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Hendecagonal Ring Fractal Micro Strip Patch Antenna for UWB Applications

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Abstract— **In recent trend, an antenna size and dimension should be simple and multifunctional. In this paper a low profile compact microstrip feed Hendecagonal ring fractal patch antenna is proposed for multiband UWB applications. The effects of fractal iterations and changing the size of the ground plane are used for improving the characteristics performance of the proposed antenna. The Return loss, VSWR and radiation properties value for the proposed simulated design further bear out the wireless applications. The low cost dielectric material FR4 (ϵ=4.4) is used as substrate for this design. The proposed antenna is simulated using Ansoft HFSS v.14 with the dimensions of 40X30X1.6mm^3 and operating frequency band varies from 3-10.4GHz with Input impedance is 50Ω and it exhibit the unidirectional pattern. Hence the proposed design is suitable for UWB Wireless applications.**

Keywords: *Hendecagonal, fractal, UWB, HFSS, Return loss, VSWR*

I INTRODUCTION

Recent development in wireless application demands antenna to design with small size and low profile to integrate with multiple portable electronic devices. Therefore a lot of concentrations are given to design UWB antennas, because the size of the antenna significantly affects the bandwidth and gain. [1]. In FCC rules, the owed frequency for UWB is varies from 3.1-10.6 GHz and it mainly provides high data rates with low energy level for short-range communications services [2]. Various compact and multiband techniques have been proposed for WLAN/ WiMAX application using Micostrip feed monopole [3], self similar ring radiators [4], and monopole with defected ground plane [5]. To further decrease the size of the antenna element various ground plane radiation modes are excited for multiband applications [6].On the other hand, the fractal geometry is used for improving the antenna parameters, and fractals with self similarity and self affinity in their structure can offer size miniaturization with multiband characteristics [7] and it proves to be a better candidate for compact multiband antenna. This geometry allows the electrons to flow through the various lengths that implies in wider frequency spectrum, multiple bands and also minimizes the antenna size by 2-4 times [8]. In this proposed design, the effects of fractal iterations and changing the size of the ground plane which improves the characteristics performance of the proposed Hendecagonal Antenna.

II ANTENNA DIMENSIONS AND FRACTAL GEOMETRY

Fig. 1(a) shows the shape and dimension of the proposed hendecagonal antenna. The proposed antenna is fed by 50Ω asymmetric microstrip line printed on FR4 substrate (∈ r= 4.4) with thickness 1.6 mm and area of the substrate in dimensions of 40X30X1.6mm^3, Fig.1(b) shows the size of the ground plane is optimized and reduced ground plane of dimension of *8X30* mm^2. The proposed antenna design is based on concept of self repeating and self similarity geometry [9-15], where patch is designed with hendecagonal ring fractal loop nested inside the larger hendecagonal ring structure (Initiator) connected to the 50 Ω microsrtip feed line. The Width of the hexagon ring strip Ws=1 mm is constant for whole iteration process of simulation and observation. The various dimensions of the hendecagonal proposed antenna are summarized in Table-1.The sides of regular hendecagonal at various stages are related with log periodic concepts and can be determined by following equation [16].

$$S_{n+1} = \theta \cdot s_n \qquad (1)$$

Table 1.Dimension of proposed antenna

Parameter	Dimension (mm)	Parameter	Dimension (mm)
L_s	40	L_1	2.9
W_s	30	L_2	1.5
L_g	40	L_3	1
W_g	30	F_W	1
S_1	7.88	L_{f1}	13.5
S_2	5.76	L_{f2}	17.3
S_3	4.18	L_{f3}	19
S_4	3.06	L_{f4}	21

Where *n* (number of Iteration) =1, 2, 3; S_1 is the Initial length of hendecagonal side (Initiator). In eqn.1, Initiator is multiplied with scaling factor (θ) for the further iterations (s_2, s_3, s_4), which is the controlling parameter in designing the proposed antenna and Scaling factor θ is assumed to be 0.734 which is parametrically optimized for this proposed design as well as controls the design dimension. The development of the proposed antenna design from initiator geometry of single ring hendecagonal loop is shown in Fig.2.The High Frequency Structure Simulator software (HFSS) has been used to study the Performance of antenna.

