Slotted Octagonal shaped Antenna for Wireless Applications

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Abstract This paper presents the design and implementation of a multi-band antenna based upon fractal sub-array concept. The antenna design has concentric octagonal slots on rectangular patch. It is demonstrated that the proposed antenna can completely covers the entire bandwidth required for various wireless application ranging from 0.5-to-5.4 GHz and can serve for GSM/UMTS/Wi-Fi/WLAN type of applications. The antenna is coaxial probe feeded and is simulated on IE3D Zeland software. Performance parameter evaluated from soft simulation and measured through VNA (Network analyzer) has high degree of accuracy. It has directivity upto 11.25 dBi Gain of about 7 dB and Efficiency upto 62% along-with satisfactory radiation characteristics. The computer simulation results shows that the antenna have good impedance bandwidth (VSWR ≤2 & S_{11}< -10 dBi) at all the multiple resonant frequencies.

Keywords – Microstrip patch, Slots, Octagonal shape, Sub array, IE3D.WLAN, Miniaturization, Iterations.

1 Introduction

In present scenario telecommunication systems require antennas having wider bandwidths and smaller dimensions than those in the conventional ones [1]–[6]. For many years, various antennas for multiband operation have been studied for communication and radar systems [7], [8]. To fulfill the present need fractal antennas provides the better alternatives and are preferred over conventional patch antennas as these are not only small and lightweight, for easy installation, but also because they have extreme wideband [5], [6], [9]–[12]. There are a variety of approaches that have been developed over design, the years, which can be utilized to achieve one or more of these design objectives. For instance, an excellent overview of .various useful techniques for designing compact (i.e., miniature) antennas may be found in [13] and [14]. Moreover, a number of approaches for designing multi-band (primarily, dual-band) antennas have been summarized in [15]. The article describes the design of concentric octagonal slots on rectangular patch antenna sub array. Performance simulations of the antenna are carried out with IE3D software, which is based on the method of moments [16].

This paper is organized as follows. Section 2 describes the fundamental of antenna design methodology. In section 3, the simulated results of proposed antenna design geometries are presented. In Section 4, we comparers the simulated results with measured results and related analysis are discussed for the proposed antenna design. Finally the concluding remarks are given in Section 5

2 Antenna Design Methodology

The geometry and detailed dimensions of proposed antenna is shown in Fig. 1, which shows that the antenna have concentric octagonal slots in rectangular patch. The dimension of upper radiating patch and ground plane are same and is 60x60 mm .The height of the dielectric substrate slab is 1.6 mm and having relative permittivity of 4.7 and loss tangent .019. The fig.1 shows dimensional view of proposed antenna in which the side length of octagon for base shape is taken as 2 cm and fig.2 represent the iterated geometries of proposed antenna shapes. In these iterated geometries order of concentric octagonal slots has been increased in scaled manner.

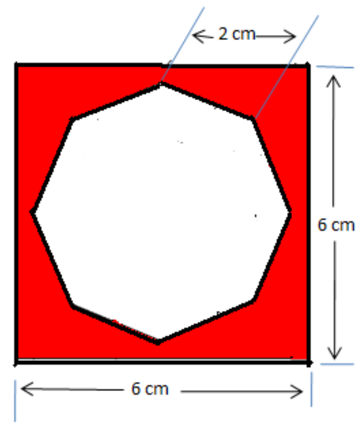
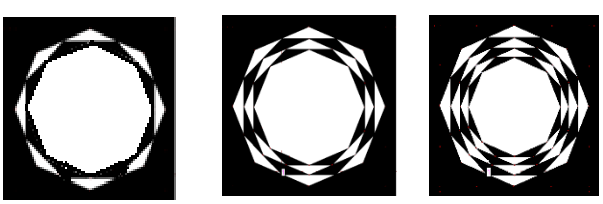


Fig.1 Dimensional view of proposed antenna (Base Shape)



(a) **(b)** **(c)**

Fig.2 Iteration of proposed fractal geometry from its base shape (a) I[st] iteration , (b) 2[nd] iteration and (c) 3[rd] iteration,

The geometric construction of this fractal shape starts with an octagon slot cut in rectangular patch, called the base shape, which is shown in

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fig.1.By adding another octagon inside the base shape, the first iterated version of the new fractal geometry, as shown in the fig. 2(a) the first Iteration is created. The process is repeated in the generation of the second and third iteration which is also shown in fig.2 (b) and 2 (c).

