

A Multiband Monopole Antenna with modified Fractal Loop Parasitic

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Abstract - A multiband monopole antenna with modified fractal loop parasitic is presented. By adding bow-tie patches and a modified fractal loop to the sides and bottom of a strip line monopole, respectively, the presented antenna can generate the multi-resonant frequencies for the application of wireless communication systems. The characteristics of the presented antenna have been examined by using the simulation software. The comparison between the simulation and measured results confirm the good agreement. The results show good multiband operation with 10 dB impedance bandwidths of 15.55%, 8.75%, and 31.94% at the resonant frequencies of 1.8 GHz, 2.4 GHz, and 3.6 GHz, respectively, which cover the operating band applications of DCS 1800, WLAN (IEEE802.11 b/g), WiMAX, and IMT advanced system (4G mobile communication system).

Keywords: multiband antenna, fractal loop, parasitic.

1. Introduction

The technology of multiband antenna had alertly excited in the recent year for the applications to multimode wireless communication systems. The presently conventional antennas for multiband operation are usually designed to the multiband monopole antennas [1]-[3]. In the literature reviews, a multiband monopole antenna with inverted U-shaped parasitic plane was proposed in [4]. The antenna has three slits to control the significant operating frequency bands: two slits on the radiator patch for controlling the first and third operating frequency bands and a slit on the U-shaped parasitic plane for controlling the second operating frequency band. Also, a monopole antenna was suitably designed for WLAN/WiMAX applications [5]. This antenna consists of a rectangular monopole antenna and a trapezoid parasitic patch placed under the rectangular monopole for operating the application bands of WLAN and WiMAX, respectively. Additionally, the fractal patch parasitic was designed to the triple-band antenna by stacking two fractal parasitic patches with a driven patch [6].

In this paper, the multiband monopole antenna with modified fractal loop parasitic is presented, which properly operates in the application bands of DCS 1800 (1710 – 1880 MHz), WLAN IEEE802.11 b/g (2.4 – 2.484 GHz), WiMAX (3.3 – 3.8 GHz), and IMT advanced system or 4th generation (4G) mobile communication system (3.4 – 4.2 GHz). The proposed antenna is composed of a radiating strip line monopole connected to the bow tie patch for operating the first and third resonant frequencies. Additionally, a modified fractal loop parasitic is placed under the strip line monopole to couple and radiate the electric field at the second operating resonant frequency. However, the parameter of the proposed antenna will be examined by simulation using the full wave method of moment (MOM) software package, IE3D. The experiments of the fabricated antenna prototype have also been executed. Also, the radiation pattern of the proposed antenna will be assessed. Furthermore, the details of design, simulation and experiment will be discussed in the following sections.

2. Antenna Design

The geometrical configuration of the proposed antenna with a modified fractal loop parasitic is depicted in Fig. 1(a). The antenna was implemented on an economical FR4 substrate

with thickness of 1.6 mm, relative permittivity of 4.1 and loss tangent of 0.019. Especially, the strip line monopole antenna with the bow-tie patches at the sides is fed by the 50 Ω microstrip feedline on the top layer of the substrate, while the modified fractal loop, which is adapted from the 1st iteration fractal loop [7], as illustrated in Fig. 2, and rectangular ground plane are placed under the strip-line monopole and the microstrip feedline, respectively, on the bottom layer of the substrate. In this design, the first resonant frequency for GSM1800 band can comfortably be controlled by varying the length L_l . Also, the second and third resonant frequencies for WLAN, WiMAX and IMT advanced system (4G mobile communication systems) are controlled by alternating the length L_r and the angle α , respectively. The optimal parameters of the presented antenna are following: $h = 1.6$, $L_2 = 8$ mm, $L_3 = 3.2$ mm, $L_a = 15.5$ mm, $L_g = 27$ mm, $L_s = 3$ mm, $W_l = 1$ mm, $W_2 = 1.36$ mm, $W_b = 7.5$ mm, $W_f = 3.2$ mm, $W_g = 23.2$ mm, and $W_s = 3.41$ mm. The significant parameters of L_l , L_r , and α will be investigated and observed for the effects of the alternately operating frequency bands in the next section.

