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Investigations on Metamaterial Slot Antenna for Wireless Applications

P Saleem Akram, B T P Madhav, P Ganesh, G Srinivas, S Salma, K Manikanta, G Likitha

Abstract*: This paper represents a Circular Complementary Split Ring Resonator (CCSRR) which produces an S band (i.e. 2GHz-4GHz) and X band (i.e. 8GHz-12GHz) frequencies and can be useful for various applications, which is evolved in the third iteration. In which first iteration was Circular ring monopole (CRM) and later a complementary split ring was introduced in the ring mono pole. The overall proposed antenna dimensions are (40mm X 34.8mm X 1.6mm) and fabricated on FR-4 substrate. Antenna with dual (high and low) bands resonant frequencies were proposed and designed by using circular ring monopole which was extended to split ring resonator yields a high gain when compared to previous designs. Proposed model Circular Complementary Split Ring Resonator (CCSRR) works in 3.7GHz for S-band applications like Wi-MAX and 8 GHz for X band applications like terrestrial communication with a gain of 12.1 dB. The proposed antenna was designed and simulated in HFSS software and results were plotted with help of origin pro software.

Index Terms*: Circular Ring monopole (CRM), Circular Complementary Split Ring Resonator (CCSRR), Metamaterials, Slot antenna.

I. INTRODUCTION

Now a day's evolution is common in each and every part of life and technology. In Antennas there were lots of evolutions with various techniques were present with their own pros and cons where each technique is evolved with a disadvantage with previous structure. For the antennas there were some techniques like DGS (Defected Ground Structure), UWB (Ultra Wide Band), and EBG (Electromagnetic Band Gap). As the microwave metamaterials has significance due to their exceptional properties which are not found in the nature. Coming to the electromagnetic materials are not the ordinary materials like negative refraction, Doppler move inversion and converse Cherenkov radiation [1].

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***** Correspondence Author

P Saleem Akram*, ECE Department from K L Deemed to be University.

Dr. Madhav B T P, Professor of ECE Department and Associate Dean R&D of K L University.

P.GANESH, B.Tech in Electronics and communication engineering at KL Deemed to be University.

G.J.Srinivas, B.Tech in Electronics and Communication Engineering at KL Deemed to be University.

S. Salma, Ph.D in Electronics and Communication Engineering at KL Deemed to be University.

Kalluri Manikanta, B.Tech in Electronics and communication engineering at KL Deemed to be University.

G.Likhitha, B.Tech in Electronics and Communication Engineering at KL Deemed to be University.

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Metamaterials means it does not have any base materials, it is a structure which comes by arranging the elements in particular order which exhibits the unique properties made by the structure but not the base material of the element. The main target of metamaterial hypothesis is to conduct the atoms and they have been realized as they are reconfigurable structures. Along with these lines it can state that versatile metamaterial unit cells are one step nearer to the objective [2]. Traditional micro strip radio wires had a few restrictions that are single working recurrence, low impedance data transmission, bigger size and polarization issues. There are number of strategies which have been accounted for upgrading the parameters of traditional micro strip receiving wires that is utilization of stacking, diverse encouraging systems, Frequency Selective Surfaces (FSS), Electromagnetic Band Gap (EBG), Photonic Band Gap (PBG), Metamaterial, etc. Microwave part with Defected Ground Structure (DGS) has been picked up notoriety among every one of the procedures revealed for upgrading the parameters because of its straightforward auxiliary plan. Carved spaces or imperfections on the ground plane of micro strip circuits are introduced to as Defected Ground Structure. Single or various deformities on the ground plane might be considered as DGS. At first DGS was accounted for channels underneath the micro strip line. DGS has been utilized underneath the micro strip line to accomplish band-stop attributes and to stifle higher mode sounds and shared coupling. After effective usage of DGS in the field of channels, these days DGS is sought after widely for different applications. This paper displays the advancement and improvement of DGS. The fundamental ideas, working standards and proportional models of various states of DGS are exhibited. DGS has been utilized in the field of micro strip receiving wires for upgrading the transfer speed and addition of micro strip radio wire and to stifle the higher mode sounds, common coupling between adjoining component and cross-polarization for improving the radiation attributes of the micro strip reception apparatus. The electromagnetic waves interact with the features of structure which are of small wave lengths, these kind of wavelength may under o heterogeneous property leads to disorder of the structure to demonstrate the Metamaterial conduct, a unit cell ought to be energized by an appropriate electric and attractive fields. For instance, the attractive field ought to be opposite to the rings and the electric field parallel to the lines of the structure. One of the rules of the metamaterial is to regulate its unit cell's response to the outside fields. Reconfigurable metamaterials have many intriguing applications in the field of receiving wire and proliferation [3]. High information rate and higher channel limit are the primary objectives of the emerging wireless technologies correspondence framework, which can be accomplished by Multiple Input Multiple Output.