3. Simulation and Experimental result

The performance of this antenna is simulated and optimized by "IE3D" 14 version of Zeland. This is used to calculate the return loss, impedance bandwidth : and radiation pattern along-with directivity, gain and antenna efficiency etc for performance analysis of the antenna. In this regard the primary step is to measure the Return Loss parameter i.e (S_{11}) and VSWR for proposed antenna. Fig.3 represents the current distribution display

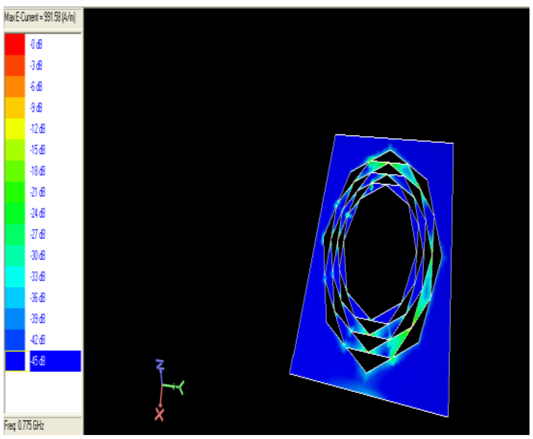


Fig. 3 Current Distribution for Slotted Octagonal shaped Microstrip Patch Antenna for 3rd iteration

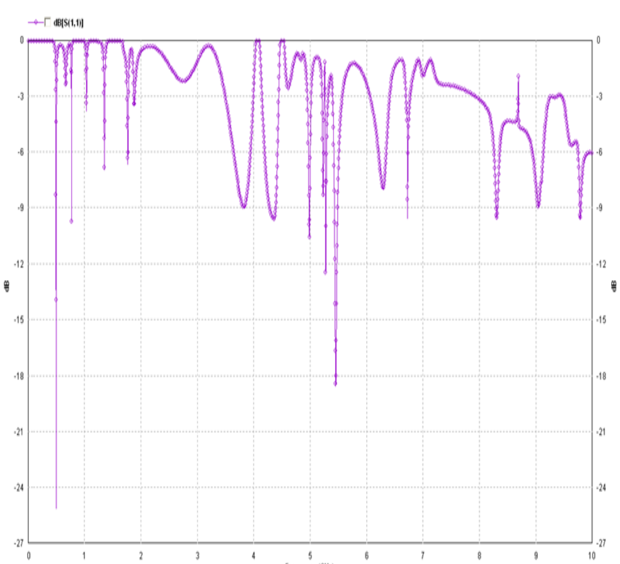
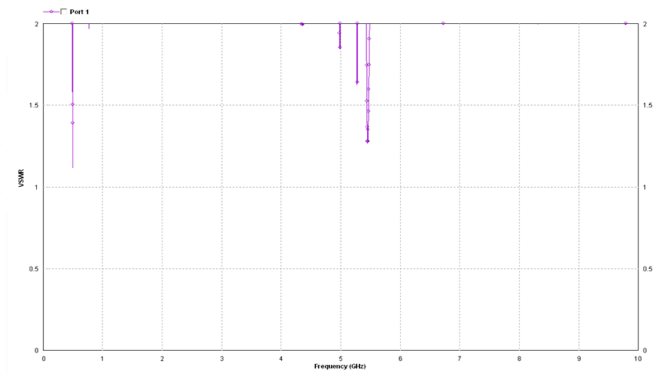


