Trident-shaped dual-band CPW-fed monopole antenna for PCS/WLAN applications

C. Wang, Z.-H. Yan, P. Xu, J.-B. Jiang and B. Li

A novel trident-shaped dual-band CPW-fed monopole antenna for PCS/WLAN applications is presented. By inserting two pairs of symmetrical strips in the middle strip of the trident-shaped antenna, dual-frequency operating bands with 10 dB return-loss bandwidths of 33.7%, ranging from 1.80 to 2.53 GHz, and of about 1100 MHz centred at 5.5 GHz have been achieved. They cover the required bandwidths of the PCS band (1.85–1.99 GHz) and WLAN bands (2.4–2.484 and 5.15–5.825 GHz). Also, good radiation patterns, and 3.6 and 9.1 dBi peak antenna gains for the lower (2.2 GHz) and upper (5.5 GHz) bands have been measured.

Introduction: Recently, wireless communication has become more and more widespread. Many antennas have been designed for the personal communication system (PCS) or wireless local area network (WLAN), such as a printed monopole antenna [1], a K-shaped dual-band antenna with a shorting pin [2] and a π-shaped dual-band antenna [3]. But their impedance bandwidth cannot fulfil the reception of the 2.4 GHz WLAN band. Also, the coplanar waveguide (CPW)-fed antenna has become very popular owing to the simplest structure of a single metallic layer, wide bandwidth and easy integration with active devices or MMICs. However, many CPW-fed antennas have low gains and cover only the 2.4/5 GHz WLAN bands [4–6].

In this Letter, a trident-shaped CPW-fed monopole antenna covering the PCS band (1.85–1.99 GHz) and WLAN bands (2.4–2.484 and 5.15–5.825 GHz) is investigated. By using two pairs of symmetrical strips, the impedance characteristics are improved. The proposed antenna also provides good radiation patterns and high peak gains.

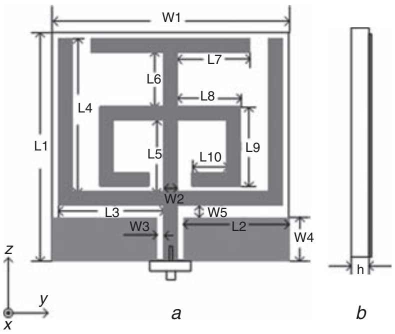

Fig. 1 *Geometry of proposed antenna*
a Top view
b Side view

Antenna design: The configuration of the proposed antenna design is shown in Fig. 1. The antenna is etched on an FR4 substrate with relative permittivity $\varepsilon_r = 4.4$ and thickness $h = 1.6$ mm and fed by a CPW transmission-line with a fixed strip thickness $W2$ and a gap distance $W3$ between the signal strip and the coplanar ground plane. The proposed antenna is symmetrical with respect to the longitudinal direction and the main structure is a trident-shaped strip. The middle vertical strip has lengths $L5 + L6$ which are nearly equal to one-half wavelength of the fundamental mode at 5.5 GHz and the two other crooked edge strips have lengths $L3 + L4$ which are nearly equal to one-half wavelength of the other resonance at 2.2 GHz. Besides, a pair of symmetrical meandered strips which have the lengths $L8 + L9 + L10$ is introduced. Their location on the middle vertical strip and their lengths are properly adjusted so that the lengths $L8 + L9 + L10 + L5$ nearly reach one wavelength of the upper resonance. The better impedance matching across the WLAN 5.5 (5.15–5.825 GHz) band can be easily obtained. At the same time, a pair of symmetrical horizontal straight strips $L7$ is added on the top of the antenna as a top-loading structure which can provide additional inductance and capacitance to mainly improve the impedance characteristic of the lower band. The optimal antenna dimensions are as follows: $L1 = 52$ mm, $L2 = 25.2$ mm, $L3 = 24$ mm, $L4 = 35$ mm, $L5 = 16.4$ mm, $L6 = 12.6$ mm, $L7 = 16.5$ mm, $L8 = 14.5$ mm, $L9 = 18$ mm, $L10 = 8$ mm, $W1 = 54$ mm, $W2 = 3$ mm, $W3 = 0.3$ mm, $W4 = 10$ mm, $W5 = 2.6$ mm.

