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Broken Heart Shaped Monopole Antenna for WiMAX Applications

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Abstract*: A monopole broken heart shaped antenna is presented in this article. The WiMAX band application has been taken as objective. The proposed antenna design is carried out in different iterations to obtain the required band. Proposed broken hearts shaped antenna works in the band from 3.2GHz – 4.1GHz.the heart shaped double slotted ring resonator (SRR) with two different radius is seen in the final iteration to enhance the bandwidth (900MHz), and gain (3dB). The other parameters such as VSWR (almost < 2 at WiMAX band), impedance (both real & imaginary), efficiency which is almost 89%has been noticed in this design. So, the proposed broken heart shaped monopole antenna which works at WiMAX band shows the moderate gain, size reduction omnidirectional pattern, high efficiency, etc. which are important in WIMAX application band.

Index Terms*: Broken heart shaped antenna, WiMAX, Slotted ring resonator (SRR), VSWR.

I. INTRODUCTION

Over the years, the incredible growth of wireless devices has significantly improved the development of advanced communications network standards. Recently, for high frequency and high-speed communication, many communication standards such as WiMAX, etc. are being developed. This rapid increase in communication standards has resulted in a high demand for narrow-band and broadband antennas with low cost manufacturing and easy integration with feed networks. In [1], the author proposed a new technique with the help of fractal defected ground structure (FDGS) to design a circularly polarized microstrip patch antenna. In [2], the author explored a new defected ground structure conceived as 'extended – arc' of asymmetric nature that not affect the resonance and co-polarized radiation but suppress the cross-polarized fields. In [3], the author described hexagonal ring patches with the combination of triangular slotted symmetrical defected ground structure (DGS) to achieve wideband applications. In [4], the author proposed octagonal slot-loaded radiating patch having defected ground structure fed with coplanar wave guide (CPW) to achieve super wide bandwidth. In [5], the author designed a microstrip patch antenna having square slot as radiating patch and arc based defective ground structure to achieve dual bans resonance in the ultra-wide band region. In [6]. the author proposed T shaped radiating patch along with semi-circular defeated ground structure for 5G wireless multi-input multi-output (MIMO) applications. An antenna with UWB frequency response having bandwidth from 3-12GHz with trident shaped radiating patch is proposed in [7]. A tapered step ground plane is used to enhance the bandwidth characteristics of rectangular and elliptical monopole antenna [8]. A CPW feed monopole antenna design based on DGS structure has reduced the antenna size [9-13]. EBG structure is used to enhance the bandwidth characteristics of the antenna is proposed in [14-19]. The effects due to changes in permittivity of the substrate are analyzed in [20-21]. An antenna having radiation like circular polarization in [22], slotted aperture antenna having multi band characteristics in [23] and array antenna based in Liquid crystal substrate are discussed in [24]. A microstrip patch antenna which operates at Ka-band satellite applications is designed with the help of varactor diodes and also improvement in terms of bandwidth is achieved [25]. A 16-element linear array antenna is designed for beam steering applications. Here a maximum beam steering of 50^{o} is obtained by proper alignment of array elements and inter element spacing of 0.73λ [26]. Hybrid beam steering array fed reflector antenna for Ka-band satellite applications is designed in [27]. Here a maximum scanning of $\pm 6^{o}$ achieved when the array elements are aligned horizontally and $\pm 3^{o}$ achieved when the array elements are aligned vertically at the focal point of the reflector.

In this article a single band broken heart shaped antenna is constructed to work at WiMAX applications. The proposed antenna designed using ANSYS electronics desktop-18, taking substrate material as Rogers RT/Duroid 5880(tm) having a thickness of 0.8mm. The proposed antenna design working, and result analysis has been carried out n this article in the subsequent sections.

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II. ANTENNA DESIGN

The proposed antenna has the size of 30 mm × 17.58 mm, which consists of a Rogers RT/Duroid 5880(tm) as substrate and the thickness of the substrate is 0. 8mm.The proposed antenna iterations are shown in Fig. 1. The antenna design iterations wise starting from a conventional elliptical patch and the ground plane with defected ground structure (DGS).

