E-shape Multiband Patch Antenna for 4G, C-band and S-band Applications

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***Abstract*—In this study, a new E shape mounted on minowaki island patch antenna on FR4 substrate is presented for communication systems applications. With insertion of shortening pin between patch and ground plane, the proposed structure resonated on 6 frequencies; hence producing Hex-band response with good realized gain and directivity radiation values and patterns. Co axial cable is used as means of excitation to excite proposed structure with minimum impedance mismatch losses. The proposed design is miniaturized up to 60.66% and can be used for GSM, GPRS, 4G, WLAN and other S-band and C-band applications.**

Keywords—Minowaki island patch; miniaturization; E shape; gain; directivity

I. Introduction

The development in wireless communication, microwave technology is increasing day by day with the passage of but these technologies requires smaller size of antennas which can be used in a numbers of applications, such as in 4G, S-band, C-band, mobile applications and other applications. As many telecommunication systems and radar communication system used several frequencies i.e. dual band antenna is more beneficial single band [1].

A new proposed antenna patch structure is suggested in this study for wireless communication application, the design results the multiband frequencies and reduced size antenna [2]. The size reduction is obtained by various ways such as using high permittivity substrate which gives good results of miniaturization but the cost of high permittivity substrate is expensive and unsuitable for low cost consumers' application [3]. Meta materials and magneto dielectrics are used for size reduction purpose but with these materials and dielectrics the miniaturization is archived but disadvantage is that this miniaturization gives the lower gain also the cost of these materials are expensive and complex to manufacture [4]. The Minowaki island shape or fractal patch results in miniaturization but this lower size of antenna gives lower gain [5].

Defected ground structure such as H, L, U shaped is used for size reduction of antenna which gives good gain and return loss but these structures gives very narrow bandwidth [6]. Defected patch structure such as H, U, Pi, E shaped is used for multiband operation of antenna which gives good return loss but these structure gives very lower gain [7]. Shorting pin method is also used for miniaturization purpose also as direction of current is changed with respect to location of the pin [8].

The use of Artificial Magnetic conductors (AMC), Split ring Resonators (SRR) has also been found effective in shifting the fundamental resonating frequency to lower levels but these techniques cause the gain to diminishing levels after few iterations. High cost and complex geometry also keeps researcher on edge at using Meta materials [9].

This paper presents a novel study of multiband enabled reduced sized antenna by introducing Defected ground structure in ground plane and E shape edged on resonating fractal patch. FR4 is used as a substrate having permittivity 4.2 which is easily available in the market, better efficiency, high bandwidth, low water absorption [10], [11]. Size reduction of patch antenna is obtained by mounting slots on ground plane while edging the patch with fractal and E slots has produce Hex Band response. All of the resonating frequencies have shown satisfactory performance parameters results with good radiation patterns and minimum mismatch losses. The proposed designed is carried out CST 2014 and can be used for S- and C-band applications.

II. Antenna Configuration

A. Width of Patch

Following formula is used for deriving patch width.

$$W = \frac{C}{2f_o\sqrt{\frac{(\in r+1)}{2}}} \quad (1)$$

B. Length of Patch

Following formula is used for deriving patch length.

$$L = L(e_{ff}) - 2\Delta L \quad (2)$$

Where,

$$L(e_{ff}) = \frac{C}{2f_o\sqrt{\in(re_{ff})}} \quad (3)$$

And

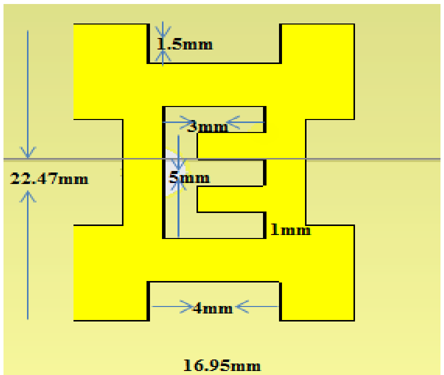
$$\in(re_{ff}) = \frac{\in r+1}{2} + \frac{\in r-1}{4}(1+\frac{12h}{W})^{\frac{-1}{2}} \quad (4)$$

A conventional antenna of 4.1GHz is designed after calculating width and patch of antenna. Regarding patch and ground structural dimensions with all slots information is covered in Table I.

