Compact Metamaterial-Inspired Broadband Monopole Antenna for WLAN/WiMAX Applications

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1. Introduction

Integration of the Worldwide Interoperability for Microwave Access (WiMAX: 2.5 – 2.69, 3.3 – 3.8, and 5.25 – 5.85 GHz) with the Wireless Local Network (WLAN: 2.4 – 2.48, 5.15 – 5.35 and 5.725 – 5.85 GHZ) is a very promising broadband wireless access (BWA) technology. These standards will be implemented simultaneously in future communications systems. Hence, WLAN and WiMAX systems require multi-band or broadband antennas. In order to reach multi-band or broadband operation, using multi-branched strips or a big radiator with appropriate slots are effect approaches [1-4], but these approaches generally lead to a large volume or requires a large ground. Metamaterials provide a conceptual route for implementing small resonant antennas. In [5, 6], Zhu et al. proposed antenna with metamaterial-inspired loading, in which a second resonance frequency was created. A previous work [5] developed a dual-band antenna for WLAN only, while another one [6] devised an antenna for WLAN and WiMAX in which a slot was cut in the antenna ground plane to create the third resonance, thus forming a defected ground-plane. However, the lower bands of proposed antennas in [5, 6] were narrow. This letter presents a broadband metamaterial-inspired antenna, capable of supporting WLAN and WiMAX applications, without a defected ground-plane. The S parameters, gains and radiation patterns are given and discussed.

2. Antenna Design

Figure 1 shows the geometry of the proposed broadband antenna, which is composed of an L-shaped monopole and an inverted-L reactive load. A CPW-fed L-shaped monopole is printed on the top layer of a FR-4 board with a relative dielectric constant of $\varepsilon_r = 4.4$ and thickness of $h = 0.4$ mm. The L-shaped monopole resonates at the upper band of WLAN and is fed by a 50 Ω CPW feedline with a width of $a = 3$ mm and gaps of $g = 0.3$ mm. Two symmetrical 19.2×17 mm² ground planes are printed on the top layer. The reactive loading is inspired by transmission-line metamaterials. After the L-shaped antenna adds the reactive loading, which is printed on the back side (bottom layer) of the FR-4 board, a broad operating band is excited. This band covers the lower band of WLAN (2.4 GHz) and the WiMAX band (2.5 GHz and 3.5 GHz). Moreover, the broadband antenna is very compact (excluding ground planes, 18.5 mm wide and 5.5 mm high). Table 1 shows the detailed parameters of the antenna.

3. Results and discussion

A prototype of the proposed broadband antenna is fabricated and tested. Figure 2 shows the return losses of the simulation and measurement. The cross-line is the simulated result of the return loss of the L-shaped monopole only. This monopole operates at the upper band of WLAN. Adding reactive loading excites a broad operating band at 2.35 – 4.20 GHz. Solid and dotted lines in Fig. 2
are the simulation and measurement results, respectively. Simulation and measurement results were consistent in all bands except 2.8 – 4.2 GHz, in which the actual return loss was better than the simulated return loss since the SMA connector is added in an actual implementation. The measured 10 dB bandwidth of return loss reached 1.85 GHz (2.35 – 4.20 GHz) and 1.37 GHz (5.11 – 6.47 GHz) respectively, and covered both WLAN bands (2.4/5.2/5.8) and WiMAX bands (2.5/3.5/5.8). Figure 3 shows the measured peak gain and efficiency as a function of frequency. Efficiencies at all operating band are above 55%. The radiation characteristics were also investigated. Figures 4a, b and c plot the measurement patterns in two cuts (x – y plane, y – z plane) at 2.5, 3.5, and 5.5 GHz.

4. Conclusion

A broadband compact CPW-fed antenna with a reactive metamaterial-inspired loading is proposed for WLAN/WiMAX applications. The L-shaped antenna exhibits the upper WLAN band and the metamaterial-inspired reactive loading creates a broad operating band, which covers the lower WLAN band and WiMAX band, successfully. The measurement results show very good gain and broad impedance bandwidth. The bandwidths of the proposed antenna are 1.85 GHz (2.35 – 4.20 GHz) and 1.37 GHz (5.11 – 6.47 GHz), and provide sufficient coverage for WLAN band (2.4/5.2/5.8) and WiMAX band (2.5/3.5/5.5).

Acknowledgments

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Table 1 Detailed dimensions of proposed antenna

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Fig. 1 Geometry of propose antenna
Fig. 2 Simulated and measured return losses as a function of frequency

Fig 3. Measured gains and efficiencies

(a) x—y plane

y—z plane
Fig. 4 Measured radiation patterns of proposed antenna (a) 2.5GHz (b) 3.5GHz (c) 5.5GHz

References