In order to achieve the best spectral efficiency we need to have the more antennas to avoid the scattering and reflection in a multipath environment [4].

In order to get desired response and tenability from radio spectrum to the optical spectrum by interfering the active materials are used. The active materials like liquid crystals, graphite and the semiconductors which can be considered by the external factors like temperature, light, voltage. The above methods cannot produce the dynamic and real time regulations. Without the need of the active materials the complicated process, micro structural reconfiguration are used.

Previously the planar microstructure was used and these are being done by the 3 dimensional rotatable resonators. The double split ring resonator has the good tenability which has the ability to overcome the defects of the conventional type of the tenable electromagnetic Meta devices [5]. Multibands were obtained by using rectangular complimentary split ring resonator (RCSRR) by using feeding technique [6]. The proposed design of antenna was evolved in three stages, in the first stage it consists of a ring monopole attached to feed line which is having a length of FL of 10.4mm and width FW of 2.4mm. Ring monopole with a radius of 8.25mm with a slot of ground 14 mm of length and 24.8mm width (14mm X 24.8mm), ground and the ring monopole part is common for all the designs. Substrate is Fr4 epoxy which is having dielectric constant of 4.4 and having length of 40mm length and width is of 34.8mm (40mm X 34.8mm X 1.6mm) is common for the all the designs. Plane ring monopole which is having radius 8.25 mm is attached to rectangular feed with FL of 10.4mm and width FW 2.4mm produces a frequency 3.7GHz and 8.1GHz, with a gain of 3.2 dB. Next step a small split ring was introduced in the ring monopole in the step 1 which is of 6 mm radius and width k is 2mm which operates at 3.9GHz and 7.9 GHz with a gain of 3.5dB. The proposed antenna introduces a ring split ring resonator in step 2 with a radius of 2.8mm and width of 0.8mm was introduced which yields a frequency of 3.7GHz and 8GHz with a gain of 12.1dB.

II. Antenna Design & Dimensions

Proposed antenna is evolved by three iterations in the first iteration Fig. 1(a) is plane ring monopole Which is having resonating frequency as 3.7GHz and 8.1Ghz later in second iteration Fig.1(c) by introducing a small split ring with a radius of 6mm and width is2mm and a cut of square in ring with a dimension (4mm X 4mm) on the first iteration design holds resonating frequencies were 3.9Ghz and 7.9 GHz. In the Fig.: (d) third iteration a CCSRR was introduced the structure. In our proposed design substrate is FR4 epoxy which is having 4.4 dielectric constant and the dimension is of (40 mm X 34.8 mm X 1.6 mm) on which a Circular Complementary Split Ring Resonator (CCSRR) which is a radiating element, Ground Fig.1(b) which is a slot for the antenna (14 mm X 24.8 mm). Fig. 2 is inserted in the split ring with a radius of 2 mm and width of 0.8mm which yields 3.7 GHz and 8 GHz.

The proposed design Fig.1(d) is the evolution of CRM [7] circular ring monopole with a ground slot on the back of the substrate and a similar to L and T slotted ground and Rectangular Complementary Split Ring Resonator (RCSRR) [8] the metamaterial structure acts as a radiating element which produces a multi bands but not appreciated gain when compared with proposed antenna Circular Complementary Split Ring Resonator (CCSRR) metamaterial structure Fig.: 2 act as a radiating element in the design Fig.1(d),although proposed design is achieved in the third iteration with it produces an low and high frequency band width with a appreciated gain [9-15].

