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Compact Dual-band Quasi-Self-Complementary Antenna for WLAN Application

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1. Introduction

The concept of self-complementary (SC) antennas was first proposed and investigated by Y. Mushiake in 1948 [1]. An antenna with a self-complementary (SC) configuration has constant input impedance and can be designed in a compact manner for wideband operation [2-4]. Due to these attractive features, SC antennas are highly suitable for wireless communication systems which need wideband operation but have limited room to mount the antenna. In practice, however, it may be more convenient for antenna engineers to design the SC antennas in an imperfect self-complementary manner. Such imperfect SC antennas are called quasi-self-complementary (QSC) antennas. Despite of the imperfectness, QSC antennas still show very good characteristics of broadband operation and nearly constant input impedance. SC and QSC antennas can be designed in a variety of geometries [3-5]. In [3], log-periodic SC structures are introduced. In [4], a QSC antenna constructed using a T-shaped strip and a complementary structure of T-shaped slit is presented, with broadband characteristic demonstrated. In [5], a small-sized QSC antenna composed of a microstrip monopole and a slot is proposed and analysed.

In this paper, a uniplanar QSC antenna printed on a FR4 substrate with dual-band operation in the 2.4/5.2 GHz WLAN is proposed and investigated. The two operating modes result from the excitation of a monopole and its quasi-self-complementary structure. Because of the stand-alone nature, the designed QSC antenna does not need to connect to a ground plane of large area to obtain a stable performance, thus resulting in a very compact design and suitable for application in wireless devices having limited space to mount the antenna. The antenna design and the simulated and measured results are presented and discussed in the following sections.

2. Antenna Design

Figure 1 shows the proposed dual-band QSC antenna which is printed on a low cost 0.8-mm thick FR4 substrate with relative permittivity 4.4 and loss tangent 0.02. The antenna is composed of two quasi-self-complementary radiating sections (located left and right) which are 1.5 mm spaced and is fed by a 50-Ω mini coaxial line. By a similar design strategy presented in [4], we first design a U-shaped monopole on the right-hand side of the antenna. The monopole has a protruded stub of 2.2 mm × 0.25 mm at its top left end to allow for resonant frequency tuning. Then the left-hand side metal of the PCB area which is mostly the mirror pattern of the strip monopole on the right-hand side is etched out to form the complementary radiating section. By designing the antenna in such a QSC configuration, we obtain an enhanced wide bandwidth for the upper band around 5.2 GHz and meanwhile excite a lower mode at 2.45 GHz. In particular, the 5.2 GHz mode is excited along the positive feeding line and extended to the U-shaped monopole and the protruded stub, whereas the 2.45 GHz comes from the excitation of the complementary radiating section. The resonant length of each of the operating modes is a quarter-wavelength corresponding to its modal frequency. The designed QSC dual-band antenna has a small size of 18.4 mm × 4.4 mm. Detailed antenna configuration and dimensions are shown in Figure 1.

3. Experimental Results and Discussion

The simulated and measured return losses of the proposed dual-band antenna are presented in Figure 2, and good agreement between them was observed. From the measured results, it shows that two resonant modes are excited. The measured 10-dB impedance bandwidths of the 2.4 GHz and 5.2 GHz bands are 5.7 % (140 MHz) and 11.5 % (585 MHz), respectively, which allow for operation in the 2.4/5.2 GHz WLAN bands. Although the measured result of the 5.2 GHz band is seen to deviate from the simulated one by about 150 MHz due to fabrication precision, it still covers the needed operating band. The measured far-field radiation patterns of the proposed antenna in three principal planes (*xz*-, *yz*-, and *xy*-planes) are plotted for the two resonant modes, as shown in Figures 3 and 4, respectively. Good broadside patterns are observed in the *yz*-planes of both resonant modes. The frequency responses of the measured peak gain of the proposed antenna are depicted in Figure 5. In this figure, a gain variation of approximately 0.8–1.4 dBi and 2.1–2.8 dBi is observed within the 2.4 and 5.2 GHz WLAN operating bands, respectively, showing very good gain performance within the frequency ranges of interest.

