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Research Article

Small-Size Meandered Loop Antenna for WLAN Dongle Devices

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This paper proposes a loop-type USB dongle antenna, which is fabricated on a 1.6 mm thick FR-4 substrate for WLAN band systems. The front side of substrate consists of a 50-ohm coaxial line and a multiarm monopole antenna, while the back side has a meandered loop antenna connected to the ground by two via holes. The meandered loop resonates half-wavelength mode at about 2.4 GHz and its higher modes. The higher modes excited by the multiarm monopole form the 5.2 GHz frequency band. The bandwidth of the antenna covers the IEEE802.11 a/b/g WLAN applications. The overall dimensions of the antenna of $30 \times 13.75 \times 1.6\,\text{mm}^3$ with an antenna area of $7.5 \times 13.75\,\text{mm}^2$ and a planar structure are exactly suitable for applying in dongle devices. The measured results of radiation patterns, antenna gain, and radiation efficiency are also proposed and discussed in the paper.

1. Introduction

In recent years, wireless communication systems have been rapidly developed for mobile phone, GPS, RFID, and WLAN applications [1]. One important feature for wireless devices is being portable that attracts consumers' interests for its convenience. Among the wireless systems, WLAN USB dongle used in the internet and Wi-Fi system is the most convenient device for its smallest dimensions. In practice, IEEE 802.11 standards for WLAN consist of 2.4 GHz (2.4–2.484 GHz) 5.2 GHz (5.15–5.35 GHz) frequency bands; therefore, the antenna used in WLAN devices needs to cover these frequency bands. Many small printed antennas have been proposed for WLAN USB dongle. In the published articles [2–5], the width of antennas are 10 mm and these antennas are for 2.4~5.35 GHz application. In this design, a width of 13.75 mm loop antenna including application bands (IEEE 802.11 a/b/g) will be proposed. Antenna portion of the antenna is minimal compared to the reference design. Small-size antenna can design specifications suitable and used in many applications and good production. Production of the original size of $30 \times 13.75 \times 1.6$ (mm^3) is suitable for small-sized USB Dongle devices.

2. Results and Discussion

The geometry of the proposed antenna is shown in Figure 1. The antenna is fabricated on an FR4 substrate with a thickness of 1.6 mm, a relative permittivity of 4.4, and a loss tangent of 0.024. And the detailed dimensions of the proposed antenna are also listed in Table 1. The overall dimension of $30 \times 13.75\,\text{mm}^2$ contains an antenna portion of $7.5 \times 13.75\,\text{mm}^2$ and a ground plane of $22.5 \times 13.75\,\text{mm}^2$. And a 50 ohm mini coaxial-line is used for RF signal input. In our design, two vias (via hold size radius 0.5 mm × height 1.6 mm) to connect the ground and back loop strip is used. By optimizing the antenna parameters, both the simulated and measured return losses meet the WLAN application bands (2.4 to 2.484 GHz, 5.15 to 5.35 GHz) as shown in Figure 2. The measured and simulated return losses have good agreements to ensure the reliability of the design. The simulated results are obtained through HFSS simulation software.

The multiline monopole and the meandered loop form a coupled-fed loop antenna structure. In antenna's lower operation bands, the meandered loop produces a half-wavelength fundamental band at 2.4 GHz. And the higher operation bands are produced by the high order modes of

Table 1: Detailed dimensions of the proposed antenna.

Parameter	L	$L1$	$L2$	$L3$	$L4$	$L5$	$L6$	$L7$	$L8$	$L9$	$L10$	$L11$	$L12$	$L13$	$L14$	W	$W1$	$W2$	$W3$
Unit (mm)	30	22.5	4.95	1.3	1.2	2.9	1.7	2.5	8.6	9	6.5	4.1	3.3	3.9	2.5	13.75	1	2	1

