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Multiple Slot Fractal Structured Antenna for Wi-Fi and Radio Altimeter for uncertain Applications

[1]Lanka Madhavi Devi, [2]C Subbarao, [3]Boppana Swathi Lakshmi, [4]T Sushma

Department of ECE, PVP Siddhartha Institute of Technology, Vijayawada, AP, India

[1] madhavidevi.kodali@gmail.com, [2] csr949@gmail.com, [3] boppanaswathi@gmail.com, [4]tsushmaece@gmail.com

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Abstract

A multiple slot fractal antenna design has been determined communication efficiency and its multi-function activities. High-speed small communication devices have been required for future smart chip applications, so that researchers have been employed new and creative antenna design. Antennas are key part in communication systems, those are used to improve communication parameters like gain, efficiency, and bandwidth. Consistently, modern antennas design with high bandwidth and gain balancing is very difficult, therefore an adaptive antenna array chip design is required. In this research work a coaxial fed antenna with fractal geometry design has been implemented for Wi-Fi and Radio altimeter application. The fractal geometry has been taken with multiple numbers of slots in the radiating structure for uncertain applications. The coaxial feeding location has been selected based on the good impedance matching condition (50 Ohms). The overall dimension mentioned for antenna are approximately 50X50X1.6 mm on FR4 substrate and performance characteristic analysis is performed with change in substrate material presented in this work. Dual-band resonant frequency is being emitted by the antenna with resonance at 3.1 and 4.3 GHz for FR4 substrate material and change in the resonant bands is obtained with change in substrate. The proposed Antenna is prototyped on Anritsu VNA tool and presented the comparative analysis like VSWR 12%, reflection coefficient 9.4%,3D-Gain 6.2% and surface current 9.3% had been improved.

Keywords: Coaxial Feeding, Fractal, Slot, Radio Altimeter, uncertain applications

1. Introduction

A realistic Multiple Slot Fractal antenna design has been figured out the surface current and 3D-gain parameters. There is a lot of demand for the high-speed compact communication devices in various fields of engineering and research. A modern and innovative product for fulfilling the future needs as per the communication demand [1]. Antennas are major communication element’s those are improving parameters like gain, efficiency, and bandwidth to provide proposer path to communication requirements. There is a big challenge to design antennas for modern communication applications with huge bandwidth and gain. The size of the antenna and its resonating frequencies will occupy significant amount of weightage while selecting the antenna for suitable applications [2].

Fractal antennas are suitable strictures where they mostly used to attain multiple frequency bands to operate the antenna for numerous applications [3]. The self-similar and repetitive structure of the fractal antenna will provide a strange structure and prominent frequency bands of resonance [4]. The multiple band operation will provide additional advantage to the antenna to operate it in various applications simultaneously without any additional supporting modules. Various designs are proposed by the researchers on fractal antennas and they are resonating in single, dual, triple, quad and multiband with moderate gain for commercial communication applications [5].
Fractals are a class of complicated forms that share a geometrical structure and are self-similar. Science and engineering have a broad range of fractal applications. One such field is fractal electrodynamics [6]. which combines fractal geometry and electromagnetic theory to study novel types of radiation, propagation, and scattering. Application of fractal electrodynamics to antenna theory and design is one of the most promising areas of study. It is also possible to create antennas with many resonances by employing fractal geometry as shown in fig 1. In simple terms, fractals are complicated geometric structures that repeat themselves. Iterative generating produces self-similar geometry with many scales that resonate at various frequency bands.

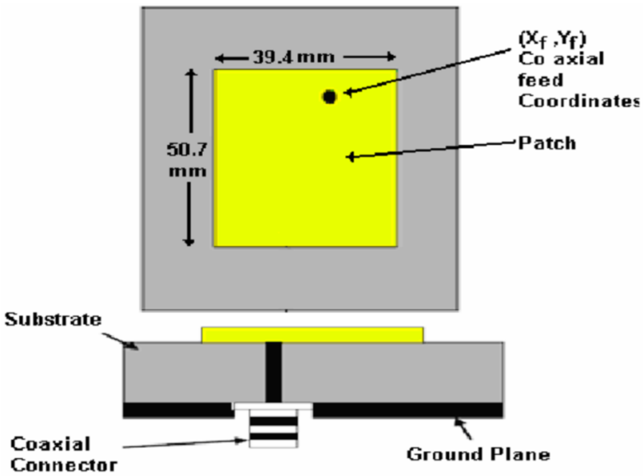


Figure 1. Coaxial fed micro strip patch antenna

The antenna rationalizing with numerous resonances has been achieved by researchers using Hilbert, Peano, and Gosper-space-filling curves. To create small multiband dipole and monopole antennas using Hilbert fractal-based designs, several alternative architectures have been suggested. Many research groups have worked on Peano space-filling curves and their fractal antennas. Modification of Gosper space-filling curve with micro and multiband antennas have utilised the structures-based space-filling geometries as part (or the whole) of the ground plane. Antenna models such as dipole and monopole are often a smaller number of applications. A few examples of slot antennas with space-filling curves are explained in [9].