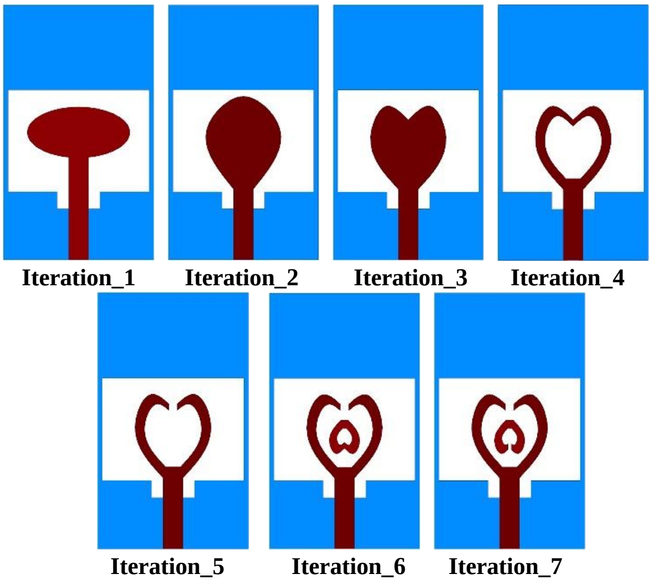

Fig. 1 Antenna Iterations

In the first iteration we have taken an elliptical shaped patch antenna latter it was modified to an egg shaped and then to heart shaped and then to heart shaped ring patch antenna and then to heart shaped slotted ring patch antenna and then an inverted heart shaped ring was inserted at the center of the hearted shaped slotted ring patch antenna and finally it was modified by inserting an inverted heart shaped slotted ring at the center of the heart shaped slotted ring patch antenna.

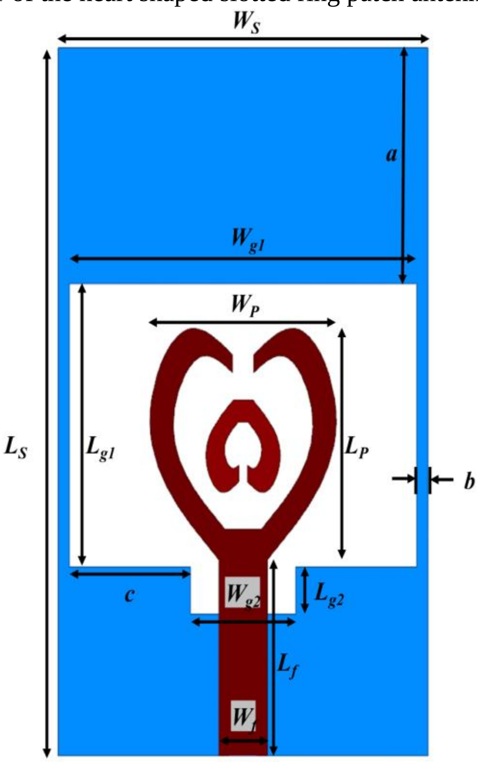

Fig. 2 Proposed Antenna Dimensions

The ground of the proposed antenna makes defected ground structure by etching two rectangles of size 12mm × 16.5mm and 2mm × 5mm respectively as shown in Fig. 2. The proposed antenna shape and dimensions are tabulated in table: I.

