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Abstract

In this paper, a triple-band internal antenna for mobile handsets is present. Dual band operation is generated by using a band reject filter as a matching circuit and without any transformations on its radiator. Moreover, the antenna gives a wide impedance bandwidth in high band by using an additional chip capacitor so that the antenna can operate in triple-band with only one radiator. Details of the proposed antenna are presented.

Introduction

Technologies for mobile handsets have made rapid progress due to development of mobile communication. Recently, there are many types of handsets such as bars, folders, sliders, swingers, and their size becomes smaller and compact. Considering the design of handsets, an internal antenna is more attractive than an external antenna. For an internal antenna, small size and multi-band operations are increasingly demanded. Since an internal antenna is electrically small, it has narrow bandwidth due to high Q and low efficiency. Therefore, designing an internal antenna is difficult especially when multiband operation is required. In general, there are two major design methods to achieve multiband operations. One is to use two or more different radiating elements, and the other is to use the first two resonant modes of a single resonant path [2]. In this paper, two operating bands are designed by using a matching circuit applied for antenna impedance. With an additional chip capacitor, the proposed antenna operates in triple-band.

Analysis and Discussions

The whole part of a handset structure affects radiation of an antenna, and this is why an internal antenna has high radiation conductance in spite of a small size [3]. Dual band operations are achieved by an impedance matching at frequency band in which the antenna element is not resonant. An impedance behavior of an internal antenna such as a PIFA, or monopole is similar to that of a 1-pole resonator. Impedance of an ideal 1-pole resonator is represented at a detuned open position as shown in Fig. 1. Real part of the impedance is 50 ohms, and it is maintained as varying with frequencies. Imaginary part of the impedance is zero at a resonant frequency. Unlike

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at the resonant frequency, other frequencies that are in the same amount away (left side or right side) from the resonance show that the imaginary part of the impedance has equal amplitude and opposite sign each other. From such impedance behaviors, an antenna can be matched in dual band by connecting a matching circuit whose real part of the impedance is 50 ohms and imaginary part is opposite to that of the antenna itself. In this work, a band reject filter is used as a matching circuit with such impedance characteristics. Impedance of a band reject filter as a matching circuit includes a real part of 50 ohms and imaginary part as shown in Fig. 1 From this Figure, it can be noticed that a slope of imaginary part of the impedance is varied with quality factor Q of the band reject filter. When an antenna as a resonator is coupled by this matching circuit, frequencies at which imaginary part of the impedance becomes zero are generated. Finally, an impedance matching can be obtained in desired frequency bands. Also resonant frequencies of the whole structure can be controlled by a resonant frequency of the matching circuit (band reject filter). Fig. 2 displays the imaginary part of the impedance after two circuits (antenna as a resonator and band reject filter as a matching circuit) are combined. Fig. 3 shows the return loss of the combined circuit, and it is shown that the resonant frequencies are varied with Q of the matching circuit. In this case, impedance bandwidth of the combined circuit is limited by Bode-Fano criterion [4].

Design and Results

Fig. 4 shows the proposed antenna mounted on a ground plane of dimension 45×84mm. Patch has a size of 36×15mm, and feed line is 20×4mm. Shorting pin is located at the left bottom on the patch. The proposed antenna is indirectly fed by a feed line and designed to resonate at 1.1GHz. Also a detuned open position of antenna impedance is found on the feed line. By using the circuit simulator, ADS, the positions of band reject filter and chip capacitor are determined. Their values are also simulated. Values of an inductor and a capacitor of band reject filter are 1.8nH and 5pF, respectively. A chip capacitor of 2.2pF is also used. The band reject filter is used for dual resonance of the antenna. The chip capacitor is used for impedance matching in high band, and thus wide bandwidth can be obtained. In Fig. 5, the structure and position of band reject filter and chip capacitor are represented. Antenna impedance determines the resonant frequency and Q of a band reject filter, and this matching circuit is coupled at the position found by simulation. Fig. 6 shows the return loss when the matching circuit is combined to the antenna. The measured bandwidths (VSWR<3) are 60MHz in low band and 420MHz in high band. The radiation patterns in H- and E-plane are shown in Fig. 7. From the radiation patterns in H-plane, it is confirmed that the proposed antenna has omni-directional radiation patterns in all frequency bands. The measured peak gains are -1.07dBi, 0.5dBi, and 1.02dBi in each Cellular (824-894 MHz), GPS (1575 MHz), and Korean PCS (1750-1870 MHz) band, respectively.

