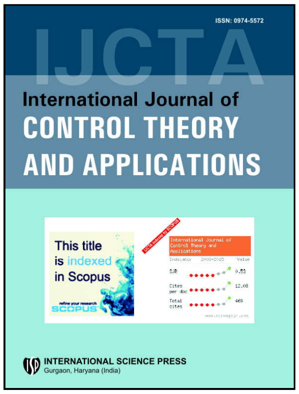

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Multiband Hybrid Microstrip Patch Antenna for L, S and C band Applications

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Abstract: A new shape of multiband hybrid microstrip patch antenna is presented in this paper. A simple and planner structure of proposed antenna fulfills the requirements of L and C band of IEEE standard at very low cost. Proposed antenna structure is obtained by combining Minkowski and inverted Koch curve and then this curve is applied at four sides of a square patch. Multiband behavior of antenna is achieved and better values of Return Loss (RL), Gain (G) and Radiation Pattern is achieved due to its small size. Simulated and measured results of proposed antenna cover ten resonant frequencies (1.00, 1.88, 2.91, 3.57, 4.85, 5.47, 5.70, 6.46, 6.73 and 7.74) GHz in L, S and C band. Better value of gain up to 20.9 dB is achieved. High Frequency Structural Simulation (HFSS) tool is used to simulate the proposed antenna.

Keywords: HFSS, Return loss, Multiband, IEEE, Gain.

1. INTRODUCTION

As per modern wireless communication system and increasing demand of wireless devices multiband, wider bandwidth and a small size antenna is required. Traditionally many antennas operate on a single resonant frequency [1-3]. So different antennas are required to operate at different frequencies and numbers of antennas are required for different applications. It will cause a huge space problem. To overcome from this problem researcher developed multiband antenna where a single antenna operates at many resonant frequencies and can be used for many wireless devices [4, 5]. Fractal antennas are introduced long years ago for their multiband, wideband and small size behavior. After fractal antenna researchers are growing interest in hybrid antenna, so by developing hybrid antenna a new area of research is introduced [6-8]. Hybrid antennas which are efficient, multiband, significant bandwidth and electrically small will fulfill many of the today's wireless communication need especially in cellular networks [9]. When any two or more than two fractal shapes are combined together to generate a new shape is known as hybrid shape. Koch curve shaped antenna based on fractal geometry was the first small sized antenna [10]. After that minkowski and inverted koch curves are mixed to form new hybrid geometry. Yadwinder et al. [11] designed hybrid fractal antenna for multiband application by mixing Koch and Minkowski curves. Antenna designed by them has different shape than proposed multiband antenna. In this paper Koch curve is inverted and then mixed with Minkowski curve to obtain generator curve which is applied at four sides of rectangular antenna. Multiband behavior and a better value of gain are obtained. The proposed antenna operates at ten resonant frequencies which lie in L, S and C band of IEEE standard. Proposed antenna fulfills the requirement of PCS, TDMA, CDMA, GSM, GPRS, cellular, digital, analog, etc. as these operates on 1.85-1.99 GHz frequency lie in L band and for air traffic control radar whose operating frequency is 0.96 – 1.21 GHz [12]. Proposed antenna also works in C band so it meets the need of satellite communication for uplink and military requirement for fixed sub-stations [13].

2. ANTENNA DESIGN

The proposed antenna structure is based on hybrid geometry shown in figure 1. Antenna is designed by mixing two curves minkowski and inverted Koch curves whose IFS code is represented using matrices given below and then mixed curve is applied at the four sides of rectangular microstrip patch. The proposed antenna is designed using substrate FR4 epoxy with dielectric constant ($\varepsilon_r = 4.4$) with thickness 1.6 mm. Proposed antenna is fabricated on same substrate, top and bottom view of fabricated antenna is shown in figure 2.

