

Wideband Fractal Monopole Antennas

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Abstract

Study of CPW-fed monopole antenna with circular and rectangular fractal shape radiator element is proposed. By using fractal slot, new design antennas have the wide measured return loss bandwidth. Besides, the omnidirectional radiation patterns of the design antennas cover the entire frequency range have been obtained. Several properties of the antennas such as impedance bandwidth, radiation patterns and gain have been investigated numerically and experimentally in detail.

1. INTRODUCTION

The increasing demand for wireless communication services spurs on the need for antennas capable of operating at a broad frequency range. Planar monopole antennas are good candidates owing to their wide impedance bandwidth, omnidirectional radiation pattern, compact and simple structure, low cost and ease of construction. Conventionally, monopole antennas are fed through a ground plane by a coaxial probe since it is structurally simple and a relatively good match can be readily obtained [1]. Recently, monopole antennas fed by printed transmission lines, such as microstrip line and coplanar waveguide (CPW) have attracted increasing attention due to their ease integration with other circuitries. Modern and future wireless systems are placing greater demands on antenna designs. Many systems now operate in two or more frequency bands, requiring dual- or triple-band operation of fundamentally narrowband antennas. A variety of techniques have been used to create multiband antennas. Several fractal geometries have been introduced for antenna application with varying degrees of success in improving antenna characteristics. Some of these geometries have been particularly useful in reducing the size of the antenna. These are low profile antennas with moderate gain and can be operative at multiple frequency bands.

In 1977, Mandelbrot arranged the information about fractal, and the relevant research of fractal extended and fast expanded. Between twenty years so far, the engineers combine the fractal structure and electromagnetic wave theory, and the successful one applied the fractal theory to electromagnetic wave radiation, propagation and scattering field. Summing up the relevant research of the fractal antenna project, there are two main directions. One is an array effect of studying the fractal, the array factor that every array unit happens while arranging with the fractal structure in simulation. Another discusses to the fractal structure of the

antenna, is studying frequency responding and radiation field type of various types of fractal antenna mainly.

Structure simplify, multiband and wideband found to main focal that antenna design in recent years, because the self-similar characteristic of the fractal antenna, and it made the antenna have limitless and multiband characteristics, so to utilize the antenna of the fractal characteristic could be designed and developed and be attracted attention gradually [2-4]. This experiment is by way of arranging in four stages with the circular and rectangular fractal self-similar rule of shapes, they could be applied to the microstrip antennas, and a limitless wideband characteristic with the fractal improves the narrow band of the microstrip antenna.

2. ANTENNA DESIGN

Figure 1 shows the geometry of the two proposed antennas for wideband applications. They are printed on the FR4 substrate of thickness 1.6 mm and relative permittivity 4.4 and have a dimension of 58 x 52 mm² in this study. The circular fractal shape monopole antenna (antenna 1) has a circular fractal shape (radius 16.2mm) and a CPW-fed with edge length of 15.4mm and width of 2.93mm, and gap distance (S) of 0.3mm between the feed line and the ground plane; The rectangular fractal shape monopole antenna (antenna 2) has a rectangular fractal shape and a CPW-fed the same than the antenna 1. The widths and lengths for both feeds are about one third of the fractal size and their lengths are close to but less than the quarter wavelength measured at the lower frequency edge. The dimensions of the antenna were firstly studied by Ansoft HFSS simulation electromagnetic software, and then verified by experiment.

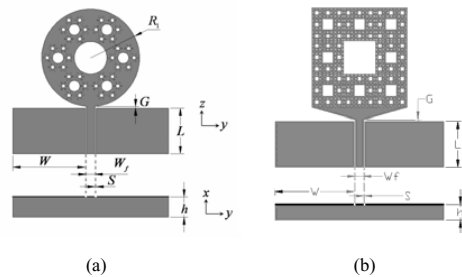


Fig. 1: The geometry of the two proposed antennas
(a) Circular fractal shape (b) Rectangular fractal shape

3. SIMULATED AND MEASURED RESULTS

A. Circular Fractal Shape Monopole Antenna

Figure 2 shows the variations of the proposed antenna 1 on stage (n_c) from 0 to 4. It shows the significant effects on the bandwidth. The stage changes show the signification factor on the variation of second resonance mode. Nevertheless, the stages have the signification affection on wideband spectrum. Figure 3 shows the simulated and measured return loss of the proposed monopole antenna 1. Evidently, the results in between experiment and simulation are in fairly good agreement. The return loss is measured by using the HP8720C vector network analyzer. The proposed antenna measured in NTUT 3D antenna chamber. The measurement chamber could be measured from 0.7GHz to 20.5GHz and covered wide band, its total dimension of 3.25 m \times 2.82 m \times 6.65 m. The impedance bandwidth of proposed antenna 1 is covered ultra-wideband band from 3.1GHz to 10.6GHz (-10dB return loss).

