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A Proposed Ultra-Wideband Antenna for 5G Communications Using Frequency Band Expanding

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Abstract: In this paper, a new compact design of Ultra Wideband (UWB) fractal antenna is presented. The antenna geometry is described by means of a spline curve and a rectangular slot. The bandwidth of antenna has been designed in a way to cover frequencies from 3.1 GHz to 28.7 GHz which suits/compatible with the new generation of 5G communications. A simulation of the geometrical design of the proposed project has been achieved and tested through the use of Ansoft HFSS software to attain the UWB antenna application requirements. FR408 substrate characteristic of Isola Company is adopted in this work, and many C shapes with 90 degrees are conducted to deny the frequency band of 3.4 GHz – 3.7GHz that might be worked with WiMAX communications. The numerical results are reported to show the ability of frequency bandwidth expanding in terms of impedance matching and radiation characteristics. A model has been implemented and tested practically, and the results identified a great agreement between the simulated design and the manufactured one.

Keywords: Ultra-Wide Band Antenna, Fractal antenna, 5G, Millimeter band antenna, compact antenna.

1. Introduction

Recently, the interest of using Ultra Wideband in communication systems has increased dramatically due to its appealing features such as: enormous channel capacity, low power consumption, low signal to noise ratio, and high resistance to human-made jamming [1]. Moreover, the design of these systems should have frequency bandwidth at −10 dB points > 20% or entire band is more than 500MHz according to Federal communications commission simplification of Ultra Wide Band of wireless applications [1]. In addition, antennas with full bandwidth or multiband at low profile characteristics have played a pivotal role in wireless communication systems. For such reasons, the demand for mercantile and warlike applications leads up to pay more attention to this type of antennas design in various directions [2- 4]. Generally, an antenna operates at a single or dual frequency bands, where different antennas needed for different applications to reduce space limitations. This can be achieved through improving the single band antenna to have multiple frequency bandwidths as reported in [1]. In the geometrical design technique of the antenna, the fractal shapes has been used to construct multiband antenna where the wideband antenna expands the bandwidth over the entire region. Many parameters affect the operation of the Ultra Wideband antennas which needs to be regulated during design procedure such as frequency band, antenna gain, radiation patterns, and polarization which lead to design many types of UWB antennas so far [5].

Applying fractals that have unparalleled geometrical properties like self-similarity and space-filling to the design of antennas to make it smaller in size, multiband and broadband properties[6]. The work presented in this paper adopts a slot dipole design for UWB communication systems based on a Koch curve with frequency bandwidth up to 28 GHz. C shape slot and shifted with 90 degrees Clock Wise has been inserted to deny the frequency band (3.4 GHz – 3.7GHz) and to fulfill WiMAX communication system requirements. The results demonstrate the capability of expanding the frequency bandwidth by using single antenna which reduce the mentioned space limitations.

The present research paper has the following outline: the next section represents an introduction of the general concepts of the designed fractal antenna. While section 3 describes the analysis of the proposed antenna design simulated results and finally, conclusions are drawn in Section 4.

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2.FRACTAL ANTENNA DESIGN

Millimeter Wave frequency indicates the wavelength between 1-10mm. In communication links, several considerations for such frequency like spectrum at the mm-wave frequency are still undeveloped; however more frequency bandwidth can be extended at these of frequencies [4]. It is known that self-resemblance feature of a fractal antenna will result in many resonance frequencies. These frequencies can transform into extensive band features by making the various frequencies closer and letting the bands overlap [7].

Fractal antenna design has started by the embodiment of printed monopole as a radiating monopole with width of Wp and length Lp on the copper substrate FR408 which is adopted by Isola manufacturing company with (μ=4,,4 ,ε = 4,,4) with width of substrate Wsub and length of Lsub ,and 1.27 mm thickness. The patch connected with a strip line of range Lf, & width Wf for feeding and 50 Ohm impedance matching. On the ground of another side of the substrate , there is a ground surface with a width of Wg and length of Lg [8]. The distance between the patch and ground surface is g. All the dimensions are in mm — the design is shown in Figure 1.

A rectangular slot with width Ws and length LS is, inserted in the Radiating, Patch and then Koch, Fractal Curve has been utilized on edge with Second, iteration.