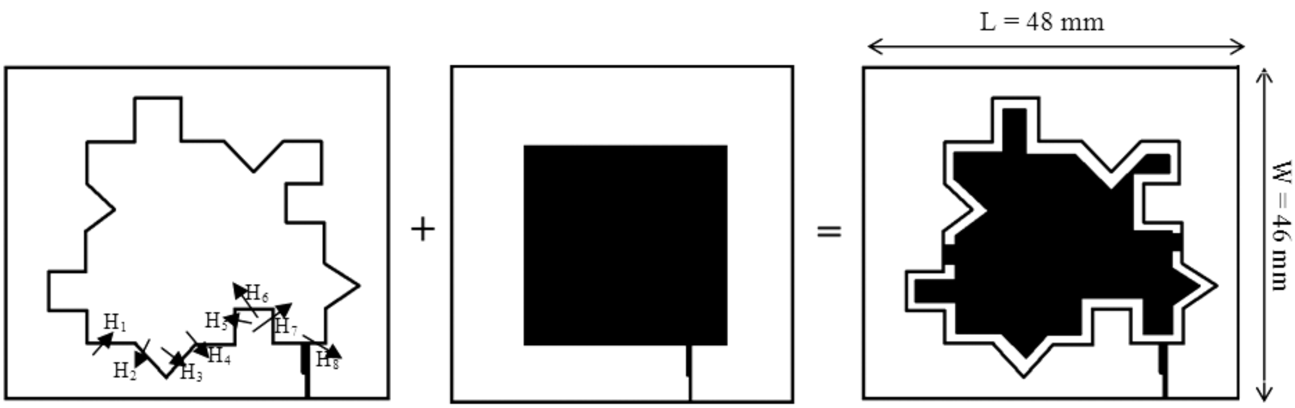


Figure 1: (a) Hybrid curve (b) Microstrip patch (c) Final proposed shape

IFS Code of curve that is applied at four sides of rectangle with segments H_1, H_2, H_3, H_4, H_5, H_6, H_7, H_8 is given by

$$H_1 = \begin{bmatrix} 1/5 & 0 \\ 0 & 1/5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix}, H_2 = \begin{bmatrix} 1/10 & \sqrt{3}/10 \\ -\sqrt{3}/10 & 1/10 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1/5 \\ 0 \end{bmatrix},$$

$$H_3 = \begin{bmatrix} 1/10 & -\sqrt{3}/10 \\ \sqrt{3}/10 & 1/10 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 3/10 \\ -\sqrt{3}/10 \end{bmatrix}, H_4 = \begin{bmatrix} 1/5 & 0 \\ 0 & 1/5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 2/5 \\ 0 \end{bmatrix}$$

$$H_5 = \begin{bmatrix} 0 & -1/5 \\ 1/5 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 3/5 \\ 0 \end{bmatrix}, H_6 = \begin{bmatrix} 1/5 & 0 \\ 0 & 1/5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 3/5 \\ 1/5 \end{bmatrix}$$

$$H_7 = \begin{bmatrix} 0 & 1/5 \\ -1/5 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 4/5 \\ 1/5 \end{bmatrix}, H_8 = \begin{bmatrix} 1/5 & 0 \\ 0 & 1/5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 4/5 \\ 0 \end{bmatrix}$$

The curve which is applied at four sides of rectangle is obtained using equation as given in [11] and for this curve it is calculated as below.

$$H = H_1 \cup H_2 \cup H_3 \cup H_4 \cup H_5 \cup H_6 \cup H_7 \cup H_8 \quad (1)$$

The length is increased after each iteration. The length of curve that is applied on four sides of rectangular patch, according to iteration number, can be calculated by [2], [4].

$$L = h\left(\frac{8}{5}\right)^n \quad (2)$$

where L = total length of the curve after n^{th} iteration. Height of the curve is ‘h’ and iteration number is ‘n’.

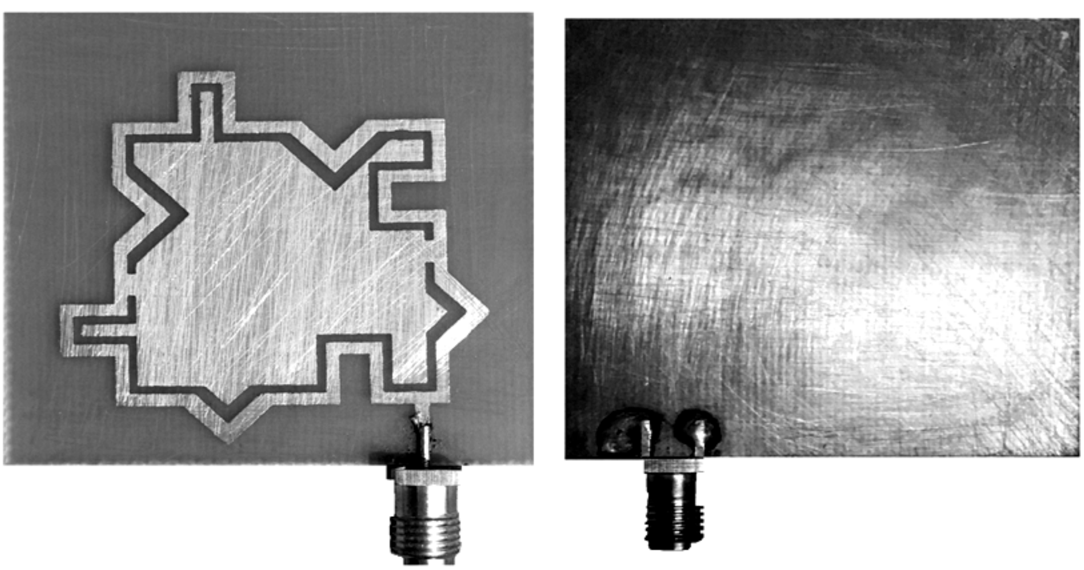
The self-similarity is given from [4], [11]

