Design of Dual-Band Antenna for WLAN/UWB Applications

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1. Introduction

Ultra Wideband (UWB) is short distance radio communication technology that can do high speed communication with the speed more than 100 Mbps in 3 – 10 GHz frequency band [1]. The UWB systems can be divided into two categories: direct sequence UWB (DS-UWB) and multiband orthogonal frequency division multiplexing (MB-OFDM). The DS-UWB proposal foresees two different carrier frequencies at 4.104 (low band: 3.1 to 5.15 GHz) and 8.208 GHz (high band: 5.825 to 10.6 GHz). Especially, DS-UWB using low band has been developed as its first generation devices. By the MB-OFDM format in 802.15.3a, the interval between 3.1 and 10.6 GHz is divided into 14 sub-intervals. Each sub-interval corresponds to one band of the MB-OFDM, with the bandwidth of 528 MHz [2, 3]. The MB-OFDM transceiver uses the low three bands (centered at 3432, 3960, and 4488 MHz) as a mandatory mode. The UWB antenna for portable systems requires an omni-directional radiation pattern, ultra-wideband, small size, flat gain and linear phase, and low-cost. Recently, many researchers have developed UWB antennas operating in the full UWB frequency band such as UWB patch antenna [4, 5], planar diamond antenna [6], two-step tapered monopole antenna [7]. The market demand for mobile phones has driven the handset antenna to be compact in size and have multi-band functions. Mobile phones require the capability to include the 2.45 GHz WLAN band.

In this paper, we have proposed a dual-band antenna with U-shaped open stub for WLAN/UWB applications. The target frequency bands are 2.45 GHz WLAN and 3.1 - 5.2 GHz DS-UWB low band or MB-OFDM lower three bands. The designed dual-band antenna consists of two semi-circle radiating patches, a rectangular slot separating the two semi-circles, one step for impedance matching, and CPW feeding. Ansoft high frequency structure simulator (HFSS) [8] is used to simulate the proposed antennas. The measured results of the fabricated prototypes will be given and compared with the simulated results. The measured results show that the proposed antenna can cover the MB-OFDM lower three bands (3.1 to 4.8 GHz) and WLAN band. The designed antenna has non-directional pattern in the horizontal plane and directional pattern in the vertical plane. The variation of the group delay is less than 1 ns and the insertion loss is almost constant across the operating frequency band.

2. Antenna Design and Simulated/Measured Results

Figure 1 shows the geometry of the proposed WLAN/UWB antenna. In this design, we have used the FR-4 substrate having the thickness of 0.8 mm and the permittivity of 4.5 and the antenna was fed by coplanar waveguide (CPW). The size of the substrate is 40 x 35 mm^2. The two radiating patches to obtain the ultra-wideband are semi-circle of radius R. To design the proposed antenna, we have used three techniques: two semi-circle radiating patches, a rectangular slot separating the two semi-circles, and one step for impedance matching. From the simulations, if the two semi-circles are not symmetrical with respect to the CPW feed line, the group delay variation is large and results in a considerable dispersion over the operating frequency band. A rectangular slot and one step connecting the feed line and the two semi-circle radiating patches are used for fine tuning of the impedance bandwidth. To achieve a dual-band operation for WLAN/UWB applications, we have inserted a U-shaped open stub into the rectangular slot. The optimal design parameters are W = 7 mm, L = 13 mm, R = 8.5 mm, G_W = 13 mm, G_L = 9 mm, and d = 1.5 mm, L_S = 22 mm, R_S = 11 mm, W_U = 6 mm, L_U = 22.5 mm, L_{U2} = 13 mm, L_{U3} = 3 mm, L_{U4} = 13.5 mm, L_W = 1 mm, g = 0.5 mm. The simulation was carried out by Ansoft high frequency structure simulator (HFSS) [8].

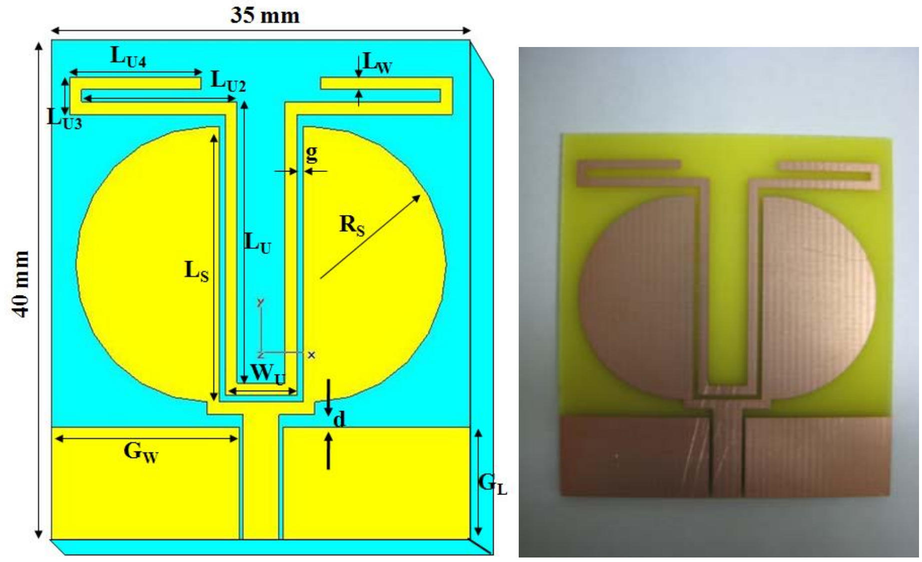


Fig. 1. Dual-band antenna with U-shaped open stub: (a) antenna geometry, (b) photograph.

