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Fractal Antenna Based on Split Ring Resonators with Defected Ground Structure

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ABSTRACT

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In this paper presents the design of a circular microstrip fractal antenna (CMFA) loaded with parasitic edge-coupled (EC) split ring resonators (SRR) and defected ground structure (DGS). The basic resonant structure is a circular patch antenna designed at 3.2 GHz on FR4 substrate with relative permittivity 4.4, and 1.6 mm thickness. One iteration of circular patch and slots is employed to form it fractal and so as to attain multiband performance, the antenna is inset fed by a 50Ω microstrip line. Further the work is extended to demonstrate the effect of placing split ring resonator to particular position of substrate, improves the impedance matching leading to improved bandwidth. In addition L shaped defected ground structures are used to improve the antenna performance. . A comparison between fractal antenna with and without SRRs and DGS is made and the results verifies that a better gain improvement and return loss. The dimensions of the antenna are 45 mm x 45 mm and it can be used for ultra wide band (UWB) applications.

Keywords: Circular Microstrip Fractal Antenna (CMFA), Split Ring Resonator (SSR), Defected Ground Structure (DGS)

I. INTRODUCTION

The modern communication world mainly focusing on the process of miniaturization of physical equipments and high throughput. However, low bandwidth is the major constrain in the case of microstrip patch antenna. To overcome this, the antenna is designed by changing the basic parameters of the antenna, which is mainly focusing on the parameter as shape. To fulfill the requirements of wireless communication performances researchers looking for more advanced antenna designs. One such field of advanced antenna design is fractal antenna. Fractal antennas are self similar antennas i.e. basic antenna shape is divided into several smaller parts, where each part is the copy of basic element.

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However, the important observation [1] is that the side lobe level for the circular patch is approximately 9 dB lower than the rectangular patch. The side lobe level observation guaranteed that the radiation pattern of circular patch antenna has a better performance when compared with rectangular patch antenna. The overall comparison of both antennas according to different performance parameter revels that, from the perspective of bandwidth and side lobe levels, circular patch antenna shows superiority over rectangular patch antenna.

A novel circular fractal antenna design using inset feed and without using inset feed presented in [2] for comparing the performance parameters such as number of frequency bands, gain and return loss. The antenna designed with resonant frequency of 3.2 GHZ. Basic antenna structure is a circular patch, and for achieving the multiband performance a single iteration of circular patch and slots is used to make it fractal. The antenna without inset cut produces 3 resonant frequency band and antenna with inset cut produces 5 resonant frequency bands and value of the return loss at all these frequency bands is below -10dB which is the acceptable value for an antenna to work efficiently. The value of VSWR is acceptable level (VSWR≤ 2) in both case of antenna. The efficiency and gain of the antenna is determined by the parameter gain, which is good in the case of antenna with inset feed while comparing with antenna without feed. But the gain of the antenna is negative only at 4.88GHZ frequency band and this frequency band can't be used for the practical applications of antenna.

The paper [3] extended the antenna design of [2] and observed the performance improvement by placing SSRs around the fractal antenna. SSRs are used for obtain better impedance matching. Dimensions of SSRs are calculated for a frequency around 8.5 GHz, since at this frequency the circular fractal antenna showed the best value of bandwidth and gain. The simulation result revels that best performance is obtained in terms of impedance matching, gain and multiband performance. Performance of the antenna is very good at 8.5 GHz WiMAX applications.

II. DESIGN OF CIRCULAR FRACTAL ANTENNA

The basic structure of the proposed antenna is circular patch. The dimension of the circular patch is calculated using [2] [4].

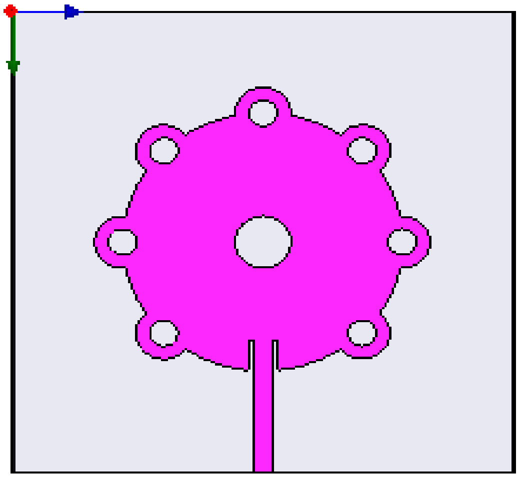

Figure 1: Circular fractal antenna

$$a = F\{1+\frac{2h}{\pi F\varepsilon_r}[\ln(\frac{\pi F}{2h})+1.7726]\}^{-1/2} \quad (1)$$

$$F = \frac{8.791\times10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

In this equation a is the radius of the circular patch and h is the height of the substrate.

