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Double Fibonacci Spiral Microstrip Patch Antenna for Dual Band Applications

Asha Meena, Anita Garhwal, Kanad Ray

Abstract: ***Double Fibonacci spiral in a circle with microstrip line feeding technique is designed in the frequency range from 0.1GHz to 6GHz. The antenna is designed and simulated in computer simulation technology microwave studio software, substrate Fr-4 with thickness 1.59mm is used and antenna parameters such as return loss, surface current, E-field, H-field and gain are calculated for Double Fibonacci spiral microstrip patch (DFSM) antenna. The antenna is used for ISM (industrial, scientific and medical) frequency band (2.45GHz) and a new unutilized band for next generation services, gain is 2.22dB and 3.16dB and bandwidth is 25.94% and 22.83% on resonating frequencies.***

Keywords: Circular patch, Fibonacci sequence, golden ratio, ISM band.

I. INTRODUCTION

Antenna is an important constituent for wireless communication system to establish a link between devices. Antenna is an electromagnetic device which can receive as well as transmit [1]. Lightweight, low cost and easy to use are qualities of patch antenna when compared to conventional antennas [2]. Patch has different types of shape and size but rectangular and circular are the most popular ones used [3].

2.4 GHz-2.5 GHz with center frequency 2.45 GHz is known as ISM band (Industrial, Scientific and Medical). An unused band 3.7GHz-4.2GHz will be launched in near future for next generation servies as mobile broadband services and 5G. C-band (4 GHz to 8 GHz) has downlink freuqencies 3.7-4.2GHz and uplink frequencies 5.925-6.425GHz, so this unused band is downlink of C-band. FCC is providing 200 MHz for this unutilized band [4-8]. In this paper, a double fibonacci spiral antenna is presented for dual band applications at 2.45GHz and 3.7GHz-4.2 GHz. The main aim of designing this antenna is that, a patient (in remote) data (glucose, blood sugar) will be captured at 2.45GHz and it will be sent to nodal health center by using 3.7-4.2 GHz frequency band. Now-a-days the nature inspired antenna takes attention of researchers. Flower petals, sunflower seed heads, spiral galaxy and tree branches etc. are examples of Fibonacci pattern design. In biological and in computing algorithm Fibonacci spiral pattern is found [9].

Several papers have been published on nature inspired antenna that has Fibonacci spiral or Fibonacci sequence. A nature inspired antenna based on oak tree shape is designed and the aim of the antenna is to improve the gain. The simulated and measured array of antenna is designed for 2.4GHz band which is called medical band [10]. With probe feeding a square shape spiral microstrip patch antenna is designed and used for satellite communication, different dielectric constant values and thicknesses are used for variations in gain and return loss results [11]. An RFID (Radio Frequency Identification Technology) antenna based on Fibonacci sequence is designed by differential algorithm (DE). The concept of designing is developed in C++ and CST software. The RFID antenna center frequency is 60GHz and obtained gain is 8dB [12]. A paper based on three design concepts; basic CDRA, half CDRA and Fibonacci CDRA (where CDRA means cylindrical dielectric resonator antenna) is presented. In this paper Fibonacci series is used for designing upto 13 number and the antenna used in C, X, Ku band for weather monitoring, satellite communication and amateur radio applications [13]. For investigation the design of Fibonacci sequence by Taguchi method on spiral micro-channel is presented [14]. Snail shell structure based two designs are presented with variation in width. In which EWFS design has equal width and IWFS design has increasing width and used for energy harvesting application [15]. The ISM frequency band is used for different applications. For breast cancer detection a spiral PIFA antenna is designed in the ISM frequency band to detect the tissues [16].An antenna is designed for lung (tumor) cancer detection by microwave imaging. In this a four layer antenna is designed in which lung tissue (70mm), bone (6mm), muscle (20mm) and fat (2mm) are included[17]. An implantable device dual band antenna in ISM (2.4GHz to 2.48GHz) band and MICS band is designed in which multilayer configuration is used [18]. Spiral antennas are different types like circular spiral antenna, dual circular spiral antenna, square spiral antenna and dual-square spiral antenna etc. Rectangular shape microstrip patch (RSMA) antenna is designed for Wi-Fi application with center frequency 2.45GHz [19].Double spiral (modified) antenna designed for wireless medical communication application. It's a magnetic-type textile antenna used in medical band [20]. Miniaturized multiband dual spiral patch antenna is designed, simulated and measured for RFID, WLAN and WiMAX applications. It is a dual square shape spiral design [21].