In this proposed work, the creators had planned out a CRM as 'Circular Ring Monopole Antenna' which takes a shot at the full UWB and halfway SWB consequently delivering out Electromagnetic Obstructions which is handled by utilizing Split Ring Resonator in this manner delivering recurrence 'Indent Function' [16-22]. With lieu of it the structured reception apparatus meets the entire UWB data transmission utilized for assortment of remote applications and a piece of the SWB transfer speed. As referenced before the structured receiving wire shows out better impedance, wide data transfer capacity, well order radiation design alongside fulfilling increase and effectiveness. So as to give supports to the entire work, an unexpected report is given in the later part [23-26]. All major measurements are appeared Table 1 with fundamental structure of CRM without SRR or Circular Ring Monopole Antenna utilizing the Customary Appproach.

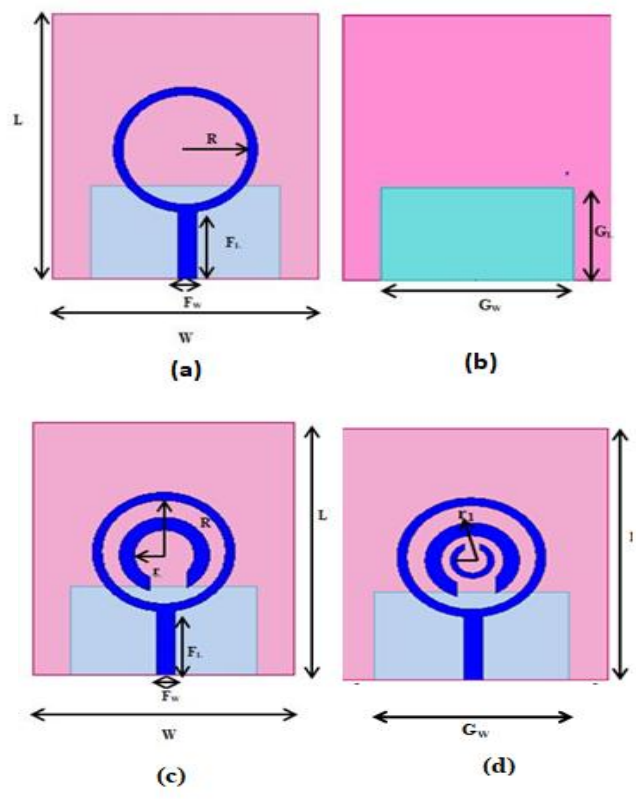

Fig.1 Proposed design (a) planar Ring monopole antenna (b)ground (c) circular split ring(d) Circular Complementary Split Ring Resonator (CCSRR)

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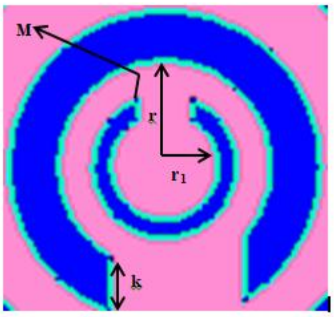

Fig.2 Circular Complementary Split Ring Resonator structure (CCSRR)

Table1. Antenna dimensions in mm

Antenna parameters	Dimensions in mm
L	40
W	34.8
F_L	10.4
F_W	2.4
G_L	14
G_W	24.8
R	8.25
r	4
r1	2
k	2
M	0.8

III. Results and Discussion

Proposed antenna was designed in HFSS v.19.0 and plotted in Origin pro software which made easy to analyze and compare the return loss of the all the three iterations and plotted in one single return loss graph. The 'Circular Ring Monopole Antenna' (CRM) is structured by utilizing Conventional Approach which incorporates numerical plan followed up by structure procedural setup. With lieu of the definitions referring to structure methods extra parameters incorporates Dielectric Constant and Height of the Substrate which has been taken in the wake of considering the graph of FR-4. Fundamental Structure of Circular Ring Monopole Antenna without EBG Since structured reception apparatus was experiencing electromagnetic impedances coming about out in wild conduct. Split Ring Resonator (SRR) In Fig.:3 Antenna1 is the reflection coefficient of the Fig :1(a) the basic ring monopole which is having a band width and it is having a dips is at 8.1 GHz and it does not yielding gain ,so further we inserted a small split ring with a radius of 6mmFig.:1(c)and reflection coefficient is in Fig.3 Antenna2 of course there it having reflection coefficient, gain but not appreciated one , again circular ring in monopole, Circular Complementary Split Ring Resonator is inserted Fig.:1(d)there is an improvement the reflection co efficient Fig.3 Antenna3 and also in gain, which works in Marine radars (Band 8-12 GHz) and terrestrial communication (S band 2-4GHz).

