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Analysis and Design of a Low-Profile Multiband Antenna for IOT Applications

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Abstract*: Increased intervention of IOT in everyday applications created an open challenge to the researchers regarding the usage of RFID technique. This requires the process of integrating IOT to various wireless standards. This work proposes, a very low profile planar circular patch united with Koch fractals and rectangles alternatively on its circumference fed by a microstrip line and two more Koch fractals on either side of the circular patch which operates over the bands of 1.5GHz-1.65GHz, 1.92GHz-2.17GH, 2.56GHz-2.85GHz, 3.68GHz-4.0GHz, 4.73GHz-4.94GHz, 5.36GHz-5.57GHz at SHF, UHF and Microwave frequency bands ,GSM 850 MHz, GSM 900 MHz, LTE-700 MHz, LTE-800MHz, TV broadcasting.

Index Terms: GSM, Internet of Things (IOT), Long Term Evolution, RFID.

I. INTRODUCTION

Internet of things (IOT) is a platform for automated information where radio frequency identification technique (RFID) operates in various electromagnetic bands which in distinctive applications for the betterment of society.

In today's contemporary world of communication networks IOT (Internet of things) plays a crucial role. IOT connects different smart internet enabled devices to communicate with each other continuously. Efficient hardware is required apart from the sophisticated communication protocol. Antennas functions as the heart of communication hardware. The antennas for IOT applications need to exhibit three major characteristics, namely: energy efficiency, low profile and ability to operate in multi antenna environment.

Vyshnavi Das S K, Dr. T. Shanmugananthadiscussed the achievement of Multiband response by introducing DGS (Defected Ground Structure) [1]. In [2]Kumud Ranjan Jha, Ghanshyam Mishra and Satish K. Sharma described a truncated octahedron which is a planar projection, a kind of the Archimedean solids. Various communication standard bandwidths such as 4G long term evolution (LTE) band, TV broadcasting band, GSM 850 MHz are met by the former antenna.The authors of [3]i.e.Vyshnavi Das S, T Shanuganatham proposed the antenna using microstrip line feeding and consists of three star fish shaped models order to enable the multiband responses the shape ofantenna is continuously disturbed which further alters the surface current circulating path. A quad-band antenna for IOT, Leveraging a combination of double PIFA (Planar Inverted-F Antenna) structure and the Defected Ground Structure (DGS)which is a novel structure is discussed byDuong Thi Thanh Tuet alin [4].Circularpatch antenna is designed in which a substrate material is deposited over a ground plane. Here, the feeding technique is microstrip line center feeding and feed is selected at the edge of an antenna. Advantages like increase in efficiency and decrement of losses in antenna are provided with the help of this feeding technique. These specifications are proposed by Vikram N, Kashwan K. in [5].In [6], Mehr-e-Munir et aldescribed an antenna whose topology is E slotted patch. This type of microstrip antenna has applications in mobile phone for 4G, L band and C-Band applications. In [7], Praveen V. Naiduet al proposed a novel tunable multi band antenna for WLAN and WiMAX applications. In [8], Muhammad Sajid Iqbalet al designed an antenna which consists of a U-shaped rectangular patch combined with two rectangular parasitic elements and quarter circular slits on radiating edges.Bandwidth is significantly increased by the addition of the quarter circular slits at radiating edges. In [9-14], the authors proposed various structures for IOT Applications.

II. ANTENNA CONFIGURATION

The proposed low profile antenna has dimensions of 128.5mm×88mm×1.6mm which is shown fig1.and is designed by FR4 substrate having dielectric constant 4.4 and loss tangent of 0.02.

The structure of antenna consists of a circular patch united with Koch fractals and rectangles alternatively on its circumference fed by a microstrip line and two more Koch fractals on either side of the circular patch.

Multiband response is achieved through the surface currents circulating on the radiating parts of the structure. The DGS (defected ground structure) with slots in it is shown in fig 2.which also helps in enhancing multiband responses. The top plane and ground plane of proposed antenna are shown in fig.1and fig.2 and optimized dimensions of proposed design are noted in Table I.