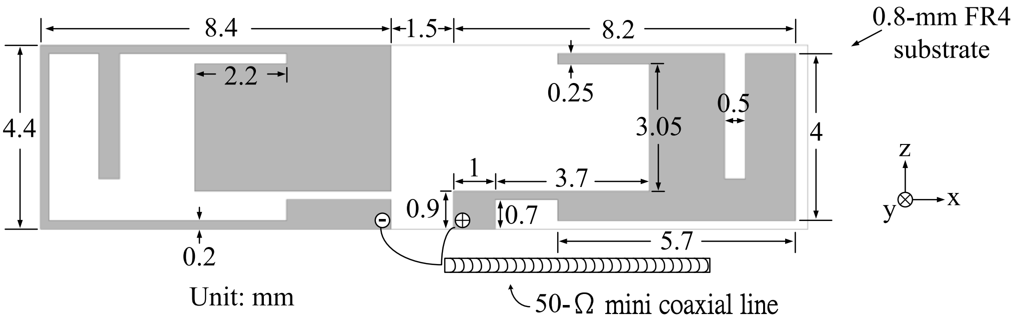

Figure 1: Geometry of the proposed dual-band antenna

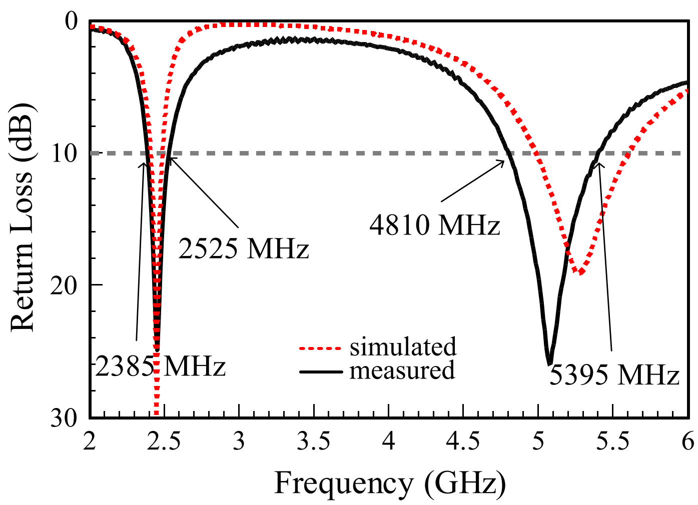

Figure 2: Measured and simulated return losses of proposed antenna

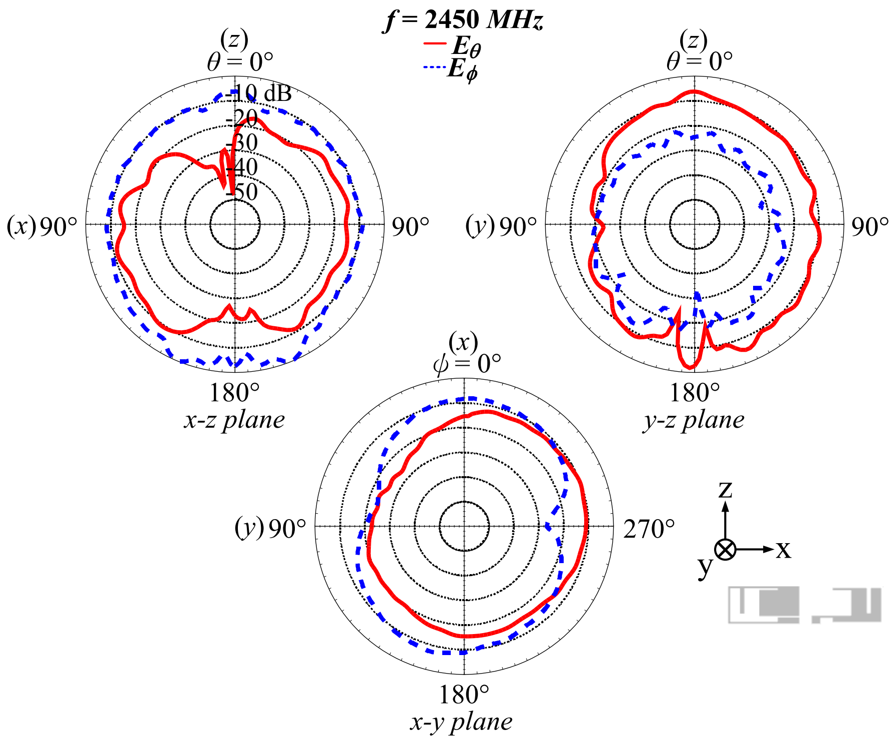

Figure 3: Measured radiation patterns for 2.4 GHz WLAN band