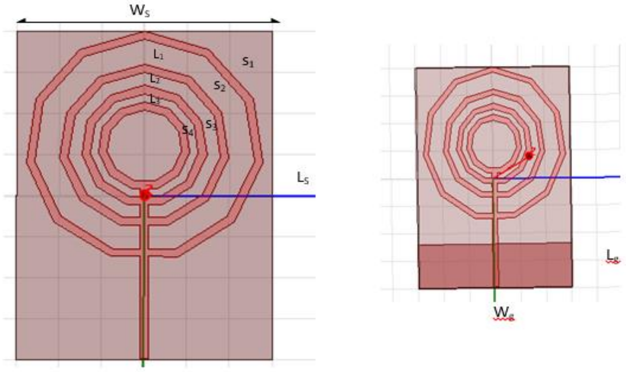

Figure.1.Proposed Hendecagonal antenna (a) Front View (b) Antenna Ground Plane dimension (8x30) mm

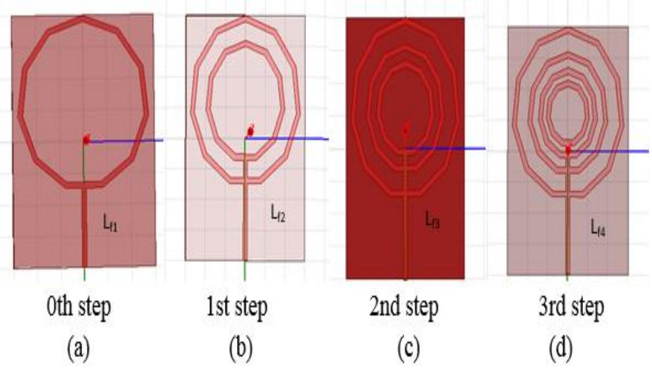

Figure 2. Changes in iteration steps from 0 to 3

III SIMULATION AND RESULTS

This section confers the proposed antenna dimension with variations in its design parameters provides various antenna parameters such as Return loss, VSWR, gain, bandwidth and radiation pattern by using HFSS simulation tool.

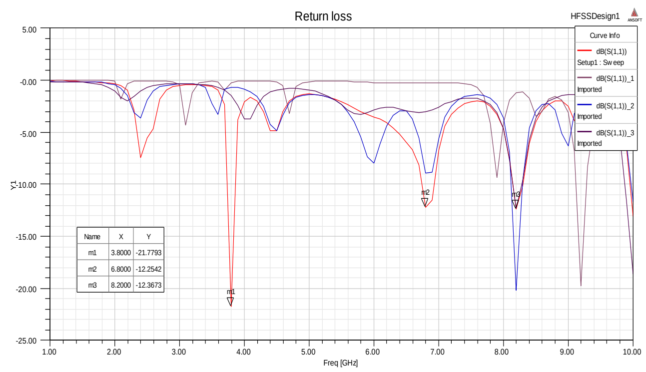

Figure 3 Simulated Return loss of antenna for various design steps as shown in fig.2 (a)-(d).

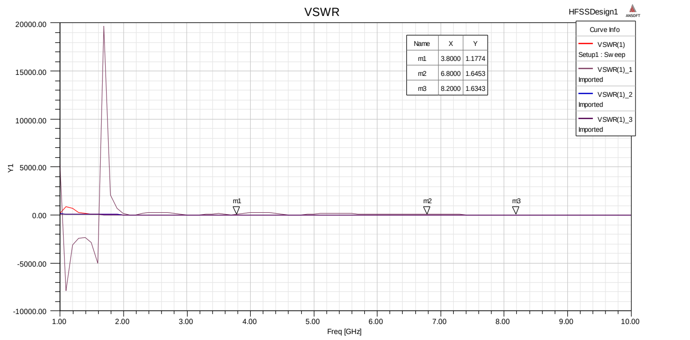

Figure.4 Simulated VSWR of antenna for various design steps as shown in fig.2 (a)-(d).