Table: I Parameters of the Proposed Antenna

Parameters	Unit (mm)	Parameters	Unit (mm)
L_S	30.00	W_S	17.58
L_P	9.80	W_P	8.70
L_f	8.30	W_f	1.50
L_{g1}	12.00	W_{gs1}	16.50
L_{g2}	2.00	W_{gs2}	5.00
a	10.00	b	0.54
c	5.75	-	-

III. EXPERIMEN RESULTS AND DISCUSSION

Fig. 3 shows the reflection coefficients of the presented antenna. The simulated result shows the -10dB return loss at bandwidth from 3.2 to 4.1GHz by using the FEM-based HFSS. From the fig.3 we can be observed that in the first iteration the antenna operates at 3.5 – 4GHz, which is due to "elliptical" shape of the patch. In the second iteration the antenna resonates at 3.6 – 4.6GHz, which is due to modification of "elliptical" shape into "dumb-bell" shape. In the third iteration the antenna operates at frequencies 3.7 – 4.5GHz, which is due to modification of "dumb-bell" shape into "heart" shape. In the fourth iteration the antenna operates at frequencies 3.2 – 4.1GHz, which is due to modification of "heart" shape patch into "heart shaped closed ring resonator / heart shaped ring slot". In the fifth iteration the antenna operates at frequencies 3.2 – 4.1GHz, which is due to modification of "heart shaped closed ring resonator" shape patch into "metamaterial inspired heart shaped slotted ring resonator".

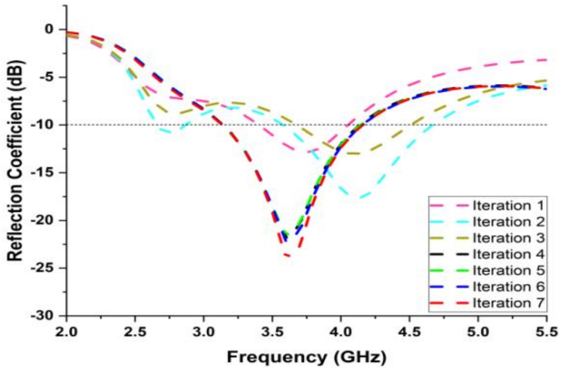

Fig. 3 Simulated Reflection Coefficients of Antenna Iterations

In the sixth iteration the antenna operates at frequencies 3.2 – 4.1GHz due to implantation of heart shaped ring slot in broken heart shaped ring slot, by the insertion of inverted and reduced size of "heart shaped closed ring resonator".

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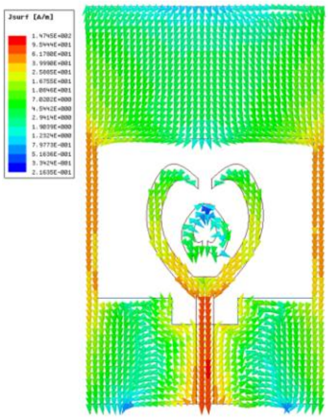
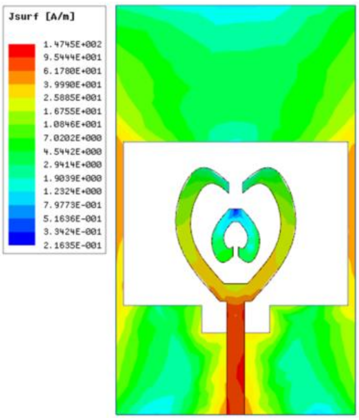
In the seventh iteration the antenna operates at frequencies 3.2 – 4.1GHz due to implantation of broken heart shaped ring slot in broken heart shaped ring slot, by the insertion of inverted and reduced size of "heart shaped slotted ring resonator".

Fig. 4 (a) and (b) shows the surface current distributions and current magnitudes of the antenna at frequencies of 3.6GHz respectively. From the figure, we can clearly observe that the heart shaped slotted ring patch antenna and both the right and left sides of the defected ground plane are radiating effectively and plays a key role in achieving the resonance at 3.6GHz. Hence, we can say that the proposed antenna is suitable for wireless applications like WiMAX.



