A Bidirectional Multiband Fractal Slot Antenna Fed by CPW

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***Abstract*—This paper presents a multiband slot antenna using a technique of fractal geometry fed by coplanar waveguide (CPW) transmission line. The presented antenna is designed at the operation frequencies 1.57, 3.7, and 4.8 GHz. The presented antenna has been created by using an initial generator model to repeat at both sides of inner patch of the antenna to operate at multiple resonant frequencies. Obviously, it has been found that the radiation patterns of the presented antenna are still similarly to the bidirectional radiation pattern at all operating frequencies. The properties of the antenna including return losses, radiation patterns and gain are determined via numerical simulation and measurement.**

Keywords-component; Fractal structure, multiband antenna,CPW, and slot antenna.

1. Introduction

Presently, the technologies of wireless communication systems have rapidly gained popular. There have been ever growing demands for greater capacities broadband service and transmission speeds. In order to response the rapidly growing demands, the multiband antenna is desired in many systems. In the literature reviews, there are varieties of the multiband antenna that have been developed over the years, which can be utilized to achieve the objectives of multiband operation, for instance, the PIFA [1] for using in mobile phone applications, the slot spiral antenna [2] for dual band or multiband operation, etc.

Recently, the possibility of developing multiband antenna has been improved due to use of fractal concept. The term of the fractal geometries was originally coined by Mandelbrot [3] to describe a family of complex shapes that have self-similarity or self-affinity in their geometrical structure. We have found some advantages of the fractal geometries, which support the attribute of multi-band frequency operations. Recently, the Sierpinski gasket monopole antenna in [4] was introduced by Puente. This popular antenna used the self-similarity properties of the fractal shape to translate into its electromagnetic behaviour. Then, the classic Sierpinski gasket can be developed by generating the Pascal triangle that was introduced in [5]. However, other antennas, which have the characteristic of multi-band created by fractal geometries, are following: multiple ring monopole antennas [6], coplanar waveguide (CPW) fed circular fractal slot antenna [7], etc.

In this paper, the fractal slot antenna fed by CPW is presented, which operates in the Global Positioning system (L1:1.575 GHz), WiMAX (3.3-3.8 GHz), IMT advanced system or 4^{th} generation (4G) mobile communication system (3.4–4.2 GHz), and WLAN IEEE 802.11j (4.9 GHz). The proposed antenna consists of a matching CPW-fed line, which connected between 50 Ω CPW line and the fractal patch of radiating slot antenna. The fractal slot is used to create the multiple resonance frequencies. However, the parameters of the proposed antenna will be investigated by simulation using the full wave method of moment (MOM) software package, IE3D. The experiments of the fabricated antenna prototype have also been performed. The radiation patterns of the proposed antenna will be also evaluated. The details of design, simulation and experiment will be discussed in the following sections.

2. Antenna Design

The configuration of the fractal slot antenna fed by CPW, as illustrated in Fig. 1(a), is developed by applying Minkowski fractal concept in [8] together with CPW-fed. The proposed antenna is created by generating the initial generator model [9], as shown in Fig. 2, at both sides of inner patch of the antenna. The antenna is fed by a 50 Ω CPW line with a strip width W_f and gap g to the fractal patch, as shown in Fig. 1(a). The altitude of initial generator model, as illustrated in Fig. 2, alternating with W_p will be investigated in the next section. In the paper, the antenna is fabricated on an economical FR4 dielectric substrate with a thickness of 1.6 mm (h), relative permittivity of 4.1 (ε_r) and loss tangent of 0.019. The 50 Ω SMA connector is used to feed the antenna at the CPW line. The optimal parameters of the proposed antenna are following: h = 1.6 mm, W_{G1} = 53.37 mm, W_{G2} = 38.54, L_{G1} = 75.20 mm, L_{G2} = 34.07 mm, L_{G3} = 39.75 mm, W = 33.93 mm, W_s = 32.57 mm, s = 2.3 mm, W_t = 0.94 mm, L_t = 21.88 mm, W_f = 3.5 mm, L_t = 14.50 mm, and g = 0.5 mm. The important parameters of L_a and W_p will be investigated and observed at the alternation of the operating frequency bands in the next section.

