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A DGS based Fractal Rectangular Patch Antenna for UWB Applications

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Abstract: In this paper, A basic rectangular patch and fractal based rectangular patch antennas are designed, simulated and investigated for Ultra-wide band (UWB) applications. The proposed antennas are designed on FR4 laminate-based substrate with dielectric constant of 4.4 fed by 50-ohm impedance microstrip feed line. Two regular fractal slots configurations have been inserted randomly to the patch to modify the reference antenna characteristics and decrease the patch area. These new proposed antenna configurations are investigated in terms of the antennas different parameters including return loss, VSWR, radiation patterns, and gain.

Keywords: UWB, Fractal Structure, Communication applications.

Introduction

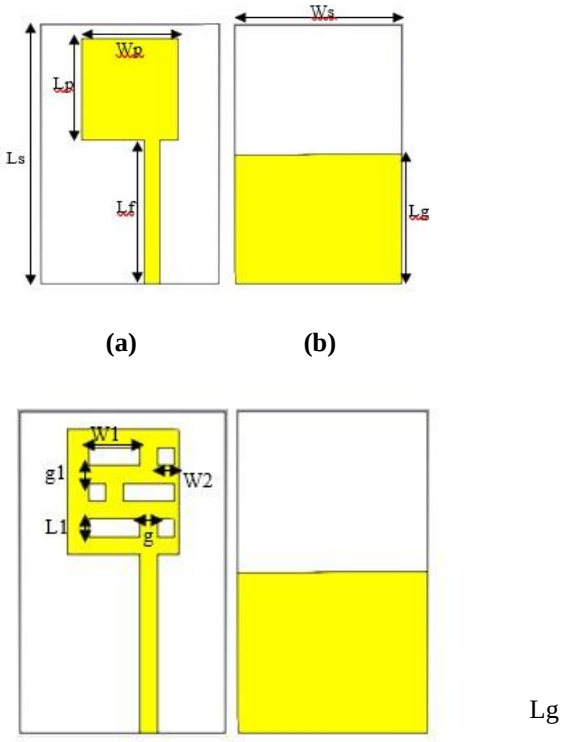
Since February 2002, the Federal Communications Commission's (FCC) in United States accredit the radio frequency band from 3.1 GHz to 10.6 GHz for commercial civil services of Ultra-wideband (UWB)communication system, a significant development in modern wireless data communication system elements is required to acquire the numerous advantages of this technology efficiently. Therefore, the field of antenna design and manufacturing faces a great attention because the antenna is an essential element in wireless communication system [1, 2].

Planner compact configuration with high performance characteristics is a main challenge and an essential target for antenna designers and researchers [3, 4]. One of the novel issues for developing the antenna miniaturization in aspect of size compactness, low profile and multi-band or broadband frequency operation is to utilize the fractal structure for the required antenna designing process [5, 6]. There are various fractal antenna geometries such as snowflake [7], tree-shaped [8], star-shaped [9], octagonal structure [10], Pythagorean tree monopole antenna [11], fourth-order Koch Snowflake fractal monopole antenna [12], fractal polygon elements embedded with antenna radiator [13], Koch base fractal antenna [14], analog-periodic square fractal radiator [15]. In [16], The performance of random irregular fractal slots created using Cellular-Automata (CA) approach and inserted in the radiator of the UWB patch antenna has been investigated. Although the design concept has its novelty and the antennas' performance in frequency domain has been studied, the time domain and group delay characteristics have not been investigated to show the effectiveness and limitations of the proposed approach in this important issue. Moreover, the idea of slot load UWB antenna added notched band characteristics which is a feasible action against the interference problem between the large frequency band of the UWB system and the other contiguous narrow band wireless communication services such as WiMAX which occupy the spectrum of 3.3–3.6 GHz, C band (3.8–4.2 GHz), WLAN (5.15–5.82 GHz) and X-band (7.25–8.39 GHz) [17, 18].

This paper proposes design of fractal regular slots patch antennas for UWB applications. The reference antenna is a monopole patch antenna. Four different fractal slots with regular configurations have been inserted randomly to the patch of the reference antenna to modify its characteristics and decrease the patch area. The new four antennas iterations are investigated in terms of the antennas different parameters including impedance band-width, radiation patterns, gain, and group delay evaluation.
The remainder of this paper is organized as follows: Section 2 describes the design aspects of the proposed fractal antennas. Simulation results shown the performance of the antennas in terms of its return loss characteristics, radiation pattern, antenna gain is discussed in Section 3. Finally, the conclusions of this paper are reported in Section 4.

Antenna Design

In this paper, mainly designed two types of antennas i.e basic antenna and fractal antenna represented in figure 1. The Defected ground structure (DGS) based ground used for increasing the bandwidth of antenna. These two antennas are designed on low cost laminate of FR4 substrate of 4.3 dielectric constant with 0.024 loss tangent and 1.6 mm thickness of the substrate. The copper is used as the radiating element used for both patch and ground designing. The reference UWB antenna monopole structure is taken from the reference [21]. The dimensions of the antenna is tabulated in table 1.



