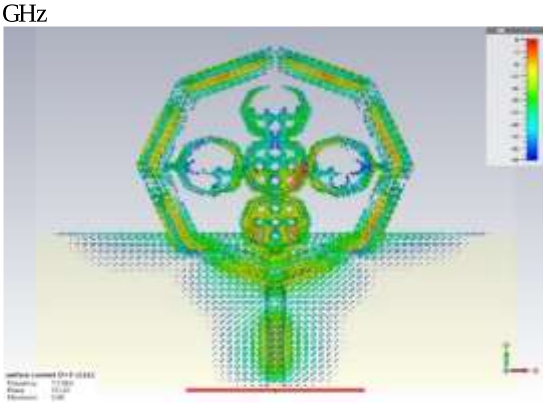
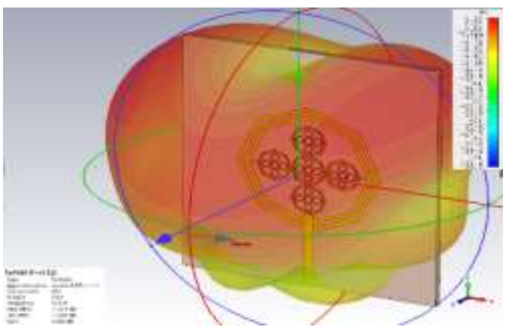
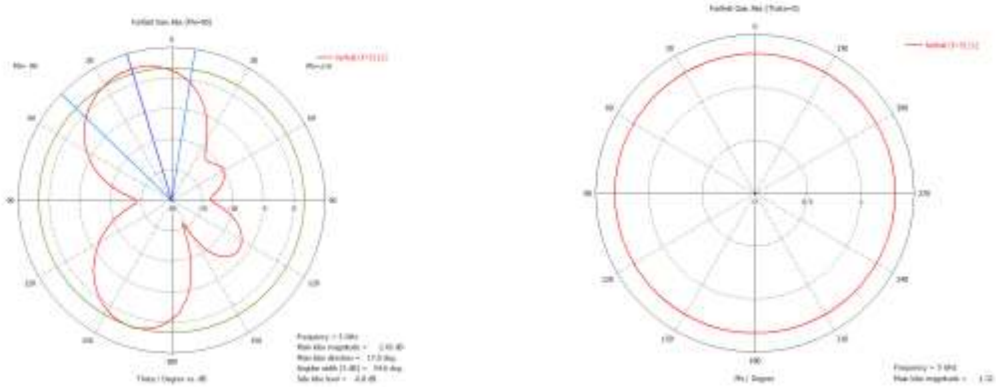
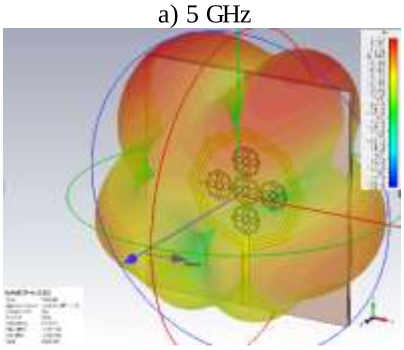

