Revolutionizing Wireless Communication: a Comprehensive Review of Fractal Antennas

Kunal Routh, Jishnu Ray, Sutapa Ray and Aparna Biswas

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Revolutionizing Wireless Communication: AComprehensive ReviewofFractalAntennas

Kunal Routh[1], Jishnu Ray[1], Sutapa Ray[1],Aparna Biswas[1]

[1] Electronics and Communication Engineering Department, Institute of Engineering and Management, Kolkata, India
kunalrouth714@gmail.com,rayjishnn@gmail.com,sutapa.ray@iem.edu.in, aparna.biswas@iem.edu.in

Abstract:

Fundamental component of modern wireless communication systems is antenna , playing a pivotal role in transmitting and receiving electromagnetic signals. They are vital for a wide range of applications, which includes different types communication systems like cellular communication, satellite communication etc.. Research in the field of antennas is crucial for advancing wireless technology, improving signal quality, enhancing communication range, and developing new applications.Fractal antennas have emerged as a groundbreaking area of research in the field of antenna engineering over the past few decades. This extensive review aims to provide an in-depth analysis of the theoretical underpinnings, design methodologies, and diverse applications of fractal antennas.The review is started by elucidating the elemental concepts of fractals and their application to antenna design. It explores the intriguing properties of space-filling & self-similarity, which make fractal geometries particularly well-suited for antenna miniaturization and multiband operation.In this comprehensive review paper of fractal antennas we aim to provide a extensive overview of their principles, design methodologies, performance characteristics, and applications

***Keywords:Fractalantenna*,Miniaturization**

INTRODUCTION

In an increasingly interconnected world, the demand for efficient and versatile wireless communication systems has never been greater. From Smartphone's to satellites, from IoT devices to autonomous vehicles, the seamless transmission of data across vast networks is the backbone of modern society. At the heart of this digital revolution lies; the antenna, a component which is fundamental that enables the propagation of electromagnetic waves. Among all the antenna designs that have emerged over the years, one stands out for its remarkable properties and versatility: the Fractal antenna[1]-[3]. The inception of Fractal antennas can be traced back to the pioneering work of mathematicians Benoît B. Mandelbrot and Waclaw Sierpinski in the mid-20th century. Their insights into the self-similar, recursive structures led to the development of fractal geometry, which subsequentyl found its way into the realm of antenna design[4]. .

Every antenna has its own independent structure, which is essential for its working. Here Fractal geometries are applied to antenna elements which alds in creating antennas of compact size and multi band behavior. The use of Fractal antenna arrays allows improving multibeam and multiband features due to the recursive nature of fractals.The Fractal antenna represent the optimum solution for the problem that an antenna need to be designed for a particular operating frequency[5]-[7].

I. Designofabsorptive/transmissivefrequency-selectivesurfacebasedonparallelresonance.

FSS(Frequency Selective Surface) is a configuration of Fractal Antenna. Band transmission and wideband is very important property of FSS. In this paper , Fss is presented as the different types of frequency wideband [1].The element of the FSS structure based on parallel LC resonators is proposed to achieve multi-band bandpass filtering responses.The measured and simulated result is very closed and coincide around the transmission. There are some errors of measured and simulated result due to fabrication or soldering[8].