The proposed dual-band antenna was constructed and studied. The dual-band antenna was measured using an Anritsu Vector Network Analyzer (37397C) in an anechoic chamber. Figure 2 shows the simulated and measured return losses of the dual-band antenna with U-shaped open stub.

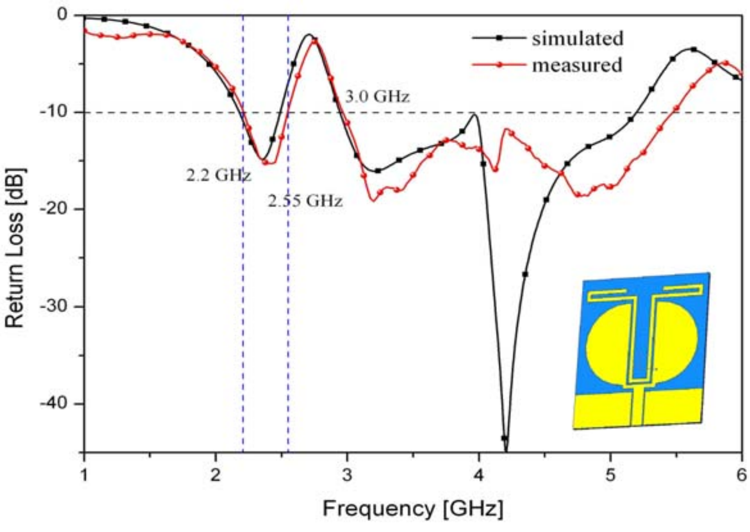
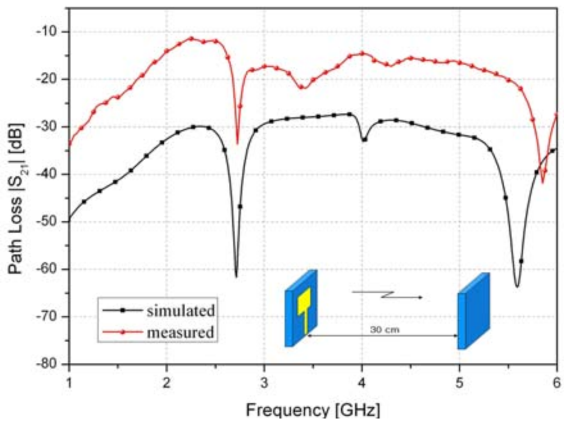
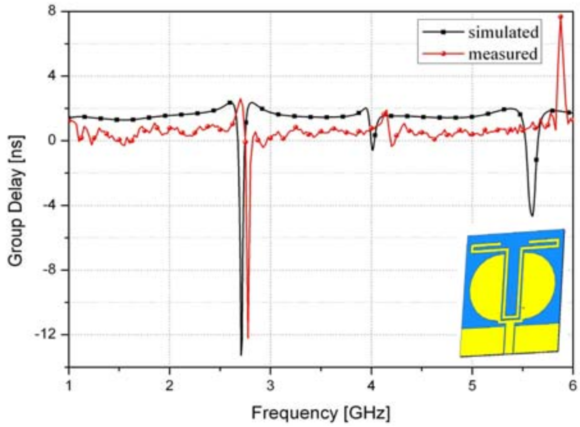


Fig. 2. Measured and simulated return losses of the proposed antenna

The measured results agree well with the simulated results. The impedance bandwidth of the WLAN and the DS-UWB low bands are 0.35 GHz (2.2–2.55GHz) and 2.6 GHz (3.0–5.6GHz), respectively. Figure 3(a) shows the simulated and measured path losses of the dual-band antenna with the U-shaped open stub. In this figure we can show that the path loss is almost constant in the DS-UWB low band. There are some discrepancies between the simulated and measured results. This is mainly due to the cable loss and the environmental effect.