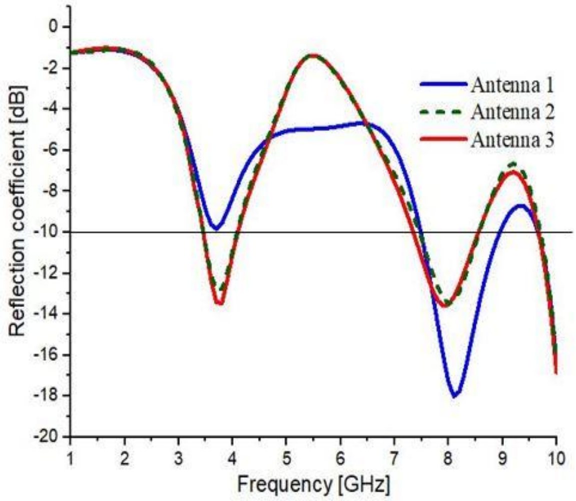

Fig.3 Reflection coefficient of all the three designs

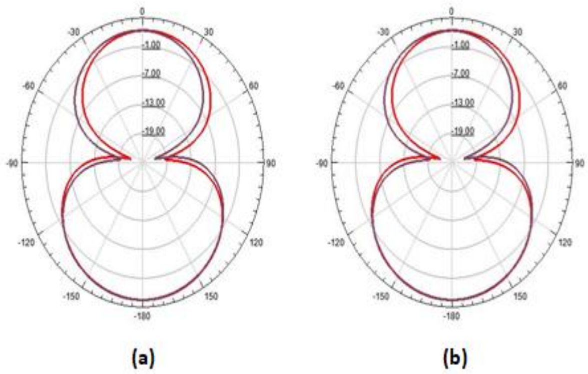

Fig. 4 Radiation Pattern of the proposed antenna model at different operating bands (a) 3.7GHz (b) 8GHz.

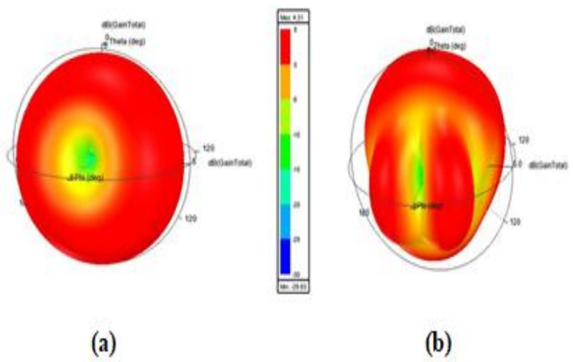

Fig .5 3D Radiation Pattern of the proposed antenna model at different operating bands (a) 3.7GHz (b) 8GHz.

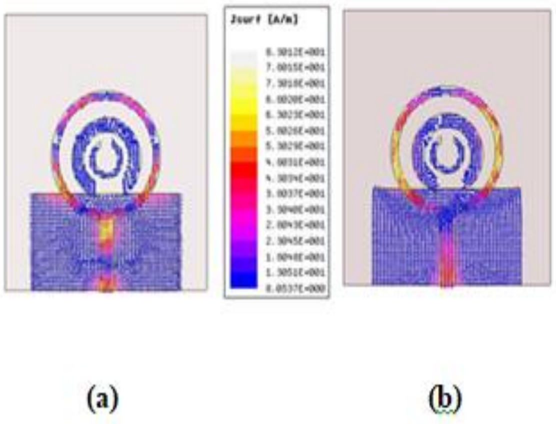

Fig. 6 Current distribution for different operating bands (a) 3.7GHz (b) 8GHz.