The resonating patch length and width is taken 16.95 and 22.47mm, respectively. Fractal slots are introduced having length and width 5.1 and 2.3mm. In center of Resonating patch, and E shape is mounted with 3mm length and 1mm of width. FR4 height is taken 2mm and height of ground and patch is taken to be 0.8 and 0.245mm, respectively.

For miniaturization, ground plane is introduced with H and L Slots. The length and width of slots is taken as 7 and 9mm and L slot length is taken as 5mm and width 9mm.

Studies have shown that E shape slotting on various patch locations exhibit different response as the current is circulated around its corners [12]. The detailed geometry of proposed structure is shown in Fig. 1(a) and 1(b), respectively.



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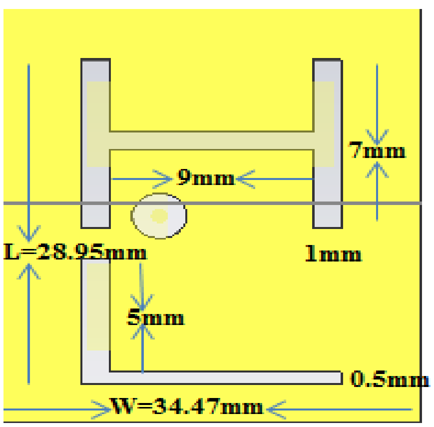

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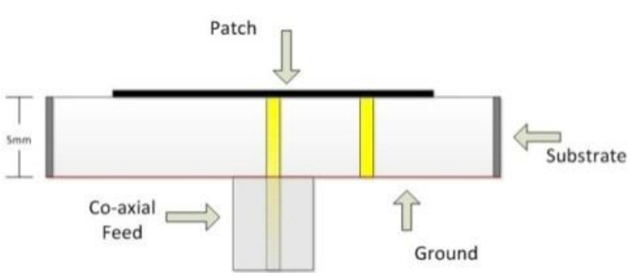


(c)

Fig. 1. (a) Front view, (b) ground view, (c) bottom view.

Fig. 1(c) shows the bottom view of our structure as evident from figure it is clear that coaxial probe feed is used as means of transmission for exciting patch antenna. The antenna is well impedance matched with Voltage Standing Wave Ration of 1.20 ensuring input power being delivered efficiently.

III. Results and Discussion

In order to evaluate performance of our proposed design, different parameter results like realized gain, voltage standing wave ratio, directivity, reflection co efficient, efficiency, bandwidth were evaluated.

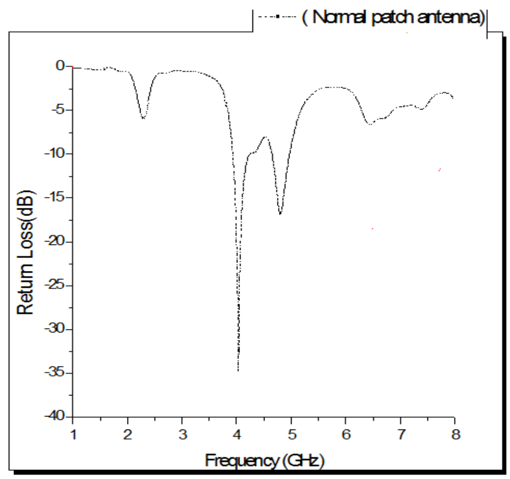


Fig. 2. Return loss of conventional antenna.

In Fig. 2, the antenna is designed for 4.1GHz and the miniaturized antenna is operating on 2.66GHz which shows in Fig. 3, due to the combination of different techniques i.e. defected patch structure, defected ground structure, shorting pin method, fractal patch structure. The frequencies are shifted downward due to the implementation of these techniques.