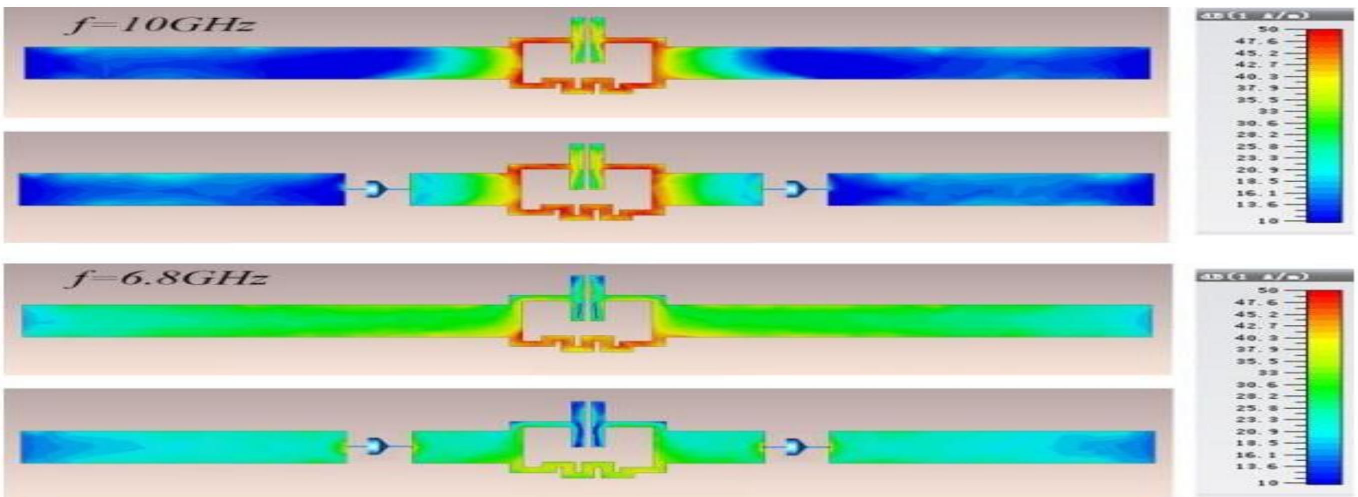

Fig.1: Surface current distribution on dipole elements with PLC lumped resistors at two resonance frequencies

Fig.1 shows that the surface currents distribution on dipole element at 10Ghz and 6.8Ghz frequencies.

II. Afrequency-selectivesurfaceabsorberbasedonfourfunctionallayers.

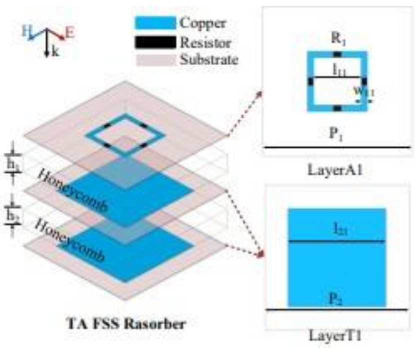

Fig. 4 Element of the TA rasorber (The dimensions: P_1 = 20 mm, R_1 = 80 Ω, w_{11} = 0.8 mm, l_{11} = 6.4 mm, P_2 = 20 mm, l_{21} = 13 mm, h_1 = 6 mm, h_2 = 8 mm).

Fig.2: Element of the TA Rasorber (The dimensions:p1=20mm, R1=80ohm. W11=0.8mm,l11=6.4mm, p2=20mm, l21=13mm, h1=6mm, h2=8mm).

TheconfigurationofFractalAntennaFSS(frequencyselective surface) is designed as four layers. Two layers arecalledtransmissionlayersandtwolayersarecalledabsorptionlayers.Thelayerscanbeusedtogeneratelowpassand band pass transmission in frequency selective surfacerasorber the measured result and simulated result closelymaintain reasonable agreement . It is also fabricated andmeasuredtheprototypetoconfirmedthedesign.Thefunctionalfourlayersareverygoodchoicetobethemeasured transmission and absorption is nearly closed withsimulationresult [12].

III. Activefrequencyselectivesurfacewithwidereconfigurablepassband

Theactivefrequencyselectivesurface(AFSS)isalsodefinedwiththewidereconfigurablepassband.Thereisusedavaractordiodetotunethepassbandandstopbandof RFSS.Varactor diode allows to tuned the two band applying avoltage. In measured result the passband decrease and if thevoltage and varactor diode increase then in the simulationresultthe passbanddecrease properly. Then the measureresult and simulation result will agree well to each other andalso maintainreasonable agreement[9][10].