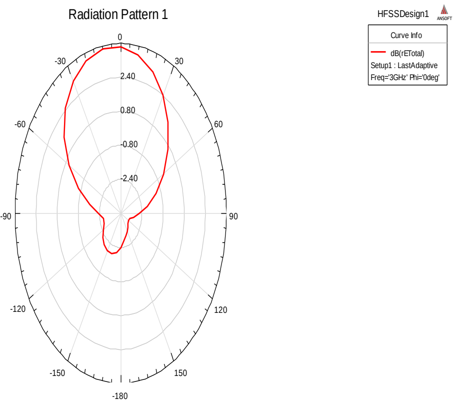

Figure 5 Simulated Radiation pattern of antenna for design step (d) as shown in fig.2

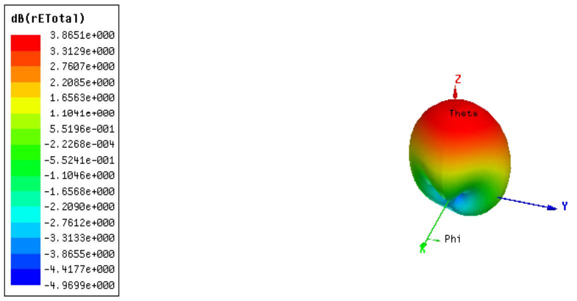

Figure .6 Simulated Gain of antenna for design step (d) as shown in fig.2

From the Fig. 3 and 4, the comparison result of simulated return loss and VSWR parameter for various iteration stages has been observed. The proposed design with only initiator (Step 0) resonates at 8.2 GHz with return loss -12db after that addition of first ring as shown in Fig 2(b) resonates same operating frequencies with return loss of -20db.Similarly the second fractal (Fig 2 c) shift the resonance frequency to the higher frequency side offer 9.8Ghz with return loss of -19.77db and third fractal (Fig 2 d) results in multiband resonance frequencies of 3.8Ghz, 6.8Ghz and 8.2Ghz with return loss of -21.77db,-12.25db and 12.3db respectively. In this proposed design, when the iteration stages increases, the antenna dimension decreases in further[15]. Fig.5 and Fig.6 shows the radiation pattern and gain of the design step (d) shown in fig.2 (d).

Table 2. Comparisons of each Iteration

Parameter	Iteration				
	Step 0	Step 1	Step 2	Step 3	Proposed antenna
Resonance frequency (GHz)	8.2	8.2	9.2	3.8,6.8 and 8.2	3.5,4.8 and 6.8
Return loss (dB)	-12.5	-20.18	-19.77	-21.7,-12.25 and -12.35	-14.12,-15.58 and -15.77
VSWR	1.64	1.2	1.2	1.17,1.64 and 1.63	1.4,1.3 and 1.3

The effect of varying the length of ground Plane (Lg)

In this proposed design, the length of the ground plane is optimized for maximum performance of the antenna, the effect of varying the ground plane length(lg) is shown in Fig.1(b), With the ground plane dimension of 8x30 mm gives good results of multiband as shown in Fig.7, From the fig.7, the antenna resonates 3.5Ghz, 4.8Ghz and 6.3 GHz with return loss of -14.128db, -15.5db and -15.77db respectively, which meet the bandwidth requirement of DCS1800, Bluetooth and WLAN 2.4/5.2/5.8GHz, WiMAX band at 3.5/5.5GHz frequency. The radiation pattern illustrates how the antenna directs the energy it radiates. The radiation pattern at 3 GHz is shown in Fig.9. The gain value illustrates the efficiency and directional capabilities of the antenna. For the proposed hendecagonal fractal antenna with change in size of the ground plane provides the simulated gain is 9.68 db shown in Fig.10.