An 5G technology is largely acknowledged for its speed and coverage. Additional cellular antennas are required to provide the promised data speeds & availability. The, Fractal slot antenna application like Intelligent buildings, telehealth, self-driving cars, and smart cities will all benefit from 5G communication rates that are 100 times faster than 4G systems. The number of linked devices for communication and IoT is increasing exponentially. But over-densification of networks causes, more issues with Fractal antenna connections. At imperative conditions, there is a need for cell site installation, so that coverage demands may be met by signal amplifiers such as boosters and repeaters. The repeater antennas must be low profile, light-weight, and capable of operating in multiple/broadband frequencies. In order to attain these fractal-shaped geometries need an intelligent antenna design. The Fractal geometries are a complicated form antenna family that prohibits self-similarity in geometric constructions. Antennas are designed using fractal geometries including Koch, tree, Minkowski, and Hilbert techniques. Antennas with fractal geometry's repeated shapes have a longer overall electrical length, which makes them more efficient and easier to integrate into a design's framework. Moreover, fractal antenna shapes aid in satisfactory electromagnetic radiation, particularly when developing multiband antennas [9].

The multiband Sierpinski fractal antenna is functioning electromagnetic activity, it is happened mostly due to its similarity analysis. In this context star-shaped fractal antenna is discussed. To construct 16 fractal architectural modules, four squares are rotating 4° with respected design requirement. There are fractal and meandering designs all over antenna models. Using Meander, Sierpinski, and customized particle swarm approaches have been presented tri-band hybrid fractal antenna and strip-band hybrid fractal antennas for GSM and WLAN applications. It has been hypothesized by single-wall carbon nanotube structures, it might be used as an antenna for RFID, Bluetooth, and WLAN. A fractal-based multifrequency-reconfigurable UWB antenna employed for industrial and commercial applications. The advanced ANN introduced to develop a circular fractal antenna (CFA). CFA is optimised using IE3D software and operates at four frequencies. A hybrid fractal planar monopole antenna has been designed and employs a hybrid construction that combines Minkowski and Koch curves for MIMO applications.

A Meta surface-inspired multiband antenna with a rounded (circular) balancing Split-Ring Resonator (SRR) is explored. Moreover, dual-band circular polarisation and gain improvement have been imported for deep VSWR analysis. The antenna compactness and axial ratio beamwidth are major performance metric which has been improved. WLAN and WiMAX circularly polarised antennas inspired by CRLH. In this case using ACS feeding approach on the unit cell to increase the impedance and axial ratio bandwidth. A metasurface15 and CRLH TL antennas-14 are recommended for the Ku, C, and S bands, respectively, using the same notion. Plus-shaped slotting fractal antenna arrays have been proposed for use in applications in the S, X and C bands. Furthermore, relatively some of the antennas cover the sub-6-GHz range, which is critical for the newest 5G antennas. Thus, a low-profile antenna spanning sub-6GHz 5G is in high insist [10]. The implemented system square-shaped SSR- based fractal antennas were commercially appropriate for GSM and sub-06 GHz indoors repeated operations with a gain and effectiveness of more than 01.80 dB and 80.00%.

A printed slot antenna construction for current compact and multi-purpose communication systems has been explained in [11]. An iteration Koch fractal curve has been inserted inside the proposed structure's rectangular slot. As a result of the Koch fractal curve's space filling feature, the suggested antenna should be relatively small. There is a slotted antenna that is fractal-shaped in this research. The proposed system antenna is made of #FR4 and is 50.00X50.00X01.6 mm in physical dimensions. The performance evaluations of the antenna according to the resonance bands as per applications and radiation characteristics with surface current distributions are analysed and presented in the subsequent sections [12].

2. Literature survey

In this section a brief discussion on Multiple Slot Fractal Structured Antenna and its performance has been explained. The earlier designs haven't been tolerated ohmic conditions and resonance frequency. Therefore, a detailed study is necessary to cross over the following conditions. A small planar quasi-self-complementary ultra - wideband antennas is described. The antenna also transmits at 02.4 GHz and rejects 05.50 GHz. The antenna's input impedance spectrum is improved by placing Koch fractal borders across the hexagonal radiators. The impedance of the antenna input is matched by an arc-shaped protruding ground plane at low frequencies. Modified meandering sections are included for Bluetooth compatibility. The radiators have a quadratic fractal slot that blocks off certain bands. The antenna's dimensions are 018.50 x 39.00 mm 2.00. Throughout the working bandwidth, the antenna exhibits a nearly constant group delay and a consistent radiation pattern. An analogous circuit for the suggested antenna is also built [13].

The ultra-wideband applications, compact planar quasi-self-complimentary antennas are suggested. The antennae also support Bluetooth 2.4 GHz broadcasts. Koch fractal boundaries are added to the hexagonal radiator to enhance impedance matching at higher frequencies. At low frequency, the antenna's input impedance is matched by a projecting arc-shaped ground plane. The addition of a stub with a modified meandering form resonates with Bluetooth the radiator is carved with a quadratic fractal groove to eliminate unwanted frequencies. Size: The antenna measures 18.50x39.00 milli-meter. The radiation pattern and the group delay of 1 ns are essentially constant over the entire operational frequency of the antenna. To the proposed system antenna, a similar circuit is being constructed. Electrical and electromagnetic simulations and measurements all came up with similar results [14].

A novel kind of planar monopole antenna is proposed that utilizes circularly polarised radiation. The proposed antenna configuration generates circularly polarised radiation by disintegrating the underlying architecture. A fractal slot added into the ground construction amplifies the cross-polar element of the polarizer antennas. Third-order iterative tuning fork antenna prototypes have been developed and tested... In order to better understand how CP radiations work, parametric studies are also carried out. Antenna modelling and test results demonstrate that the proposed antenna is capable of providing approximately 38.40 percent return loss bandwidth (BW) and a 03.00 dB AR bandwidth (ARBW) that is nearly 015.50 percent. In addition to WiMAX and WiMAX, the antenna recommended may be utilized for LTE Band.