$$D = \frac{\log(N)}{\log(R)} = \frac{\log(8)}{\log(5)} = 1.29 \quad (3)$$

Where N = total number of segments, R = number of parts in curve

On As shown in above figure firstly two curves one is minkowski and other is inverted koch are combined together to shape a hybrid geometry shown in fig. 1(a) after that a rectangular microstrip patch is taken as shown in fig. 1(b) then hybrid curve is superimposed on microstrip patch and final generated geometry is shown in fig. 1(c) which is our proposed antenna geometry.

Dimensions of substrate are length (L) = 48 mm and width (W) = 46 mm, patch length (La) = 39 mm and width (Wa) = 37 mm as per shown in fig. 1(c) and 1(b) respectively. Microstrip line feed is used to calculate better results of proposed antenna with port impedance resistance = 50 ohm. By varying feed position and substrate material results are calculated but better results by using FR4 epoxy as substrate are calculated and best feed position is also shown in figure 1. Width of feed line is kept 1 mm for better results. Proposed antenna is also fabricated using FR4 substrate material and SMA female connector is used to provide excitation to antenna and is shown in figure 2 below.



(a) (b)

Figure 2: (a) Top view of fabricated antenna (b) Bottom view of fabricated antenna

3. RESULTS AND DISCUSSION

3.1. Return Loss (S_{11})

The Proposed antenna operates on ten resonant frequencies at which value of return loss is acceptable (below -10 dB). The values of return losses in dBs are -16.91, -36.02, -13.32, -15.81, -18.21, -21.96, -16.43, -25.46, -13.12 and -19.40 at frequencies in GHz s are 1.00, 1.88, 2.91, 3.57, 4.85, 5.47, 5.70, 6.46, 6.73 and 7.74 respectively. It is clear from above operating frequencies that proposed antenna works in L, S and C band of IEEE standard. Comparison graph of simulated and measured return loss is shown in figure 3.

3.2. Radiation pattern

The term radiation pattern refers to the angular or directional dependence of strength of electromagnetic waves from antenna. Two dimensional graphical representation gain at phi = 0 deg and 90 deg of proposed antenna at all resonant frequencies is shown in figure 4.