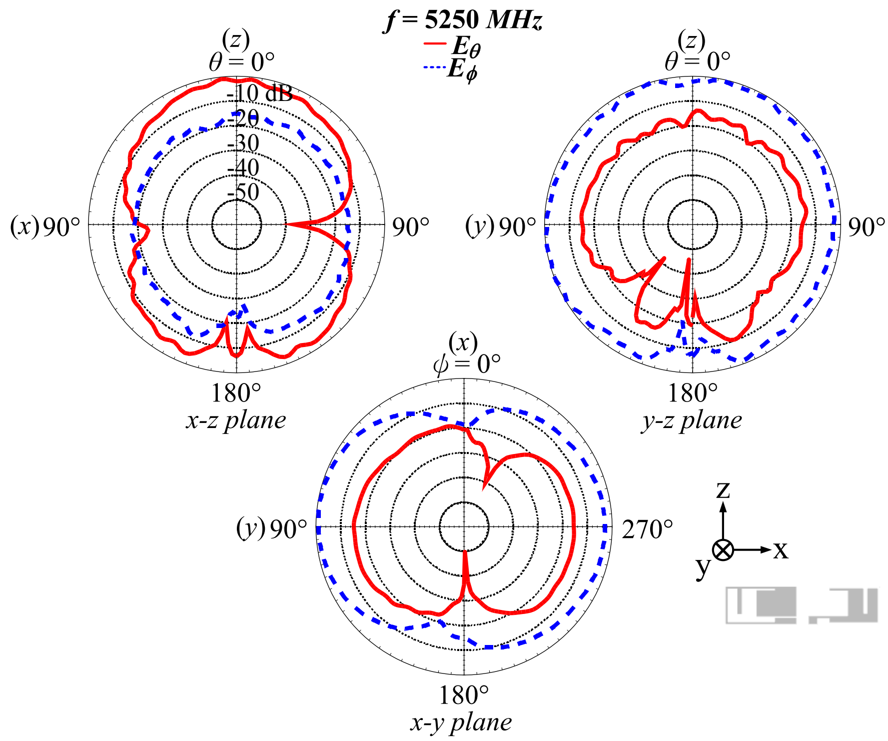

Figure 4: Measured radiation patterns for 5.2 GHz WLAN band

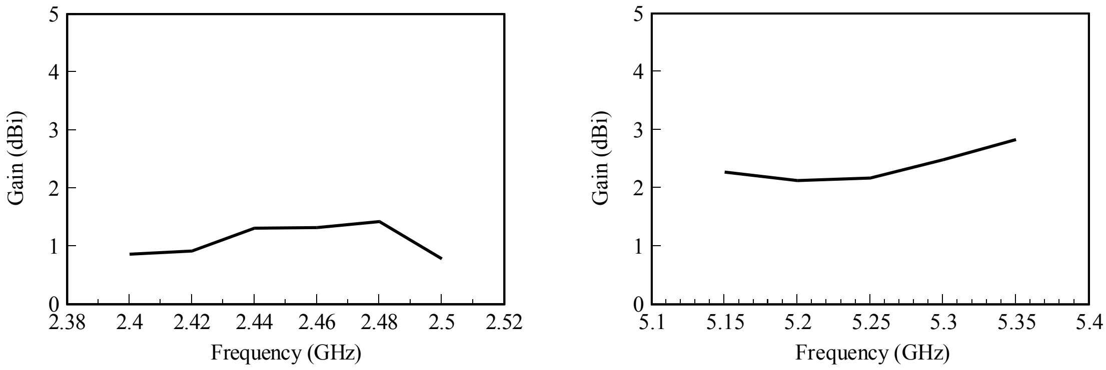

Figure 5: Measured peak gain variations of the proposed antenna for (a) 2.4 GHz WLAN band and (b) 5.2 GHz WLAN band

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