For WBAN applications, in this provide a compact, low-profile wearing antenna. A flexible polyvinyl polymeric substrate is used in the proposed triangle patch antenna. As a result of the fractal shape, meandering slit, and flawed ground structure used in the final version, the antennas can function at 02.45 GHz and has extremely small footprints. Experimental and computational results were very closely aligned while building a prototype antenna for testing. Using a more compact design, our device has an impedance BW of 07.75 percent, an output peak gain value of 02.06 dB, and an overall radiated competence of 75.00%. A realistic heterogeneous HUGO voxel model is used to test our approach. Thus, flexible and body-worn gadgets may benefit greatly from this technology [15].

The need for small portable communication devices has increased recently. Internal antenna devices have emerged to meet this demand. Antenna size restricts device miniaturisation. Microstrip antennas (MSA) and planar inverted-F antennas (PIFA) are low-profile antennas that may be incorporated into portable wireless devices. This work provides a planar inverted F antenna for PCS, UMTS, and WIBRO.

Small electronic systems have been in high demand for decades. Integrated circuit developments minimise system size. Small and low-cost antennas are in high demand as electronic devices shrink in size. Patch antennas are popular for integrated RF front-end systems because they work well with microwave integrated circuits. A 60 GHz MSPA has been designed to suit the growing need for combined RF front-end devices. Far-field gain of 07.91dB over a paraboloidal rectangular aperture antennae is achieved with this antenna. Impedance matching is achieved by using a 50.00-ohm coaxial probe fed antenna. At 60GHz, this antenna works quite well, with a maximum of 61.15 GHz at this frequency. It is a low-cost, lightweight, medium gain, narrowband microwave antennas used as a feeding element for other antennas and as a reference antenna in research facilities. It can also receive signals from tiny electromechanical sensors through a signal conditioning circuit [16]. This study analyses and designs a dual feed asymmetric antenna. The antenna covers X-band from 08.20 GHz to 08.60 GHz and 11.50 GHz to 12.40 GHz. The dual band nature is owing to the structure's current pathways. This antenna measures 48 mm x 48 mm when mounted on #FR4 with a dielectric constant of 04.40 and a height of 01.60 mm. The antenna has virtually Omnidirectional radiation and modest gain across all working bands. Its uni-planarity, easy feeding, and small form facilitate modular design. Tapered step-ground antennae with wide bandwidth supplied by central processing unit Antenna bandwidth were enhanced by adding tapered step ground to a monopole antenna. Antenna prototyped on 20x20x1.6 mm FR4 substrate (r =4.4). Circular aperture with tapered step grounded model operates from 5-18 GHz. The modelling and observed findings correspond well. The new study additionally examines parametric analysis with varying substrate materials. A fractal is a recursively created object of fractional dimension. Many items, including antennas, may be constructed using fractal recursion. This research provides a revolutionary electronic bandgap fractal technique. Antenna with dual band structure. EBG ground plane construction reduces surface wave losses and slot aperture patch allows dual band operation. The antenna is small, measuring @50.00 mm x @50.00 mm x @2.00 mm. The obtained findings reveal that the suggested antenna's gain and radiation pattern are stable at both resonating frequencies.[17]

A CPW-supplied antenna with an electromagnetic bandgap construction is required for wideband applications with a tapered step ground plane. The ground plane and EGB architecture may be made more bandwidth-efficient by using tapering steps. Research on elliptical and rectangular monopole antenna performance is conducted and assessed. A dielectric constant of 4.40 is used to print the recommended objects on FR4 substrates measuring 20.00X20.00X01.6 mm. A parametric examination of antenna behaviour with variations in substrate permittivity is documented and presented in this paper. The suggested models have outstanding wideband communication features with consistent gain and efficiency. This paper presents a metamaterial loaded flexible CPW fed antenna. The antenna's flexibility is studied and tested at different bending angles. At 00.44 mm in width and width, the LCP antenna fits neatly in the palm of your hand. Inductively coupled planar (ICP) antenna for WiMAX/WLAN (5.9 GHz). This was accomplished utilising metamaterial and split ring resonators, as well as CSRRs on each side of the feedline and ground. The findings for axial ratio, reflection coefficient, and radiation patterns for both flat and bending antennas are confirmed using measurements [18].

Flexible inkjet-printed antenna models are developed for vehicle instrument communication applications on paper and transparent PET substrates. When it comes to car instrument communication, Model 2 uses a flexible PET substrate, whereas Model 1 is designed for low-cost photo paper. On a PET substrate, the proposed antenna type has an impedance range of 88% and an antenna bandwidth of 7.60GHz. A few of the wireless applications that the suggested antenna may support are UMTS, LTE2600, WLAN, WiMAX, IEEE802.11p protocol-based V2X 05.80 GHz, DSRC, and Wi-Fi. It is discovered that the prototyped models match the simulation findings perfectly in the form of reflection coefficient, emission patterns, & gain. The presented methodologies may be used to create complicated advanced antennas and communication modules for different flexible substrates. This article presents a 40*30*0.1 mm3 tiny and ultrathin frequency reconfigurable antenna for automotive communication. A circular ring topology with angled parasitic circular components is proposed for a Rogers ULTRALAM-3850 liquid crystal polymer (LCP) substrate with r = 02.90. It's possible to alter operating bandwidth around defined resonant modes of 02.4 GHz, 05.90 GHz, 09.05.00, and 12.50.05.00 by manipulating the BAR64-03W PIN diode switching components of the antenna design. Other aspects studied in this research were the effect of radome substrate permittivity and the enclosure's far-field properties when placed on top of the motor vehicle on the proposed reconfigurable antenna's presentation in different switching modes. The paper goes on to investigate the impact of radome paint on signal propagation in real-time by monitoring the received signal intensity. The proposed antenna's gain ranges from 00.51 dB to 06.12 dB when used alone, and from 02.85 dB to 08.54 dB when used with a random antenna [19].