(a) **(b)**

(c) **(d)**

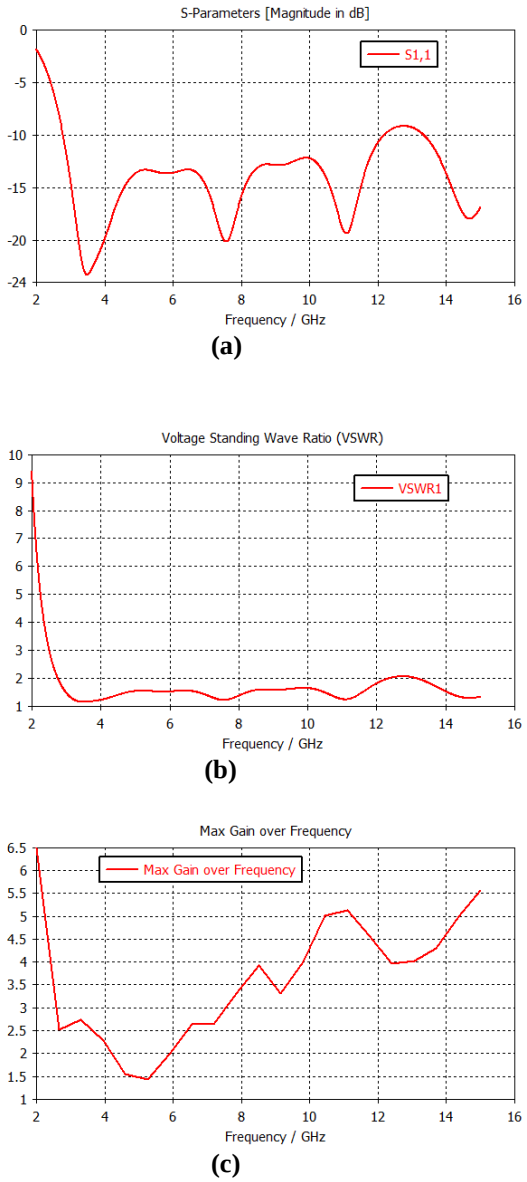
Fig.1: Antenna Structure (a) Basic antenna front view (b) Basic antenna Back View (c) Fractal antenna front view (d) Fractal antenna Back View

Table 1: Dimensions of the antenna structure

S.No	Parameter	Value in mm
1	Ws	24
2	Ls	36
3	Wp	13
4	Lp	14
5	Lf	20
6	Wf	2
7	Lg	18
8	L1	2
9	W1	6
10	W2	2
11	g	2
12	g1	2

Simulation Results

The Designed antenna is simulated under the PML boundary conditions. The simulated results completely cover the UWB range of frequencies. The antennas are Designed and simulated in commercially available CST microwave studio suite. The time domain solver is used for the investigation of antenna simulation results. The simulation results of return loss, VSWR and Gain Vs frequency are represented in figure 2 for basic antenna. The radiation patterns of 3D and 2D for the frequencies of basic antenna at 3.5 GHz, 7.55 GHz and 11.1 GHz are represented in figure 3. Both figure 2 and 3 obeys the basic antenna covers the entire UWB frequencies for wireless applications.

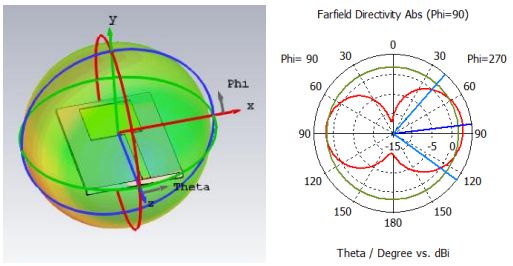


(a)

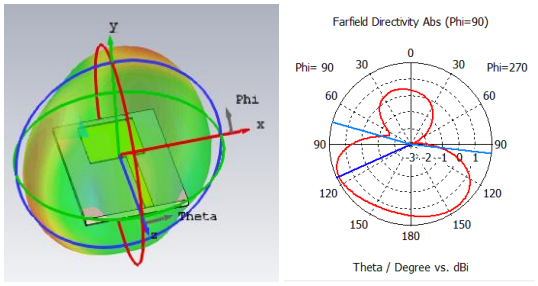
(b)

(c)

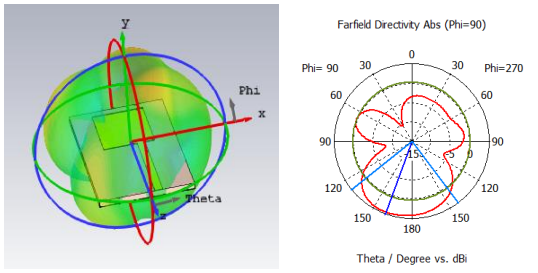
Fig.2: Basic antenna Simulation results (a) return loss (b) VSWR and (c) Gain Vs Frequency



