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Wideband Monopole Antenna for Multiband Mobile Communication Applications

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요 약

본 논문에서는 이동통신 시스템에 적용이 가능한 새로운 형태의 소형 폴디드 모노폴 안테나를 제안한다. 제안된 안테나는 낮은 주파수 대역에서는 CDMA와 GSM 대역에서 동작이 가능하고, 높은 주파수에서는 GPS, DCS, USPCS, UMTS, WLAN (2.4, 5.2, 5.8 GHz)대역 뿐만 아니라 IEEE 802.16e mobile WiMAX대역에서 동작하는 광대역 특성을 나타낸다.

Abstract

A folded monopole antenna is proposed for mobile communication applications. The proposed antenna covers CDMA and GSM at low frequency band, and it has a wide bandwidth (6.85 GHz) at high frequency band to cover GPS, DCS, USPCS, UMTS, WLAN (2.4, 5.2, 5.8 GHz), and the future application of IEEE 802.16e mobile WiMAX.

Key words: Internal antenna, mobile WiMAX, multi-band antenna, wide band, WLAN

Ⅰ. Introduction

With rapid growth in wireless communication systems, a great demand in developing compact multi-band or wide-band internal antenna suitable for mobile communication applications has been increased. Also, as IEEE 802.16 Working Group created a new standard of the WiMAX (World interoperability for Microwave Access, 2.5, 3.5, 5 GHz), it is very important to design the antennas which can support this future applications for mobile phones [1-3]. Many studies have been conducted to design multiband or wideband internal antennas which can cover most operation bands (880-2450 MHz) of major wireless services: CDMA (824-894 MHz), GSM (880-960 MHz), GPS (1575.42 MHz), DCS (1710-1880 MHz), PCS (1850-1990 MHz), UMTS (1920-2170 MHz), and WLAN (2400-2484 MHz) [4-6]. However, none of

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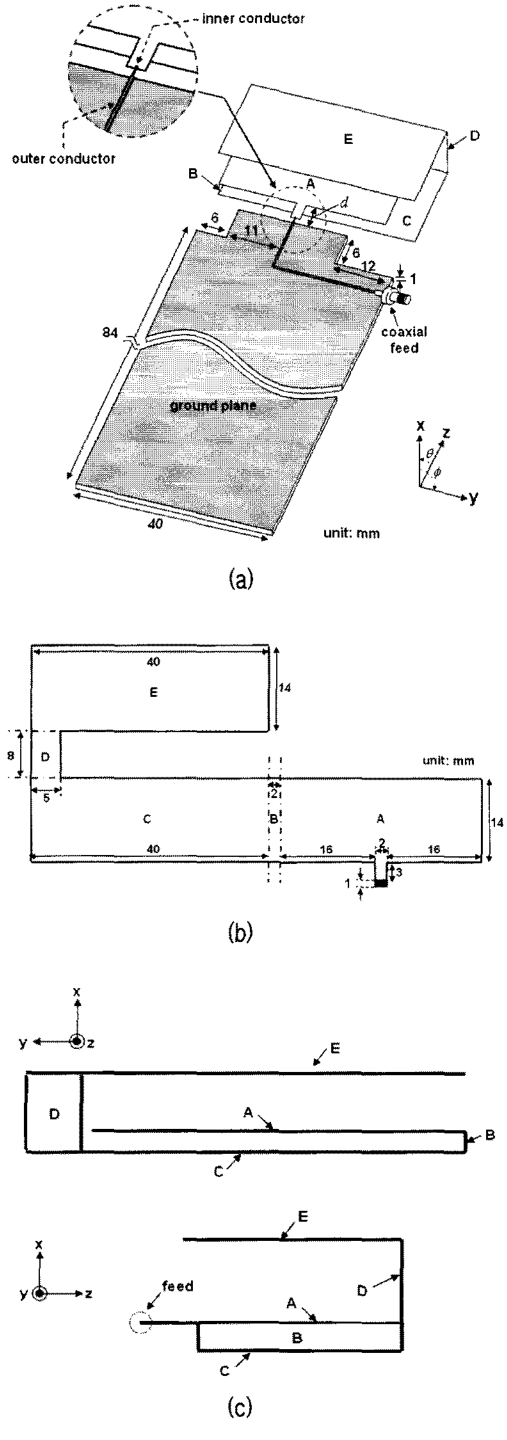
these designs can simultaneously cover all of these operating bands. Therefore, it will be challenging and meaningful to design a compact antenna which can simultaneously cover all of these frequency bands as well as higher frequency bands including WLAN (5.2, 5.8 GHz) and WiMAX (2.5, 3.5, 5.5 GHz) for future mobile phone applications. This letter proposes a monopole structure for multiband/wideband operations. The proposed antenna simultaneously covers CDMA, GSM, GPS, DCS, PCS, UMTS, WLAN (2400-2484, 5150-5350, 5725-5875 MHz) and future applications of IEEE 802.16e mobile WiMAX bands.