A partly defective ground design is used to increase the proposed antenna's impedance matching and operational bandwidth. IEEE802.11a/h/j/n and Wi-Max may be avoided by putting the ST-SRR construction into the feed line of the UWB antenna to prevent interference. The notch band function is reconfigured by adding a pin diode to the ST-SRR structure. With a fractional bandwidth of 138.630 percent for S11 010.00 dB, the antenna recommended operates between 002.7 and 014.09 GHz the suggested UWB's notch bands may be shifted between 03.43–3.75 GHz and 04.87–06.40 GHz by manipulating the PIN diode. The simulated and measured findings accord well. This antenna may be reconfigured for reconfigurable UWB communication applications [20].

Coplanar waveguides feeding a planar antenna for vehicular communications are proposed in this work. Primarily, the antenna uses an FR4-based customized Z-shaped radiator FR4-based customized Z-shaped radiators with a 40-30-1.6-mm3 footprint. It is possible to transfer among functioning frequencies using BAR64-03 W Switching devices. The proposed antenna switches between complementary working bands 02.39–02.8 GHz, 03.32–04.11 GHz, and 07.34–09.03 GHz. The suggested design is a hybrid reconfigurable antenna that emits circularly polarised radiation. The measured and predicted results of the built antenna agree well. The radiation performance of standalone reconfigurable antennas and virtual environments on vehicle bodies is studied [21]

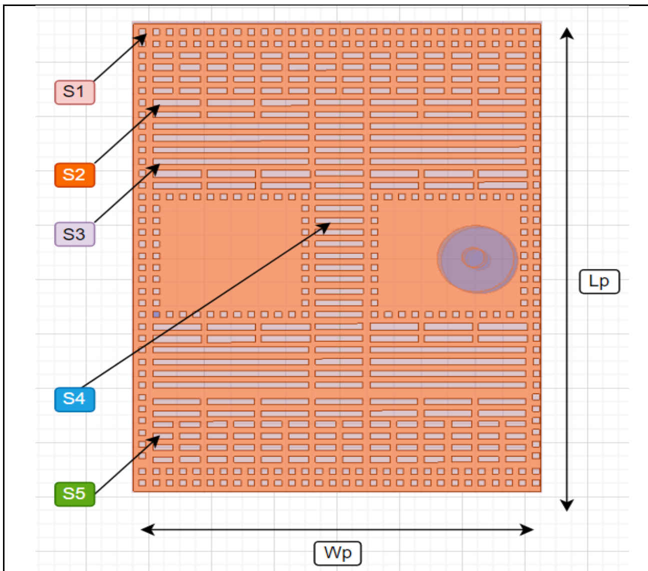
Study reference	Technology	Key point
Reference [16]	Double Elliptical Micro-Strip Patch Antenna (DEMPA)	In order to create a statistical parametric link between the design parameters and antenna return loss, DOE was used to reduce the amount of design work.
Reference [17]	new vision for designing 6G networks	To give a complete overview of cooperative communication among all

		strategies and probable spectrum management difficulties and viable solutions
Reference [18]	ML algorithms	discusses ways to link ML algorithms with other technologies to handle disasters and pandemics
Reference [19]	Cosmology Large Angular Scale Surveyor (CLASS)	Modelling and detecting air circular polarization owing to Zeeman-splitting of molecular oxygen emission lines in the geomagnetic field and a machine learning approach for removing CMB foregrounds from full-sky maps are next discussed.
Reference [20]	Digital Darwinism	This book takes you through the rapid and unpredictable changes that today's company executive's face.

The above all survey briefly providing information about various antenna models and its merits and demerits. It is identified that many earlier models have been employed antenna designs but those are more economic and real-time implementation somewhat difficult. Therefore, a novel Multiple Slot Fractal Structured Antenna design has been proposed, which is explained in below section 3.

3. Antenna Configuration

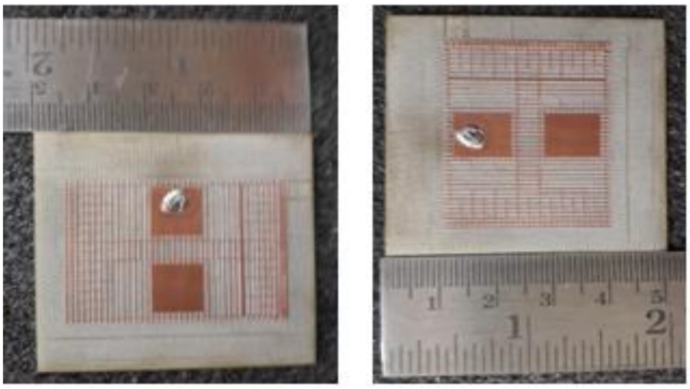
In this section Multiple Slot Fractal Structured Antenna implantation and its design metrics has been listed out. The multi slot models like dimensions S1, S2, S3, S4, S5, L_p and W_p area has been employed. Fig 2 demonstrates that the use of coaxial feeding, and it has been necessary in order to produce antennas that were capable of fitting the needed and calculated impedance matching location on the FR4 substrate [21]. The dimensions of the three different types of slots that were used in the design of the antenna. Small slots (S1) are utilised on all four sides, and their dimensions are 00.05 mm by 00.05 mm. Slot S2 has dimensions of 00.30 mm by 00.05 mm, Slot S3 has dimensions of 01.45 mm by 00.05 mm, Slot S4 has dimensions of 00.35 mm by 00.05 mm, and Slot S5 has dimensions of 00.25 mm by 00.05 mm.