Conclusions

In this paper, dual resonance is realized by combining a band reject filter to a PIFA. An additional chip capacitor improves the bandwidth in high band so that finally the proposed antenna is able to cover triple band of Cellular, GPS, and Korean PCS. Performance of the antenna is verified by simulations and measurements. In next work, improvement of the bandwidth in low band will be studied and the proposed antenna will apply to the practical system.

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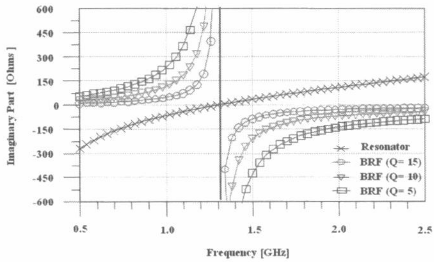

Figure 1. Imaginary part of impedance of ideal resonator and band reject filter

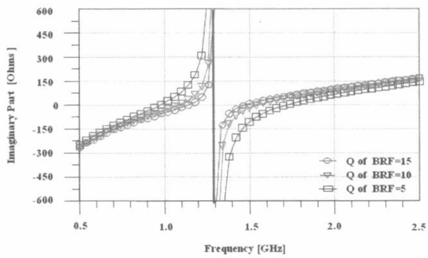

Figure 2. Imaginary part of impedance of the combined circuit

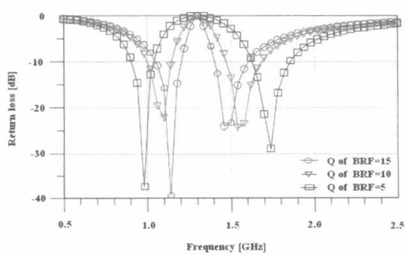

Figure 3. Return loss of combined circuit varying with Q of band reject filter

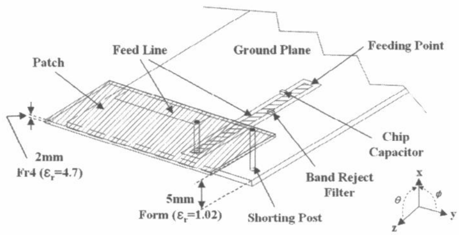

Figure 4. Structure of the proposed antenna

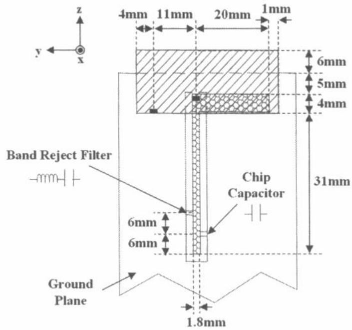

Figure 5. Dimension of the proposed antenna (top view)

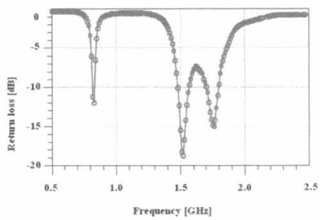

Figure 6. Measured return loss of the combined circuit

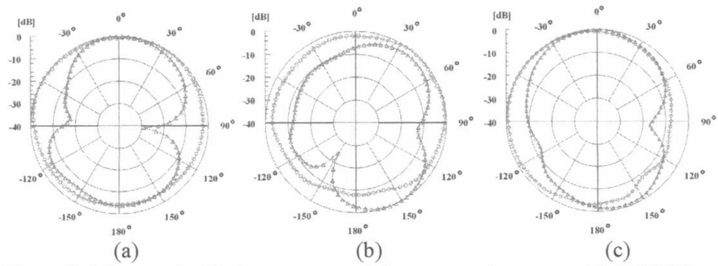

Figure 7. Measured radiation patterns of the proposed antenna: (a) 859 MHz, (b) 1575 MHz, (c) 1810 MHz