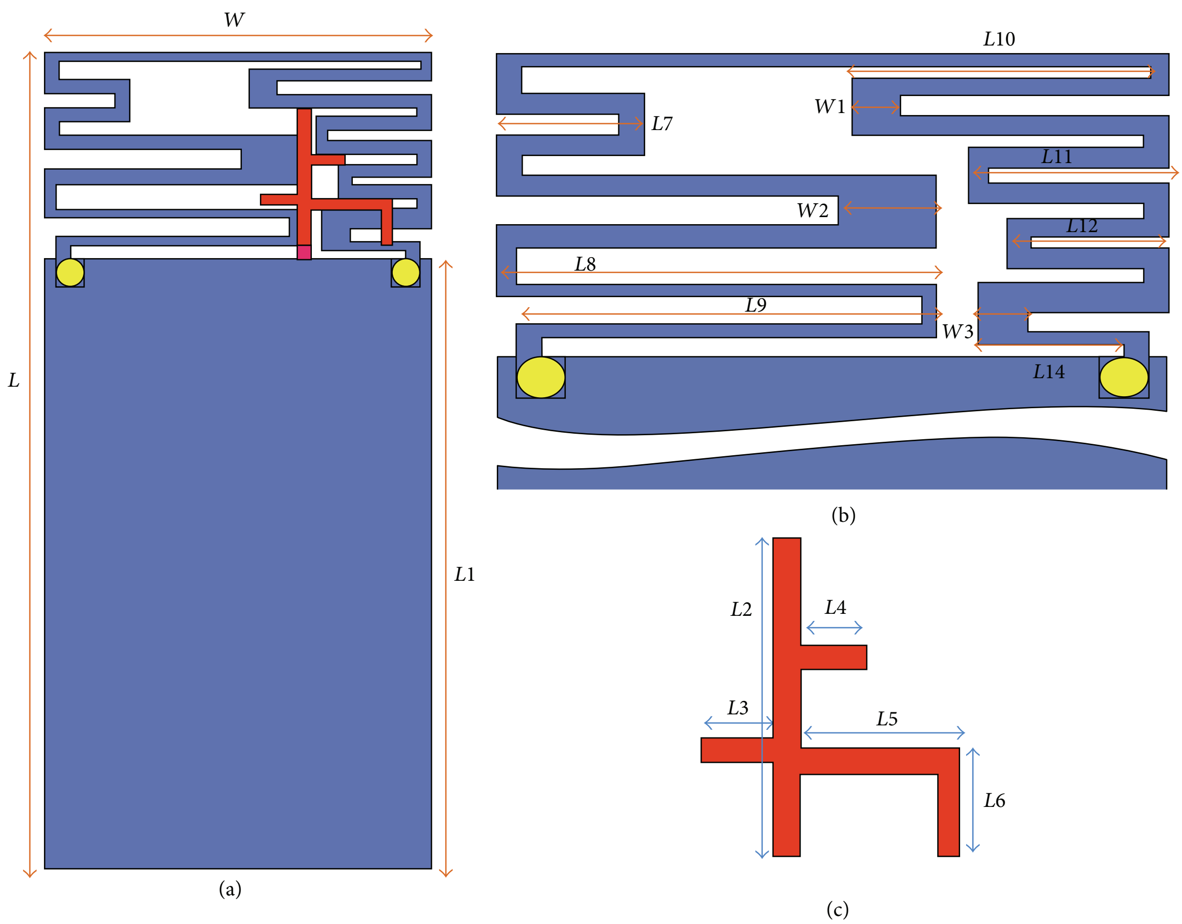


Figure 1: (a) Overall antenna; (b) on the back loop structure; (c) the multiline monopole; (d) antenna specification.

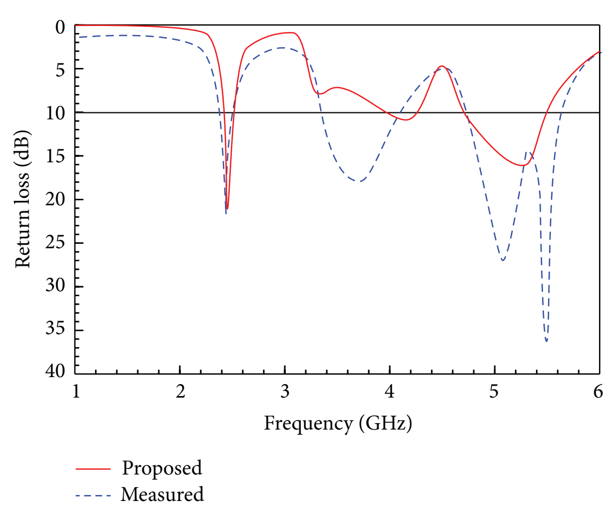


Figure 2: Simulated and measured return losses of the proposed antenna.