Parameter	Dimension in mm
S1	0.05X0.05
S2	0.30X0.05
S3	1.45X0.05
S4	0.35X0.05
S5	0.25X0.05
Lp	40 mm
Wp	30 mm

Figure 2. *Fractal Antenna Structure*

The antenna prototypes has been shown by placing a ruler on top of it, which shows its dimensions. The developed antenna's performance parameters are detailed in the next part of the results and analysis.



(a) (b)

Figure 3. *Prototyped Antenna Dimensional View*
(a) Horizatal view (b) vertical view

There is few number of antennas in a linearly phased array. The ground plane was cut to provide a broad resonance in the minimun operational band range, as depicted in figure 3. Rather by using a patch antenna, the ring slot is employed [22]. The slot was powered by a microstrip wire running from the patch's centre to the antenna's bottom edge.The top most patch, like a microstrip antenna, transmits at a greater frequency than the rest antenna design. Compared to the slot-ring structure, the top conductors is smaller in diameter [23-25]. It is possible to include a phase shifter into a planar corporate feeding network utilising edge feed configuration. At 02.4 GHz, the half-wavelength structure dictates the slot size. When using FR-4, the antenna's size was restricted to 03.005 millimeters because of its thickness of 00.16 millimeters. The substrate's dielectric constant is 04.40 and its loss tangent is 00.02.
CST, a commercialized electromagnetic simulation, was used to create the antenna and optimize its parameters. Listed in Table I are the optimal antenna dimensions. According to the simulated reflection coefficient, the antenna performs well. Additionally, the radiation efficiency, as well as gain normal to the antenna construction, as well as gain normal to the antenna construction were modeled [26].
There is a 02.35-02.35 GHz bandwidth for both lower and higher frequencies. Bands that include WiFi, Bluetooth, and LTE may be found here (02.6GHz). A strong antenna gain is shown in Figure 3. 0At 02.45 GHz, 02.53 dBi of gain, 02.6 dBi of gain, and a maximum of 04.2dBi of gain may be expected from the antenna's size and thickness [27-29]. Its radiation efficiency is top-notch throughout the board. 0093.00% at 02.45 GHz, 92.00% at 02.60 GHz, and 074.00% at 005.3 GHz. The uncartain antenna's radiation pattern in the E- and H-planes for three primary operating frequencies has been improved.

Table 1: *Dimensions of Antenna*

Parameter	**Measurement(mm)**
#W_g	035.00
#W_p	023.00
#L_p	013.00
#W_s	031.00
L_s	#22.00
W_d	#2.00
W_f	#2.00

The Fractal Structured 4 elements have been linearly phase antenna made from the previously synthesised single antenna element. The antenna components are spaced D apart in a linear fashion. By adjusting the parameter in the simulation, the ideal spacing was determined [30]. A short bandwidth, high gain, and low sidelobe level are all requirements for a phased array antenna while scanning at its maximum angle. The emission prototype of a linear array is denoted as.

$$S(\theta) = f(\theta) \sum_{i=1}^{k} a_i \, e^{j(k-1)kD \sin\theta} \qquad (1)$$

For example, f (θ) is the antenna radiation design, and ai is the individual element weighting factor. K is the number of elements.
In this architecture, the components are all given the same weight. By changing the phase among the array's antenna components, you can shift the array's principal beam's angle. Due to the formation of grating lobes of equal strength to the main lobes, the scanning angle of the antenna estimated in (2) is constrained. To simulate the suggested array's inter-element spacing, 35.00mm, 40.00mm, and 50.00mm were used. The scanning angle of each element is then tested by supplying it with a different phase [31]. It is compared to the simulation findings. In order to compare performance, SLL and mutual coupling are utilised.