As our proposed design fundamental resonating frequency shifted downward to 2.66GHz while having the patch dimensions of 4.1, our proposed design showed size reduction up to 60.67% since conventional design for 2.66GHz would require dimensions of 950mm^2 and our design has dimensions of 375.86mm^2 only.

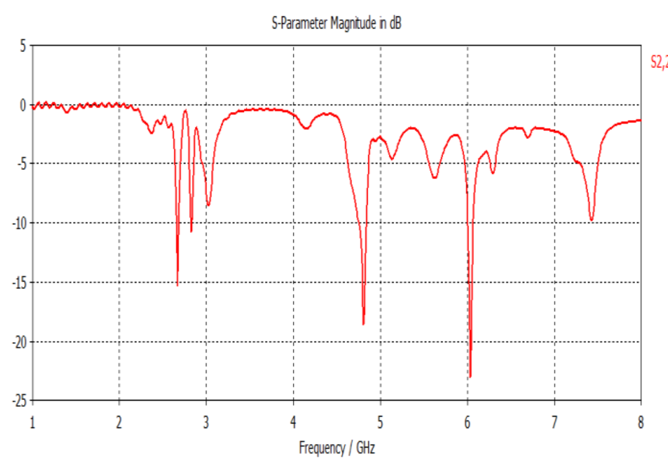


Fig. 3. Return loss of miniaturized antenna.

Reflection coefficient or Return loss graph is shown in Fig. 3. Return loss impedance bandwidth of -10dB clearly shows six different frequencies exhibiting Hex Band Response.

All of the resonating frequency performance parameters are covered in Table I and mismatch losses are shown in Table II.

TABLE I. SIMULATION RESULTS

FREQUENCY (GHZ)	DIRECTIVITY	GAIN	BANDWIDTH	RETURN LOSS
2.66	4.25	3.43	70	-15.2
2.87	3.68	3.75	40	-20.7
3.01	4.15	3.69	30	-8.5
4.80	5.41	4.71	110	-18.7
6.03	5.41	4.71	190	-23.7
7.42	5.46	4.28	81	-10.1

TABLE II. MISSMATCH LOSSES

FREQUEMCY (GHZ)	2.66	2.87	3.01	4.80	6.03	7.42
VSWR	1.02	1.25	1.11	1.09	1.05	1.21

Fig. 4 mentions and shows all the radiation frequencies 1D radiation patterns. From Radiating Frequencies, it is clear that our proposed structure is resonating at six different directions which is a good response for an antenna since this behavior leads to usage of structure for different application purposes.

As in 2.66GHz the main lobe magnitude is 3.4dB, main

Lobe direction is 80.0 deg and angular width is 86.2 deg while side lobe level is -6.8dB.

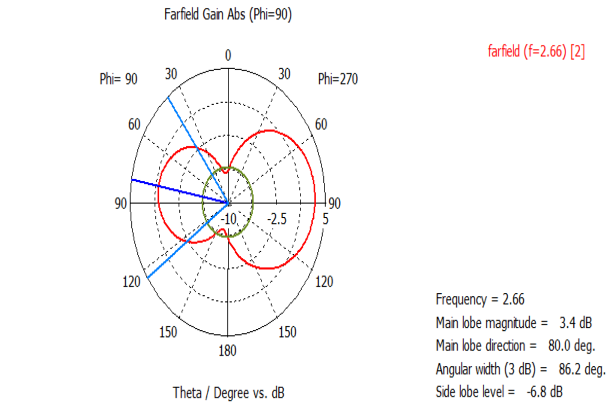
In 2.87GHz the main lobe magnitude is 3.7dB, main lobe direction is 83.0 deg and angular width is 86.3 deg while side lobe level is -14.2dB.

In 3.01GHz the main lobe magnitude is 3.7dB, main lobe direction is 88.0 deg and angular width is 93.1 deg.