(a) **(b)**



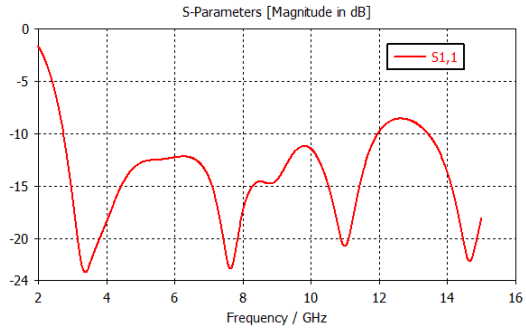
(c) **(d)**



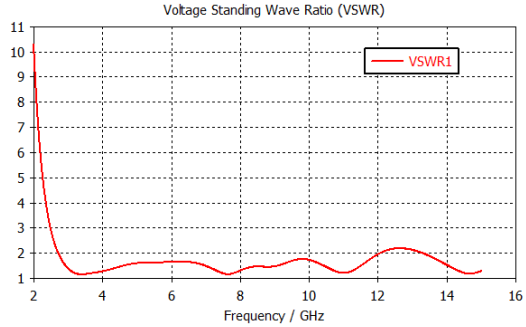
(e) **(f)**

Fig.3: 3D and 2D Radiation patterns at (a) and (b) at 3.5 GHz, (c) and (d) at 7.55 GHz and (e) and (f) at 11.1 GHz frequency respectively

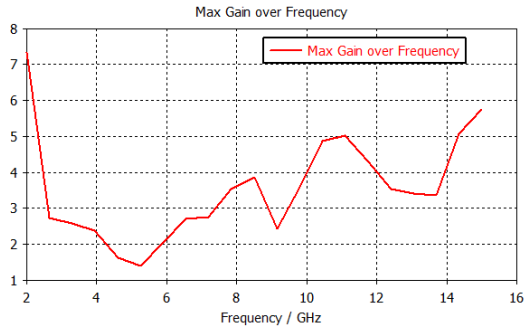
The proposed fractal antenna is represented in figure 1 (c) and (d) simulated in time domain solver of CST studio suite under PML boundary conditions. The simulated results of return loss, VSWR and Gain vs frequency are represented in figure 4. The figure 5 shows the radiation patterns of 3D and 2D for the frequencies of 3.38 GHz, 7.64 GHz and 11 GHz respectively. The basic rectangular patch and fractal based rectangular patch antennas are best suitable for UWB applications.



(a)

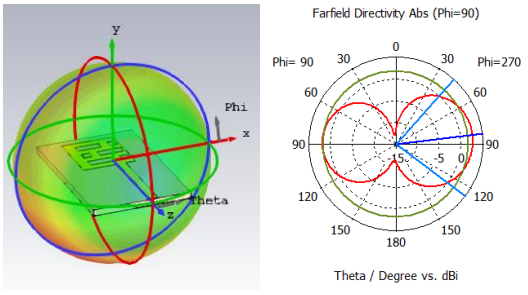


(b)

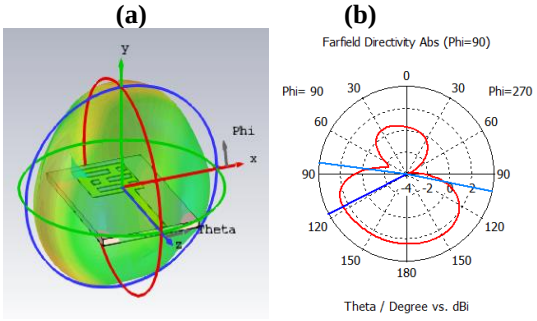


(c)

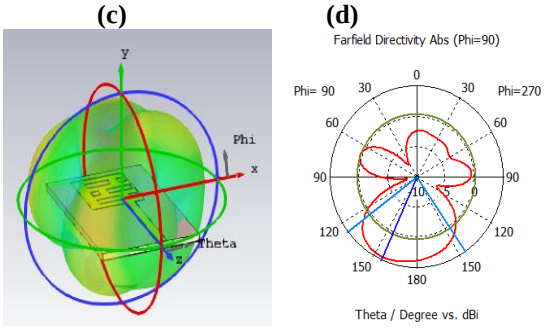
Fig.4: Fractal antenna simulation results (a) Return Loss (b) VSWR (c) Gain Vs Frequency



(a) **(b)**



(c) **(d)**



(e) **(f)**

Fig.5: 3D and 2D Radiation patterns at (a) and (b) at 3.38 GHz, (c) and (d) at 7.64 GHz and (e) and (f) at 11 GHz frequency respectively

Conclusion

This paper presented design of fractal regular slots patch antennas for Ultra-wideband (UWB) systems. The reference antenna is a monopole type patch antenna of a rectangular radiator mounted on a dielectric substrate and fed by a 50Ω feed line. Two fractal slots with regular configurations have been inserted randomly to the reference patch antenna. These two proposed antennas iterations are investigated in terms of the antennas different parameters including return loss, VSWR, radiation

patterns and gain. Good radiation pattern has been observed which alternating gradually from a stable directive-monopole pattern to slightly near to omnidirectional characteristic. The maximum gain is more than 4.97 dB. The group delay mainly constant with a small variation less than 1.65 ns over entire UWB spectrum ensure good antenna performance. The proposed antennas to be good candidates for the UWB portable applications.

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