A Compact Diversity Antenna for Handheld Terminals

Hai-Lin Xiao, Zai-Ping Nie, and Yu-Jing Wu

Abstract—The handheld terminals antenna should have a small size, sufficient gain and big bandwidth. In this paper, a compact planar inverted-L diversity antenna for handheld terminals is proposed. Three diversity antennas operating at 2.15 GHz are designed and the effect of important parameters of the proposed antenna is measured. The isolation is found to be better than 13 dB, the usable bandwidth is about 13%. Moreover, the measured radiation patterns are also obtained that the backward radiation is decreased.

Index Terms—Diversity antenna, diversity gain, isolation, radiation pattern.

1. Introduction

In order to improve the quality of wireless downlink signal, more than one antenna can be used at terminal side. In these kinds of handheld terminals, two or more antenna elements are envisaged and thus the limited space available for antenna is an open issue. It is difficult to implement multiple antennas on handheld terminal as small as a handset. In [1], Yang Ding et al. introduced a novel dual-band printed diversity antenna operating at UMTS (1920 MHz to 2170 MHz) and 2.4-GHz WLAN (2400 MHz to 2484 MHz), but it is too big for the small handheld terminals. Dual-printed inverted-F antenna diversity systems for terminal devices operating at 5.2 GHz with both switched and combing schemes were presented in [2]. However, the relatively large antenna volume and the strong coupling between its two elements restrict its application for handheld terminals. Dual-printed inverted-F antenna diversity systems for terminal devices operating at 5.2 GHz with both switched and combing schemes were presented in [2]. However, the relatively large antenna volume and the strong coupling between its two elements restrict its application for handheld terminals. To date, there have been considerable researched compacted antennas for handheld terminals[3][5]. Many of these configurations are not suitable for handheld devices due to space limitation[6][8]. The basic requirements of the antenna elements at the handheld terminals are low profile and low cost while maintaining high bandwidth, good isolation and antenna diversity employment.

Traditionally, monopole antennas are often used in handheld terminals due to their low cost and attractive bandwidth and radiation characteristics. However, monopole antennas are easily damaged, due to their nonrigid structure. Damage of the monopole antenna accounts for approximately one half of faults in vehicle-mounted cellular telephone use[9][10]. Also, more than half of the radiated power from a handset-mounted monopole antenna may be absorbed in the user’s body [11][12]. The absorbed power is a potential health concern, and it results in reduced antenna efficiency. A compact planar inverted-L diversity antenna is an alternative to monopole antennas that can be designed to reduce these problems. It can be made conformal with the handset for protection from damage.

A compact planar inverted-L diversity antenna for handheld terminals is proposed. The effect of important parameters of the proposed antenna is measured and the design methodology is described. Because back radiation is suppressed through reasonable design, it can also be made conformal with the handset for protection from user’s body damage.

2. Handheld Terminals Antenna Design

The planar inverted-L diversity antenna for handheld terminals is designed to operate at 2.15 GHz. The configuration of one antenna element is illustrated in Fig. 1. The diversity antenna consists of three ports fed by co-axial cables. The antenna is mounted on the grounded FR4 substrate with dimension 42 mm×42 mm×1 mm and relative permittivity εr = 4.26. Each antenna volume is only 0.14×0.1×0.06λ0 (λ0 is vacuum wavelength).

There are three antenna elements, the antenna 1, antenna 2 and 3, which are orthogonal, polarization magnetic dipoles. In order to enhance the isolation between antenna 1 and 3, two slots (W × L) are designed on both sides of the FR4 substrate as Fig. 2 (a) shows.
To analyze the performance of the antenna scheme, it is useful to define the initial dimensions of test-antenna geometry. By optimizing the design, the final dimension of the antenna is obtained: \( L_1 = 8 \text{ mm}, \ L_2 = 9 \text{ mm}, \ L_3 = 5.5 \text{ mm}, \ f_s = 8 \text{ mm}, \ L_s = 1.5, \ \beta = 45^\circ, \ d_f = 5, \ W_s = 6.5, \ W_i = W_2 = 10 \text{ mm}, \ d = 6, \ d_s = 17, \ W_i = W_i = W_s = 14 \text{ mm}, \ L_2 = 20 \text{ mm} \) (for antenna 1 and 3), \( L_2 = 21 \text{ mm} \) (for antenna 2), \( W_c = 25 \text{ mm}, \ L_s = 2.6 \text{ mm} \). From Fig. 2 and Fig. 3, the proposed diversity antenna is characterized by compact size, no additional cost, and easy manipulation.

Fig. 4 illustrates the measured S-parameters. It shows that the usable bandwidth is about 13%, and the isolation is below \(-13\) dB at the resonance frequency. The gain is about 2 dB while the isolations between the designed antennas are greater than 13 dB.

Fig. 5 Measured radiation patterns of the planar inverted-L antenna at 2.15 GHz, (solid line) co-polarization and (dotted line) cross polarization: (a) E-plane radian pattern (antenna 1), (b) H-plane radian pattern (antenna 1), (c) E-plane radian pattern (antenna 2), and (d) H-plane radian pattern (antenna 2).
In this design, the antenna 3 has the same symmetric geometry configuration as the antenna 1, and thus the two antennas can be used to obtain space and radiation pattern diversity. Moreover, the antenna 1 (or the antenna 3) and the antenna 2 can be used to support three kinds of diversity techniques, such as space diversity, radiation pattern diversity and polarization diversity. From Fig. 5, it is observed that the reduction of backward radiation is obtained, because most of energy is radiated into +z direction. The measured radiation patterns also show that such design antenna is suitable for handheld terminals. The proposed diversity antenna is characterized by compact size, large bandwidth, omnidirectional radiation pattern, and reduction of backward radiation. More importantly, it supports the employment of diversity techniques.

3. Conclusions

A planar inverted-L diversity antenna for handheld terminals was proposed in this paper. The effects of important parameters of the proposed antenna are discussed and the design methodology is described. The proposed diversity antenna has compact size, large bandwidth, high isolation and gains, and reduction of backward radiation. Moreover, it can be easily manipulated, and it can supports three kinds of different diversity employment, and protects from user’s body damage. The proposed diversity antenna will be used on the user equipment side of MIMO systems.

References


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