A Compact UWB MIMO Antenna with Enhanced Isolation for WBAN Applications

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***Abstract* – In this paper, a compact UWB MIMO antenna with enhanced isolation for WBAN applications is proposed. The proposed antenna consists of two folded antenna elements, a ground plane, and a T-shaped isolator. The overall dimension is 26 mm × 26 mm × 5 mm. In order to enhance the isolation between the two antenna elements (S_{21}), the T-shaped isolator is placed between antenna elements. Simulated results show that the proposed antenna on a human equivalent phantom has the 10-dB return loss bandwidth of 5.8 GHz ranging from 3.0 to 8.8 GHz, the isolation of less than -12 dB and ECC of less than 0.1 within the operating frequency band. The antenna provides the pattern diversity in H-plane, which can improve the performance of the antenna diversity.**

***Index Terms* — Wireless body area network (WBAN), ultra-wideband (UWB), antenna diversity, MIMO, isolation.**

I. INTRODUCTION

In recent years, many researches have paid great attention to wireless body area network (WBAN) systems for various applications. WBAN is an integration of low-power, miniaturized and lightweight wireless devices in, on, or around a human body [1]. The research of WBAN antenna has a number of challenges because of a small size, a multipath fading problem and low specific absorption rate (SAR) standard [2].

Ultra-wideband (UWB) has been attracted for WBAN applications because the UWB system emanates low radiated power and consumes low-power. A frequency band of UWB is classified into two parts; low band (3.24 – 4.74 GHz) and high band (6.24 – 10.23 GHz) [2]. To realize UWB antennas for WBAN applications, textile antennas, directional antenna, and tapered monopole antenna were studied in [3]-[5]. However, the performances of these antennas are affected seriously by the multipath fading due to the human body parts and movements. MIMO technique is one of promising diversity techniques to mitigate the multipath fading effect [6]-[9]. However, the mutual coupling between antenna elements forming MIMO system can deteriorate the radiation performance including radiation efficiency [8] especially when the antenna elements need to be placed within a small volume. In evaluating the performance of a MIMO antenna, the isolation and envelope correlation coefficient (ECC) are the two key factors. In particular, the ECC between two antenna elements is very important parameter because it is directly related with the spectral efficiency and determines the performance degradation of whole MIMO system [7].

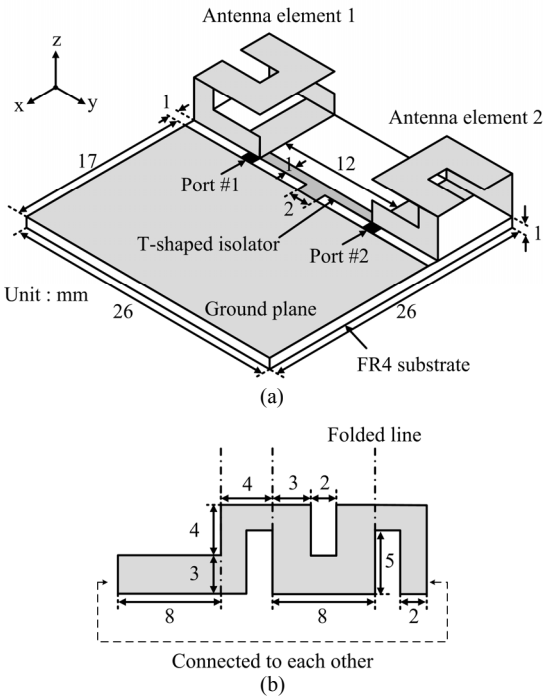


Fig. 1. Proposed antenna structure:
(a) Geometry of the proposed antenna, (b) Single antenna element

In this paper, a compact UWB MIMO antenna with enhanced isolation for WBAN applications over UWB frequency band (3.0 – 8.8 GHz) is proposed. The 10-dB return loss bandwidth of this antenna is enough to cover the UWB low band.

II. ANTENNA DESIGN AND SIMULATION RESULTS

The geometry of the proposed antenna is shown in Fig. 1. The proposed antenna is comprised of two folded antenna elements, a T-shaped isolator, and a ground plane. A FR4 substrate with a relative permittivity (ε_r) of 4.4 and a thickness of 1 mm is used. The overall size of the substrate is 26 mm × 26 mm. Two folded antenna elements are placed symmetrically on the top side of substrate. A distance between two antennas is 12 mm. Each antenna element is directly fed by a 50 Ω coaxial cable. The dimension of the T-shaped isolator is 12 mm × 3 mm. The isolator is connected to each antenna element and the ground plane.

