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On the Design of Wheel Shape Fractal Antenna

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Abstract—**This paper presents the design of a wheel shaped multiband fractal Antenna. This Fractal antenna has been designed on substrate ε_r = 4.3 and thickness h = 1.53 mm. This new antenna has been fed with CPW – Fed. The antenna exhibits the multiband resonances due to self-similarity in antenna structure. The experimental results indicate that resonant frequencies occur at 1.34 GHz, 2.575 GHz, 4.22 GHz with impedance bandwidth of 40.77%, 19.02% and 26.94 % respectively. The first lower end resonant frequency of this antenna shifted to 1.0 GHz in comparison to 1.67 GHz resonant frequency of simple circular coaxially feed patch. This indicates the size reduction of the antenna. The experimental radiation pattern of antenna is similar at all resonant frequencies. Such type of antenna can be useful for mobile and wireless communication.**

Index Terms—**Microstrip antenna, Fractal antenna, Multiband, Resonant frequency and Miniaturization1.**

I. INTRODUCTION

The progress and dramatic development of a variety of wireless applications have remarkably increased the demand of multi-band/wideband antennas with smaller dimensions than conventionally possible. The antenna size with respect to the wavelength is the parameter that will have influence on the radiation characteristics. Conventional microstrip antenna has limitation of narrow bandwidth, low gain and size of $\lambda/2$. For efficient radiation, the size of the antenna should be of the order of half a wavelength or larger. But as antenna size reduces, the bandwidth, gain, efficiency and polarization purity of antenna deteriorate[1-2]. This is due to the increase in mismatch between the source and antenna. There are several techniques published in open literature to decrease the size of microstip patch antenna such as shorting pins and planes, introducing of U-slots, using of high permittivity materials and Fractal geometry [3 -4].

Fractal geometry is a very good solution for this problem. In the recent years, several research papers have been published on fractal antenna [5-8] based on self-similarity and space filling properties of antenna. The self-similarity property of fractal antenna gives rise to multibands and ultra wide bandwidth [5-7]. It has been found out that CPW - fed offers less dispersion at higher frequency and broader matching in comparison to microstrip feed [8]. This paper presents the new CPW – Fed wheel shaped multi-wideband antenna of compact size. Such type of antenna is useful for wireless communication.

II. FRACTAL GEOMETRY OF ANTENNA

The antenna structures based on fractal geometry shown in Figure 1. This fractal antenna has been designed on substrate dielectric constant ε_r =4.3, thickness 1.53 mm with CPW-fed. A circular solid microstrip antenna of radius a = 25 mm has been taken as a base to construct fractal antenna. The 4th iterative structure has been generated from this solid circular patch. In 1th iteration a circular patch has been curved in the star shape. The 8 circles of diameter 2.5mm has been etched at equal distances from the star shaped portion. This is called 1st iteration. In first iteration a circle of radius 20.5 mm has been subtracted from circular patch with eight small etched circles. In second iteration, a circle of half radius of first has been taken and a circle of approximately half radius of initial solid patch has been subtracted from second circle with eight small grooves and the process is repeated. The infinite iterative structure is not possible because of fabrication constraints. In this paper, a fourth iterative wheel shaped fractal antenna has been finalized and extensively studied for antenna characteristics.

III. CPW – FEED

The antenna is fed with CPW- fed as shown in Figure 1. The advantage of coplanar feed is that feed of antenna and radiating elements are printed on the same side of the substrate. In the Coplanar technology, no via is required for ground purpose. So, this technique is less costly than microstrip circuit. The CPW-fed antenna not only performs better in respect of bandwidth and but radiation pattern is also good [8].The 50 Ω impedance is achieved by adjusting the width (w) of the inner conduct and the gap width (g) between the ground plane and the inner conduct. Of course, it is also relevant to the relative permittivity and the thickness of the substrate. In this paper, the Teflon substrate with thickness of 1.53 mm, relative permittivity of 4.3 is used.

The antenna dimension has been transferred into layout of the antenna circuit using corel draw. The fabrication constraints have been taken into consideration. The layout of the antenna circuit has been

given to the photolithography section for fabrication. First, Photolithography section has made the negative of the circuit layout. After verifying the layout of the circuit, the FR4 substrate has been given for fabrication. The antenna circuit has been printed on the substrate. The fabricated antenna has been assembled for testing using Vector network analyzer.