$$\beta = kD\sin(\theta) \qquad (2)$$

Due to the antennas element's dual-band nature, we evaluate its radiation pattern at 3 major working wavelengths. It is found that, at an antenna separation of D=040.00 millimetres slot can growth the VSWR and surface current. At lower frequencies (02.45 GH and 02.6 GHz), the maximum scanning angle is 40, whereas at high frequencies (05.3 GHz) it is 22. At the antenna input, both frequency bands have large scanning angles because of the same applied phase. The proposed multi-slot fractal antenna system can works with 3.1GHz frequecy as well as any uncetrtain dimensions. the deimesion may vary from 0.094λ0 x 0.077λ0 x 0.0062λ0 at 50X50X1.6 mm. The uncertainty is main parameter in antenna system due to multiband performance, detailed bandwidth and compactable area. The 3D-gain has been better through small size antenna system. The parameters like constructive interference, multiple current raises are robust with uncertain capable antennas. The electrical properties with small size multi-slot fractal antennas has been offered constrctive frequecy of operations.
The resistive loads have been employed at 100, 180, and 240. The final wideband Wilkinson power divider design supporting effective antenna functionality. The Fractal Structured design uses the same substrate like complete antenna array. FR-4 is used to connect the two components. S-parameters of a single 3-port Wilkinson power divider [32]. The suggested power divider's operational bandwidth covers both working frequencies of the proposed antenna. The three-level wideband Wilkinson power dividers coupled to supply a four-element phased array antenna. The scattering characteristics of the proposed 4 port feeding components-based simulation suggest that Fractal Structured is more robust. For both feeding structures' reflection and transmission coefficients can summarise the simulation results [33]. The finished piece is 156.00 mm x 83.10 mm x 01.60 mm in size. There are excellent mutual couplings and return loss, according to the findings of the one-to-four wideband power splitter [34]. The coaxial fed antenna systems have providing VSWR 2.5 at 4.4 GHz frequency. The surface current 10mA at 28.504 mm2 dimensions the electric magnitudes of 0.094λ0 x 0.077λ0 x 0.0062λ0 had been attained. The following numerical results are more improved in Multiple Slot Fractal Structured Antenna model.

4. Results and Analysis

In this section a brief disscusion on Fractal Structured multi slot antenna design has been employed. Figure 4 depicts the planned antenna's reflection coefficient and VSWR analysis. It resonates at frequencies in the 3.1 and 04.3 GHz wireless communication bands. In the range of 02.9-3.2GHz and 04.3 GHz, it is displaying bandwidth of 00.12 GHz, respectively (04.28-04.4 GHz).The measured and simulation results of both VSWR and reflection coeffieinct are showing good matching at two bands.

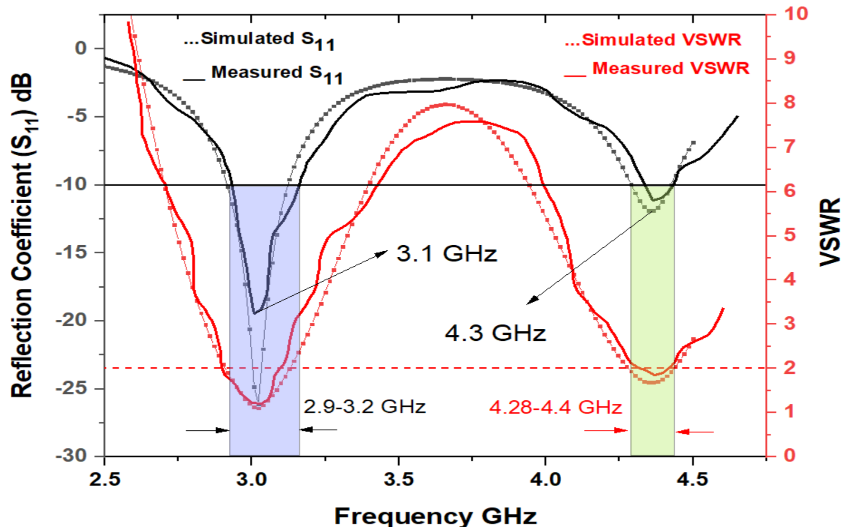


Figure 4. *Reflection Coefficient & VSWR Vs Frequency*

The emission characteristics of the antenna at dual band is presented in Fig 5. At 3.1 GHz it is showing gain of 8.4 dB and at 4.3 GHz it is showing 7.6 dB. In both the modes of 3D pattern, the antenna projecting an average gain of 8 dB with excellent directive pattern.

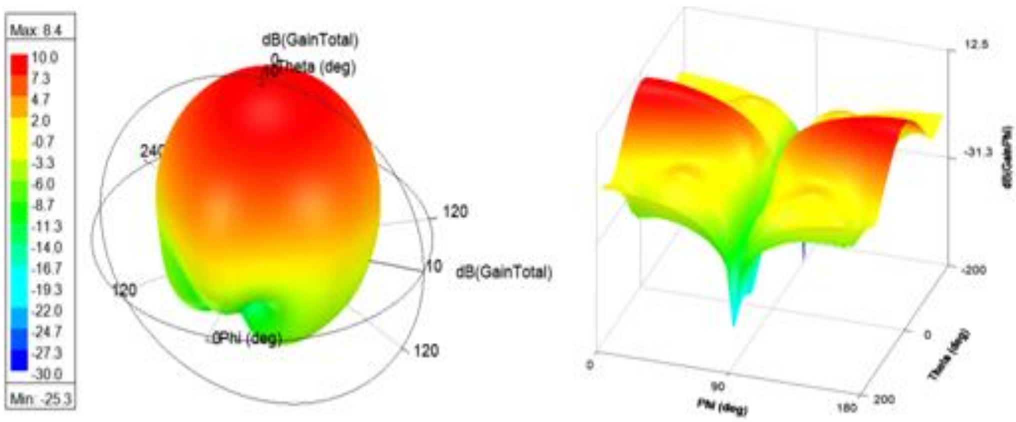


Figure 5. *3D-Gain at 3.1 GHz*

The below Figure 6 clealry explains about 3D-gain analysis at 3.1 GHz, in this analysis 3D-gain and angle of roatation has been improved. The theta in degrees are changing from o to 270 degress. The operating frequecy at 3.1 GHz has been gotten more 3D-gain differanted to all other frequencies.