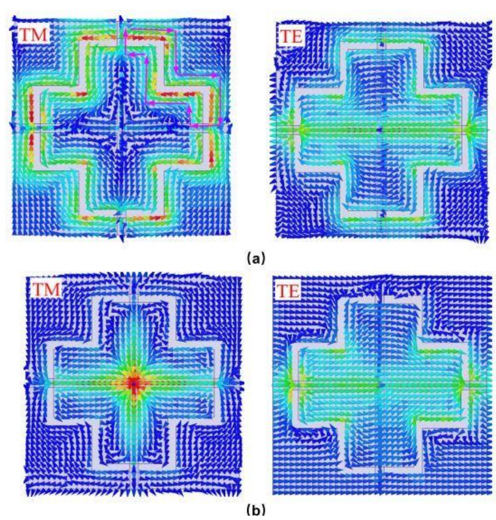

Fig.3:Current distribution under oblique incidence at 30deg. (a) 6.4Ghz. (b) 8Ghz

IV. ASurfaceBasedReconfigurableRasorber(Frequency selective) With Switchable TransmissionBand.

Fractal antennas have many types of configurations like- FSS,FRS etc. The working is completely based on the arrangement of periodic layers & the type of surface it is. In a two types of selective surfaces- 1) frequency(FSS) 2) resistive design [4] based recon figural r absorber with switchable transmission / reflection was made. The originality of the proposed design is in its reconfigurable reflection band. The proposed r asorber can be a very good choice for various radar cross section (RCS) reduction application. Here is only one prototype is produced

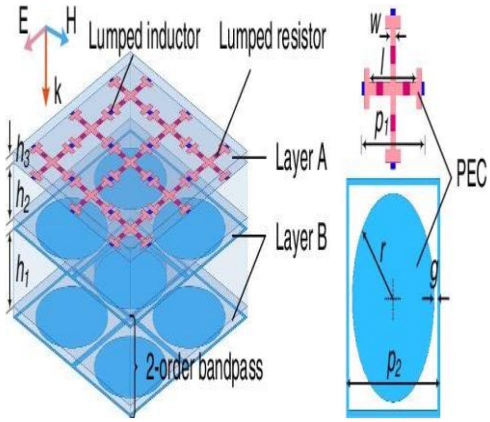

Fig.4:Frequency selective Rasorber With switchable transmission band.

V. Frequency-SelectiveRasorbersBasedonCentrosymmetricBended-StripResonator.

Here the design based on frequency selective r absorbers[5]onCentrosymmetricbendedstripresonator.Heretwoproto types are first fabricated then measured to analyzetheabsorptionortransmissionperformanceoftheproposed FSR's(T-A FSR & A-T FSR). The m resultswhicharemeasuredisinwellenoughconditionforbetteragreements with simulated results, which clearly exhibitthejustness of theproposeddesign.

