Dual-wideband microstrip antenna for LTE indoor base stations

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In this Letter, a dual-wideband microstrip antenna for long-term evolution (LTE) applications is proposed. The antenna is fed by a single port, and designed to operate at 800–960 MHz and 1700–2700 MHz simultaneously. The antenna has a return loss of less than −14 dB for both frequency bands, and gain of 3–4 dBi at the lower band and 6–8 dBi at the higher band. The proposed antenna may find its applications in second generation (2G), 3G, 4G LTE and WiFi systems.

Introduction: With the fast development of mobile communication technologies, demand on the design of wireless communication devices has increased accordingly. In particular, as an essential part of a wireless system, antennas must provide a reliable wireless link, be cost effective, as well as have low profiles. Furthermore, antennas for indoor wireless systems are required to operate at multiple frequency bands for the second generation (2G), 3G, and 4G long-term evolution (LTE) systems. Especially for the LTE system, antennas that can operate at 700, 750, 800, 850, 900, 1900, 1700/2100, 2500 and 2600 MHz bands (depending on the country's regulation) are needed. Due to the required large operating bandwidth, most current designs of indoor LTE base station antennas are monopole type, with large thickness and relatively low gain [1].

For wideband microstrip-type indoor base station antennas, a dual-polarised patch antenna is proposed in [2] for 1900–2700 MHz, a slot-coupled stacked-patch array antenna is introduced in [3] for 1700–2700 MHz. For dual-wideband operations, a dual-broadband planar antenna for 800–980 MHz and 1540–2860 MHz is presented in [4], however the antenna needs to be separately fed for lower and higher band operations; a double-layer magnetoelectric dipole antenna is proposed in [5] for 790–1010 MHz and 1380–2780 MHz, while the size of the antenna is large and it requires complicated fabrication process. In this Letter, we propose a low cost and easy-to-fabricate microstrip-type indoor base station antenna for dual-wideband operations at 800–960 MHz and 1700–2700 MHz.

Antenna design: The perspective view of the proposed dual-wideband LTE antenna is shown in Fig. 1*a*. The antenna contains three separate radiating elements: a top rectangular patch with two U-shaped slots and two long rectangular slots for covering the higher frequency band of 1700–2700 MHz (see Fig. 1*b*), and two lower folded inverted-L-shaped elements for covering the lower frequency band of 800–960 MHz (see Fig. 1*c*).

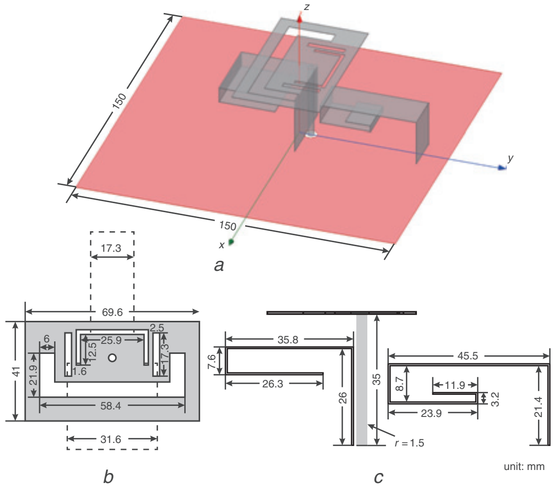

Fig. 1 *Geometry of proposed dual-wideband antenna*

a Perspective view
b Top view
c Side view

Conventional microstrip antennas have a low impedance bandwidth of only a few per cent [6]. Typical techniques to extend the bandwidth of microstrip antennas include: using low substrate with low dielectric constant, increasing the substrate thickness, adding slots on the radiating patch, and adding parasitic radiating elements etc. In our design, we adopt the first three techniques mentioned above in order to cover the approximately 45% bandwidth of the higher frequency band (1700–2700 MHz). For the antenna to operate at the lower frequency band of 800–960 MHz, we apply the technique of creating multiple resonances to cover the approximately 18% bandwidth. The folded design of two lower elements are for the purpose of reducing the overall size of the antenna. The top rectangular patch is directly fed by a feeding pin, and the two lower L-shaped elements are fed by the coupling from the feeding pin and the edge of the top patch.

It is also worth noting that the thickness of the metallic elements plays an important role in the characteristics of the antenna, which is set to be 0.6 mm in our design. The antenna is simulated using Ansys' High Frequency Structure Simulator. Since there are over 30 dimension variations in the design, optimisation techniques are also applied in simulations to acquire the optimum return loss. Then the antenna is fabricated according to the finalised dimensions and shown in Fig. 2*a*. All three elements are fabricated using 0.6 mm thick brass sheets. The top plate is directly cut by a computer numerical control (CNC) machine. The bottom two plates are cut by the CNC machine first, and then manually folded with the required dimensions according to Fig. 1*c*. The ground plane is cut from a 0.6 mm thick aluminium sheet. A N-type connector with a long feeding pin of 35 mm in length is used and the top plate is directly soldered onto it. In order to attach two lower elements, a folded part is created at the bottom of each one (see Fig. 2*a*). Then they are fixed firmly to the ground by screws, as shown in Fig. 2*b*. It is important to note that the vertical part of the lower wider element must be parallel to the feeding pin, as this directly affects the impedance matching at the higher resonant frequency of the 800–960 MHz band.