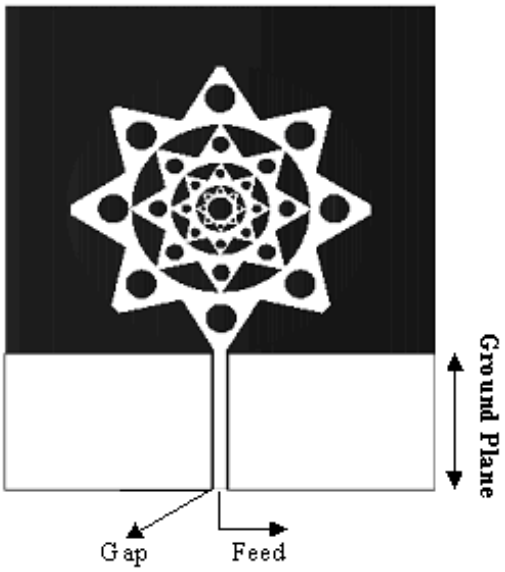

Figure 1. Wheel Shape Fractal Antenna

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The wheel shaped Fractal antenna has been designed on substrate ε_r = 4.3 and thickness h = 1.53 mm , fabricated and tested. The photograph of the fractal antenna is shown in Figure 2. The antenna has been tested using vector network analyzer R & S ZVA 40. The resonant frequency of solid circular patch antenna has been calculated 1.67 GHz of dimension 25 mm radius on substrate ε_r =4.3 and thickness 1.53 mm . The wheel shape fractal antenna has also been tested. The experimental results return loss Vs frequency of fractal antenna has been shown in Figure 3. This wheel shaped fractal antenna exhibits Multi-resonance frequencies at 1.34 GHz, 2.575 GHz, and 4.22 GHz. The impedance bandwidth of each band is 546 MHz, 489 MHz and 113.7 MHz respectively. The antennas shows good impedance matching at each resonance frequency. It is observed that impedance matching at first resonance frequency is very good. This is because of CPW-feed. The first resonant frequency of antenna is shifted at lower end frequency of first band 1.0 GHz in comparison to resonant frequency of conventional circular Microstrip antenna 1.67 GHz. This indicates the size reduction of antenna.

V. RADIATION PATTERN

The experimental radiation pattern of fractal antenna have been measured in inhouse anechoic chamber using antenna measurement system. The measurement have been taken at selected frequencies. The radiation pattern of the antenna have been shown in Figure 4 to 8 at frequencies 1.05 GHz, 1.658 GHz, 2.65 GHz., 4.398 GHz and 5.093 GHz. The radiation pattern i.e gain polar plot has been taken in E-plane. The radiation pattern has been observed good at all the frequencies. This is because of CPW-Fed, which is good for impedance matching as well as good radiation pattern. The gain of this fractal antenna at these frequencies 0.228 dB, 1.77 dB, 2.76 dB, 0.317 dB and 1.42 dB. From the radiation pattern, it has been observed the self-similarity in the radiation pattern. The self-similarity in the radiation is because self-similarity properties in the antenna structure. At higher frequency, the ripple in the radiation pattern has been observed that is because of the edge reflection of antenna.