After the circular patch design, a ring structure is constructed by etching a circle of radius a/5mm at the centre of circular patch. The fractal structure is designed by placing small rings of dimension 1/10th of original ring at an angle of 45^0, as shown in fig.1.

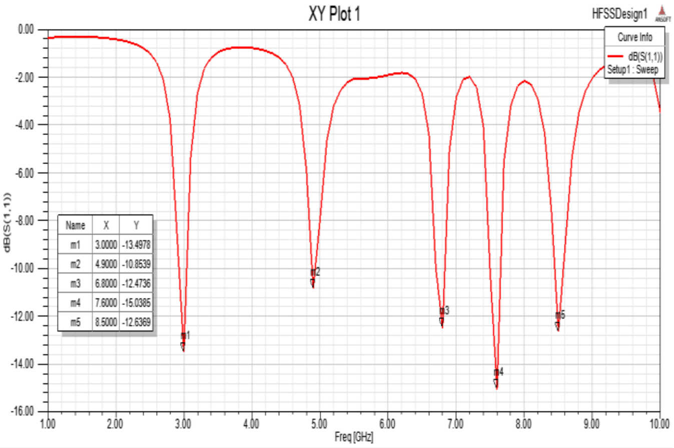

Figure 2: Simulated S-parameter for circular fractal antenna

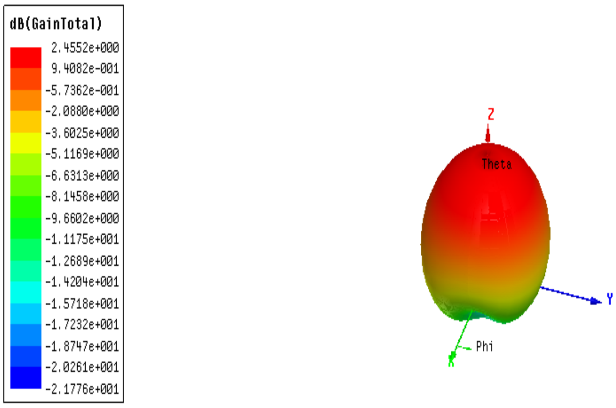

Figure 3: Simulated polar plot for circular fractal antenna

Simulated S-parameter of circular fractal antenna shown in Figure 2. The circular fractal antenna shows multiband behaviour and it resonate at five points which are 3GHz,4.9GHz,6.8GHz, 7.6GHz and 8.5GHz.While comparing with other frequencies antenna shows better performance in 7.6GHz. The obtained gain of the antenna is 2.455dB. Simulated polar plot for circular fractal antenna is shown in Fig.ure 3 and radiation pattern is shown in Figure 4.

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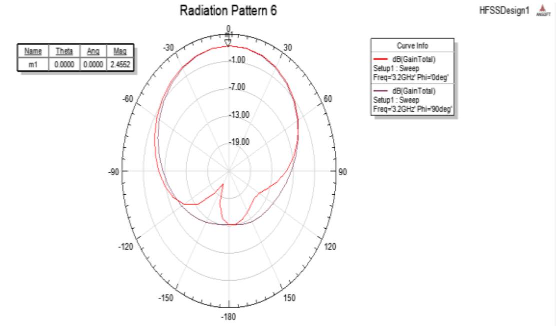