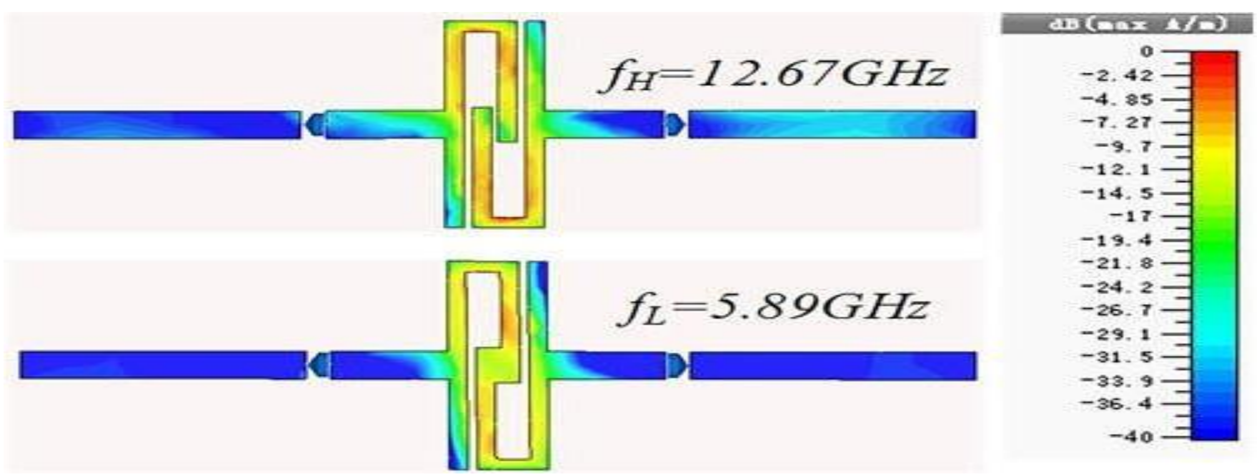

Fig.5: Distributionofsurfacecurrentintheresistivesheetlayers at 12.67Ghz and 5.89Ghz.

VI. FullyReconfigurableRasorberWithEnhancedAbsorptionBandwidthandSimplifiedBiasNetwork.

Thedesignbasedonfullyreconfigurablefrequencyselectiver absorber[6].It is with a feature of enhanced absorption bandwidth with a simplified bias network. The simple & the biasnetwork which proficient is raised in such a way that theperformance of the r absorber is remained unaffected. Thisfully fabricated prototype is tested experimentally where agood covenant is obtained between simulated & measuredresult.

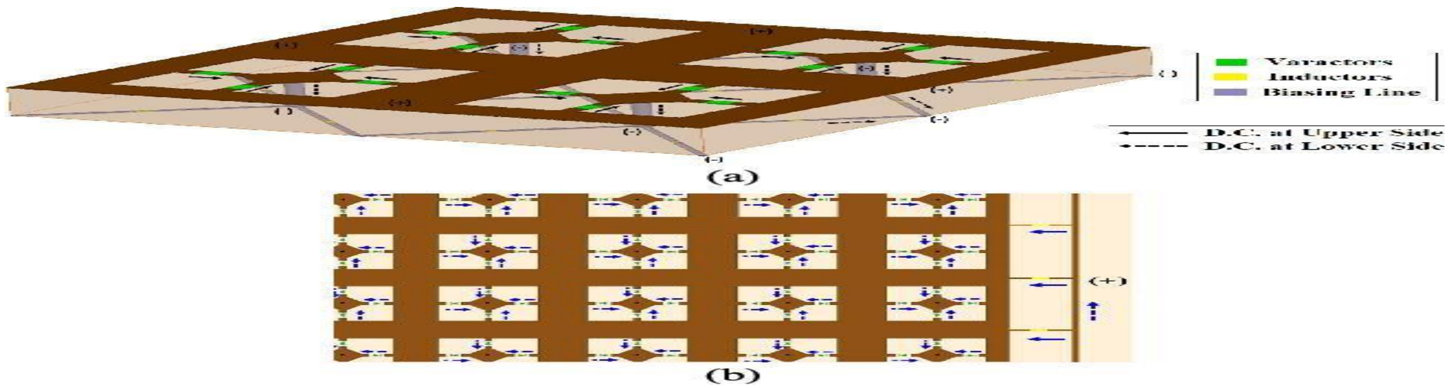

Fig.6: Arrangementofbiasing(a)unit-cell,(b)array'stopside.

➢ CONCLUSION

In conclusion, fractal antennas represent a captivating domainof research with the capability to reshape the landscape ofantennadesignandRFengineeringincludingadvancementsinmaterials,fabricationtechniques,andintegrationintoemergingtechnologieslike5G,IoT,a ndspace-basedcommunication systems. After a detailed analysis of the mainconcepts and current advancements in the field, this paperaimstoprovideresearcherswithvaluableinsightsandperspectivesforfurtherexplorationandexperimentationinthefascinatingdomainof fractal antennas

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