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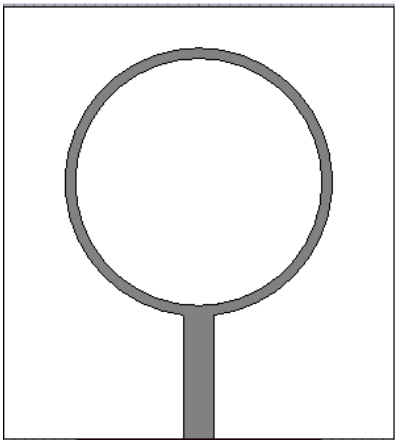
***Correspondence Author(s)
Asha Meena, Sobhasaria Group of Institutions, Sikar, India.
Anita Garhwal, Sobhasaria Group of Institutions, Sikar, India. Amity University Rajasthan, India.
Kanad Ray: Corresponding author, Amity university Rajasthan, India.

Fractal antenna has the broken curves, symmetric and space filling properties and miniaturization. A fractal spiral antenna in which log spiral transformation techniques is used. It is a modified version of sierpinksi carpet pattern fractal antenna [22].A spiral antenna is designed and simulated with metallic rings concept and miniaturization is achieved 13.5% [23]. Different shaped fractal patch antennas are also reported in literature for multiple applications [24-26]. Nature inspired sunflower patch antenna [27], tree [29] using Fibonacci sequence are reported.

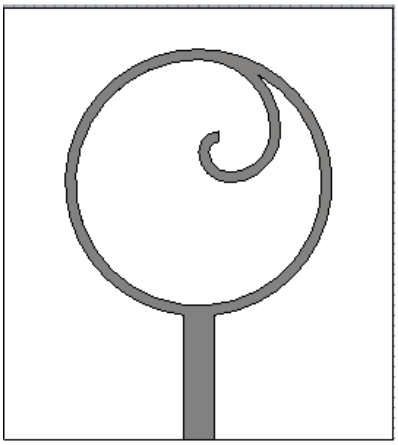
This paper has following sections: introduction, antenna design, simulation results and conclusion.

II. ANTENNA DESIGNS

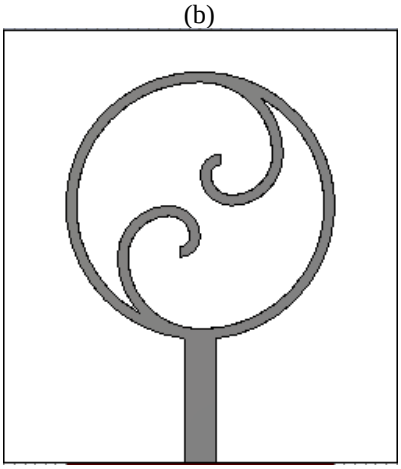
The antenna design starts with a circular patch with 1mm thickness(distance between outer radius 13mm and inner radius 12 mm) and then a spiral is added in the circle. and then final design which has a circle with 1mm of thickness and two inscribed spirals and these can see in fig.1. The antenna design is inspired from Fibonacci series spiral pattern that starts from 1 and continues. In this antenna Fibonacci series used is 2, 3, 5, 8, 13 for both spiral pattern which are shown in proposed design, the used circle having 1mm of thickness and used for connecting both spirals in antenna design. The design of Fibonacci sequence double spiral patch antenna is shown in fig.1. The used substrate is Fr-4 having dielectric constant 4.3 and dimension of substrate is 38mm*42mm, defected ground plane is used with a "L" shape cut and microstrip feed line is used in the design. The starting design consists of a circle which has a width of 1mm along with feed which has dimension 12.05mm*3mm. After that a spiral is inscribed in the circle, after that another spiral is inscribed for bandwidth enhancement and finally a slot is used in ground along with all considerations explained above. The antenna design, front view, back view and reflection coefficient are shown in fig.1, fig.2 and fig.3 and dimensions which are used in designing the DFSM antenna shown in table 1.