Figure 4:Simulated radiation pattern for circular fractal antenna

III. DESIGN OF CIRCULAR FRACTAL ANTENNA WITH SSR

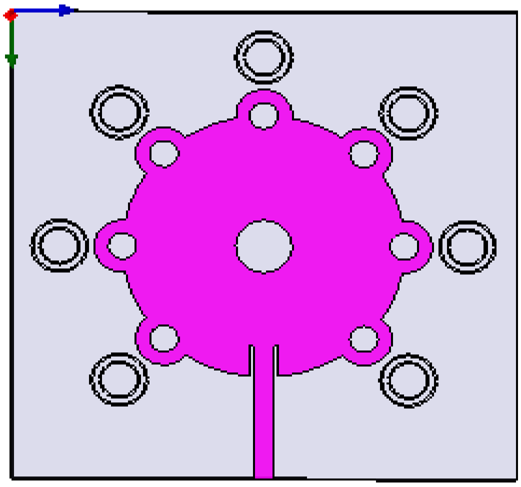

Figure 5: circular fractal antenna with SSR

As per second step introducing split ring resonators near to the circular fractal at an angle of 450. SSR used here for achieving more impedance matching. The dimensions of SSR are calculated using the equations mentioned in[4]. A single split ring resonator is shown in fig.5

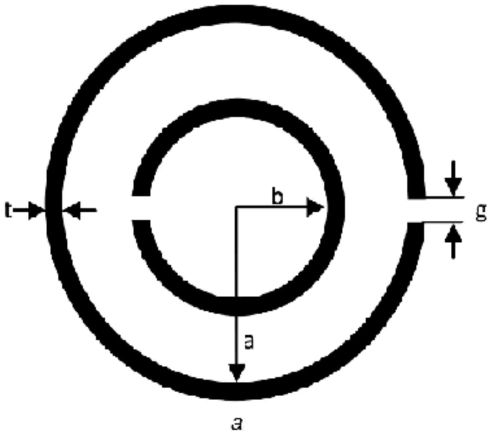

Figure 6: SSR

The SRRs used here are parasitic MTM, and are excited by the surface currents available beneath the metal patch, surface currents are electromagnetic waves travelling normally to the surface inside the substrate.

The splitted circular rings are formed with metallic strips of width, t, and radii (b+t) and forming the inner and outer rings, respectively with inter ring spacing, (b-a). The splits on the inner and outer rings have identical gap dimensions g which lies on diametrically opposite sides of the same axis. When an external magnetic field is applied along the z-axis, an electromotive force appears around the SRR and couples the two metallic rings with the induced current passing from one ring to the other ring through a distributed capacitance formed due to the inter ring spacing. The gap within the rings formed by the splits help to obtain a resonant structure with a much smaller dimension compared to a quarter of a wavelength for a closed unsplitted ring. Thus the electrical size of the SRR can be considered small compared to the free space wavelength and a quasi-static model is plausible.