Figure 2 exemplify the simulated S11 parameters that represents the frequency bandwidth extended from (3.2 to 8.91) GHz. However, to expand the frequency bandwidth, a Koch, Fractal, Curve has been inserted on the minimal side of the Radiation Patch which attached to the microstrip feed line. With a second iteration and steps in the form of a rectangular cutting with width We & length of Lse on the minimal Corner the resonance frequency of the Radiation Patch has been made at a frequencies over 9 GHz[9]. The S11 parameters of the Radiation Patch show the frequency bandwidth expanding from 3.1GHz to 16 GHz as shown in Figure 3.

To enhance matching between the feeding microstrip line with the radiation Patch, a rectangular, slot excavated at the top border of the ground surface with a width of Wsg and length of Lsg [10]. Accordingly a bandwidth of impedance has expanded to the band from 3.01GHz to 17,8GHz. A slot has been inserted in the top edge of Antenna, it is a C, shaped and shifted on 90 degrees. The C shaped slot has been used in order to decline the frequency band of communication system WiMAX that operates in the band of (3.41- 3.79) GHz. Figure 4. Shows the proposed shape of UWB fractal antenna.

3.UWB FRACTAL ANTENNA DESIGN ESTIMATION

The proposed UWB patch has been designed to work on a frequency band from 3.1 GHz with the observed of the effectiveness of the different parameters on the work of the UWB antenna. It has confirmed that the controlling parameter of the Fractal Antenna is, the antenna element circumference which is 2(Wp+ Lp) in expression of guided, wavelength, which is $\lambda guid$

$\lambda guid = \lambda 0 / \sqrt{\varepsilon eff}$, so the lower resonant frequency relative to the radiating patch is

$fL = C0 / 2(Wp+ Lp) \sqrt{\square eff}$

Identifying the effectiveness of the various changes of the parameters such as: the length of the patch and the slot, the width of the slot and its thickness, and the position where the slot is inserted. It has been noticed that the status of the invested band depends on the length of the slot ds

Where $ds = Win + 2 * Lsn$

After the parametric exploration, it has been found that as the width of the slot expanded, the notched band transfer to a higher frequency.

Fig5. Shows the frequency band of the proposed UWB fractal Antenna after parametric research, the frequency band expanded to 28.7 GHz

The Gain of the UWB Antenna shown in Figure6.

Figure 7. clarify the artificial results which received from HFSS simulation for superficies apportionment of the, a current of the UWB antenna at two frequencies, 3.5, &19 GHz.

The simulated results of irradiation,pattern for the Fractal antenna shown in Figure 8. At two different frequencies of 14 GHz, 21 GHz. The almost omnidirectional pattern observed in H-plane, and the pattern, in the E-plane is about, bidirectional for both 14GHz and 21GHz frequencies.

A model has been designed and implemented practically using the Ministry of Science and Technology's laboratories. The proposed implemented model has been tested for return loss and gain of the antenna and the results identified a great agreement between the simulated design and the manufactured one. Fig (9) shows the return loss of the manufactured model

4. CONCLUSION

A compact Ultra Wide Band Fractal antenna in the present research has been designed and implemented with extra wide frequency band from 3.1 GHz to 28.7 GHz that is suitable to be used in 5G mobile communication due to its small size and possessing of omnidirectional radiation, pattern and good Gain in the hall frequency band. There is a stop band for this antenna in the frequency band of 3.4 to 3.8 GHz to reject the radiation in this band to operate with WiMAX communication system. The numerical results are reported to show the ability of frequency bandwidth expanding in terms of impedance matching and radiation characteristics. A model has been implemented and tested practically, and the results identified a great agreement between the simulated design and the manufactured one.

