Compact Multiband Omni-Directional Printed Antennas

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Abstract—This article presents a design of a printed antenna with simply shaped radiator element for multi-operating bands of the wireless communication systems. With a simple design configuration including different U shapes on a printed FR4 substrate, the proposed antennas covering the GPS (1575 MHz), Mobile-WiMAX (3400–3600 MHz) and 5 GHz WLAN (5150–5350/5725–5825 MHz) bands. Several properties of the proposed antennas in multiband operation, such as radiation pattern and measured return loss are numerically and experimentally investigated.

Index Terms—Multiband, printed antennas, wireless communication.

I. INTRODUCTION

MULTIBAND operations of wireless communications systems have developed rapidly, increasing the need for low-profile, low-cost, multiband antennas for mobile terminals. Many antennas with broadband and multiband functionality, including inverted-F antennas, monopole antennas, planar antennas and slot antennas, have been described in recent years [1]–[7]. Printed antennas with moderate radiating characteristics can be operated at multiple frequency bands. They support dual-band operation in the wireless local area network (WLAN) communication systems [1]–[3]. The printed antennas presented in this work have a simple configuration and slot form. It is applied for use in GPS (1575 MHz), Mobile-WiMAX (3400–3600 MHz) and 5-GHz WLAN (5150–5350/5725–5825 MHz) applications.

II. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed printed antenna with a double-layered metallic structure for multiband applications. It is printed on a 1.5-mm-thick FR4 substrate with a relative permittivity of 4.4 and dimensions $45 \times 15 \text{ mm}^2$. The design includes a U-shaped ground plane. A feed microstrip line is matched in both sides using $\lambda/4$ transformers. The optimal dimensions of proposed antennas are $W_f = 2.8 \text{ mm}$, $W_m = 1.7 \text{ mm}$, $W_p1 = 2 \text{ mm}$, $W_p2 = 15 \text{ mm}$, $W_s = 1 \text{ mm}$, $W_s1 = 4 \text{ mm}$, $W_s2 = 2 \text{ mm}$, $L_f = 5 \text{ mm}$, $L_m = 22 \text{ mm}$, $L_p1 = 7.2 \text{ mm}$, $L_p2 = 6.6 \text{ mm}$, $L_s = 0.5 \text{ mm}$, $L_s1 = 2.2 \text{ mm}$, $L_s2 = 4.7 \text{ mm}$, $L_{strip} = 6 \text{ mm}$, $L_{strip1} = 1.5 \text{ mm}$, $L_{strip2} = 4 \text{ mm}$, $W_{strip} = 1 \text{ mm}$, $W_{strip1} = 4 \text{ mm}$, $W_{strip2} = 2 \text{ mm}$, For the ground $W_g = 15 \text{ mm}$, $W_{g1} = 3 \text{ mm}$, $W_{g2} = 4.5 \text{ mm}$, $L_g = 13.1 \text{ mm}$, $L_{g1} = 11.9 \text{ mm}$, $L_{g2} = 0.5 \text{ mm}$, For the U-shape $W_u = 2.3 \text{ mm}$, $W_u1 = 1.7 \text{ mm}$, $L_u = 6 \text{ mm}$, $L_{u1} = 8 \text{ mm}$ and $T = 5 \text{ mm}$. The dimensions of the antennas are determined using Ansoft HFSS simulation electromagnetic software, and then verified experimentally. The designs with and without the U-shaped are investigated and the effect of the U-shape dimensions are discussed.

III. RESULTS AND DISCUSSIONS

For antenna 1, when changing $L_{strip}$ the cutoff at the upper frequency is shifted from the required band as shown in figure 5, similar effect when changing $W_{strip}$ as shown in figure 6. Figure 7 shows the simulated and measured return loss of the proposed printed antenna with simple and low profile structure for GPS, WLAN at around 1575 MHz and 5-GHz WLAN (5150–5350/5725–5825 MHz) after optimizing the previous dimensions for achieving the required bands.
After inserting the U-shape shown in figure 2, Mobile-WiMAX (3400–3600 MHz) is added to the GPS application. When minimizing Wu to 0.3 mm, the required band for WiMAX was lost. At Wu = 1.3 mm the antenna has selective return loss for DCS1800 (1710-1880) MHz, PCS1900 (1880-1900) and UMTS (1920-2170) as shown in figure 8. Similarly changing Wu1 and T dimensions, the same results are achieved as shown in figure 9 and 10. Figure 11 shows the simulated and measured return loss of the modified printed antenna.
The antenna designs are symmetrical for the sake of achieving far field omni-directional patterns in the required bands as shown in figures 12. The solid line presents the co-radiation and the dashed line presents cross-radiation.

IV. CONCLUSION

Printed antennas were developed for multiband operation. Experimental results demonstrate that the simple design with the U-shaped ground plane are in a good agreement with the simulated results and with the appropriate tuning of dimensions, the appropriate operating bandwidth, measured return loss and radiation patterns for GPS (1575 MHz), Mobile-WiMAX (3400–3600 MHz) and 5-GHz WLAN (5150–5350/5725–5825 MHz) applications are presented.

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REFERENCES