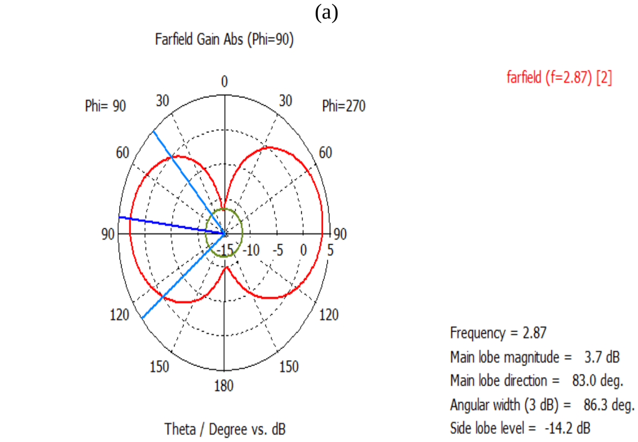
In 6.03GHz the main lobe magnitude is 2.7dB, main lobe direction is 00.0 deg and angular width is 103.4 deg while side lobe level is -4.7dB

In 4.80GHz the main lobe magnitude is 4.7dB, main lobe direction is 100.0 deg and angular width is 190.7.3 deg.

In 7.42GHz the main lobe magnitude is 2.8dB, main lobe direction is 180.0 deg and angular width is 42.7 deg while side lobe level is -11.6dB.



(a)



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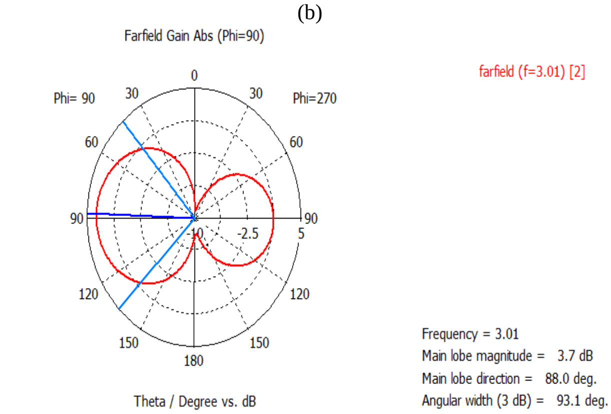

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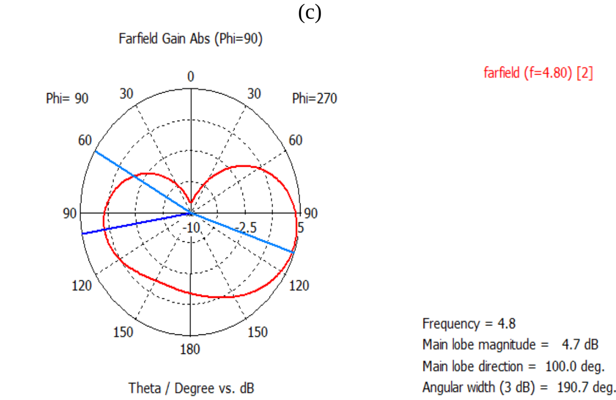

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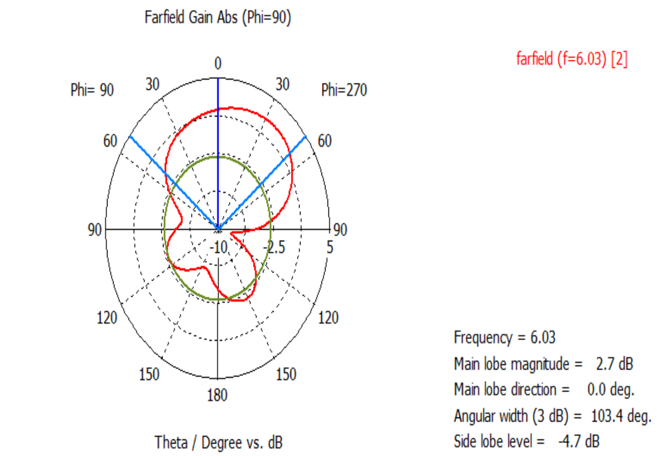