Figure 2. Photograph of the Wheel Shaped Fractal antenna

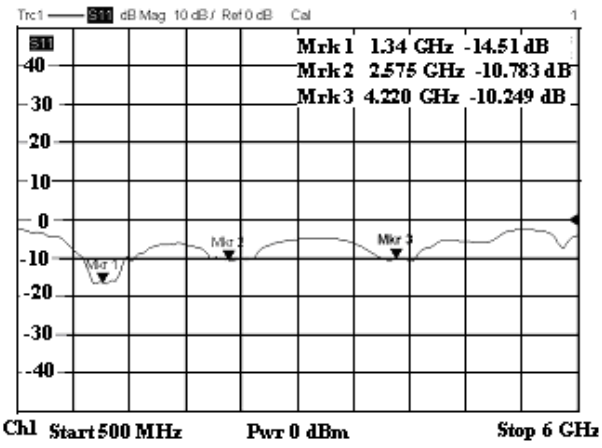

Figure 3. Experimental Result of Wheel shape Fractal Antenna

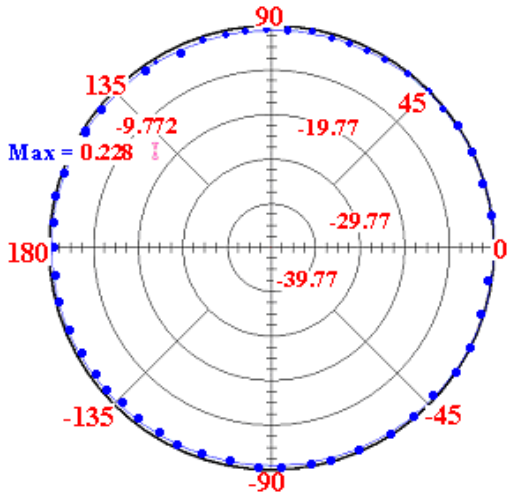

Figure 4. Experimental Radiation Pattern of Fractal Antenna at Frequency 1.05 GHz

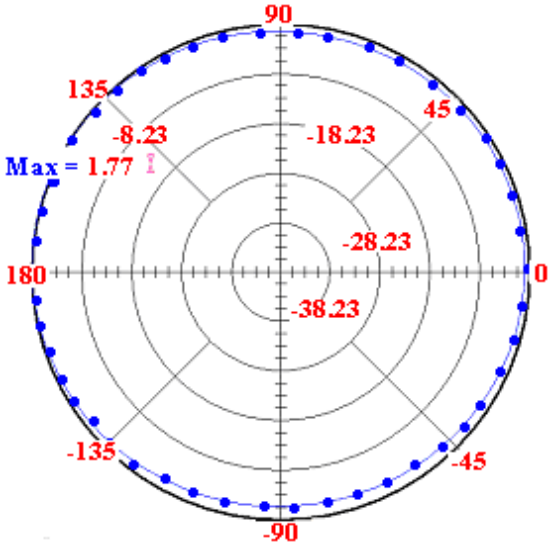

Figure 5. Experimental Radiation Pattern of Fractal Antenna at Frequency 1.658 GHz

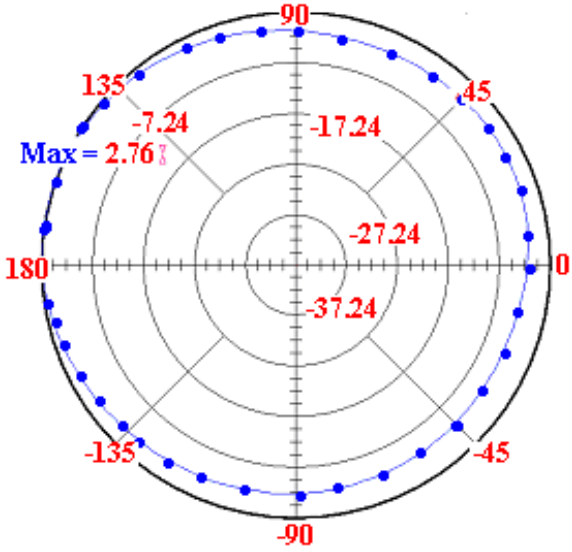

Figure 6. Experimental Radiation Pattern of Fractal Antenna at Frequency 2.65 GHz

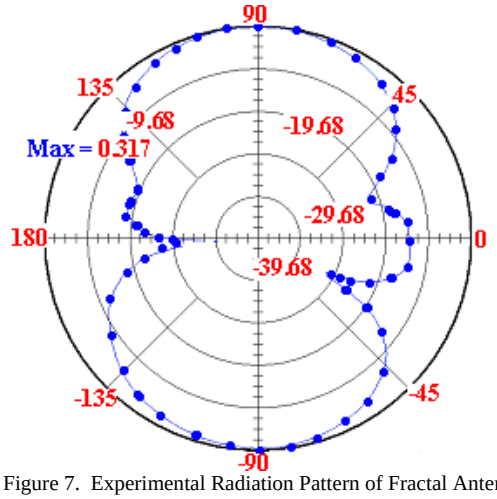

Figure 7. Experimental Radiation Pattern of Fractal Antenna at Frequency 4.398 GHz

VI. CONCLUSION

The wheel shaped fractal antenna has been fabricated and tested. The antenna exhibits the multiband properties due to fractal geometry in antenna. This antenna offers the wide impedance bandwidth at all multibands. The antenna also indicates the size reduction in comparison to simple circular antenna. The antenna radiates similar radiation pattern at all the frequencies. The CPW-fed in this antenna has been proved good for broader matching in comparison to Microstrip feed. Such type of antenna is very useful for mobile and radar communications.

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