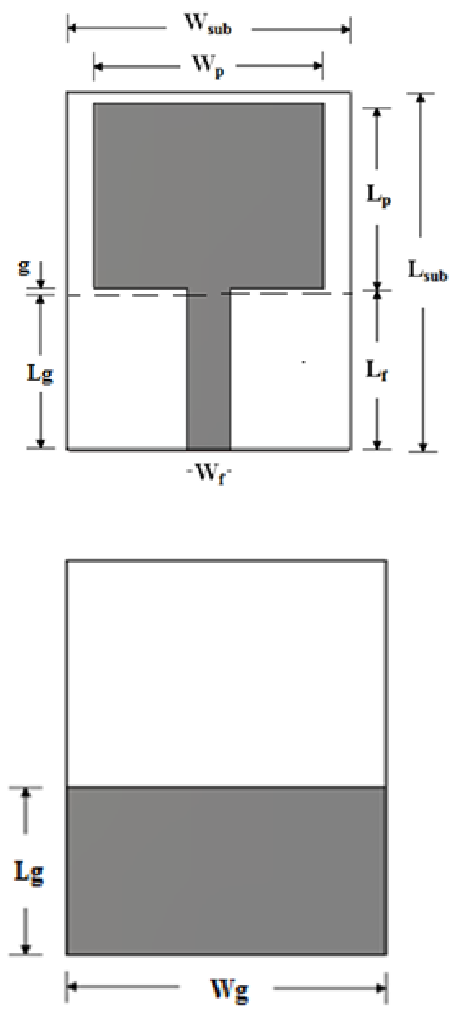


Figure 1. First Patch design' a) Front, view, b) Back, view

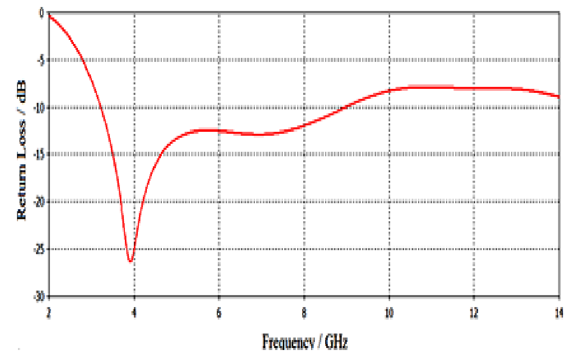


Figure 2. shows an example of the simulated S11 parameters which presents the bandwidth extended from 3.2 to 8.91) GHz

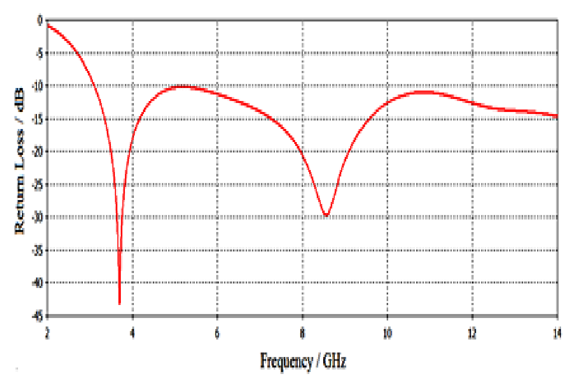
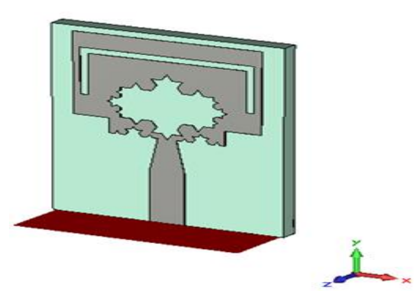
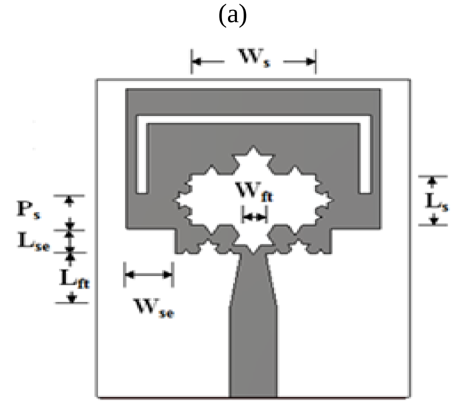


Figure 3. S11 Parameters of the Antenna with expanding frequency band



(a)



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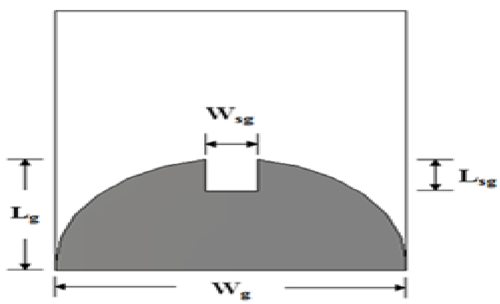
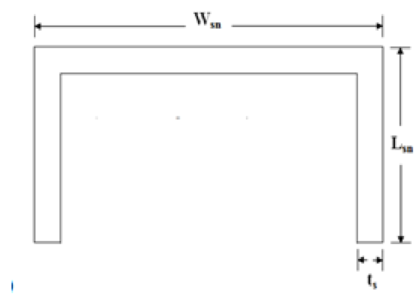