3. Simulation and experiment

This section presents the examination on the effects of altering significant parameter L_l , L_r , and α , respectively, as illustrated in Fig. 3. As the parameter L_l increasing, the first resonant frequency is mainly affected, which is shifted to the left as shown in Fig. 3(a). Also, the increasing parameter L_r affects significantly to the shifting of second resonant frequency to the left, as shown in Fig. 3(b), due to the electrical length of the modified fractal loop increasing. However, the increasing parameter α , affects mainly to the increasing return loss level and shifting of the both of second and third operating resonant frequency bands to the right, as depicted in Fig. 3(c). Because the coupling effect between the bow-tie patch and the loop disturbs to the second operating frequency band and also the decreasing electrical length of the bow tie patch disturbs to the third operating frequency band. Therefore, the appropriate parameter $L_l = 35$ mm, $L_r = 18.13$ mm, and $\alpha = 69.44^\circ$ are chosen to cover the operating frequency bands of 1.62 – 1.90 GHz, 2.31 – 2.52 GHz, and 3.23 – 4.38 GHz for the applications of DCS 1800 (1710 – 1880 MHz), WLAN IEEE802.11 b/g (2.4 – 2.484 GHz), WiMAX (3.3 – 3.8 GHz), and IMT advanced system or 4th generation (4G) mobile communication system (3.4 – 4.2 GHz). Therefore, the appropriate parameters are selected to fabricate by etching into chemicals. The photograph of fabricated antenna is shown in Fig. 1(b). The simulation and measured return losses of the antenna are depicted in Fig. 4(a). It is obviously found that, a different between simulation and measured return loss of antenna occurs due to the fabrication and the effect of an SMA connector to feed the antenna. However, as the results, it can be clearly seen that the proposed antenna can be satisfied for the operations of DCS 1800, WLAN IEEE 802.11 b/g, WiMAX, and IMT advanced system or 4th generation (4G) mobile communication system. Moreover, the average gains of simulated and measured results are approximately 1 dBi at each operating frequency band, as shown in Fig. 4(b). The measured X-Z plane and Y-Z plane radiation patterns are shown in Fig. 5. It is clearly observed that the X-Z plane patterns at three resonant frequencies are almost the omni-directional radiation patterns, while the Y-Z plane patterns are similar to the bi-directional radiation patterns, which occurs the peak gain at approximately 0 and 180 degrees. Additionally, the advantage of the modified fractal loop parasitic is the coupling effect and the radiating electromagnetic wave to enhance the X-Z plane and Y-Z plane radiation pattern at third operating frequency band.

4. Conclusion

The strip line monopole antenna combined with the bow-tie patch and the modified fractal loop parasitic has been presented for the multiband wireless communication applications. It has been shown that the presented antenna can be independently controlled the different resonant frequencies by significant parameter of L_l , L_r , and α . Moreover, the radiation patterns at all of operating frequencies are similar to omni-directional patterns, which can support the applications of DCS 1800, WLAN IEEE 802.11 b/g, WiMAX, and IMT advanced system or 4th generation (4G) mobile communication system.

Acknowledgments

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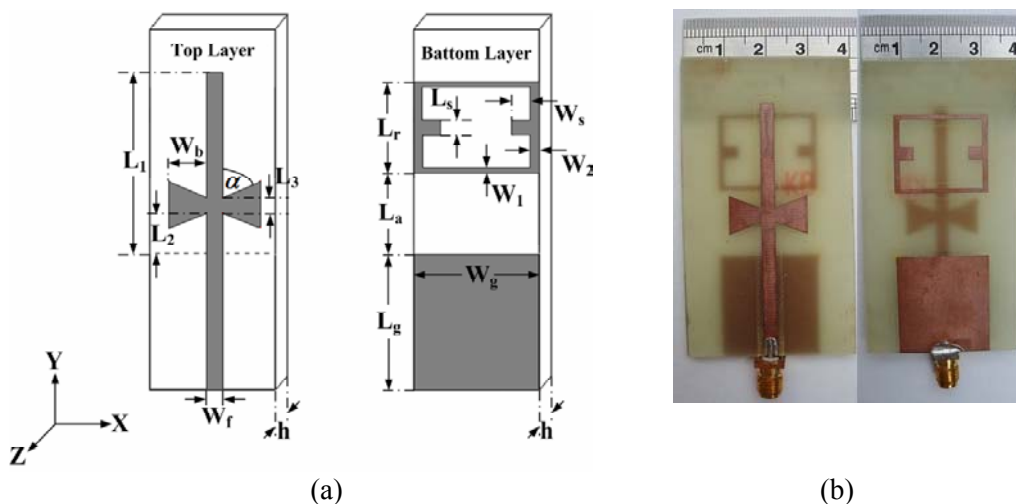


Figure 1: the geometry configuration of the proposed antenna (a) schematic and (b) prototype.

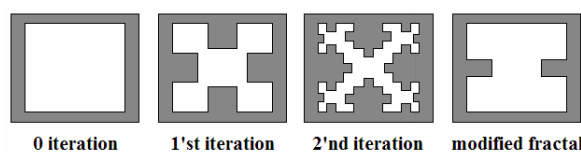


Figure 2: the different types of fractal loop parasitic.