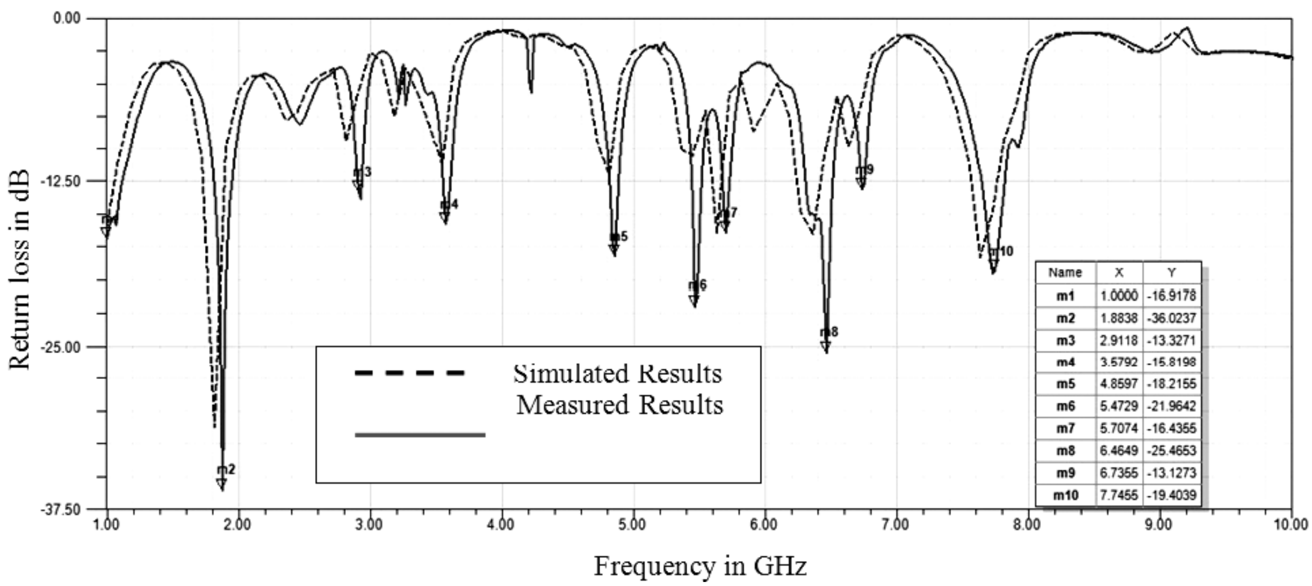
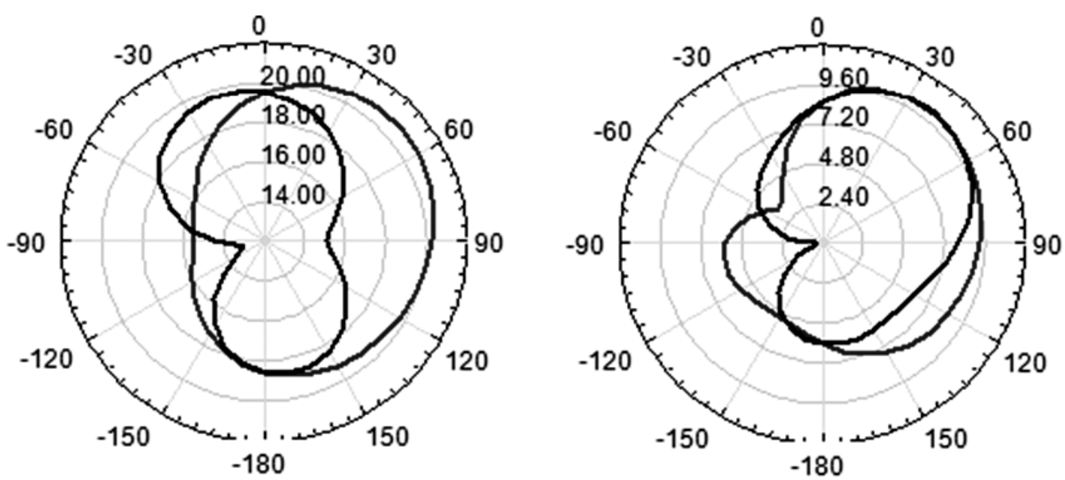
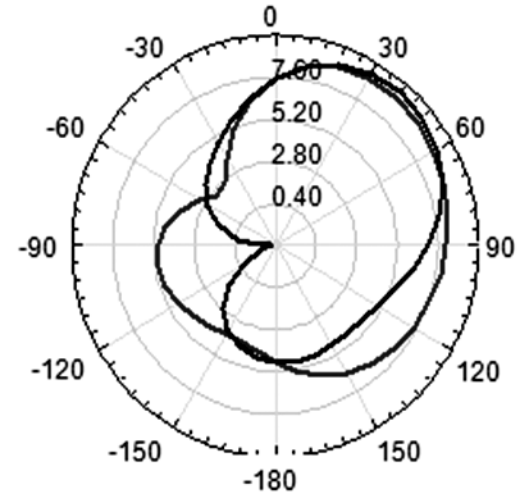


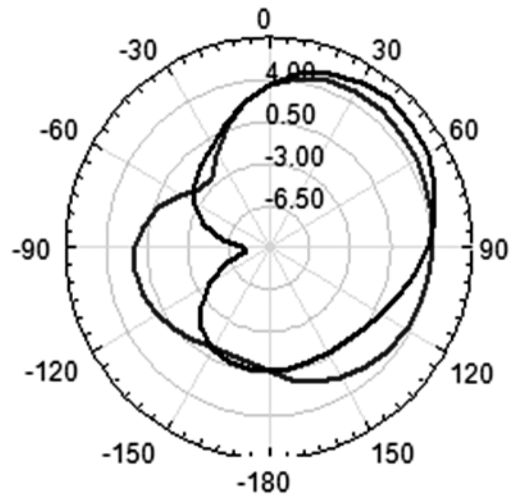
Figure 3: Comparison results of simulated and measured return loss versus frequency