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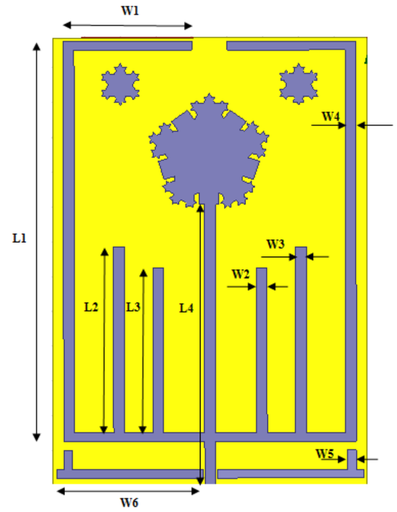


Fig.1.The geometry of front view of proposed low profile antenna

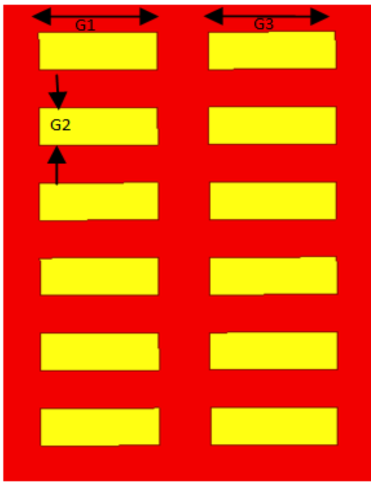


Fig.2. Geometry of back view of defected ground structure (DGS) of proposed antenna

Table I: The optimized dimensions of proposed antenna

Parameter	Size(mm)	Parameter	Size(mm)
L1	115	W4	3
L2	56	W5	3
L3	50	W6	41
L4	82	G1	28
W1	36	G2	10
W2	3	G3	30
W3	3		

The radius of circular patch is calculated by using

$$a = \frac{F}{\left\{1+\frac{2h}{\pi \varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{1/2}} \quad (1)$$

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

The effective radius of patch is given by

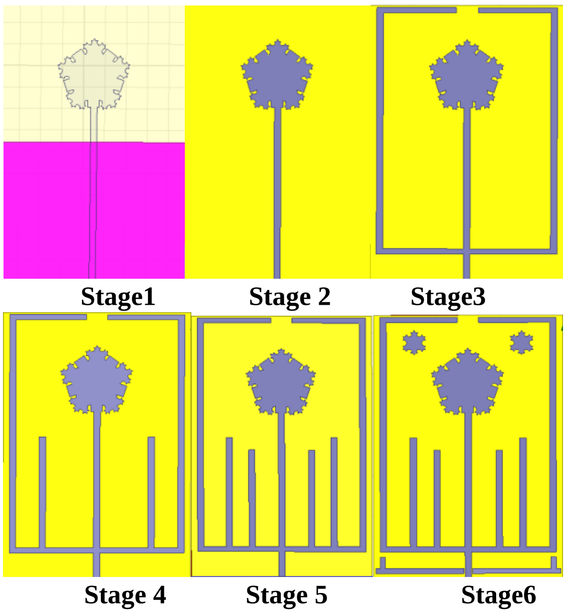
$$a_e = a\left\{1\frac{2h}{\pi \varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right) 1.7726\right]\right\}^{1/2} \quad (3)$$

The resonant frequency is given by

$$(f_r)_{110} = \frac{1.8412\, v_0}{2\pi a_e \sqrt{\varepsilon_r}} \quad (4)$$

A. Evolution of Proposed Antenna

Different stages of evolution for the proposed antenna are shown below:



Stage 1 consists of a circular patch antenna united with Koch fractals and rectangles which are fed by a microstrip line with defected half ground plane. In stage 1, the antenna operates at 6.5GHz.

In addition to stage 1, stage 2 consists of antenna connected to the defected ground plane with rectangular slots in it. This stage resonates the antenna to work at 6GHz frequency.

Stage 3 consists of an outer rectangular split ring around the circular patch. In this stage, antenna operates at 5.8GHz.

Stage 4 consists of two rectangular stubs placed apart from the feed line. This made the antenna to operate at both 2.65GHz and 5.45GHz.

Stage 5 consists of four rectangular stubs placed parallel to the feed line. In this stage, antenna operates at 1.65GHz, 2.65GHz, 3.85GHz and 4.85GHz.

Stage 6 consists of two L shaped stubs in the vicinity of start of the feed line and two Koch fractals on either side of the circular patch. In this stage, the antenna operates in 1.65GHz, 2.05GHz, 2.65GHz, 3.85GHz, 4.85GHz and 5.45GHz. The simulated S11 plots of different stages in theevolution of proposed antenna are depicted in the fig 3.