The measured gain of the proposed antenna 1 is given in Figure 4. The gain changed range from 2dBi to 8.5dBi and increased slow with operation frequency in full wide band. The impedance performance of the proposed antenna 1 is shown in Figure 5. It exhibits that real part around 50 Ω in between 27 Ω and 76 Ω on the wideband spectrum. However, imaginary part of the proposed antenna 1 is around zero, without big variation. Figure 6 (a, b and c) show the measured radiation pattern of the stage 4 proposed antenna 1 at 4GHz, 6GHz and 8GHz, respectively. It is noticed that the E-plane pattern is tradition antenna the same and becomes more directional with the increase of frequency. The H-plane pattern of antenna 1 is omnidirectional at 4GHz and only distorted slightly at 6GHz and 8GHz. So the radiation patterns are generally omnidirectional over the entire bandwidth, similar to a conventional antenna.

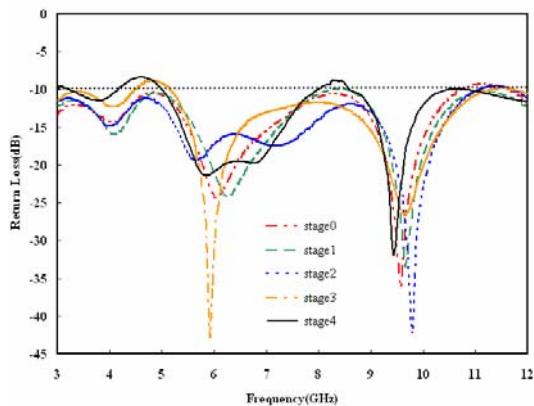


Fig. 2: The variations on stage from 0 to 4 of the antenna 1

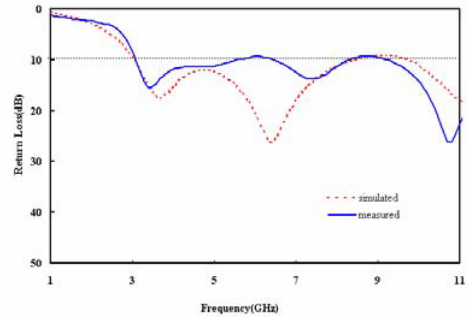


Fig 3: The simulated and measured return loss of the proposed antenna 1

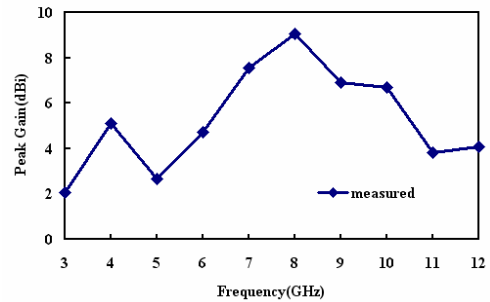


Fig. 4: The measured gain of the proposed antenna 1

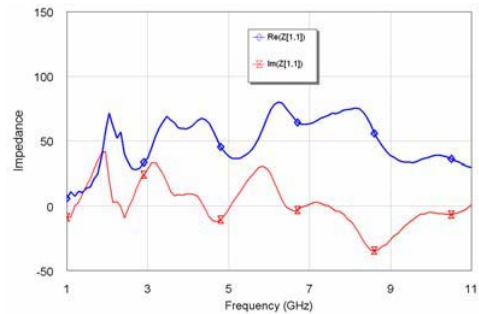
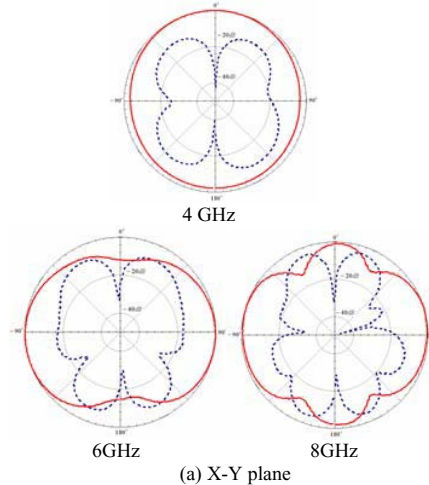


Fig. 5: The impedance of the proposed antenna 1

..... cross-pol. — co-pol.