c)7.1 GHz

Figure 11 Distribution of current on the surface

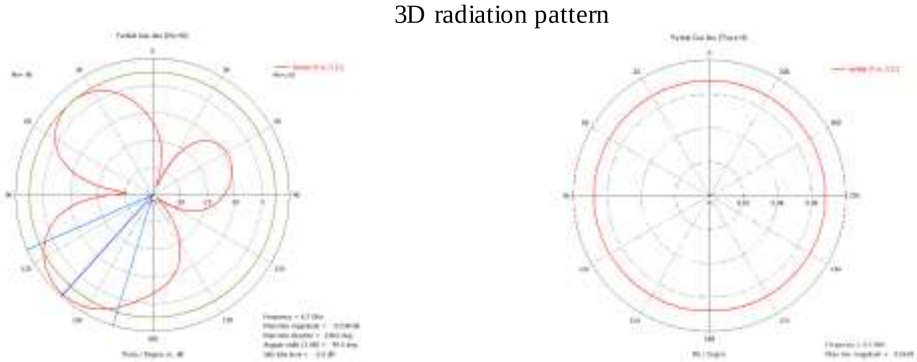

3D radiation pattern



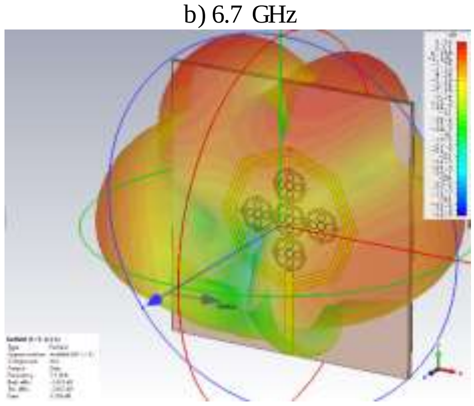
a) 5 GHz



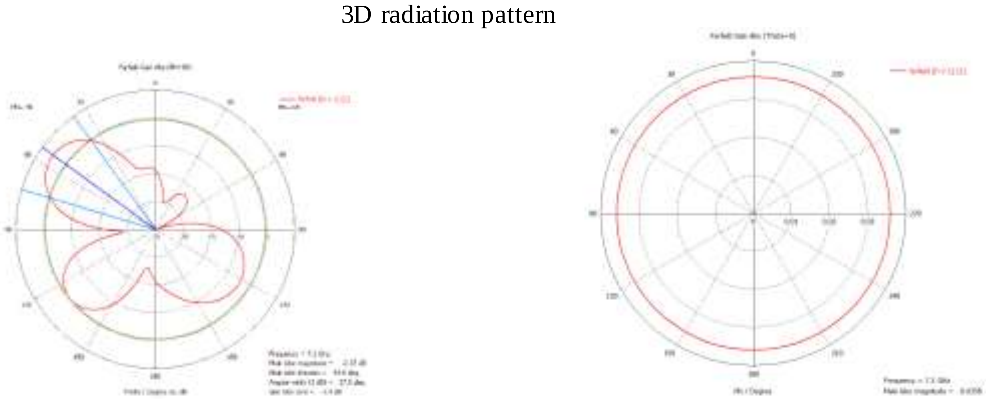
3D radiation pattern



b) 6.7 GHz



3D radiation pattern



c) 7.1 GHz

Figure 12 Pattern of E and H Plane Radiation

At different frequencies, Figure 12 shows the 3D radiation pattern, the E plane, and the H plane. In the H plane of the proposed structure, there is an omnidirectional radiation pattern, and in the E plane, there are eight organised radiation patterns. The suggested structure displays a consistent radiation pattern as a result of the union of metamaterial and fractal structure. Figure 13 depicts the directivity plotted versus frequency, demonstrating that the directivity exceeds 4.5dBi in all operational zones. Figure 14 demonstrates that in all operational zones, the gain exceeds 2.5 dBi.

Antenna	Resonant frequency (GHz)	Operating bands GHz	Bandwidth (MHZ)	Gain (dBi)	Directivity (dBi)
A	5	4.25 - 5.38	1130	****	
B	5.1	4.61 - 5.38	770		
	6.4	6.32 - 6.48	160		
C	5.1	4.65 - 5.29	640	3.54	4.62
	6.7,7.1	6.52 - 7.36	840	4.89,3.78	7.26,6.61