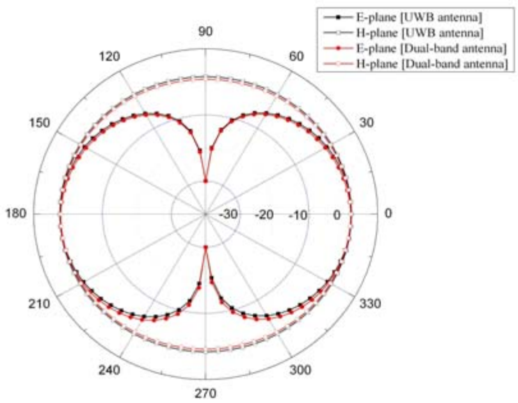
(a)



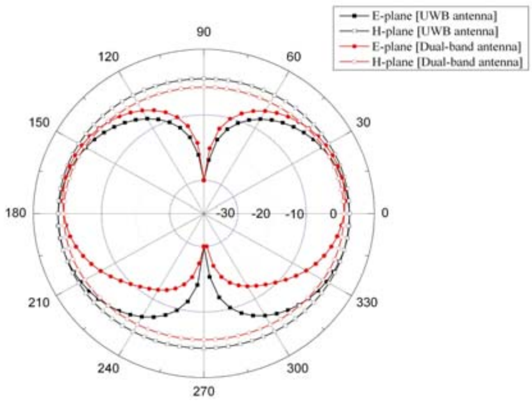
(b)

Fig. 3. Dispersion properties of the dual-band antenna with U-shaped open stub: (a) path loss, (b) group delay.

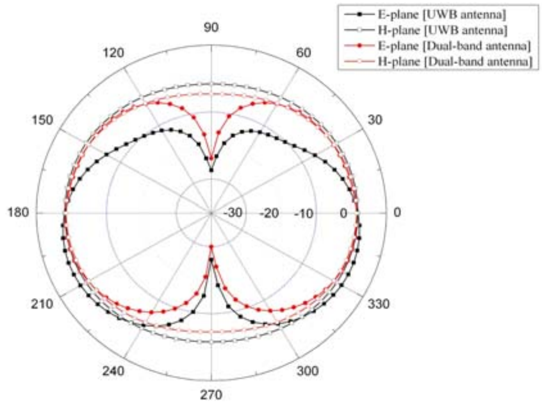
Figure 3(b) shows the simulated and measured group delays when the transmitting and receiving dual-band antennas were separated by 30 cm. From the figure it can be seen that the variation of group delay is less than 1 ns in the DS-UWB low band except near 4 GHz frequency. From the result, we can expect that the pulse communication will be possible with low distortion.



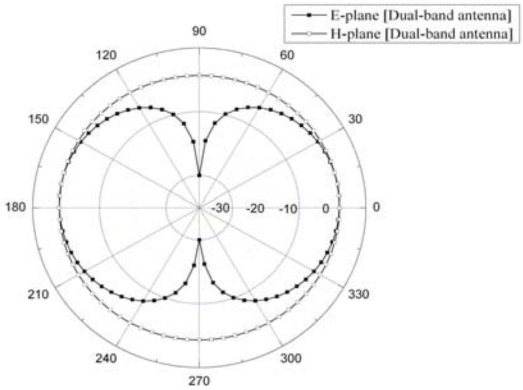
(a)



(b)



(c)



(d)

Fig. 4. Simulated radiation patterns at: (a) 3 GHz, (b) 4 GHz, (c) 5 GHz, (d) 2.45 GHz.

Figure 4 shows the simulated radiation patterns at 3, 4, 5, and 2.45 GHz. The radiation patterns are similar with those of dipole antenna in the E-plane and omni-directional in the H-plane. From the figure, it can be seen that the radiation patterns are very stable over the operating frequency band.

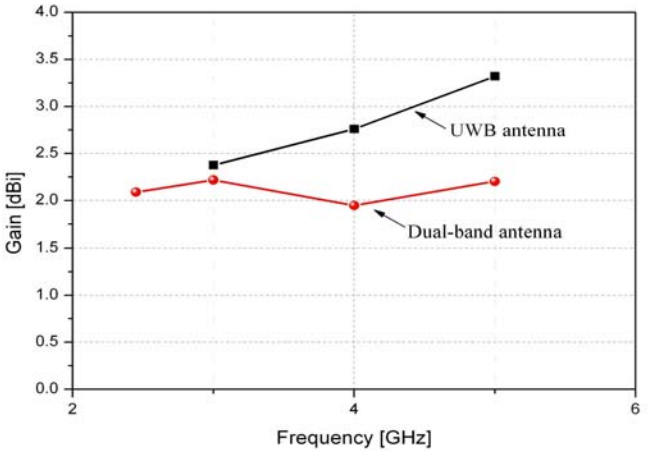


Fig. 5. Simulated antenna gain versus frequency.

Figure 5 shows the simulated antenna gain. From this figure, we can show that the gain of dual-band antenna with U-shaped open stub is smaller than the proposed UWB antenna. But the proposed dual-band antenna with U-shaped open stub shows a good dual-band characteristic.

3. Conclusion

A novel dual-band antenna has been designed, fabricated, and characterized for WLAN/UWB dual-band operation. To design the dual-band antenna for WLAN/UWB applications, first, we have designed the UWB antenna with two symmetrical semi-circles and second, the dual-band antenna with U-shaped open stub operating in the WLAN/UWB dual band. The good characteristics for UWB antenna have been achieved in the impedance matching, path loss, group delay, and gain variation. The radiation patterns are similar with those of dipole antenna in the E-plane and omni-directional in the H-plane.

Acknowledgments

This work was supported by the second stage of BK21.

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