Ⅱ. Antenna Design and Structure

Figure 1(a) shows the geometry of the proposed antenna which has a folded radiating element connected with the 84×40 mm^2 ground plane mounted on 1 mm thickness of the FR4 substrate. Figure 1(b) shows the radiating element unfolded into a planar structure. The side view of the proposed antenna is shown in Figure 1(c).

The antenna is fed at the centre of the element "A" which is constructed on the same level of the ground plane. The radiating element "C" is parallel to "A" and is located 2 mm below "A". The radiating elements "A" and "C" are electrically connected by a vertical element "B". The radiating element "E" is parallel to "C" and is located 8 mm above "C". "E" and "C" are also electrically connected by the other vertical element "D". At first, when the rectangular patch element "A" fed by a coaxial cable and ground plane are considered only, then the antenna has a similar structure of the conventional printed monopole antenna and gives a wideband feature.

Therefore, the high frequency bands, GSP, DCS, PCS, UMTS, WLAN and WiMAX can be obtained from this radiating element "A". Secondly, extending and guiding the resonant current path into three layers



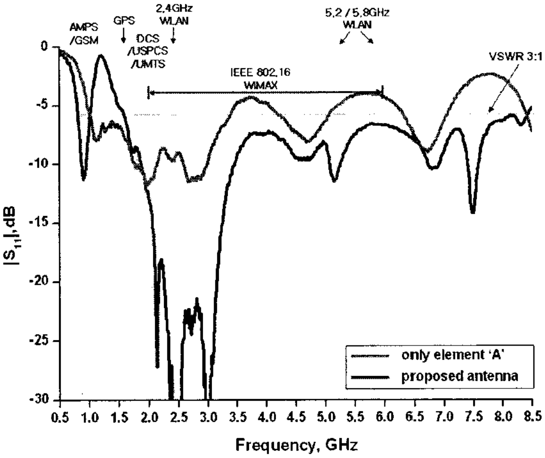
<Fig. 1> Geometry of the proposed antenna: (a) overall view, (b) unfolded structure of radiating element, (c) side view

by folding the radiating element along the x-axis, the proposed antenna gives wideband and multiband operations, and the overall dimenesion of an antenna is effectively reduced [8]. The folded planar monopole is constructed by the other rectangular radiating elements ("B", "C", "D", and "E") which provide a long current path to obtain a low frequency band operation at CDMA and GSM band. The electrical length from the feed point in element "A" to the edge of element "E" is about $\lambda/4$ at CDMA and GSM bands so that the whole structure of the porposed antenna including the ground plane acts as a half-wave dipole at the lowest frequency band.

The impedance matching over all operating frequency bands can be achieved by adjusting the distance (d=4 mm) between the element "A" and the ground plane. The distance (2mm for this work) between the element "A" and "C" is a main factor for impedance matching at the high frequency band since it leads to the large amount of couplings. Further improvement of the impedance bandwidth at high frequency bands is achieved by partially removing the ground plaen at two upper corners as shown in figure 1(a). Now the proposed antenna simultaneously covers CDMA, GSM, GPS, DCS, PCS, UMTS, WLAN (2400-2484, 5150-5350, 5725-5875 MHz) and future applications of the IEEE 802.16e mobile WiMAX bands.

Ⅲ. Measured Results

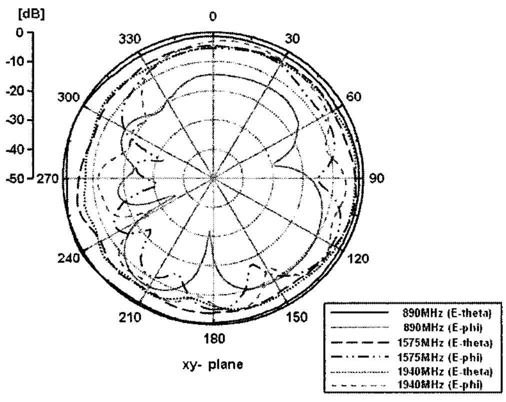
Figure 2 shows the return loss (S11 [dB]) when the radiating element "A" exists only and the proposed antenna is considered. The antenna impedance is matched under VSWR less than 3, which is a typical antenna specification for mobile phone applications. The measured bandwidth is about 190 MHz (820 - 1010 MHz) for the CDMA and GSM bands and 6850 MHz (1570 - 8420 MHz) for the high frequency band