(a)

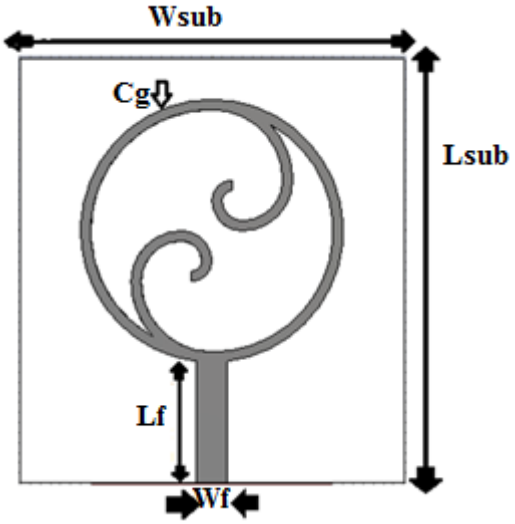


(b)

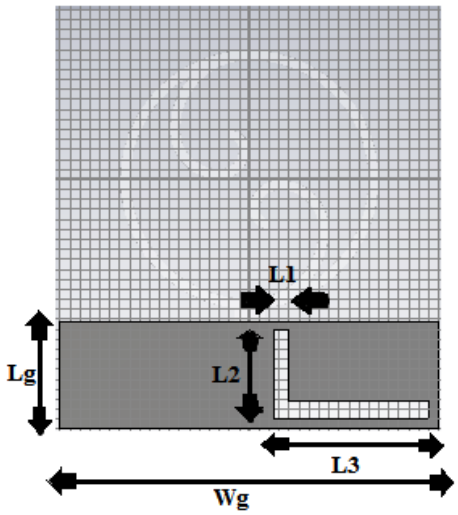


(c)

Fig.1. (a) Circle width is 1mm (b) One inscribed spiral in circle (c) Final design Double Fibonacci Spiral Microstrip (DFSM) Patch Antenna



(a)



(b)

Fig.2. DFSM design (a) Front and (b) Back view of Patch Antenna

Table -1 Dimension of DFSM Patch Antenna design

Parameters	Dimensions
Wsub	38mm
Lsub	42mm
Wg	38mm
Lg	10.75mm
L1	1.5mm
L2	9mm
L3	15.5mm
Wf	3mm
Lf	12.05mm
Cg	1mm