(c)



(d)

Figure 4. The shape of the proposed UWB Fractal Antenna

(a) 3D view (b) front, view (c) back, view, (d) used slot

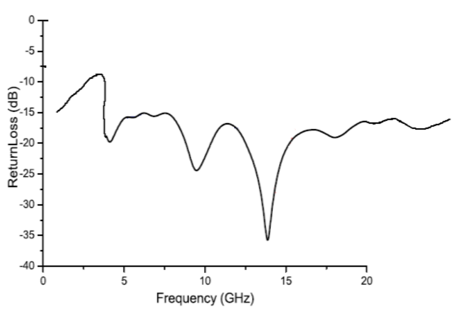


Figure 5. S11 parameter of the proposed simulated UWB Fractal Antenna

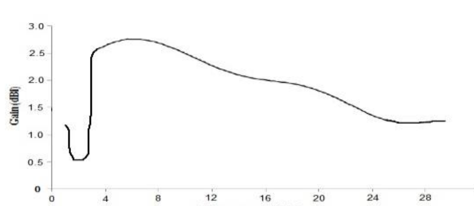
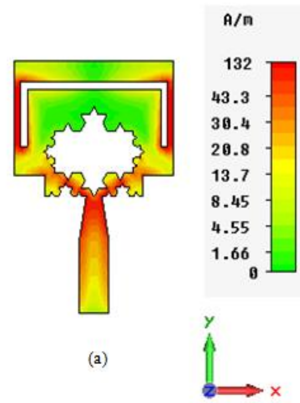


Figure 6. The Gain of the UWB Fractal Antenna



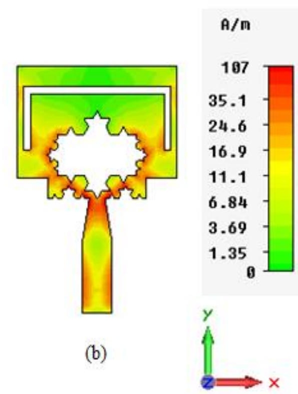


Figure 7. The artificial results of superficies apportionment of the current of Antenna (a) at 3.1 GHz (b) at 19 GHz

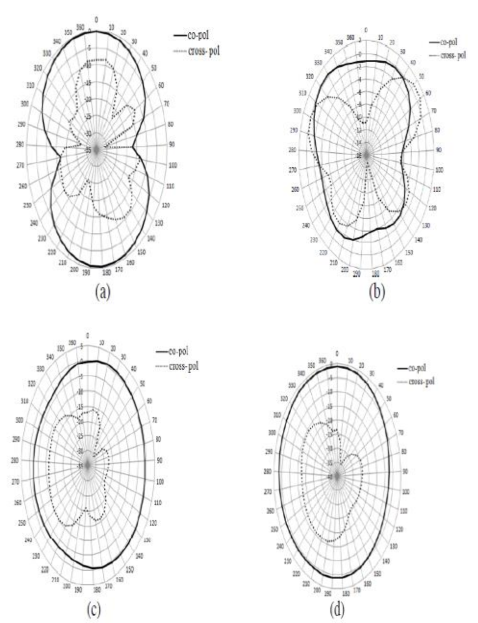


Figure 8. artificial results of irradiation, the pattern for the Fractal antenna of E, plan (a) At 14GHz, (b) at 21GHz. H, plan (c) at 14GHz, (b) at 21GHz

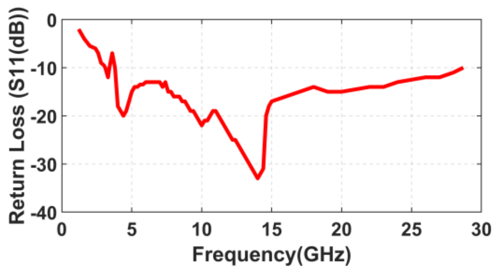


Figure 9. S11 of implemented antenna

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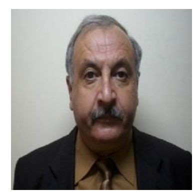

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