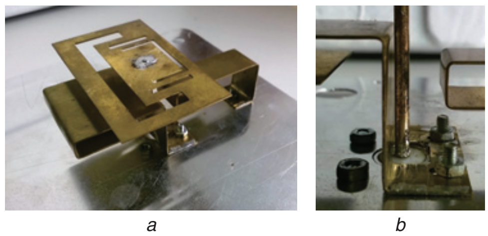

Fig. 2 *Photographs of fabricated antenna*

a Perspective view
b Zoomed view of the feed

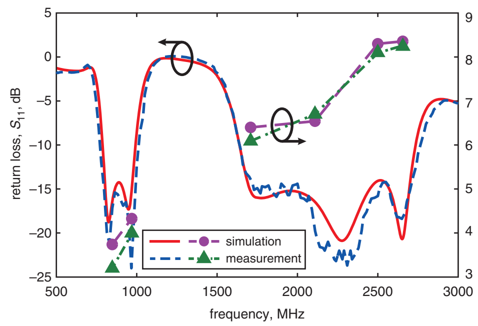

Fig. 3 *Comparison of return loss and gain from simulation and measurement*

Results and discussion: The return loss of the proposed antenna (S_{11}) is measured using a vector network analyser (VNA) Rohde and Schwarz ZVB20 and shown in Fig. 3. It can be seen that at the lower band of 800–960 MHz, two resonances are clearly visible, which are due to the two lower radiating elements. At the high band of 1700–2700 MHz, three resonances are attributed to the width of the rectangular patch, the larger U-slot and the smaller U-slot. Thanks to these resonances, we can achieve S_{11}<−14 dB at both frequency bands, equivalent to the voltage standing wave ratio of <1.5 and thus satisfies our design requirement. Fig. 3 also shows the gain of the antenna measured in an echoic chamber. Due to the small size of the ground plane, the antenna has a moderate gain of 3–4 dBi at the lower frequency band,

and over 6 dBi at the higher frequency band, with the maximum measured gain of 8.2 dBi near the highest resonant frequency.

Fig. 4 shows the measured radiation patterns at five frequencies: 850, 915, 1710, 2110, and 2500 MHz in the *x-z*, *y-z* and *x-y* planes (see Fig. 1).

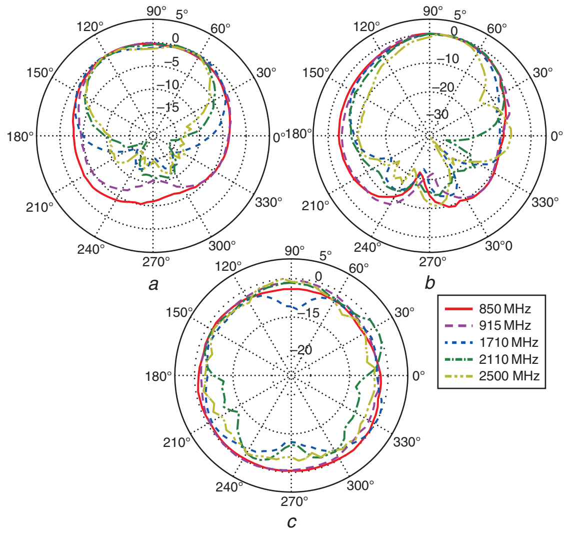

Fig. 4 *Measured radiation patterns of proposed antenna*
a xz-plane
b yz-plane
c xy-plane

At the lower band, the 3-dB beamwidth is approximately 150°; while at the higher band, the antenna becomes more directive and has a 3-dB beamwidth of about 100°.

Conclusion: We have proposed a microstrip type dual-wideband antenna for LTE indoor base stations. The antenna has a low profile of approximately 35 mm, more compact than existing monopole-type designs, and offers excellent return loss characteristics. The proposed two-layer configuration provides a solution to the challenging requirement of having wide bandwidth at both 800–960 MHz and 1700–2700 MHz bands simultaneously. It is expected that the presented antenna may find its immediate applications in all mobile and wireless systems, including 2G, 3G, 4G LTE, and WiFi.

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One or more of the Figures in this Letter are available in colour online.

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References

1 Zhou, L., Jiao, Y.-C., Qi, Y., Weng, Z., and Ni, T.: ‘Wideband ceiling mount omnidirectional antenna for indoor distributed antenna system applications’, *Electron. Lett.*, 2014, **50**, pp. 253–255
2 Secmen, M., and Hizal, A.: ‘A dual-polarized wide-band patch antenna for indoor mobile communication applications’, *Prog. Electromagn. Res.*, 2010, **100**, pp. 189–200
3 Caso, R., Serra, A.A., Pino, M., Nepa, P., and Manara, G.: ‘A wideband slot coupled stacked-patch array for wireless communications’, *IEEE Antenn. Wirel. Propag. Lett.*, 2010, **9**, pp. 986–989
4 Cui, Y., Li, R., and Wang, P.: ‘Novel dual-broadband planar antenna and its array for 2G/3G/LTE base stations’, *IEEE Trans. Antennas. Propag.*, 2013, **61**, pp. 1132–1139
5 Feng, B., Hong, W., Li, S., An, W., and Yin, S.: ‘A dual-wideband double-layer magnetoelectric dipole antenna with a modified horned reflector for 2G/3G/LTE applications’, *Int. J. Antenn. Propag.*, 2013, **11**, Article ID 509589, pp. 1–9
6 Shackelford, A.K., Lee, K.-F., and Luk, K.M.: ‘Design of small-size wide-bandwidth microstrip-patch antennas’, *IEEE Antennas Propag. Mag.*, 2003, **45**, pp. 75–83