(a)



(b)

Fig. 4 (a) Antenna Current Distribution
(b) Antenna Current Magnitudes

Table: II Bandwidth, Return Loss and Gain comparison of Antenna Iterations

Antenna Iterations	Band Coverage (GHz)	RL (GHz)	Imp BW (%)	Peak Gain (dBi)	Avg Gain (dBi)
Iteration_1	3.5-4.0	3.7	13.51	2.734	2.714
Iteration_2	3.6-4.6	4.1	24.39	2.784	2.735
Iteration_3	3.7-4.5	4.1	19.51	2.788	2.778
Iteration_4	3.2-4.1	3.7	24.32	2.829	2.889
Iteration_5	3.2-4.1	3.6	25	2.855	2.896
Iteration_6	3.2-4.1	3.6	25	3.015	2.973
Iteration_7	3.2-4.1	3.6	25	3.117	2.98

The feed line of the proposed heart shaped patch antenna plays an important role in current flow. The proposed antenna achieves a reflection coefficient whose values are less than -10dB for the frequency band of 3.2GHz to 4.1GHz and attains a 0.9GHz because in both the heart shaped slotted ring patch antenna and the ground plane, the surface current maintains a harmonic order flow.

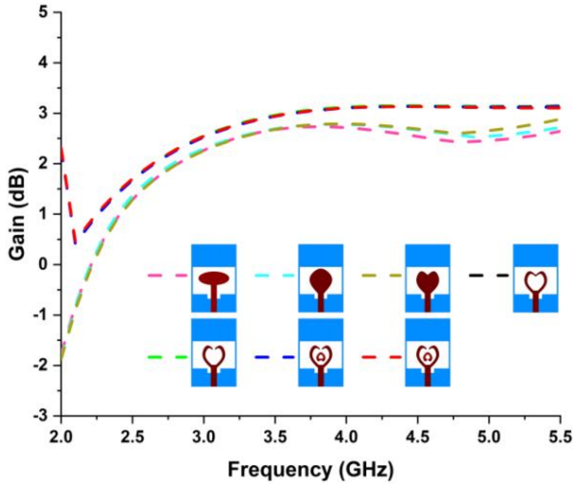


Fig. 5 Simulated Gain comparison of Antenna Iterations

Fig. 5 shows the simulated gain comparison of antenna iterations. From the figure we can observe that the gain for the proposed antenna varies from 2.7 – 3.1dB in 3.2 – 4.1GHz and the average gain is 2.98dB.