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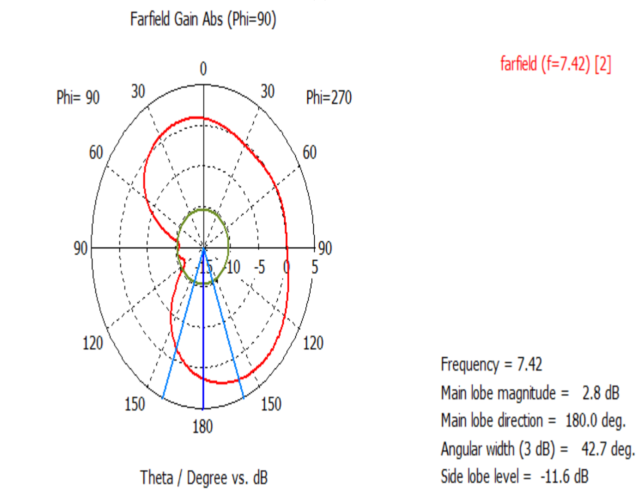
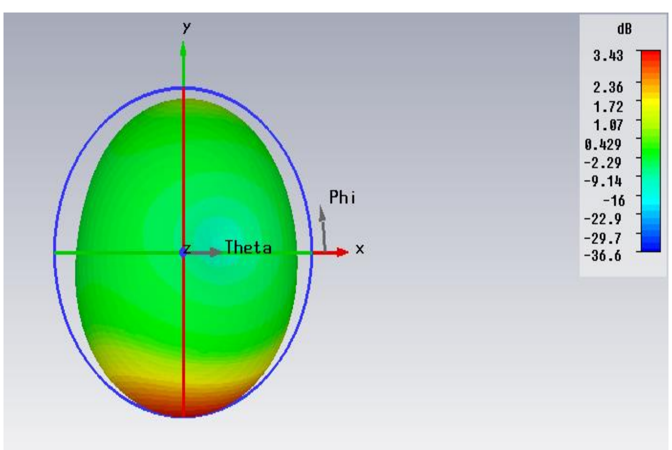


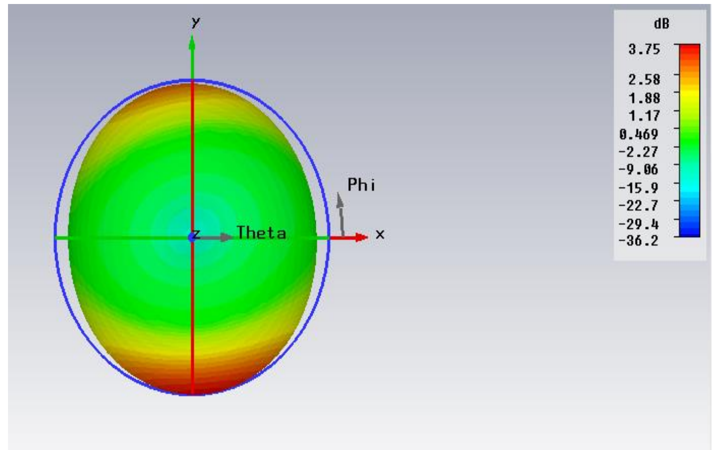
(f)

Fig. 4. 1D Ration Pattern of the proposed miniaturized antenna for (a) at f=2.66 GHz (b) at f=2.87GHz(c) at f=3.01GHz (d) at f=4.80GHz (e) at f=6.03GHz and (f) at f=7.42GHz.

Fig. 5 shows 3D radiation pattern of miniaturized proposed antenna. All the images are extracted from Computer Simulation technology 2014.