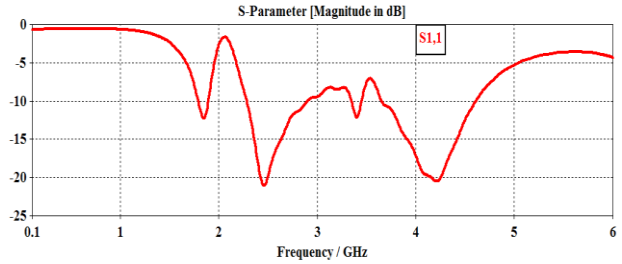


Fig.3. S_{11} parameter of Double Fibonacci Spiral Microstrip Patch Antenna

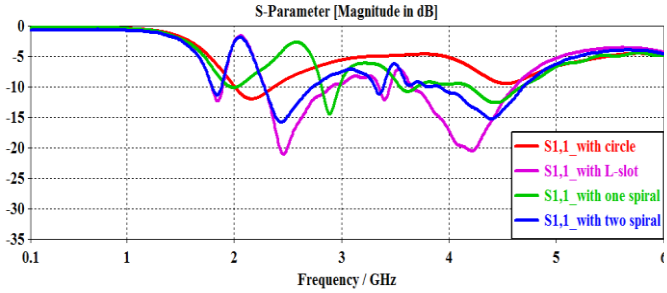
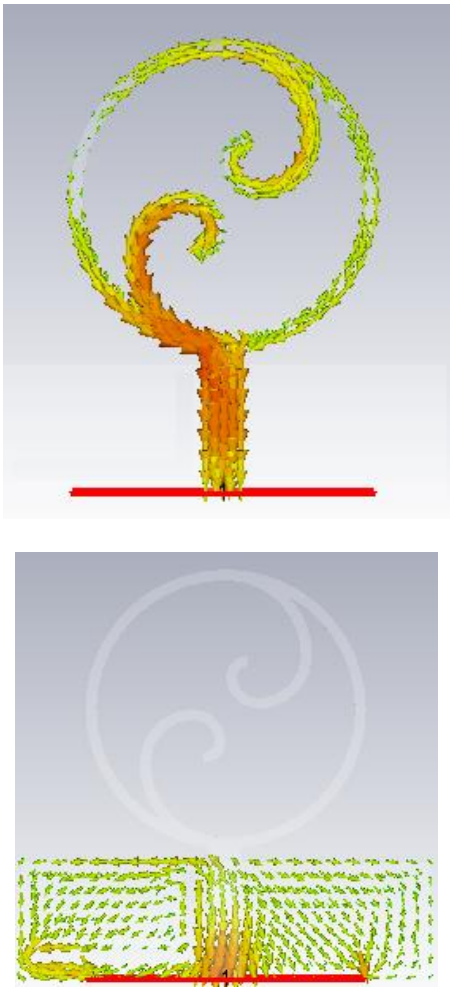


Fig.4. S_{11} parameter of DFSM Patch Antenna

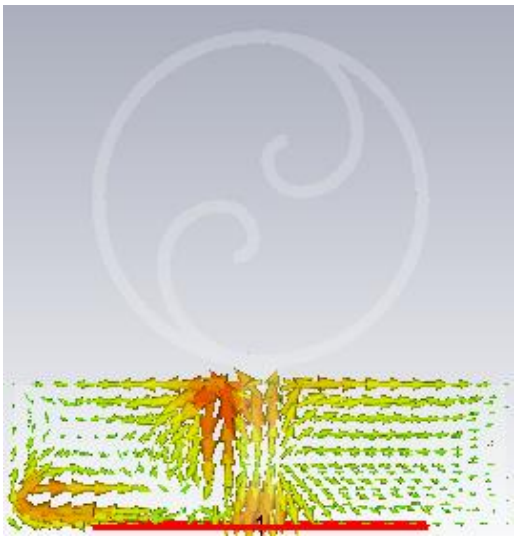
In fig.3 the S_{11} parameter of DFSM design is shown. The antenna is resonating at 2.45GHz and 4.22GHz. The 2.45GHz band used for ISM band and 4.22GHz band will be used in future. This unused band will be used from 3.7 to 4.2GHz frequency range but in DFSM design the desired results are obtained at 4.22GHz. In fig.4 reflection coefficients are shown with different parameters which are used in designing. Final design which has an L-slot in ground is also shown with other return loss results.

III. SIMULATION RESULTS

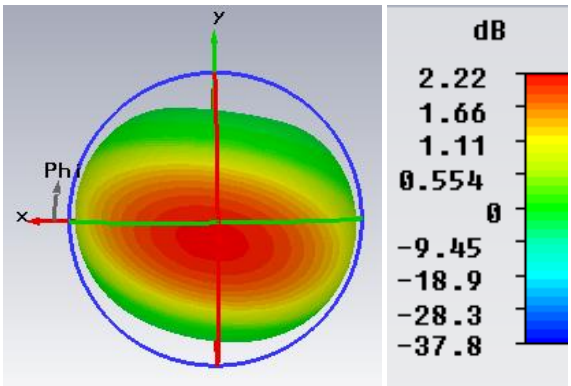
The simulated results of Double Fibonacci Spiral Microstrip (DFSM) Patch Antenna design is in figures in which pictorial view, front view and back view of antenna are shown and simulated parameters are surface current, E-field, H-field, gain etc(return loss is shown above). The surface current distributions at resonating frequencies 2.45GHz and 4.22GHz are shown in fig.5. At 2.45GHz current flow is more in one spiral as compared to other spiral as shown in figure and at 4.22GHz current flow is even in all patch design along with Fibonacci spirals and feed has good flow of current. As we can see that at 2.45GHz frequency current distribution is better as compared to 4.22GHz frequency.