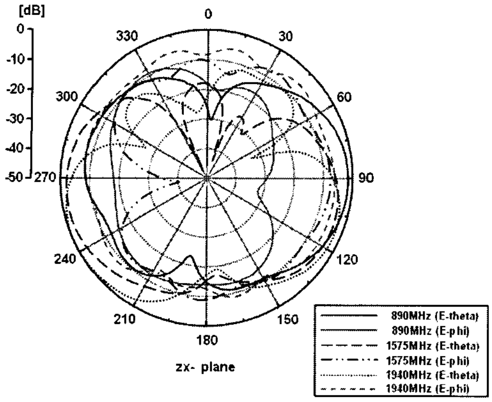
<Fig. 2> Measured dB magnitude of S_{11}

including the GPS, DCS, PCS, UMTS, 2.4/5.2/5.8 GHz WLAN, and IEEE 802.16e WiMAX bands.

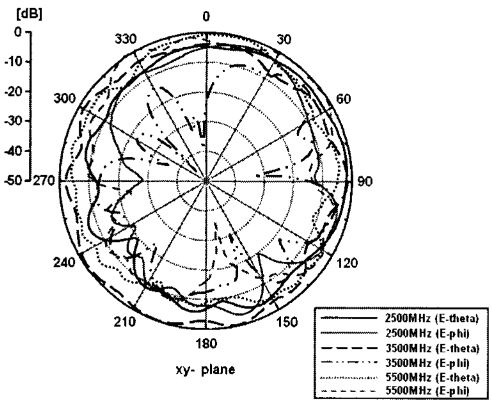
Figure 3 shows the radiation pattern measured at CDMA/GSM, GPS, DCS/USPCS/UMTS, and WiMAX bands in the xy- and the zx- plane. The Eq component is dominant for the lower frequency bands, but the Ej component becomes more dominant for the higher frequency bands due to the longer resonant length along the y-axis. The antenna acts as an z-axis dipole, and its radiation patterns in each operating frequency are also varied as those of the z-axis dipole. Although the measured antenna efficiencies are not included, the peak gains are high in all operating frequencies as shown in Figure 4.



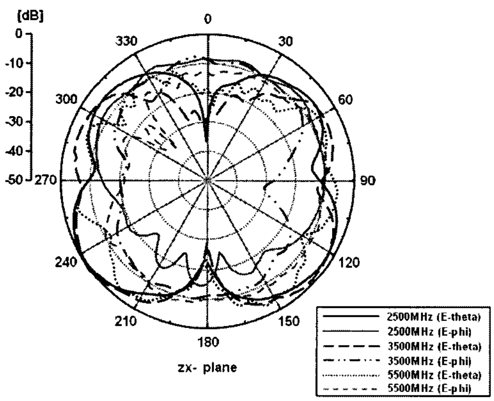
(a)



(b)

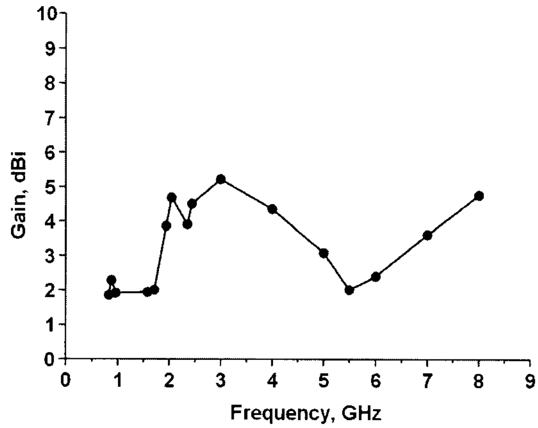


(c)



(d)

<Fig. 3> Measured radiation patterns: (a) xy-plane at CDMA/GSM, GPS and DCS/PCS/UMTS bands, (b) zx-plane at CDMA/GSM, GPS and DCS/PCS/UMTS bands, (c) xy-plane at WiMAX band, (d) zx-plane at WiMAX band



<Fig. 4> Measured peak gains of proposed antenna

IV. Conclusions

A folded monopole antenna is proposed and implemented for mobile communication apllications. The measured bandwidths are very wide and the peak gains are over 1 dBi in all operating bands. One can see that the radiation performance of the proposed antenna is suitable for CDMA, GSM, GPS, DCS, PCS, UMTS, WLAN and future application of IEEE 802.16e Mobile WiMAX bands.

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