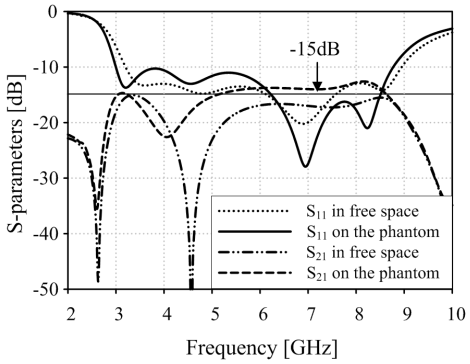
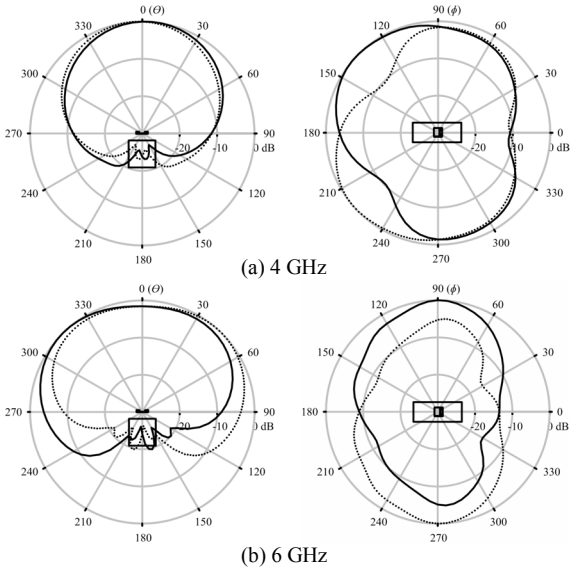


Fig. 2. S-parameter characteristics of the proposed antenna on the phantom and in free space



(a) 4 GHz

(b) 6 GHz

Fig. 3. Simulated radiation patterns in E-plane(left) and H-plane(right) (——— port #1 excited, ····· port #2 excited)

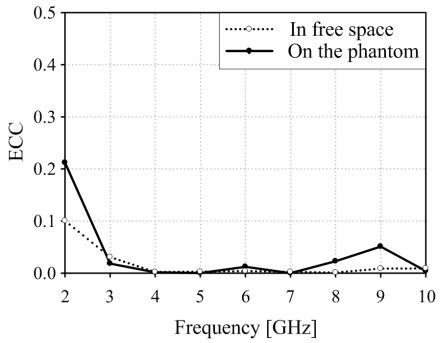


Fig. 4. Envelope correlation coefficient (ECC)

Fig. 2 shows the simulated s-parameters when the antenna is placed in free space and on a human equivalent flat phantom. The human equivalent flat phantom has the electrical property of human body [10]. The dimension of the phantom is 150 mm × 60 mm × 60 mm. The distance between the antenna and the phantom is 15 mm. In free space, the simulated result shows that the 10-dB return loss bandwidth is 5.7 GHz ranging from 3.2 to 8.9 GHz. The isolation (S_{21}) is less than -15 dB over the operating frequency band. On the phantom, the 10-dB return loss bandwidth is 5.8 GHz ranging from 3.0 to 8.8 GHz. The isolation (S_{21}) is less than -12 dB over the operating frequency band of antenna. The operating frequency band shifted slightly toward a lower frequency side due to the phantom effect.

Fig. 3 shows the radiation patterns in the E-plane and H-plane at 4 GHz and 6 GHz. The proposed antenna has outward directional radiation patterns away from the flat phantom. In the H-plane, the main beam direction of each antenna element is almost opposite to each other. This property is desirable to improve both isolation and ECC performance of MIMO antenna.

The ECC ρ_e of the proposed antenna is shown in Fig. 4. The ECC is calculated using the 3D radiation patterns. The ECC is below 0.1 over the operating frequency band when the antenna is placed on the flat phantom and in free space.

III. Conclusions

In this paper, a compact UWB MIMO antenna with enhanced isolation for WBAN applications is proposed. The proposed antenna has the 10-dB return loss bandwidth of 5.5 GHz ranging from 3.0 to 8.8 GHz on the human equivalent flat phantom. The isolation between the antenna elements is less than -12 dB over the operating frequency band. The pattern diversity property of the proposed antenna improves the overall antenna performance. All results indicate that the proposed UWB MIMO antenna is a good candidate for WBAN applications.

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