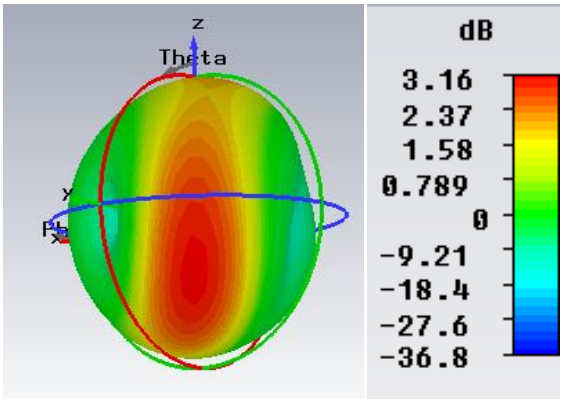
(a)2.45GHz fornt and back view of patch and ground



(b)4.22GHz fornt and back view of patch and ground
Fig.5. Surface current distribution at resonating frequency



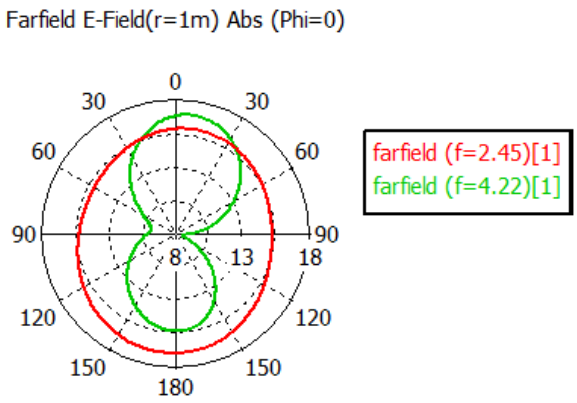
(a)2.45GHz



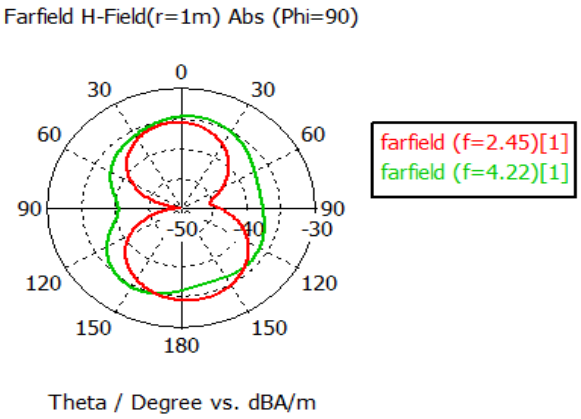
(b)4.22GHz

Fig.6. Farfield plot at resonating frequency

In fig.7 the radiation patterns of E-plane and H-plane are shown at different frequencies 2.45 and 4.22GHz.



(a)E-field



(b)H-field

Fig.7. E-field and H-field on resonating frequency

IV. CONCLUSION

Double Fibonacci Spiral Microstrip Patch Antenna for Dual band Applications is presented. This antenna is designed in the frequency band 0.1GHz to 6GHz. The Double Fibonacci Spiral Microstrip (DFSM) Patch Antenna is having positive gains 2.22dB at 2.45GHz and 3.16dB at 4.22GHz.

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The antenna is designed for ISM (Indusrial, Scientific and Medical) frequency band and a new unutilized band for remote health care of patient. Patient's data like glucose, blood sugar will be monitered at 2.45GHz and sent to nodal remote health center by using 3.7GHz to 4.2 GHz untilized band.

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