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A WIDEBAND HORIZONTALLY POLARIZED OMNIDIRECTIONAL ANTENNA FOR LTE INDOOR BASE STATIONS

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ABSTRACT: A wideband horizontally polarized omnidirectional antenna is proposed for 4G LTE indoor base stations. Within the band from 1.71 GHz to 2.69 GHz, the antenna achieves a return loss of greater than 14 dB. The antenna consists of four arc printed dipoles which are arranged on a circumference and fed in phase. By attaching a pair of parasitic elements around each dipole, the bandwidth of the antenna is improved significantly. Moreover, by introducing four pairs of directors, the antenna gain variation in the azimuth plane is reduced to 1 dB in the operating band, and omnidirectional radiation patterns are achieved. The measured results are in good agreement with the simulated results. © 2015 Wiley Periodicals, Inc. Microwave Opt Technol Lett 57:2112–2116, 2015; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.29287

Key words: base stations; dipole antennas; Yagi-Uda antennas; omnidirectional antennas

1. INTRODUCTION

With the development of modern mobile communications, indoor base stations are paid more and more attention, due to their significant advantages such as small size, low cost, ease of installation, and maintenance. One challenge in the design of indoor base station antennas is to achieve a low profile and low production cost while maintaining the antenna performance, such as wide bandwidth. In indoor base stations normally mounted on the ceiling in the center of a room, omnidirectional antennas are often needed to realize a 360° full coverage [1]. To meet the requirement of the 4G Long Term Evolution (LTE) bands (1710–2690 MHz), a wide bandwidth of at least 45% is demanded. In addition, to increase the channel capacity, polarization diversity is used, such as vertical/horizontal dual-polarization.

To develop a horizontally polarized (HP) omnidirectional radiation pattern, the circular loop antenna is considered. In [2], a novel wideband loop antenna with periodical capacitive loading and a bandwidth of 31.2% is proposed. However, its bandwidth is still not enough. To achieve a wider bandwidth, a novel loop antenna concept is proposed in [3], which is obtained by replacing the loop with several dipoles arranged on a circumference and fed in phase. Based on this concept, several HP omnidirectional antennas composed of printed dipoles are proposed in [4–9]. In [4], a HP omnidirectional antenna composed of 8
Figure 3  Simulated current distribution of the proposed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Figure 4  Simulated radiation patterns in the azimuth plane (XY plane) and elevation plane (YZ plane) of the proposed antenna at 2.7 GHz. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Figure 5  Comparison of the radiation patterns of the proposed antennas with and without directors. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]
printed dipoles is presented, with a 10-dB return loss bandwidth of 62.5%, but the gain variation in the azimuth plane is as high as 4.5 dB. In [5,6], similar antennas are presented and combined with monopoles to form dual-polarized omnidirectional antennas, both with relatively narrow bandwidth. In [7,8], a HP omnidirectional antenna composed of four arc printed dipoles is proposed, with a bandwidth of 1.7–2.2 GHz. In [9], a HP omnidirectional antenna composed of four flag-shaped radiators and four parasitical strips is presented to cover the band of 1.76–2.68 GHz, while the gain varies remarkably in the azimuth plane. In addition, omnidirectional patterns can also be achieved using several magnetic dipoles [10].

In this letter, a HP omnidirectional antenna is proposed, with improved bandwidth and reduced gain variation (maximum to minimum). In Section 2, the omnidirectional antenna is described. In Section 3, simulated and measured results are presented. Finally, some conclusions are drawn.

2. ANTENNA DESIGN

Inspired by the omnidirectional antenna proposed in [7] (with a bandwidth of 1.7–2.2 GHz) and the authors’ previous research in printed dipoles [11], an innovative wideband omnidirectional antenna is designed to cover the band from 1.71 GHz to 2.69 GHz, by introducing four pairs of parasitic elements and four pairs of directors. The geometry of the proposed omnidirectional antenna is shown in Figure 1.

The four dipoles are arranged on a circumference and fed in phase. The arc parasitic elements close to the arc dipole arms are used to broaden the bandwidth, and the directors are used to reduce the gain variation in the azimuth plane (maximum to minimum). The dipoles are printed on the bottom of the FR4 substrate with a thickness of 1 mm. Four Γ-shaped baluns used to feed the dipoles are printed on the top side of the substrate, connected by four 100-Ω microstrip lines and terminated with a small circular patch located in the center. A 50-Ω coaxial cable is used to feed the antenna, whose inner conductor is connected with the center circular patch and its outer conductor is connected with the dipoles. Some key parameters are defined and optimized to achieve a wide bandwidth and minimum gain variation in the azimuth plane. The optimized parameters are presented in Figure 1.

Figure 2 shows the simulated return losses for the proposed antenna with and without the parasitic elements. It can be seen that the proposed antenna has much wider bandwidth than the antenna without parasitic elements. Across the desired band 1.71–2.69 GHz, the proposed monopole has a return loss of greater than 14 dB.

