

## A Dual-Band Internal Antenna for Mobile Handsets: the Consideration of the Handset Case, Battery, Head, and Hand

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This paper proposes a compact internal antenna of the modified planar inverted F antenna (PIFA) type with a parasitic patch. It also considers the influences of the handset case, battery, and head. A low profile design is implemented on both the top and bottom sides of the FR-4 substrate. The proposed antenna, with the small size of  $27.5 \times 12 \times 7$  mm<sup>3</sup>, can be easily placed in the actual handset. The measured bandwidths of the proposed antenna with handset case and battery (VSWR  $\leq 2$ ) can cover 140 MHz (1740 - 1880 MHz) in KPCS (Korean PCS) band and 90 MHz (2400 - 2490 MHz) in Bluetooth band. The shifting of resonance frequency is slightly changed when the proposed antenna installed in the handset case with battery is next to the phantom head. However, the radiation patterns of the far-field characteristics have a strong influence on the phantom head while retaining the slightly variation with VSWR value.

The effects of antenna performance due to the head and hand are also investigated. The hand is located near the phone in handset communication as close as the distance between the phone and head. Therefore, the effects of the hand should not be ignored. The holding pose is wrapping the phone case with all fingers in the vicinity of the lower part of one. It is interesting to note that the maximum peak point of SAR values occurs near and at the nail region of the second finger instead of the right edge region at the head. The edge part of the second finger in the right hand is located between the right hand side of the head and the radiation element of the backside of handset phone. This means that the finger is more susceptible to absorption of the radiation field when wrapping the handset phone. For example, the peak 1g SAR value is about 1.22 W/kg on the finger of hand while retaining the 1g SAR value as 0.8 W/kg inside of the head. We can find that the position of wrapping the handset phone is important to reduce the effect of an electromagnetic wave absorption in head and hand.

Numerical simulation and experiment results of antenna electrical performance are investigated by considering the antenna, phone case, battery, phantom head, and hand. Additionally, the proposed antenna is also considered with a SAR value in case of applying to the head and hand. By investigating the effects of the antenna performance such as the impedance bandwidth, radiation patterns, gains, and SAR value due to human body such as the head and hand in advance, the try and error procedure of mobile phone antenna design in the practical situation can be further reduced.