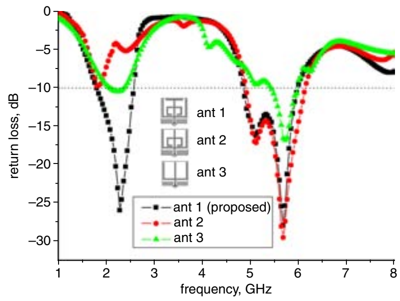

Fig. 2 *Simulated return losses for trident-shaped antennas with different impedance matching strips*

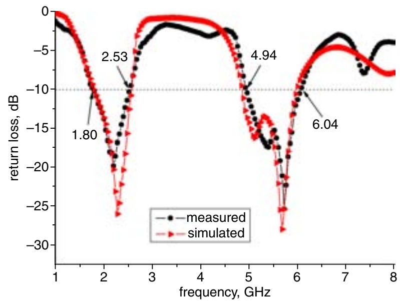

Fig. 3 *Simulated and measured return losses for proposed antenna*

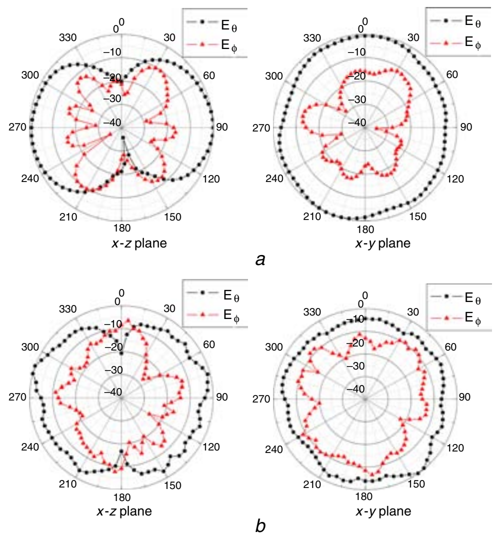

Fig. 4 *Measured radiation patterns for proposed antenna*
a f = 2.2 GHz
b f = 5.5 GHz

Results and discussion: Fig. 2 shows the HFSS-simulated return losses, where a good dual-band performance can be seen from the proposed antenna (denoted as ant 1). Obviously, for the case without the upper horizontal straight strips (denoted as ant 2), multi-resonant modes with worse and good impedance matching for the lower (2.2 GHz) and upper (5.5 GHz) bands, respectively, are excited. However, for the case without both strips in the middle strip of the trident-shaped antenna (denoted as ant 3), two worse resonances are excited at both bands. Therefore, it is demonstrated that the resonance of the upper band is sensitive to the pair of symmetrical meandered strips and the pair of horizontal straight strips on the top of the antenna can effectively affect the impedance matching of the lower band. The simulated and measured return losses of the proposed antenna are shown in Fig. 3. It can be observed that measured results reasonably agree with the simulated results with an acceptable frequency discrepancy. The measured impedance bandwidth of the lower band centred at 2.2 GHz has a wide bandwidth from 1.80–2.53 GHz with a percentage bandwidth of about 33.7% covering the PCS (1.85–1.99 GHz) band and the

WLAN 2.4 (2.4–2.484 GHz) band. And the upper band centred at 5.5 GHz with a wide bandwidth from 4.94–6.04 GHz determined by 10 dB return loss is good enough to cover the WLAN 5.5 (5.15–5.825 GHz) band.

Measured radiation patterns are shown in Fig. 4. It is seen that the vertical (*x-z* plane) patterns are monopole-like for operating at all frequencies. On the other hand, the horizontal (*x-y* plane) patterns are nearly omnidirectional. The peak antenna gains for frequencies across the two bands are shown in Fig. 5. Since the basic size ($L1 \times W1$) of the proposed antenna is nearly one-half wavelength of the average resonant frequency, the peak gains can reach about 3.4–4.0 and 8.6–9.2 dBi for the lower and upper bands, respectively.

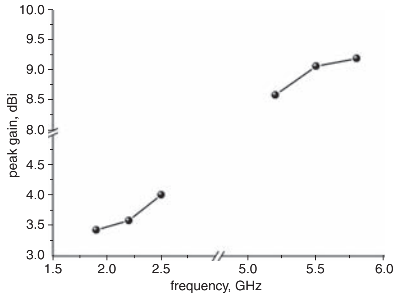

Fig. 5 *Peak antenna gains for proposed antenna*

Conclusion: In this design, by using two pairs of symmetrical strips, the proposed antenna can provide sufficient impedance bandwidth and suitable radiation patterns for PCS and WLAN systems. Furthermore, high antenna gains of operating frequencies can also be obtained. This design will be useful for wireless communication systems.

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One or more of the Figures in this Letter are available in colour online.

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