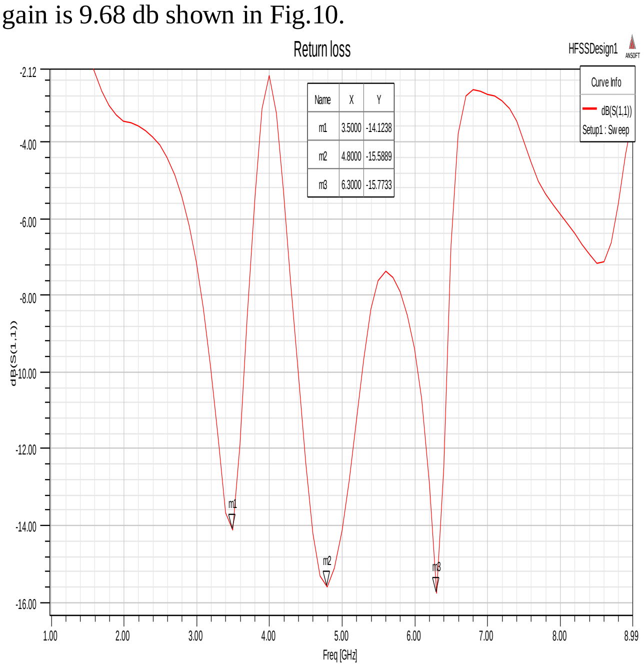

Figure.7. Simulated Return loss of antenna for ground plane (Lg) 8mm

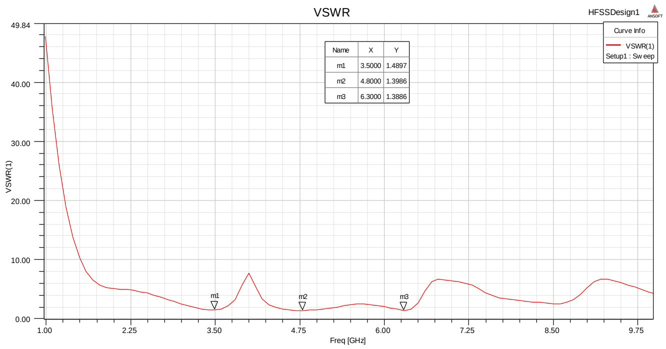

Figure.8. Simulated VSWR of antenna for ground plane (Lg) 8mm

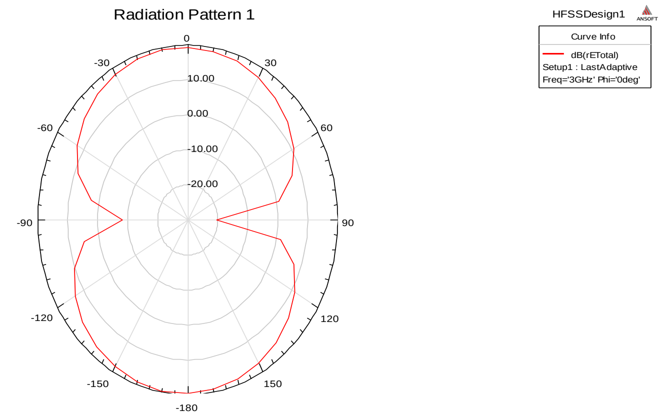

Figure 9. Simulated Radiation of antenna for ground plane (Lg) 8mm

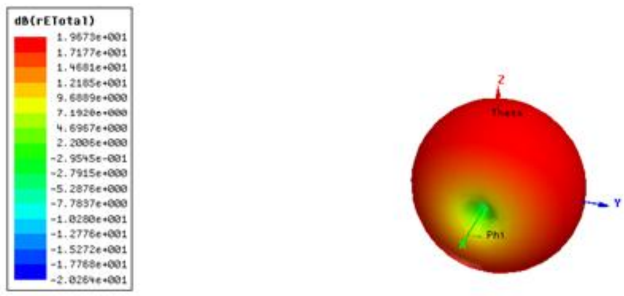

Figure 10. Simulated Gain of antenna for ground plane (Lg) 8mm

IV CONCLUSION

A well compacted hendecagonal ring fractal patch antenna has been designed using FR-4 substrate with overall dimension of 40X30X1.6 mm^3. Ansoft HFSS simulation tool is used for simulation and analysis of this proposed antenna for various applications like DCS1800, WLAN 2.4/5.2/5.8GHz, and 3.5/5.5GHz WiMAX band of operation. Multiband resonant frequencies are obtained by optimize the number of hendecagonal ring fractal as well as by changing the size of the ground plane. The return loss and VSWR plot shows the step by step improvements and 3rd iteration of the fractal structure and length of the ground plane (Lg) 8mm proves the high bandwidth impedance. The proposed hendecagonal antenna is operating in three different frequency bands with resonating frequency of

3.8, 4.8, and 6.3 GHz and provides good return loss of -14.12,-15.55 and-15.77 db with reasonable gain which makes the proposed antenna a appropriate candidate for wireless applications.

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