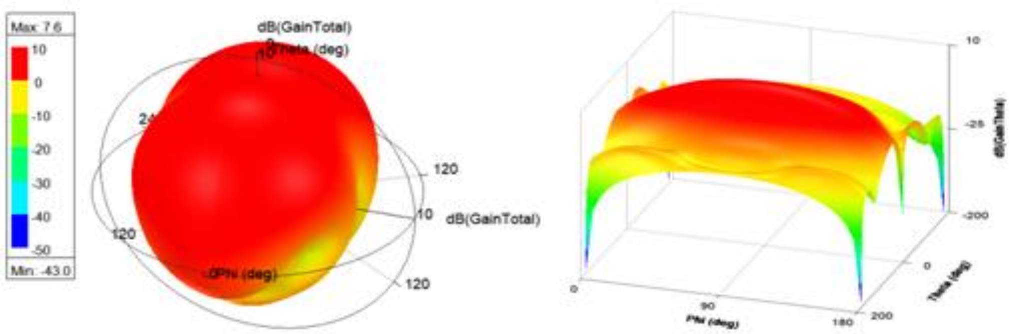


Figure 6. *3D-Gain at 4.3 GHz*

Figure 7 depicts the heat radiation in polar coordinates for E and H-plane with low cross polarization. The surface current distribution plot providing differential results for both the resonating frequencies.

The surface current density is more at central portion of the radiating structure for the 3.1 GHz, whereas at 4.3 GHz it is mostly concentrated at slotted portion.

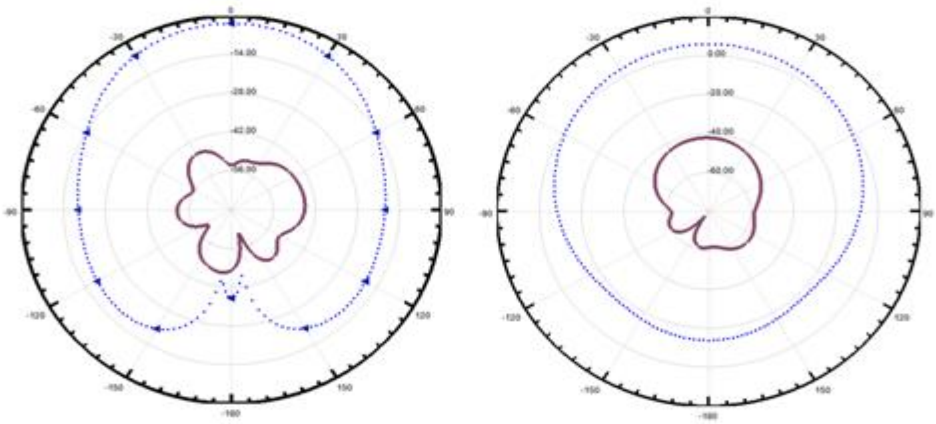


Figure 7. *Radiation Pattern in E & H-Field*

The figure 8 has been explained about surface current distribution as well as E & H-field analysis. The radiation patterns of major and minor lobes are more improved theire VSWR at selected operational frequecy.

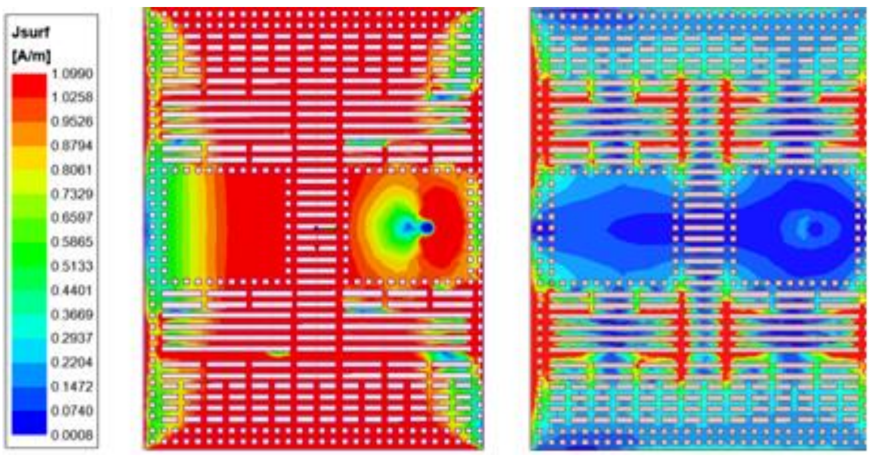


Figure 8. *Surface current distribution, (a) 03.10 GHz, (b) 04.30 GHz*

Anritsu combinational analyzer has been implemented to compute the scattering elements of the designed antenna and the Fig 9 shows the evidence for the resonating bands on the screen of the analyzer. The following analzer can generated experimental outcome like real time communcation manner.