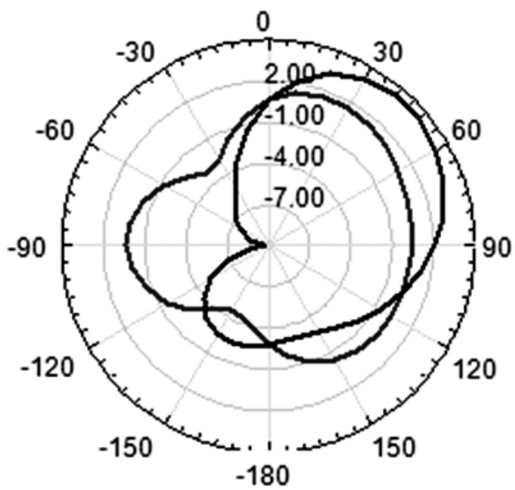
(a) **(b)**


0
30
60
90
120
150
-180
-150
-120
-90
-60
-30
7.00
5.20
2.80
0.40

(c)


0
30
60
90
120
150
-180
-150
-120
-90
-60
-30
4.00
0.50
-3.00
-6.50

(d)


0
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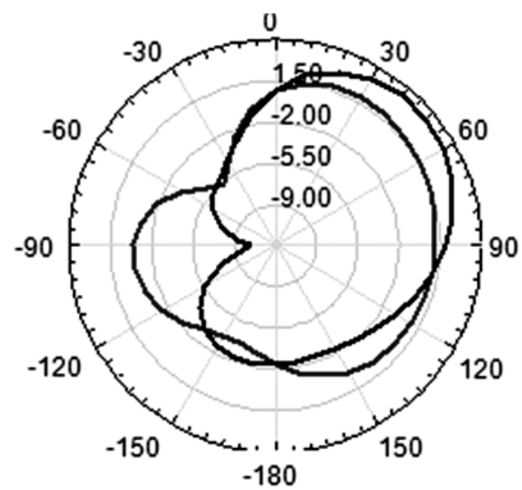
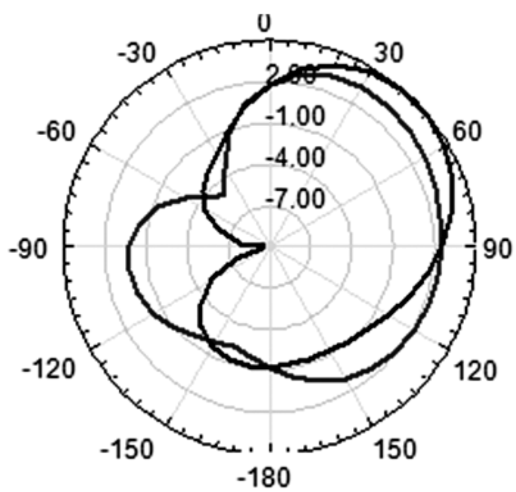
-60
-30
2.00
-1.00
-4.00
-7.00

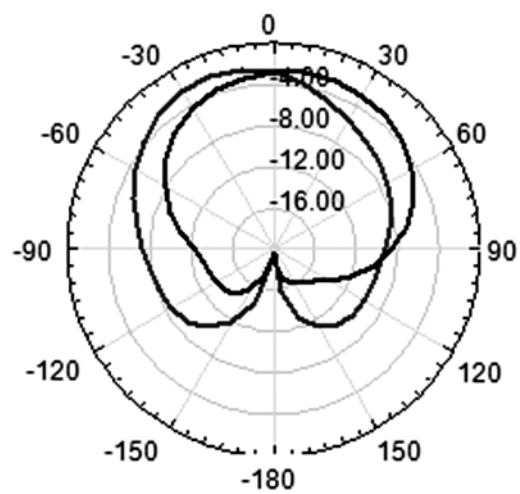
(e)


0
30
60
90
120
150
-180
-150
-120
-90
-60
-30
1.50
-2.00
-5.50
-9.00

(f)