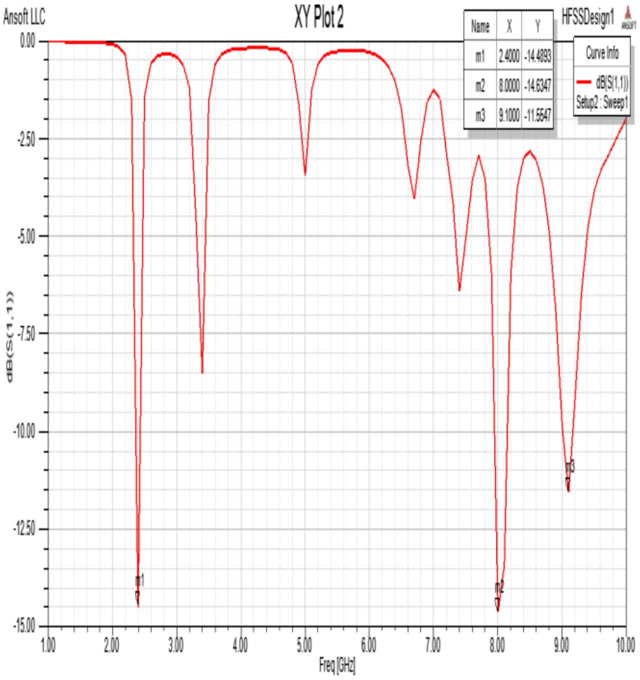

Figure 7:Simulated S-parameter for circular fractal antenna with SRR

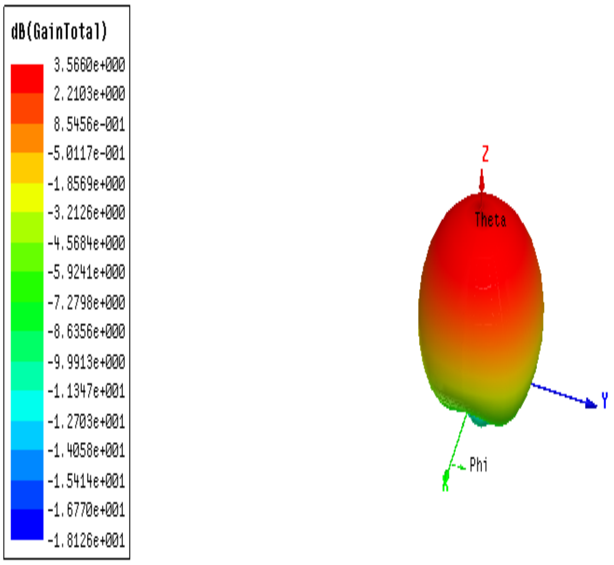

Figure 8: Simulated Polar plot for circular fractal loaded with SSR

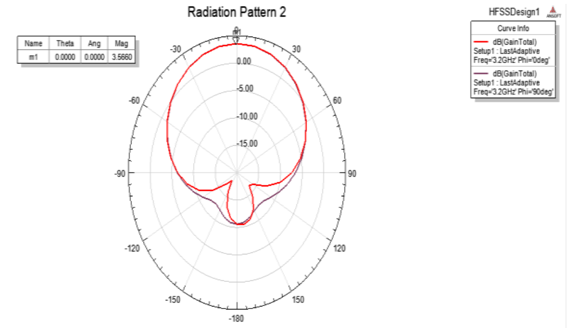

Figure 9: Simulated radiation pattern for circular fractal antenna with SRR

Plot for S-parameter of circular fractal antenna with SSR is shown in figure 7. In the presence of split ring resonators some frequencies shift occurrence while comparing with basic structure. The fractal antenna with SSR resonates only at three points which are 2.4GHz, 8GHz and 9.1GHz. But major advantages are the lower return loss and improvement of gain. The simulated result shows antenna with a gain of 3.5dB.

IV. DESIGN OF CIRCULAR FRACTAL ANTENNA WITH L SHAPED DGS

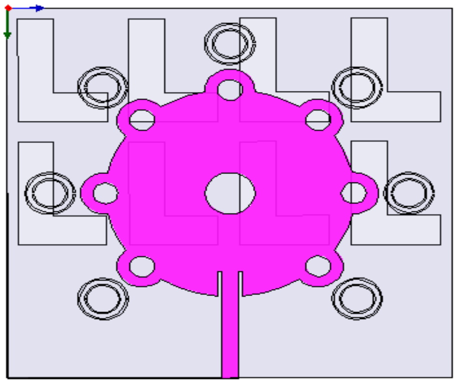

Figure 10: Front view of circular fractal antenna with SSR and DGS

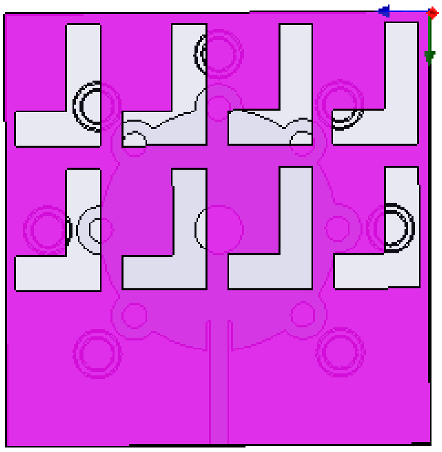

Figure 11: Back view of circular fractal antenna with SSR and DGS

As a modification L shaped ground structures are implemented in the third step. Totally 8 L shaped structures are etched in the two rows of ground with 4 structures each. The dimensions of the L shaped structure is calculated using [5]. The front and back view of circular fractal antenna with SSR and DGS shown in figure 10 and figure 11.