(a) X-Y plane

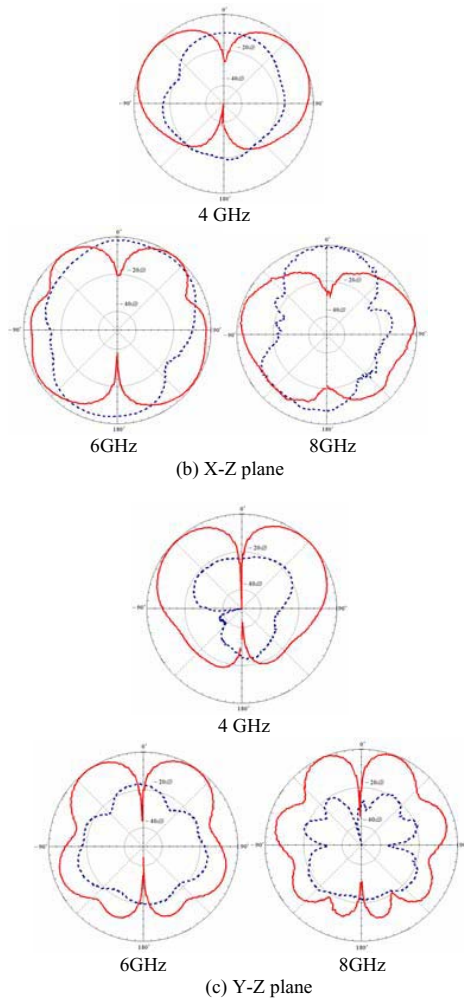


Fig. 6: Measured radiation patterns of the proposed antenna 1

B. Rectangular Fractal Shape Monopole Antenna

Figure 7 shows the variations of the antenna 2 on stage (n), from 0 to 4. It shows the significant effects on the bandwidth. The stage change shows the significant factor on the variation of last resonance mode only. Figure 8 shows the simulated and measured return losses of the proposed monopole antenna 2. Evidently, the results in between experiment and simulation are apparent difference; this could be due to the effect of the SMA port. The measured bandwidth of proposed antenna 2 is covered two resonance mode from 1.5GHz to 6GHz and from 6.7GHz to 11GHz, respectively. The measured gain of the proposed antenna 2 is given in Figure 9. The gain changed range from 4dBi to 8dBi and increased slowly with operation frequency in full operation band. The impedance performance of the proposed antenna 2 is shown in Figure 10. It exhibits that real part around 50 Ω in between 27 Ω and 90 Ω on the wideband spectrum. The imaginary part of the proposed antenna 2 is around zero, without big variation. Figure 11 (a, b and c)

show the measured radiation pattern at 4GHz, 6GHz and 8GHz, respectively. It is noticed that the E-plane pattern is like antenna 1 and becomes more directional with the increase of frequency. The H-plane pattern of antenna 2 is in fairly omnidirectional at 4GHz, other frequency points are the same than the antenna 1.

According to fractal relevant dissertations, high level stages could to achieve ideal wideband. Therefore, this experiment is by way of arranging in four stages with the circular and rectangular fractal shapes, and hope to obtain the wide-band phenomenon. Through antenna 1 measured result to display, not only have wideband effect but also reach ultra-wideband band standard (from 3.1GHz to 10.6GHz and -10dB return loss). And antenna 2 is covered two resonance mode from 1.5GHz to 6GHz and from 6.7GHz to 11GHz.