3. Simulation and experiment

This section presents the investigation on the effect of varying important parameters L_a and W_p, as depicted in Fig. 3, and discusses the results. As the parameters L_a and W_p increasing, the first and third resonant frequencies are slightly shifted to the left because this does not really increase the length of slot antenna. However, these parameters control the level of the return loss in the second resonant frequency because these parameters affect the coupling between the slots of the proposed antenna. Also, the suitable parameter L_a = 48.16 mm and W_p = 11.31 mm are selected in order to cover the operating frequency bands of 1.51 – 1.68 GHz and 3.3 - 5.2 GHz for the applications of GPS (1.575 GHz), WiMAX (3.3-3.8 GHz), IMT advance system or 4G mobile communication system (3.4-4.2 GHz), and WLAN IEEE802.11j (4.9 GHz). Consequently, the optimal parameters, L_a = 48.16 mm and W_p = 11.31 mm, are chosen to manufacture by etching into chemicals. The prototype of the proposed antenna is shown in Fig. 1(b). The simulated and measured return losses of the antenna are shown in Fig. 4(a). It is clearly observed that, the measured return loss of the antenna slightly shifts to the left because of the inaccuracy of the manufacturing process by etching into chemicals. However, the proposed antenna still covers the operating bands of 1.5-1.64 GHz and 3.2 – 5.2 GHz. Moreover, the average gains of simulated and measured results are about 2 dBi at each operating frequency band, as shown in Fig. 4(b). The radiation patterns are measured at 1.57, 3.7, and 4.8 GHz, as depicted in Figs. 5. The radiation patterns at the three resonant frequencies are similar to the bi-direction radiation patterns. In the X-Z plane, it can be clearly observed that the magnitude of cross-polarization increases and the HPBW of co-polarization decreases as increasing frequency. Also, the maximum gains of radiation patterns in Y-Z plane are approximately occurred at 0 and 180 degrees.

4. Conclusion

A Multiband fractal slot antenna fed by CPW has been proposed for multiband wireless communication applications including GPS, WiMAX, IMT advance system or 4G mobile communication system, WLAN IEEE 802.11j. Above all, the radiation patterns at each operating frequency are almost similar to bi-directional, which is an advantage of the fractal concept over the conventional multiband antenna.

Acknowledgments

This work was supported by the Thailand Research Fund (TRF) under the grant contract number RTA-4880002.

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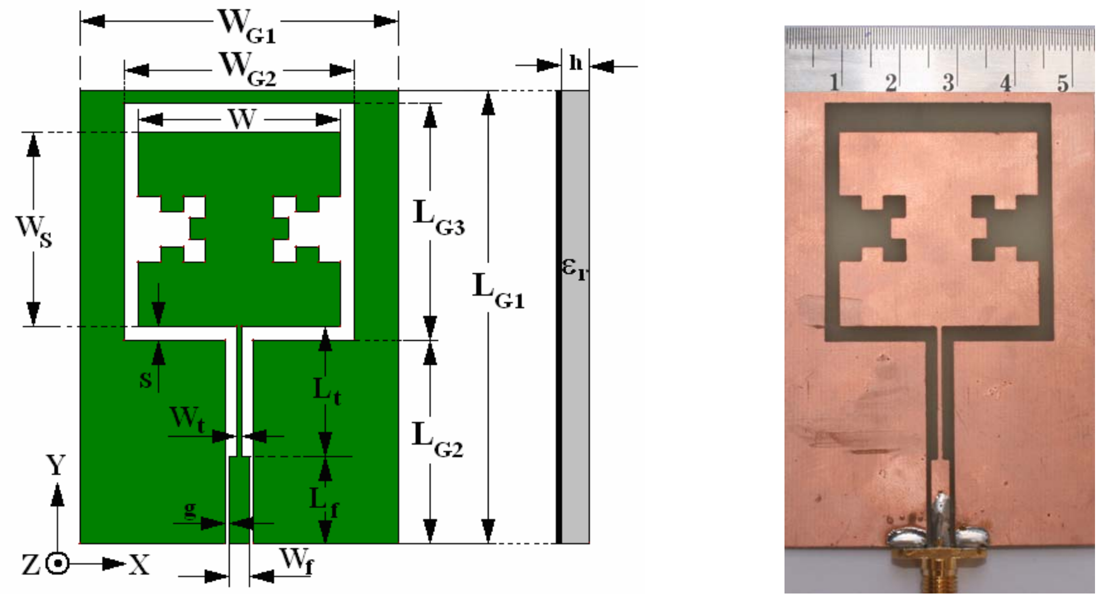


(a) (b)

Figure 1: Antenna geometry for the proposed antenna (a) schematic and (b) prototype.

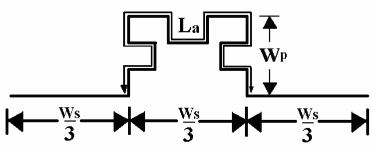


Figure 2: The initial generator model for the proposed antenna.