0
30
60
90
120
150
-180
-150
-120
-90
-60
-30
2.00
-1.00
-4.00
-7.00

(g)


0
30
60
90
120
150
-180
-150
-120
-90
-60
-30
-4.00
-8.00
-12.00
-16.00

(h)

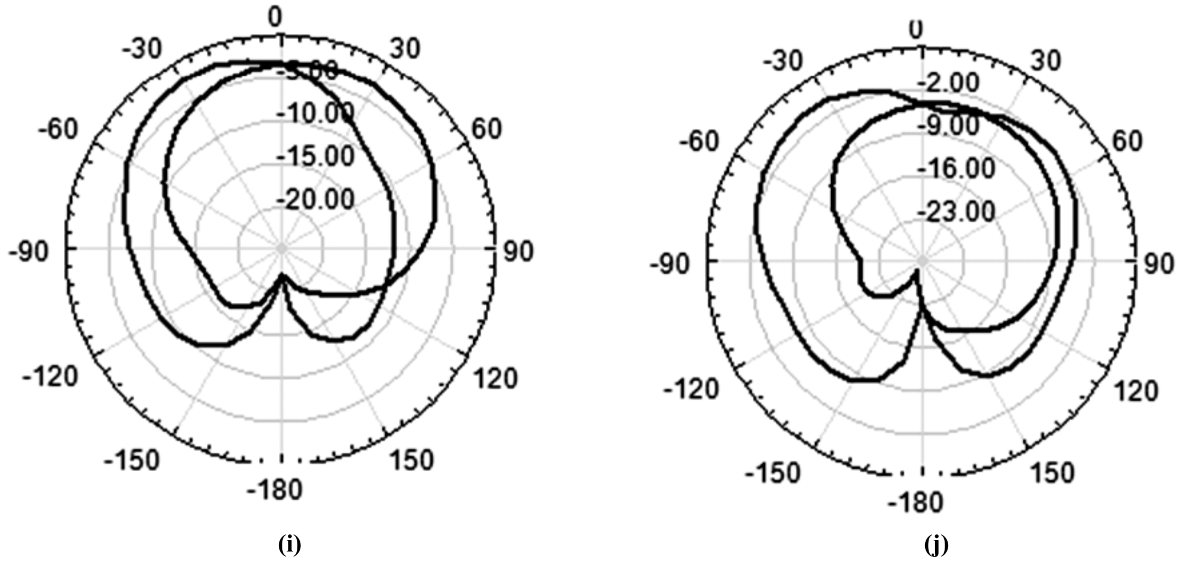


Figure 4: Radiation pattern of proposed antenna at frequencies (a) 1 GHz (b) 1.88 GHz (c) 2.91 GHz (d) 3.57 GHz (e) 4.85 GHz (f) 5.47 GHz (g) 5.70 GHz (h) 6.46 GHz (i) 6.73 GHz (j) 7.74 GHz

Comparison table of proposed antenna with other antennas available in literature is shown in table 1.Reddy et al. designed antenna which works at single frequency. Karli et al. and Sharma et al. designed antenna which works at two and four frequencies whereas proposed antenna works at ten frequencies. Hence proposed antenna has better results than other similar antennas present in literature.

Table 1
Comparison with other antennas

Antenna	*No. of resonant frequency*	*Size*
Proposed Antenna	10	39 × 37 × 1.6
Reddy [10]	1	42 × 42 × 2.2
Karli[11]	2	18 × 60 × 1.6
Sharma [12]	4	100 × 50 × 1.6

4. CONCLUSION

A compact novel shape of proposed antenna is simulate and fabricated by mixing Minkowski curve with inverted Koch curve and then superimposing them on square patch. The results are measured which proves that proposed antenna is capable of working on L, S and C band of IEEE standards. Proposed antenna has maximum gain of 21 dB and ten working resonant frequencies whereas similar antennas present in literature works at the most four frequencies. Proposed antenna is simulated and fabricated. Simulated and experimental measured results are found good agreement with each other and this antenna in L Band can be used for aircraft surveillance, CDMA, PCS, TDMA, GPRS, GSM, Digital, Cellular, analog communication applications. In C band this antenna can be used for satellite communication applications, military necessities for present NATO fixed systems in some countries and Essential military requirements for satellite downlinks; the mobile satellite sub-band 7250-7300 MHz is for naval and land mobile earth stations.

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