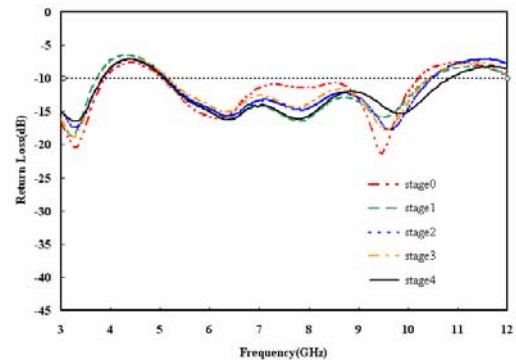


Fig. 7: The variations on stage from 0 to 4 of the antenna 2

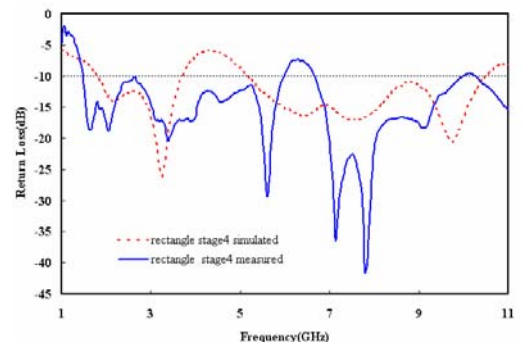


Fig. 8: The simulated and measured return losses of the proposed antenna 2

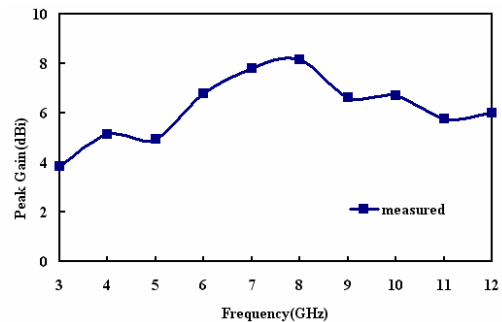


Fig. 9: The measured gain of the proposed antenna 2

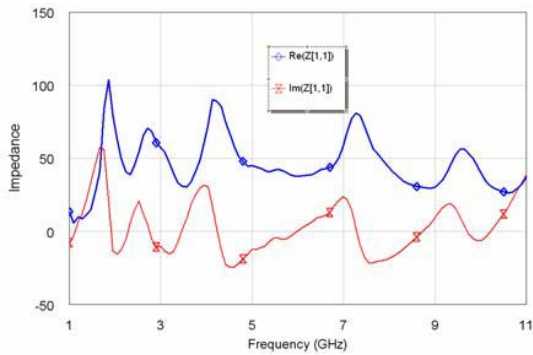
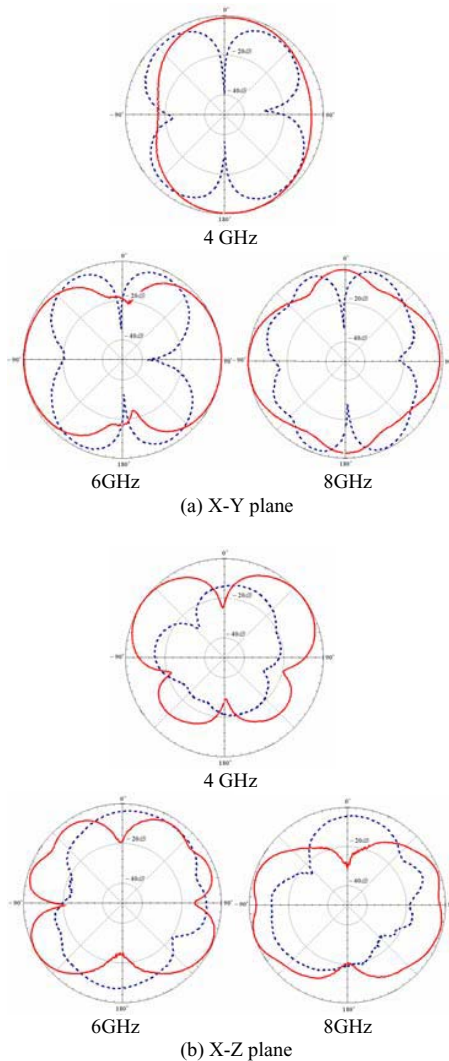
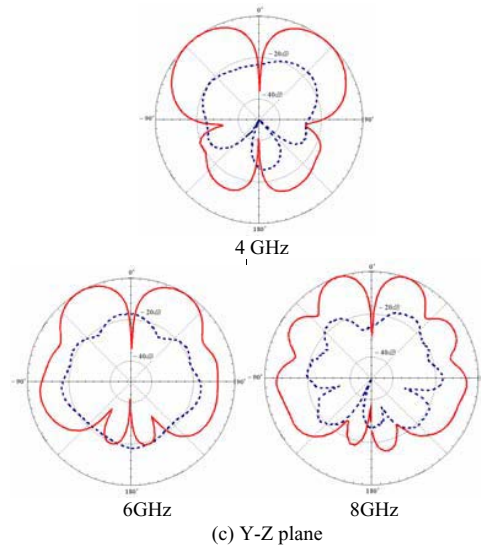


Fig. 10: The impedance of the proposed antenna2



(a) X-Y plane

(b) X-Z plane



(c) Y-Z plane
Fig. 11: Measured radiation patterns of the proposed antenna 2

4. CONCLUSION

Two CPW-fed printed fractal monopole antennas have been developed and both of them can achieve wide bandwidths and stable radiation patterns across the whole bands. From the investigation of various UWB antennas, it is found that the feed and the fractal make a strong effect on the antenna's impedance bandwidth and radiation patterns. Experimental results show that by choosing fractal shape and tuning their dimensions, good measured gain and stable radiation patterns can be obtained.

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