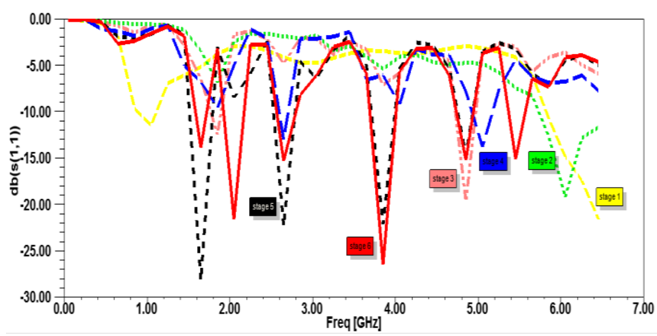


Fig.3. Return loss plot of different stages.

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B. Optemetrics

The lengths of fourrectangular stubs apart from the feed line and nearer to the field line are varied and therelated return loss plot isshown in fig 4

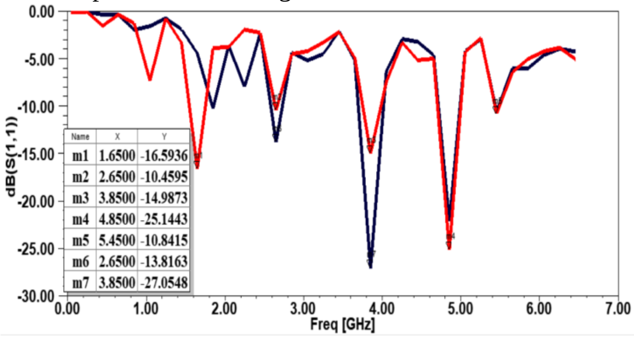

Fig.4. Return loss plot

C. Current Distributions

The Current Distributions of radiating plane and ground plane at1.65GHz frequency are shown in fig 6.

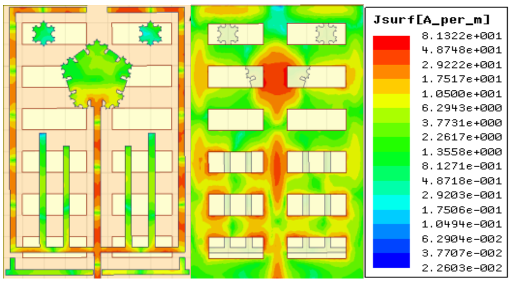

Fig.6. (a) Radiating plane (b) Ground plane

The current distributions of radiating plane and ground plane at 3.85GHz frequency is depicted in the fig 7.

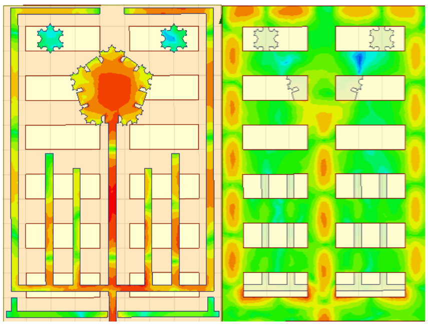

Fig.7. (a) Radiating plane (b) Ground plane

The current distributions of radiating plane and ground plane at 5.45GHz frequency is depicted in the fig 8.

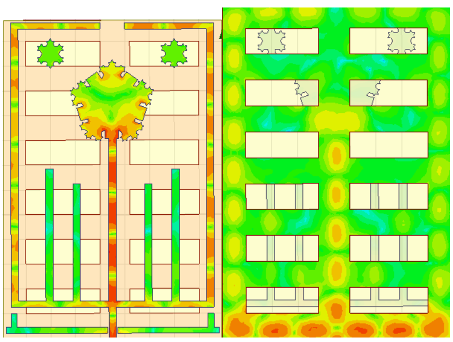

Fig.8. (a) Radiating plane (b) Ground plane

D. Results

The return loss plot and VSWR plot of the proposed antenna at the operating frequencies 1.65GHz, 2.05GHz, 2.65GHz, 3.85GHz, 4.85GHz and 5.45GHz are shown in fig 9 and fig 10 respectively.