(a)



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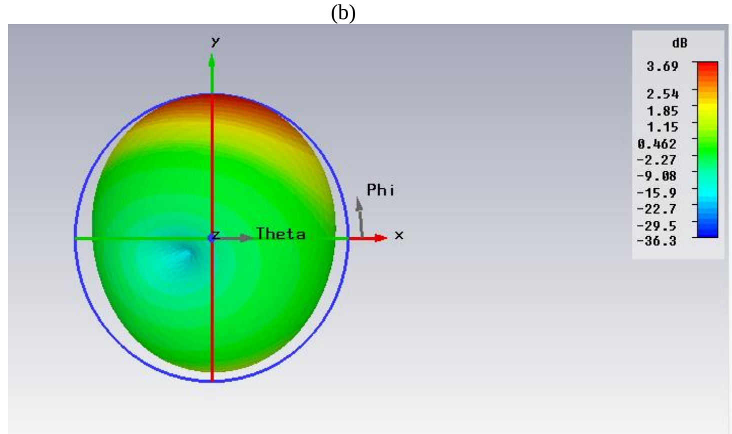

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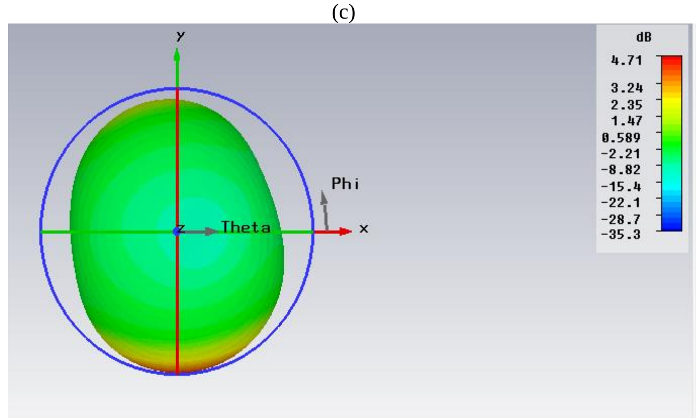

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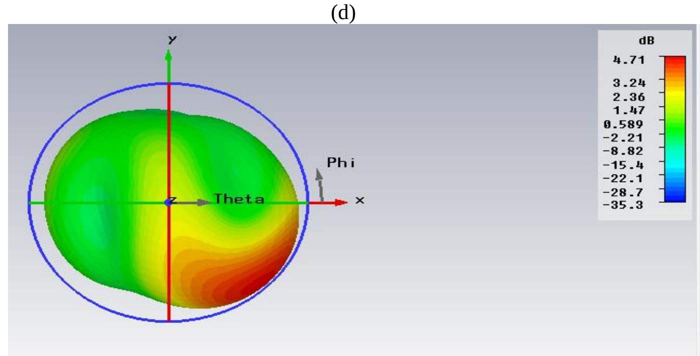

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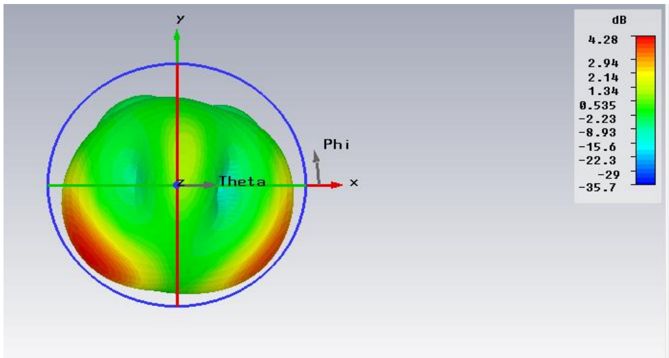

(f)

Fig. 5. (a) 3D Gain of 2.66GHz, (b) 3D Gain of 2.87GHz, (c) 3D Gain of 3.01GHz, (d) 3D Gain of 4.80GHz, (e) 3D Gain of 6.03GHz, (f) 3D Gain of 7.42GHz,

IV. Conclusion

In this paper, a novel fractal E slot mounted patch is proposed with H and L slots in ground. With Slots in ground miniaturization response is observed and due to fractal slotting, the antenna exhibit Hex Band Response with reduction up to 60%. Antenna performance parameters showed excellent results as gain varied form 3.79dB to 4.7dB with bandwidth up to 180MHz and minimum mismatch losses. The proposed antenna can be used for different S and C band application Systems.

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