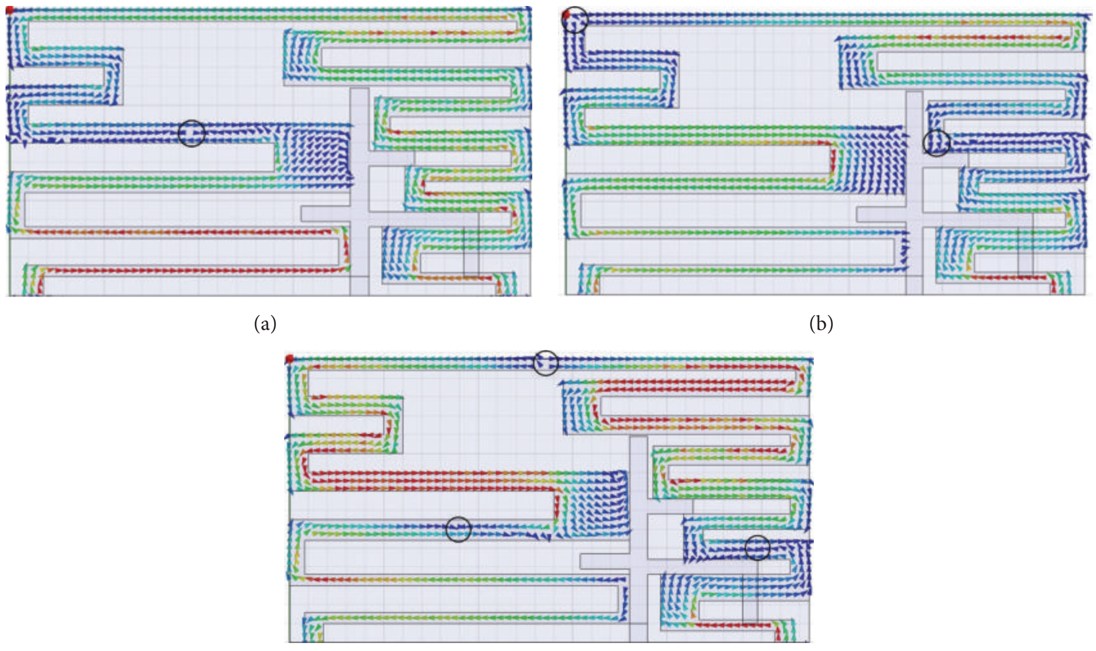


Figure 3: Simulated surface current distribution on the proposed antenna's (a) 2.45 GHz, (b) 4.13 GHz, and (c) 5.25 GHz.

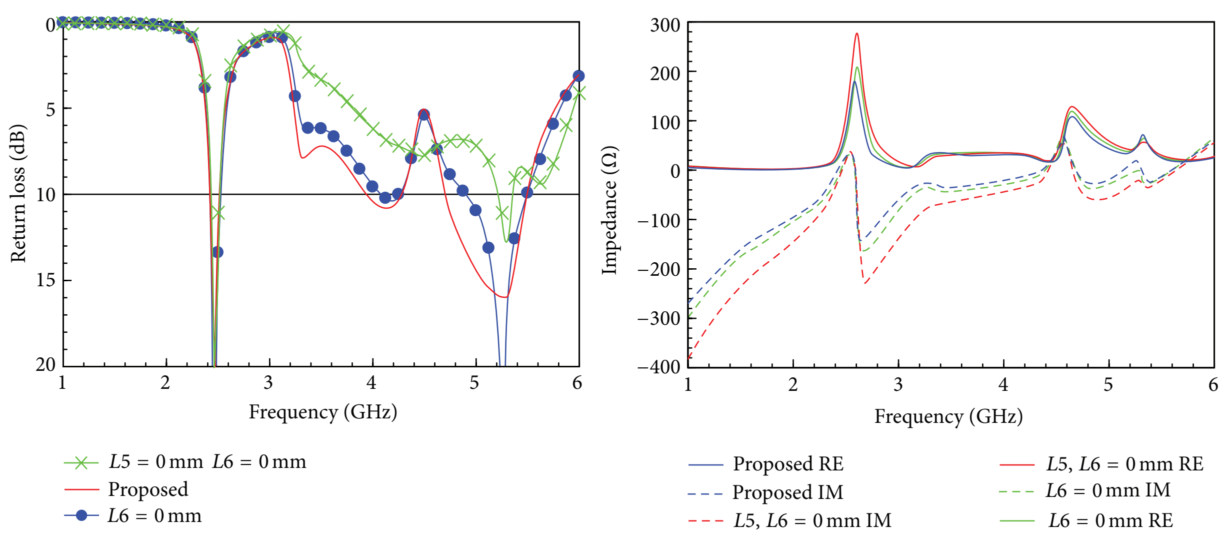


Figure 4: Simulated return losses and impedance of the proposed antenna with and without L5 and L6.

the loop. The simulated current distribution of the antenna at (a) 2.45 GHz, (b) 4.13 GHz, (c) 5.25 GHz is shown in Figure 3. From the figures shown in Figure 3, It is indicated that the loop produces 0.5, 1, and 1.5λ modes (at 2.45, 4.14, and 5.25 GHz).