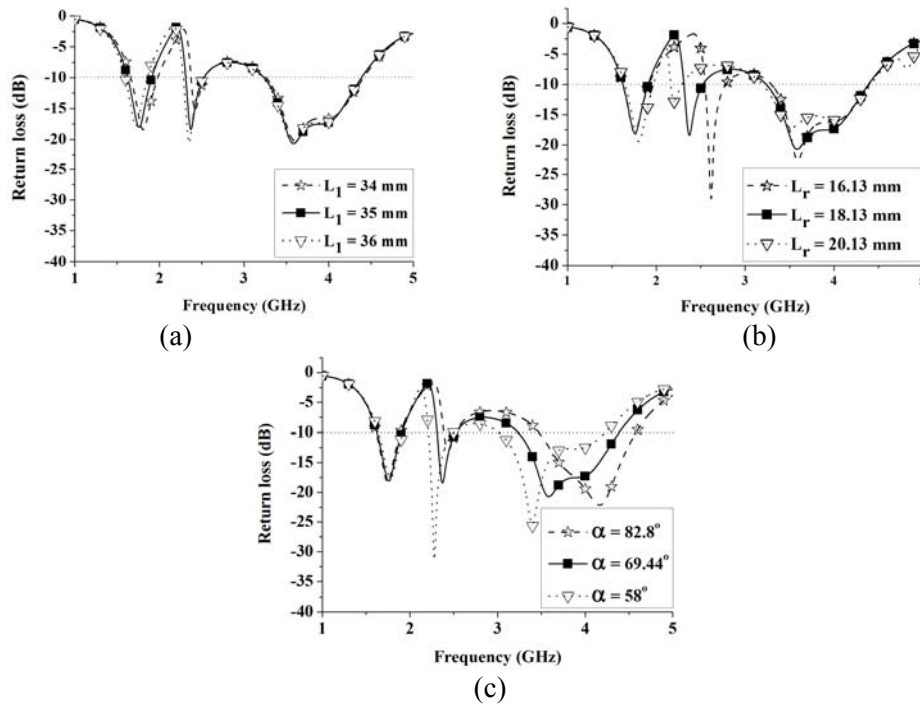


Figure 3: The simulation return losses for various parameters (a) L_1 , (b) L_r , and (c) α .

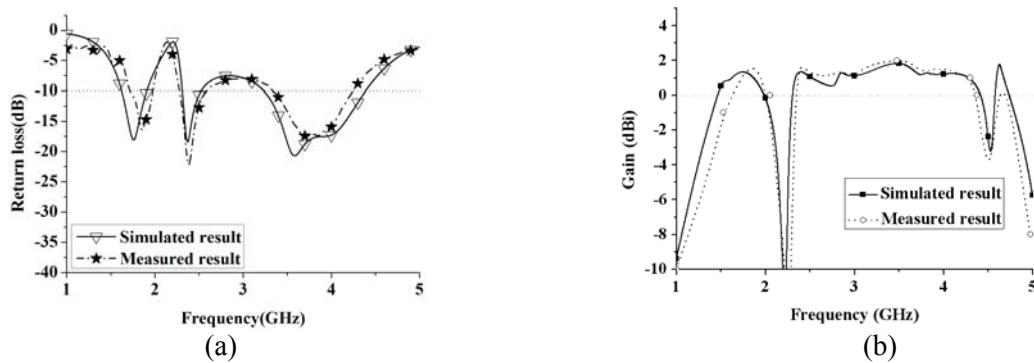


Figure 4: Simulation and Measured results of the proposed antenna for (a) return loss and (b) gain.

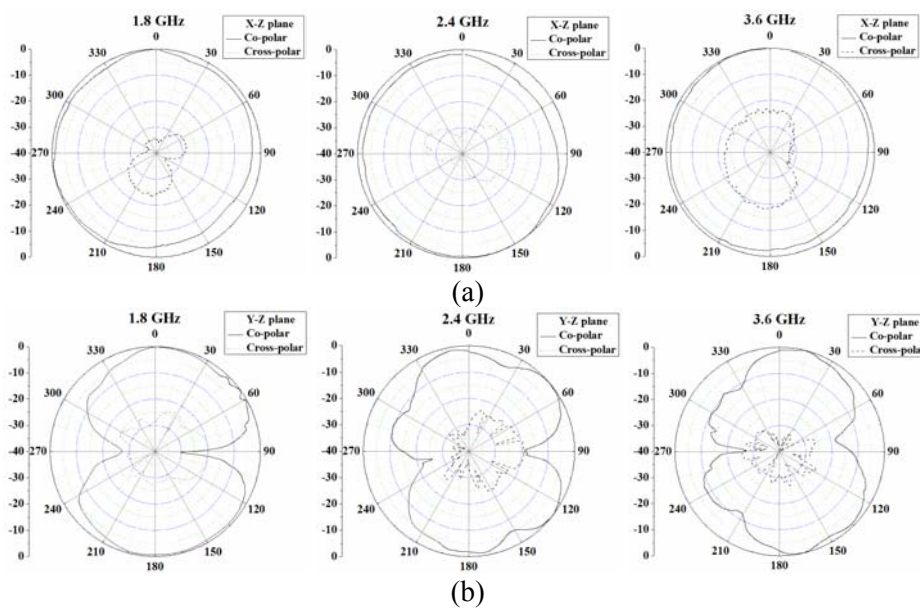


Figure 5: Measured radiation patterns of the proposed antenna at 1.8 GHz, 2.4 GHz, and 3.6 GHz for (a) X-Z plane and (b) Y-Z plane.