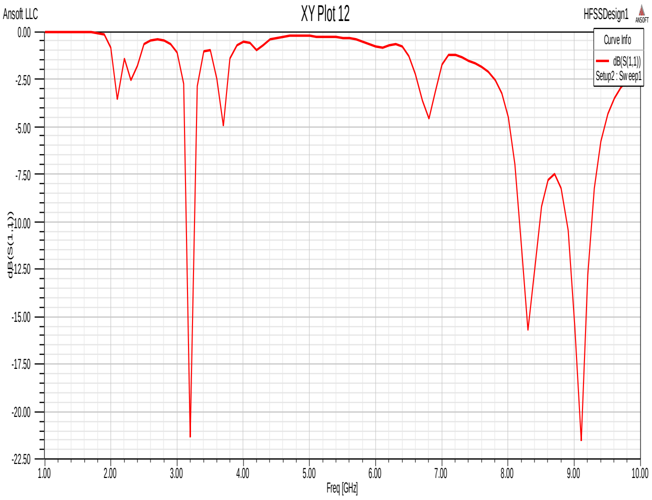

Figure 12: Simulated S-parameter of circular fractal antenna with SRR and DGS

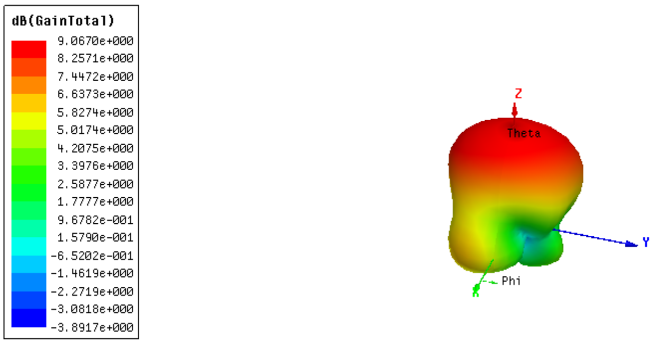

Figure 13: Simulated Polar plot for circular fractal loaded with SSR and DGS

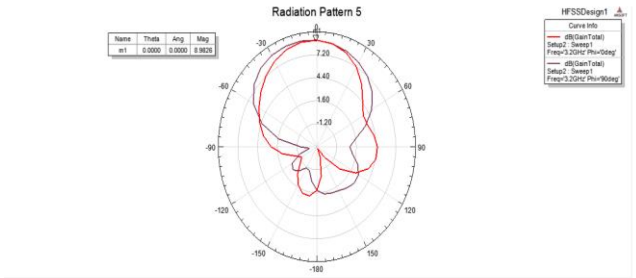

Figure 14: Simulated radiation pattern for circular fractal antenna with SSR and DGS

Presents of defected structure produces both advantages and disadvantages. The DGS producing frequency shift can be observed from the Plot for S-parameter of circular fractal antenna with SSR and DGS as shown in figure 12. Polar plot of the proposed antenna is shown in figure13. The fractal antenna with SSR and DGS resonates at three points which are 3.2GHz, 8.3GHz and 9.1GHz with return loss of -21.5dB, -15.5dB and -21.5dB respectively. The obtained 9.06dB gain of modified antenna is 18.5829dB. The radiation pattern for circular fractal antenna with SSR and DGS is shown in figure 14. It shows the presence of higher side lob levels.

V. RESULTS AND DISCUSSION

The fractal structure uses a virtual combination of capacitor and inductor due to which antenna resonate at different frequencies. As number of iterations increases in the antenna, there having an increase in the number of resonating frequencies and thus antenna shows multiband characteristics. The better performance enhancement of antenna not only getting through fractal geometry but also depends on the feeding mechanism, substrate properties and ground structuree etc. The proposed antenna having reduced number of frequency bands compared with the basic fractal structure due to SSR and DGS producing current disturbance. The proposed system also producing higher back lobe comparing with fractal antenna and fractal antenna with SSR. Major advantages of the proposed antenna is lower return loss and double the value of gain comparing with fractal antenna with SSR.