Fig. 4 Return Loss curve for Octagonal shaped microstrip Patch antenna for 3rd iteration

The fig. 4 , showns the Return loss curve for antenna geometry for 3rd iteration. Analysing of return loss curve it is found that the proposed antenna operates in the range from .5GHz to 5.4 GHz : at frequency 0.5 GHz the value of return loss comes to be -25.5 dBi as shown in the curve as its first resonance frequency. Similarly the VSWR curve for the antenna is shown in fig. 5 . From the figures 4 &



5 it is noticeable that at all the resonating frequency Return loss and VSWR follows the criteria of VSWR ≤2 & S_{11}< -10 dBi.

Fig.5 VSWR curve for Slotted Octagonal shaped Microstrip Patch Antenna for 3rd iteration

Other important parameters such as Directivity, Gain and Antenna efficiency are also evaluated /simulated for antennas. From fig 6, the curve is drawn in between Directivity and frequency and it is meaningful that value of directivity increases from 6 dBi to 11.25 dBi

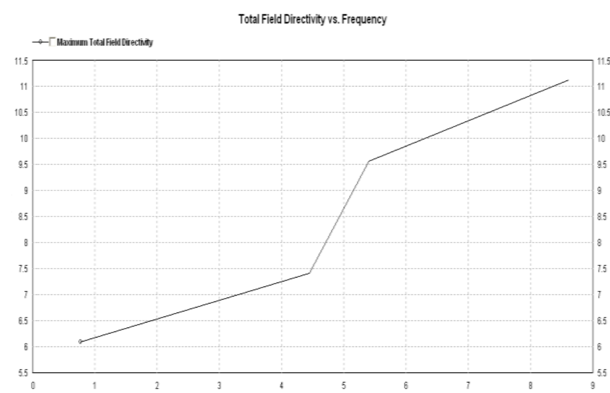


Fig.6 Directivity curve for Slotted Octagonal shaped Microstrip Patch Antenna for 3rd iteration

Similarly the fig 7 and fig. 8 shows the curves for Gain and Efficiency of antenna.

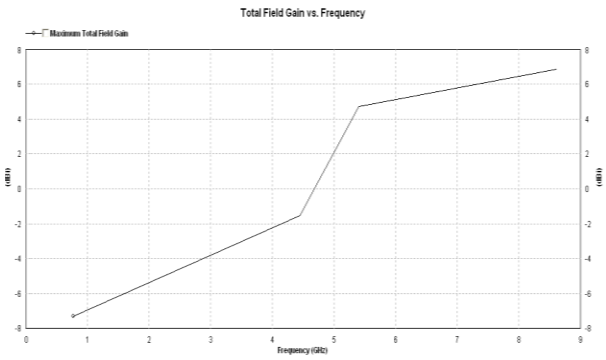


Fig. 7 Total Field Gain curve for Slotted Octagonal shaped Microstrip Patch antenna for 3rd iteration

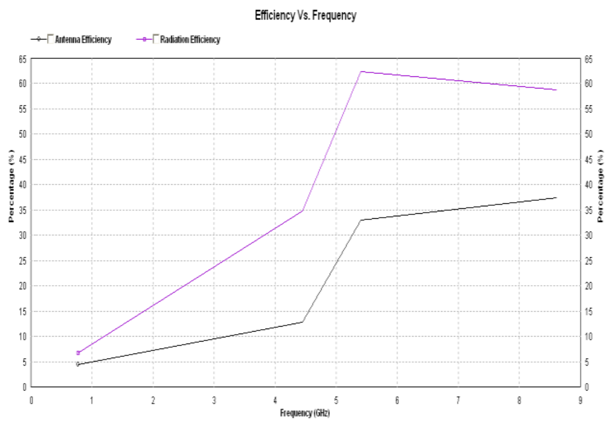


Fig.8 Antenna & Radiation Efficiency curve for Slotted Octagonal shaped Microstrip Patch Antenna for3rd iteration