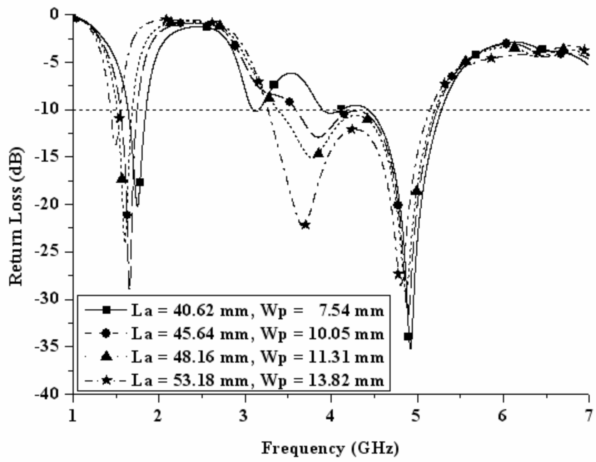
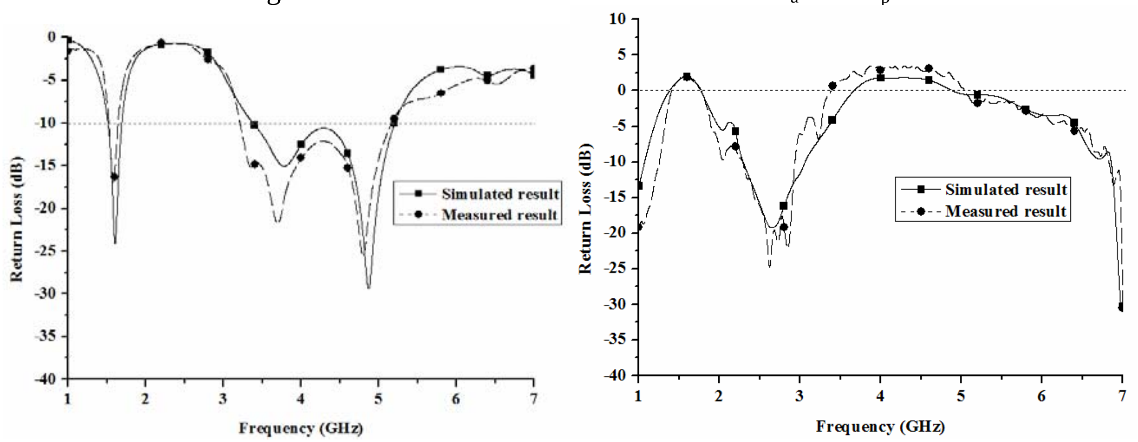
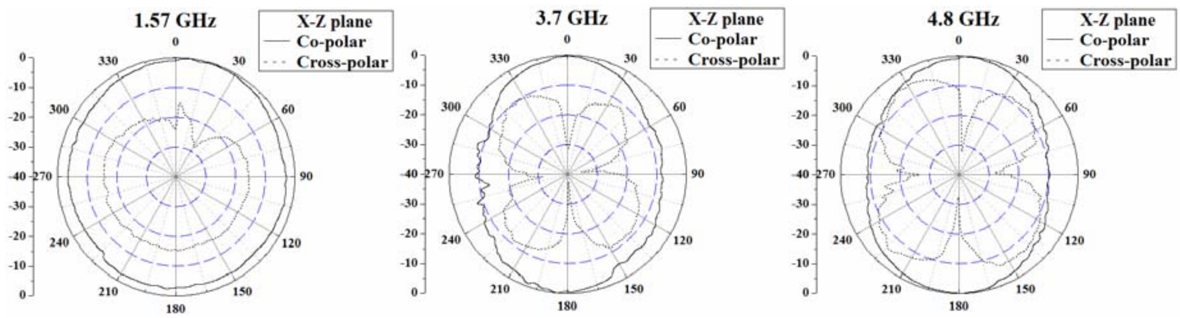


Figure 3: Simulated return losses for various L_a and W_p.

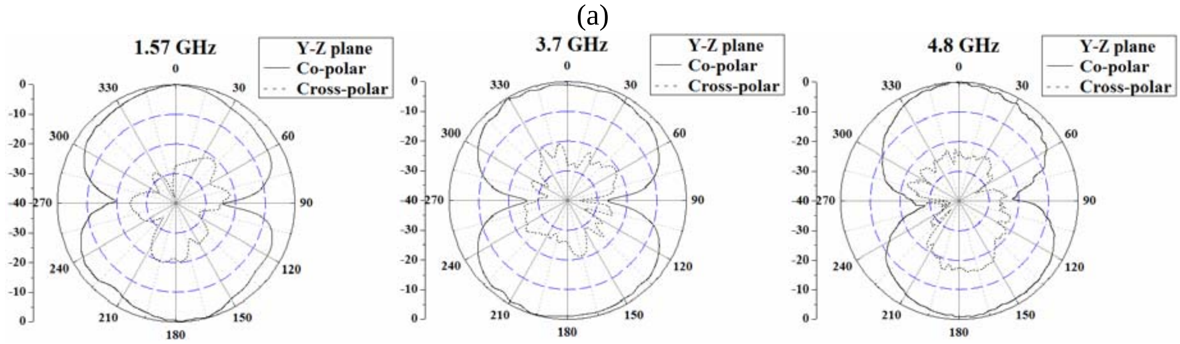


(a) (b)

Figure 4: Simulated and Measured results of the proposed antenna for (a) return losses and (b) gain.



(a)



(b)

Figure 5: Measured radiation patterns of the proposed antenna at 1.57 GHz, 3.7 GHz, and 4.8 GHz for (a) X-Z plane (b) Y-Z plane.