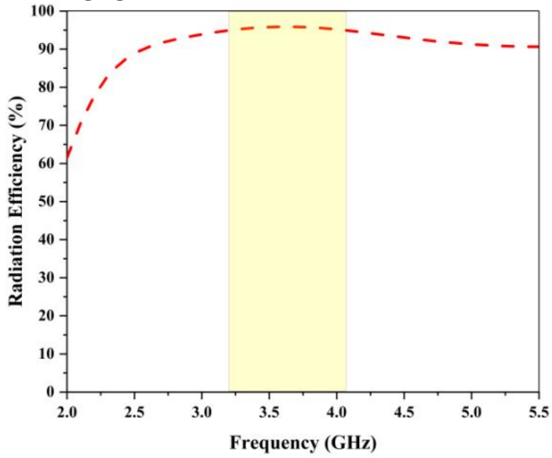


Fig. 6 Simulated Efficiency Vs Frequency of Proposed Antenna

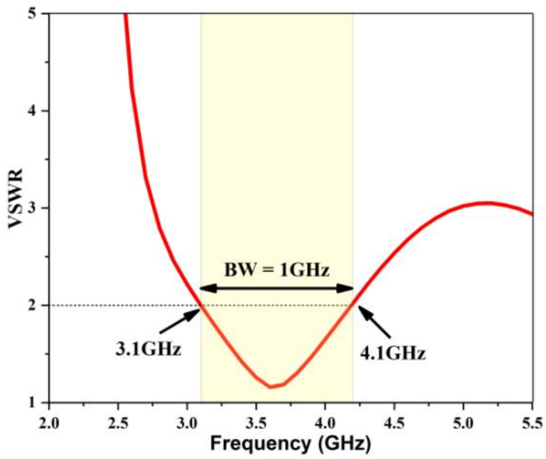


Fig. 7 VSWR of the Proposed antenna

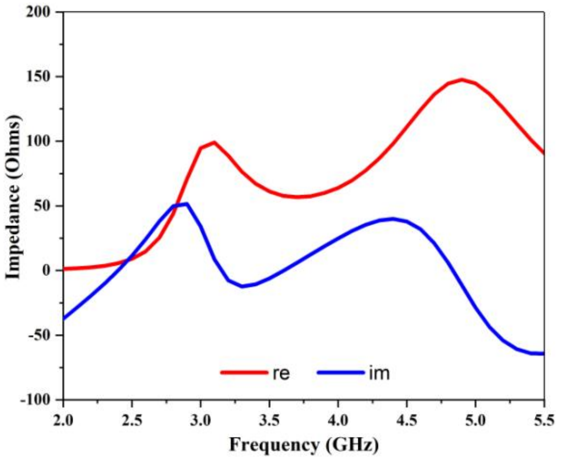
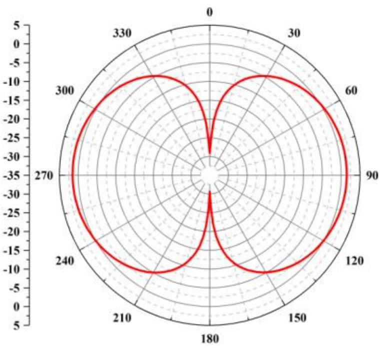
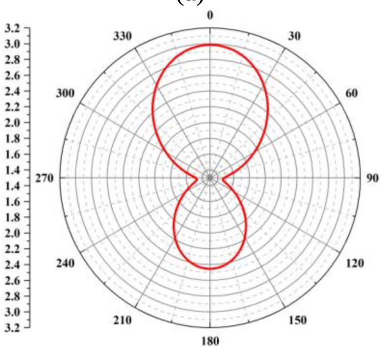


Fig. 8 Impedance characteristics of the proposed antenna

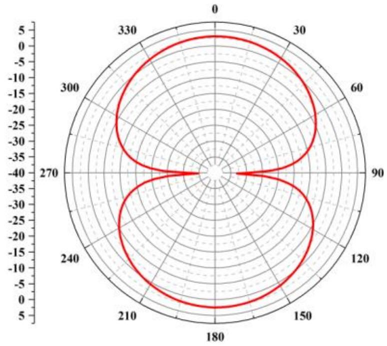
Fig: 6 shows simulated efficiency of the proposed antenna. From the figure we can observe that the efficiency for the proposed antenna varies from 94 – 96% in 3.2 – 4.1GHz and the average gain is 95%. Fig: 7 shows the VSWR of the proposed antenna. From the figure we can understand that the VSWR at the working band (3.1GHz – 4.1GHZ) has proper impedance matching. Fig: 8 shows the real and impedance characteristics of the proposed antenna. From the figure we can understood that at the working band the real impedance value varies between 50ohms – 60ohms, which implies perfect impedance matching. Fig: 9 shows the simulated radiation patterns of the proposed antenna. All these values are tabulated in Table: II.



(a)



(b)



(c)

Fig. 9 Simulated Radiation Pattern
(a) XY-Plane (b) YZ-Plane (c) ZX-Plane

IV. CONCLUSION

A broken heart shaped monopole antenna has been designed in ANSYS Electronic desktop-18 and analyzed in this article. The proposed antenna works at WiMAX application band. Several iterations has been analyzed to get the required band. The proposed broken heart shaped antenna has covered 900MHz bandwidth from 3.2GHz to 4.1GHz and an average gain of 3dB with an efficiency of 87% which implicates that it is good candidate in the modern WiMAX wireless applications. With respect to antenna analysis the other parameters such as impedance, current distribution, E field distribution, VSWR and radiation patterns has been discussed in this article which strongly resembles the WiMAX application characteristics.

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