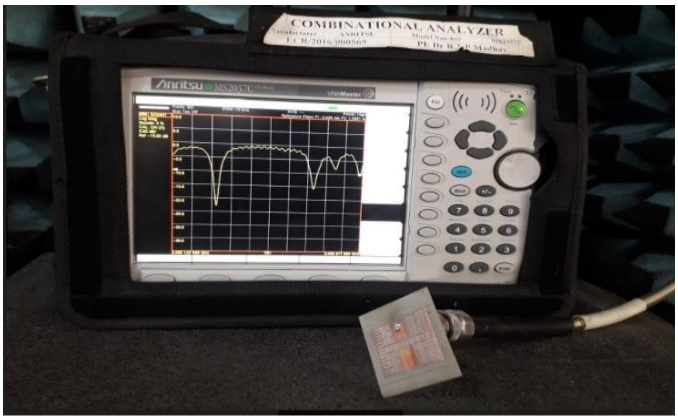
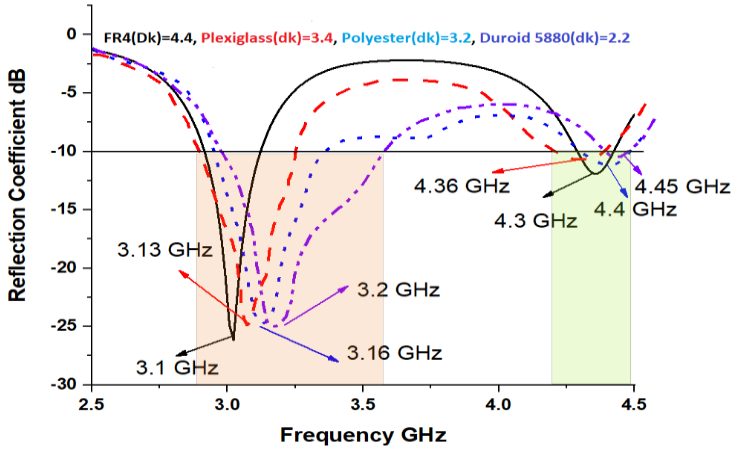
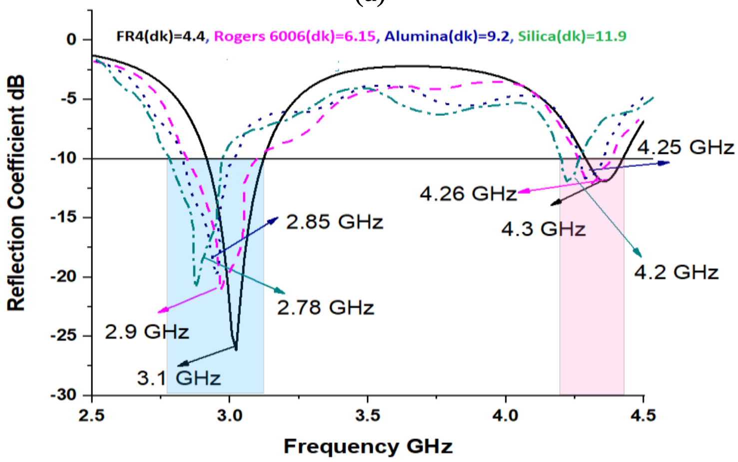


Figure 9. *Measurement of S_{11} on Anritsu VNA*

As a part of study in the performance charactertics analysis, substrate material effects are shown in this section. The proposed system is prototype in FR4 and the analysis is presented in the previous section. By changing the substrate material in the present design, the performed parameters are analyzed and presented in this work. The recommended antenna will have a similar operation like high end models with less computational design. The findings of electrical and electromagnetic calculations of experiments has beed recognised as like top operational models and it can match the simulation results for reflection coefficient, emission patterns, and gain.



(a)



(b)

Figure 10. *Parametric Analysis with Change in Substrate Material, (a) Dk above 4.4, (b) Dk below 4.4*

Fig 10 depicts the reflection coefficient variation with respect to the variations in the substrate material. Fig 10(a) shows the analysis with material dielectric constant 4.4 below cases and Fig 10(b) shows the analysis with material dielectric constnat 4.4 above cases. It has been clearly observed that the depending on the application, the proper substrate material can be selected.

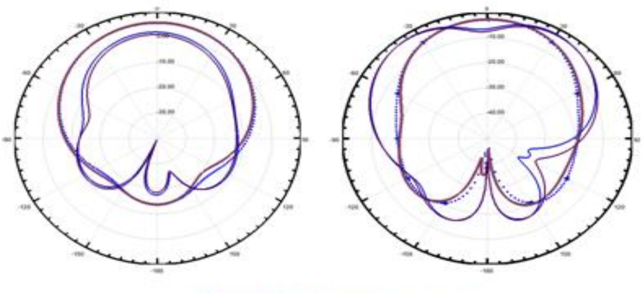


Figure 11. *Radiation pattern variation with change in substrate material*

FR4 substrate based antenna resonating at 3.1 and 4.3 GHz, the other popular substrate materials analysis presented in Fig 11 shows clear indication of the corresponding resonant frequencies as per the applied substrate material. The radiation pattern also giving evidence of the orientation of direction and pattern with change in substrate material.

5. Conclusion

In this study, a multi-slot fractal antenna has been constructed and examined. Wi-Fi and radio altimeter technologies use a 03.1 and 04.3 GHz antennas. The present design provides an average gain of 08 dB across two bands and a maximum gain of 08.4 dB, 07.6 dB at 03.1 and0 4.3 GHz. As part of the present design, several substrate materials with dielectric constants from 02.2 to 11.90 ranged from the basic resonant band (02.9 GHz) up to the second resonant band (4.36-4.45GHz). The suggested design prototype provides high correlation between simulation and measurement findings, as well as assurance for its uncertain applications. The proposed multi-slot fractal antenna has been provding bandwidth 9.5%, VSWR 12%, reflection coefficient 9.4%,3D-Gain 6.2% and surface current 9.3% had been attained. Therefore, it is identified that proposed multi-slot fractal antenna has been used at high speed and effiecent communnication related WI-FI and radio altimeter applications. The implemeted desing is compete with modern antennas and outperforms the design operation.

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