Apart from above shown parameters the proposed antenna have the promising radiation patterns in 3- dimensional (fig. 9 and 10 shown below) and 2-dimensional plane in form of polar plots. The polar plots for E-plane ($\Phi = 0^0$ deg.) and H-plane ($\Phi = 90^o$ deg.)- given in fig. 11
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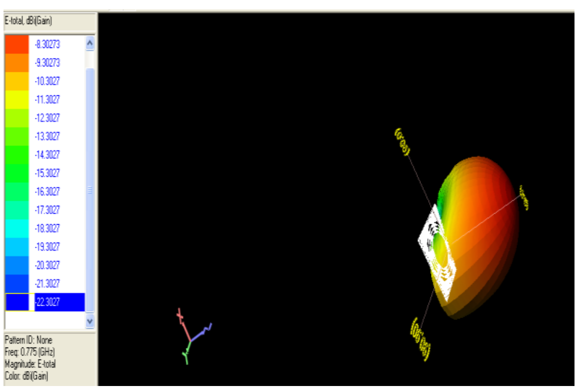


Fig. 9 Radiation Pattern at Frequency 0.5 GHz for Slotted Octagonal shaped Microstrip Patch Antenna for 3rd iteration

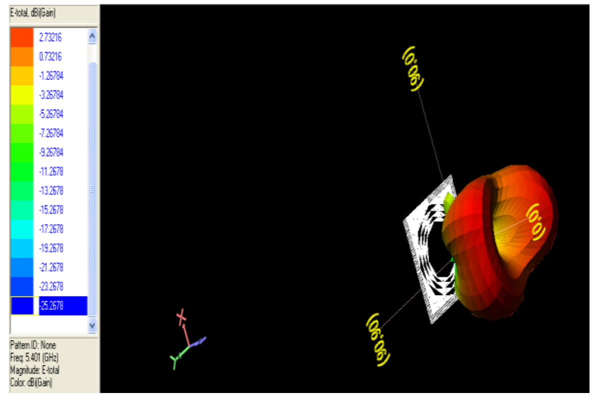
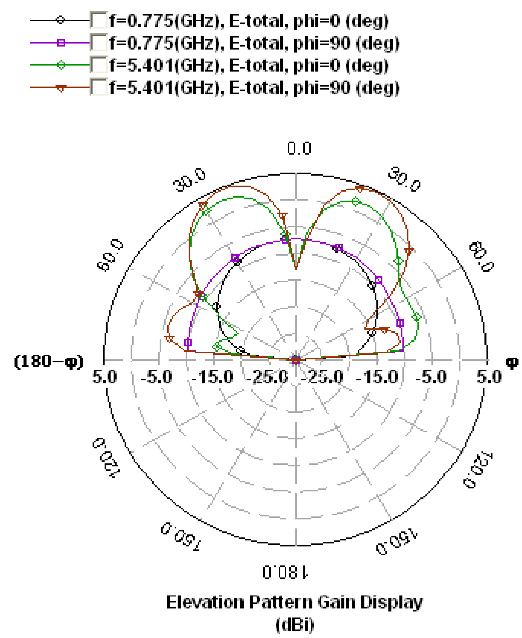


Fig. 10 Radiation Pattern at Freq. 5.401 GHz for Slotted Octagonal shaped Microstrip Patch Antenna for 3rd iteration



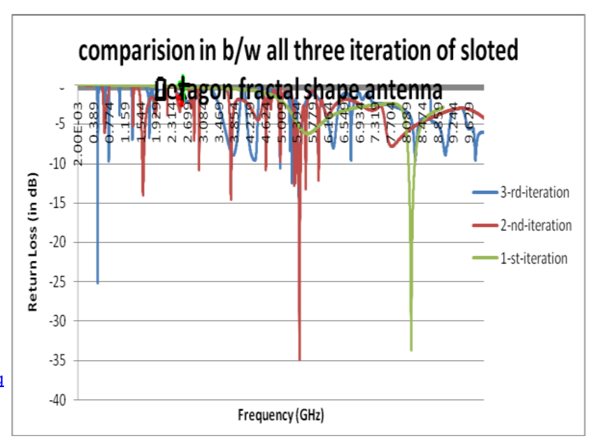


Fig. 11 2-Dimensional Radiation Pattern at frequencies 0.77 & 5.40 GHz for E-Plane Radiation Pattern (Φ = 0^o deg.) and H-Plane Radiation Pattern (Φ = 90^o deg) for Slotted Octagonal shaped Microstrip Patch Antenna for 3rd iteration