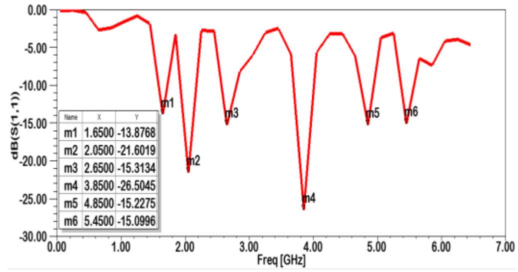

Fig.9.Plot of S11 of the proposed antenna

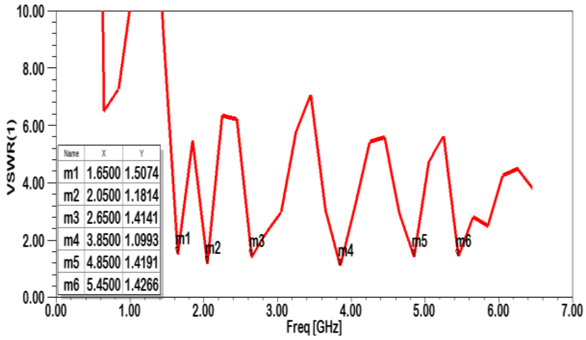

Fig.10. VSWR plot of the proposed antenna

The radiation patterns of E-Plane and H-Plane of the proposed antenna at 1.65GHz, 2.05GHz, 2.65GHz, 3.85GHz, 4.85GHz and 5.45GHz is simulatedand the plots are shown in Fig.11 and Fig.12.

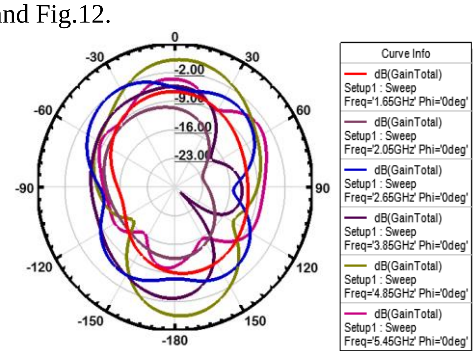

Fig.11. Radiation pattern of the Proposed antenna at phi=0°

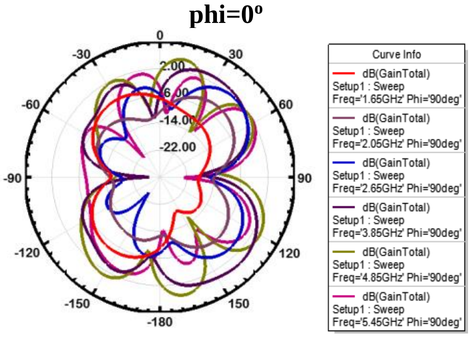

Fig.11. Radiation pattern of the proposed antenna at phi =90°.

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The simulated 3-D gain of the proposed antenna at 3.85GHz is given in the fig 12.

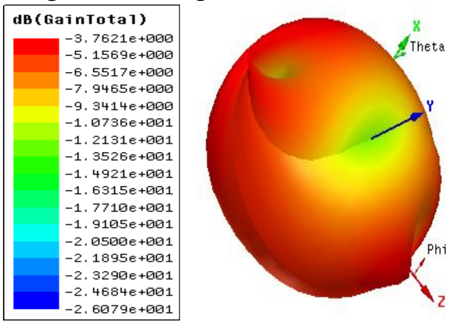

Fig.12. 3-D polar plot of gain of theproposed antenna at3.85GHz

E. Comparison Table

Comparison of operating frequencies and size of different antennas with reference papers:

Table II. Comparison of antennas with reference papers

Structure	Operating Frequencies	Size of antenna
[1]. Truncated icosidodecahedron	1.61GHz,2.94GHz, 3.57GHz,3.94GHz, 4.49GHz,5.2GHz,6 .35GHz	130*90 *6.35mm^3
[2]. Octahedron Shaped Planar	920GHz 2.4GHz 5.4GHz	130*90*1.6 mm^3
[3]. Triple Starfish shaped Microstrip patch antenna	0.8GHz,2.4GHz,3. 2GHz,4.8GHz,5.8 GHz	110*90*6.3 5 mm^3
[4]. Double Planar Inverted F (PIFA) Structure	900MHz,1.8GHz, 2.6GHz,5GHz	56*60*1.52 mm^3
[5]. Circular Patch Antenna	2.45GHz	120*80 *1.6 mm^3
[6]. E slotted patch	2.1GHz,3.8GHz,7. 02GHz	22.47*16.9 5*1.5 mm^3
[7]. Tunable multi band antenna	2.5 GHz, 3.5 GHz, 5.5 GHz	16*27*1.6 mm^3
[8]. Proposed antenna	1.65GHz,2.05GHz, 2.65GHz,3.85GHz, 4.85GHz,5.45GHz	128.5*88*1 .6 mm^3

The proposed antenna is found to be compact compared to that of the reference antennas cited above.

III. CONCLUSION

The proposed antenna is of compact planar structure which operates in multiband of frequencies of UHF, SHF and Microwave bands. It operates in the frequency ranges of Bluetooth, WiFi, and WiMAX, GSM 900 band applied for Cellular application. It operates for WLAN and WiFibands which facilitates the antenna a suitable candidate for IOT applications.

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