Figure 3 shows the simulated current distribution of the proposed antenna at 1.7 GHz and 2.7 GHz, as obtained by HFSS. It can be seen that the surface current at 1.7 GHz flows in the same direction along the inner circular loop that is composed of four pairs of arc dipole arms, while the surface current at 2.7 GHz flows along the outer circular loop that is composed of four pairs of arc parasitic elements and directors. The in-phase current distribution along the circular loop can produce a HP omnidirectional pattern in the azimuth plane.

The simulated radiation patterns at 2.7 GHz in the azimuth plane (XY plane) and in the elevation plane (YZ plane) for the proposed antenna are shown in Figure 4. The gain in the azimuth plane is around 0 dBi, and the gain variation is less than 1.0 dB. The cross-polar levels for both planes are less than −15 dB. The patterns in other frequencies are similar.

To understand the effect of the directors, the radiation patterns of the proposed antenna with and without directors are comparably presented in Figure 5. As can be seen, due to the directors, the gains in Φ = 0°, 90°, 180°, and 270° have been

Figure 6 Prototype of the proposed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Figure 7 Simulated and measured S11 of the proposed antenna. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]
improved by about 3 dB, thus the gain variation (maximum to minimum) in the azimuth plane can be reduced and good omnidirectional pattern properties are obtained.

3. SIMULATED AND MEASUREMENT RESULTS
A prototype of the proposed antenna is fabricated, as shown in Figure 6. The $S_{11}$ parameter of the proposed antenna is measured.
REFERENCES


4. CONCLUSION

A wideband horizontally polarized omnidirectional antenna is presented for indoor base station applications, composed of four dipoles. By adding a pair of parasitic elements to each dipole, the antenna achieves a bandwidth of 1.71–2.69 GHz. Good omnidirectional pattern properties are obtained by introducing four pairs of directors.

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SMALL-SIZE LTE/WWAN PLANAR PRINTED ANTENNA FOR ULTRATHIN SMARTPHONE APPLICATION

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ABSTRACT: A compact small-size LTE/WWAN planar printed antenna for ultrathin smartphone application is presented, which achieves two wide operating bands of 647–972 MHz and 1605–2770 MHz to cover LTE (LTE700/2300/2500) and WWAN (GSM850/900/1800/1900/UMTS2100) bands. A feeding strip and an inverted M-shaped parasitic shorting strip are combined to form the proposed coupled-fed antenna with a simple structure and small size of 15 × 36 mm². So it can be easily printed on the circuit board and it is convenient to adjust antenna performance. At the same time, a rectangular notch on the circuit board not only can be used to place the battery for ultrathin smartphone application but also changes the ground plane current path to achieve a better impedance matching, especially in the low-band (698–960 MHz). Moreover, the proposed antenna allows tighter integration of multiple electronic components, such as USB, microphone. In addition, the design process and measured results of the proposed antenna are also provided below. © 2015 Wiley Periodicals, Inc. Microwave Opt Technol Lett 57:2116–2120, 2015; View this article online at wileyonlinelibrary.com. DOI 10.1002/mop.29286

Key words: planar printed antenna; small-size antenna; ultrathin smartphone; LTE/WWAN bands; notchd circuit board

1. INTRODUCTION

With the development of data communications and multimedia service, the fourth generation mobile communication that adapts to a variety of needs on fast-moving data and computation begins to rise. Just to cover the WWAN (GSM850/900/1800/1900/UMTS2100) bands has been unable to meet the market needs, and the LTE (LTE700/2300/2500) bands become an indispensable part of mobile communications. To cover LTE/WWAN bands in a limited space is difficult for antenna design [1]. Meanwhile, decreasing the thickness has become the development trend for the smartphone [2], for example, the thickness of iPhone6 is 6.9 mm, and the thickness of Huawei’s Ascend P6 is only 6.18 mm. The antenna taking ultrathin, miniature, and multiband (2G/3G/4G) into account is a great challenge for mobile phone antenna design.

For covering the LTE/WWAN eight communication bands, many technologies have been researched, such as using the coupled feed technology [3–5], loading lumped chip elements [6], loading parallel resonant technology [7], and reconfigurable technology [8]. However, the 3D structure of the above antennas is not suitable for ultrathin smartphone application. Though the printed antennas in [9–14] are two-dimensional planar structures, they can not achieve the target of miniaturization and eight-band. The areas of the antennas in [9–12] are larger than 15 × 45 mm², which occupy a big space. While the antennas in [13,14] can not cover the LTE/700 band. Moreover, combining with battery and model of screen, reference 15 designs a multi-band PIFA antenna with the overall thickness of 9 mm. To further decrease the overall thickness of the mobile phone, an effective method embedding the battery to notched circuit board is proposed in [16,17], which does achieve ultrathin smartphone application and enhance the operating bandwidth. But the