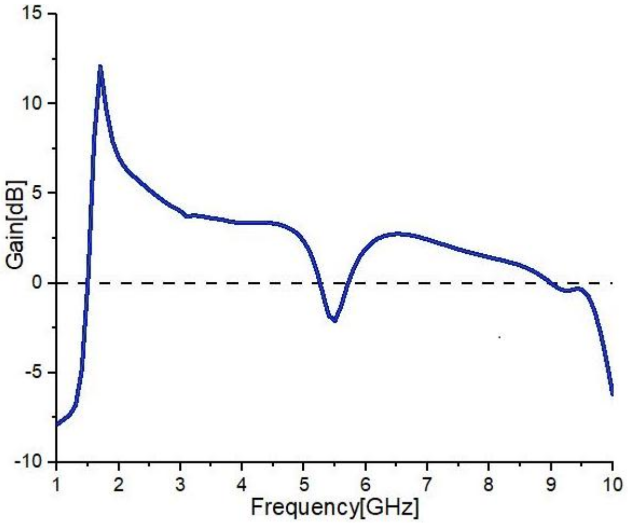

Fig.7 Gain vs frequency plot for proposed design

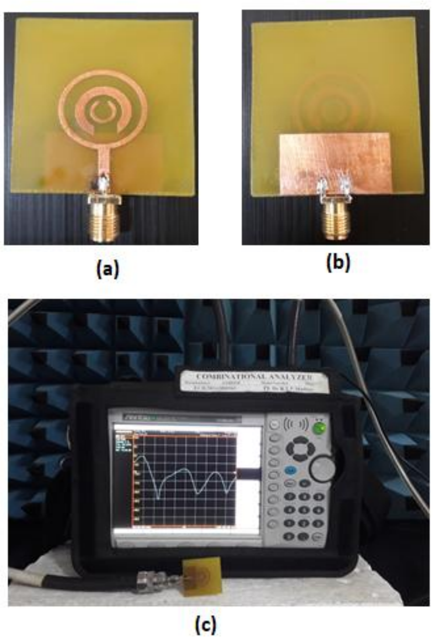

Fig.8 Fabricated proposed antenna (a) front part of proposed antenna (b) Ground part of proposed antenna (c) Reflection coefficient measurement on Combinational analyzer

IV. CONCLUSION

Paper proposed a dual band antenna for Wi-Max and terrestrial communication. It was employed with ring mono-pole and a metamaterial structure which is present on the substrate act as a radiating element with a ground slot on the back part of the substrate final proposed design holds a gain of 11.2 dB at obtained frequencies 3.8GHz and 8GHz.

Later by inserting a split ring inside the ring mono pole and again introducing circular split ring resonator which completes a metamaterial structure and yields a better operation frequencies of 3.7GHz and 8GHz and gain of 12.1dB when compared to previous two structures. A fine analysis was carried over the designs and concluded that proposed antenna works in S band, by using this particular band we can operate satellite communications (2-4GHz) which can and X band applications (7-11.2GHz) marine and space communication is possible through this antenna.

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AUTHORS PROFILE

P Saleem Akram is working as faculty in ECE Department from K L Deemed to be University. He is currently working on antenna design.

Dr. Madhav B T P is now working as Professor of ECE Department and Associate Dean R&D of K L University. He is currently with the ALRC-R&D and working on microwave antenna design, applications liquid crystals and conformal and wearable antennas.

P.GANESH was born in 1998 at Machillipatnam. He is currently pursuing B.Tech in Electronics and communication engineering at KL Deemed to be University. His areas of interest include slotted antenna.

G.J.Srinivas was born in 1998 at Eluru. He is currently pursuing B.Tech in Electronics and Communication Engineering at KL Deemed to be University. His areas of interest include metamaterial antennas.

S. Salma was born in 1994 at Srikalahasthi. She is now pursuing Ph.D in Electronics and Communication Engineering at KL Deemed to be University. Her areas of interest include Reconfigurable Patch antennas.

KALLURI MANIKANTA was born in 1997 at chintapalli. He is currently pursuing B.Tech in Electronics and communication engineering at KL Deemed to be University. His areas of interest include metamaterial antennas.

G.Likhitha was born in 1998 at Ongole. She is now pursuing B.Tech in Electronics and Communication Engineering at KL Deemed to be University. Her areas of interest include Reconfigurable Patch antennas.