TABLE 1. RESULT ANALYSIS

Antenna	Frequency (GHz)	Return loss	Gain (dB)
Circular fractal antenna	3	-13.4978	2.4
	4.9	-10.8539	
	6.8	-12.4936	
	7.6	-15.0385	
	8.5	-12.6369	
Circular fractal antenna with SSR	2.4	-14.4893	3.5
	8	-14.6347	
	9.1	-11.5547	
Circular fractal antenna with SRR and DGS	3.2	-21.5	9.067
	8.3	-15.5	
	9.1	-21.5	

VI. CONCLUSION

The project proposes a multiband circular fractal antenna loaded with SRR's and DGS and comparing the results for each case. The antenna design was a step by step procedure, and the desired results are obtained. i.e., lower return loss and improved value of gain. The frequency shift from the designed frequency is due to fringing effect of microstrip patch antenna and higher back lobe are the drawback of this design. Even though applications of this antenna is huge in different field of communication.

The antenna can be used at different bands within WiMAX IEEE 802.16d (2-11 GHz) nonline of sight point to multipoint applications such as wireless metropolitan area network single-carrier physical layer (WMAN-SCa PHY), WMAN orthogonal frequency division multiplexing physical layer (WMAN-OFDM PHY), WMAN orthogonal frequency division multiple access physical layer (WMAN-OFDMA PHY) and wireless HUMAN (high-speed unlicensed metropolitan area network). Performance of the antenna is very good at GHz WiMAX application.

The hybrid combination of fractal structure including more iterations with or without SRRs and different DGS may be exploited to get better performance of antenna, which leads to a good future scope in this area.

VII. REFERENCES

[1]. Alam, A K M & Ashique, Ratil H. (2014)." A Comparative Study of Rectangular and Circular Microstrip Fed Patch Antenna at 2.45 GHz". International Journal of Scientific and Engineering Research.

[2]. N. Sharma, A. Kaur and V. Sharma, "A novel design of circular fractal antenna using inset line feed for multiband applications," 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), Delhi, 2016, pp. 1-4.

[3]. V. Sharma, N. Lakwar, N. Kumar and T. Garg, "Multiband low-cost fractal antenna based on parasitic split ring resonators," in IET Microwaves, Antennas & Propagation, vol. 12, no. 6, pp. 913-919, 23 5 2018.doi: 10.1049/iet-map.2017.0623.

[4]. Pendry, J.B., Holden, A.J., Robbins, D.J., et al.: 'Magnetism from conductors and enhanced nonlinear phenomena', IEEE Trans. Microw. Theory Tech., 1999, 47, (11), pp. 2075–2084

[5]. Lokhande, Pramod Vasant and B. T. Salokhe. "Jaysingpur Design & Simulation of Circular Microstrip Antenna with Defected Ground Structure (DGS) for WLAN Applications." (2013).

[6]. B. Rama Rao, S.Alekhya, Dr. P.V. Sridevi "Design of Circular with triangle Microstrip Fractal Antenna for Dual band and UWB applications" IJSER ,Volume 4, Issue 7, July2013, ISSN 2229-5518.

[7]. Zhangfang, H., Wei, X., Yuan, L., Yinping, H. and Yongxin, Z. (2016)." Design of a modified circular-cut multiband fractal antenna". The Journal of China Universities of Posts and Telecommunications, 23(6), pp.68-75.

[8]. Bhatia, S.S. & Sivia," Analysis and design of circular fractal antenna array for multiband applications" J.S. Int. j. inf. tecnol. (2018).

[9]. Miniaturized wideband microstrip antenna for recent wireless applications" Shandal S.A., Mezaal Y.S., Mosleh M.F., Kadim M.A. (2018) Advanced Electromagnetics, 7 (5) , pp. 7-13.

[10]. ALLURI, Srinivasarao; RANGASWAMY, Nakkeeran."A super wideband circularshaped fractal antenna loaded with concentric hexagonal slots". International Journal of Engineering & Technology, S.l.], v. 7, n. 3.29, p. 211-213, aug. 2018. ISSN 2227- 524X.

[11]. R. Chauhan and S. Gupta, "A Circular Fractal Antenna Array," 2019 National Conference on Communications (NCC), Bangalore, India, 2019, pp. 1-6. doi: 10.1109/NCC.2019.8732218 1

[12]. A Garhwal, M R Ahmad, B H Ahmad, S Rawat, P Singh, K Ray and ABandyopadhyay "Circular

and Elliptical Shaped Fractal Patch Antennas for Multiple Applications" IJEAT, ISSN: 2249-8958, Volume-8 Issue-5, June 2019

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