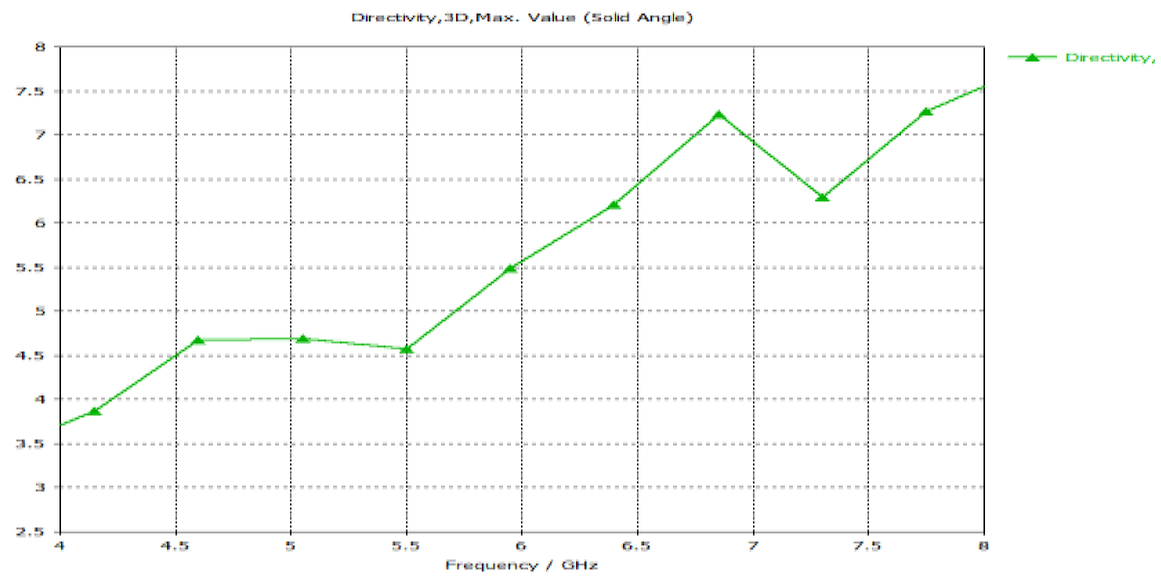
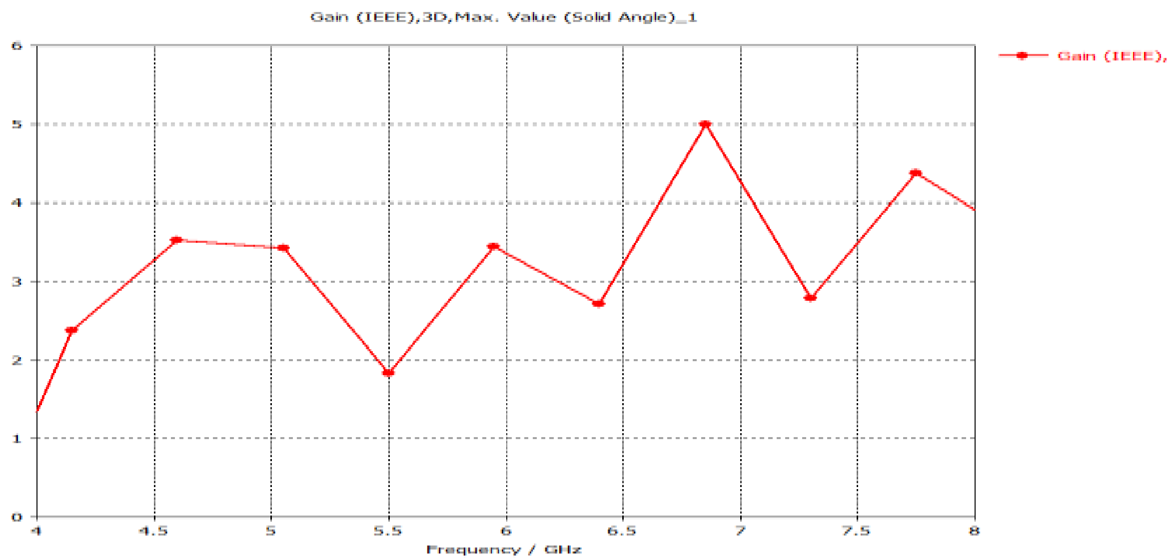


Figure 13 Directivity vs



frequency

Figure 14 gain vs frequency

5. Conclusion

It is suggested to use a metamaterial-based fractal antenna for C band wireless communication. The recommended construction is constructed on a substrate of FR4 measuring 60 x 64 x 1.6 mm. Three stages make to the recommended structure's development. Ant 1 is a straightforward octagonal ring that works between 4.25 GHz and 5.38 GHz and has a bandwidth of 1130 MHz. Octagonal SRR has been added, allowing Ant 2 to function between 4.61 GHz and 5.38 GHz and 6.32 GHz and 6.48 GHz, respectively, with impedance bandwidths of 770 function between 4.61 GHz and 5.38 GHz and 6.32 GHz and 6.48 GHz, respectively, with impedance bandwidths of 770 MHz and 160 MHz. Then, with the use of fractal geometry, Ant 3 with impedance bandwidths of 640 MHz and 840 MHz were created. These antennas operate between 4.65 GHz and 5.29 GHz and 6.52 GHz and 7.36 GHz, respectively. The metamaterial structure makes it possible to operate in two bands, and the fractal form increases the bandwidth at higher frequencies. The simulation data for various parameters are displayed. The suggested fractal antenna's compact size, strong gain, steady radiation pattern, and moderate directivity make it perfect for C band wireless applications such WLAN, RADAR, and satellite communication

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