Fig.12 Comparision curve (simulated) of S_{11} (dB) for all three iteration of Slotted Octagonal shape antenna

The fig. 12 shows the comarative analysis of all the three iteration of Slotted Octagonal antenna ,from the above fig. it is clear that the resonance frequency is decrementing in logarathmic ratio when we proceed from lower iteration to higher iteration the same is also elaborated in tabular form Table 1 So from these it is quite clear that the Iterative fractal behaviour of this antenna is verified. From the analysis of the table givin below it can also be demonstrated that multiband nature of antenna increses as number of iteration increses.

Table 1 Comparative analysis of Return loss for all three iteration of Slotted Octagonal antenna

Freq.	**S_{11}-3rd-Iter.**	**Freq.**	**S_{11}-2nd-Iter.**	**Freq.**	**S_{11}-Ist-Iter.**
0.5	**-26**	**1.6**	**-14**	**9.2**	**-33**
4.3	**-11**	**3.8**	**-15**		
5	**-10.5**	**5.4**	**-35**		
5.4	**-18**				

the 3rd Iteration of proposed antenna is fabricated on 1.6 mm thick Glass Epoxy substrate material having dielectric constant 4.7 and Loss Tangent of about .019 The fig. 13 shows the testing of fabricated antenna through VNA-Network analyzer for comparision in between simulated and measured results.

Fig. 13 Testing of Octagonal shaped Microstrip Patch Antenna for3rd iteration with Network analyzer (VNA) screen showing the Return Loss plot (curtsey – Microwave Engg. Lab, AIACTR, Delhi)

Comparison results in between simulated and measured return loss (S_{11}) is shown in the fig.14. It can be concluded that the measured results matches with simulated results with good degree of accuracy. The partial deviation of measured results from simulated results occurs due to design imperfection and noisy environment.

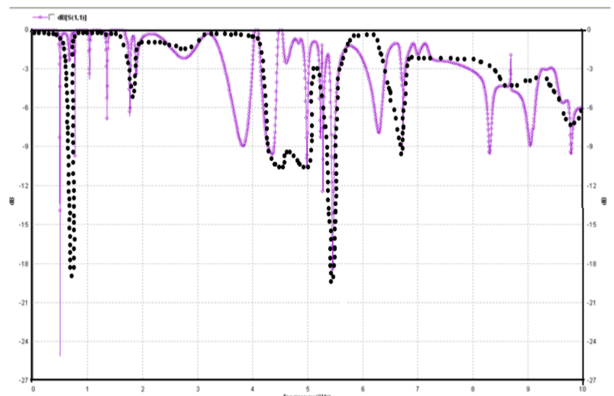


Figure 14 Comparative graphs in between simulated and measured results for third Iteration of Complementary Slotted Octagonal antenna

4 Conclusions

A single dual layered octagonal slotted rectangular microstrip patch antenna for wireless applications is designed and proposed. The proposed antennas have all the advantages of Iterative fractal

Sub-array implementation .Its performances parameters are studied for its iterative geometries. Incorporating the fractal design approach the resonance frequency of the same size antenna decreased from 9.2 GHz to .5 GHz along-with satisfactory radiation characteristics. Furthermore, this antenna has many advantages such as easy fabrication, low cost and compact in size. Therefore, such type of antennas can be useful for GSM / UMTS/PCS/WCDMA type of wireless applications in personal communication It can also fulfills the requirements of indoor wireless system applications.

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