Some parametric study of the antenna is also investigated in this paragraph. Figure 4 shows the simulated return losses and the impedance of the proposed antenna with and without L5 and L6. When without L5 and L6, the higher mode's impedance is not matched. Figure 5 shows the simulated return losses and the impedance of the proposed antenna with different lengths of L8 and L9. When the length of L9 is decreased, the proposed antenna excites lower mode at 2.4 GHz to increase bandwidth of low operation band. Figure 6 shows the simulated return losses and the impedance of the proposed antenna with different lengths of L10. When the length of L10 equals 6.5 mm, the two higher modes generate the best impedance matching in Figure 6. Figure 7 shows the simulated return losses and the impedance of the proposed antenna with different lengths of W2. We can find

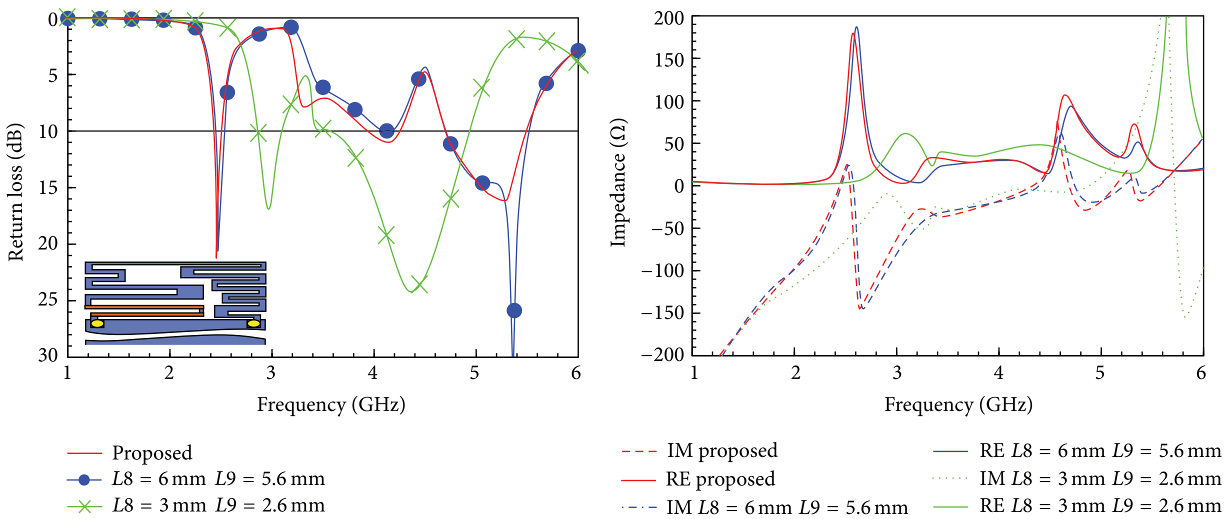


FIGURE 5: Simulated return losses and impedance of the proposed antenna for different lengths of L8 and L9.

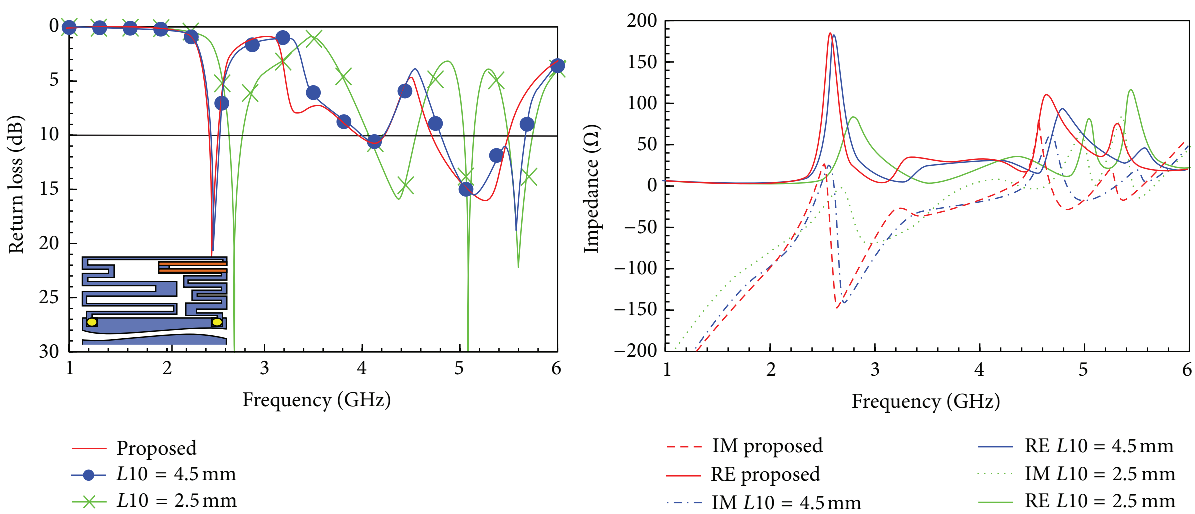


FIGURE 6: Simulated return losses and impedance of the proposed antenna for different lengths of L10.

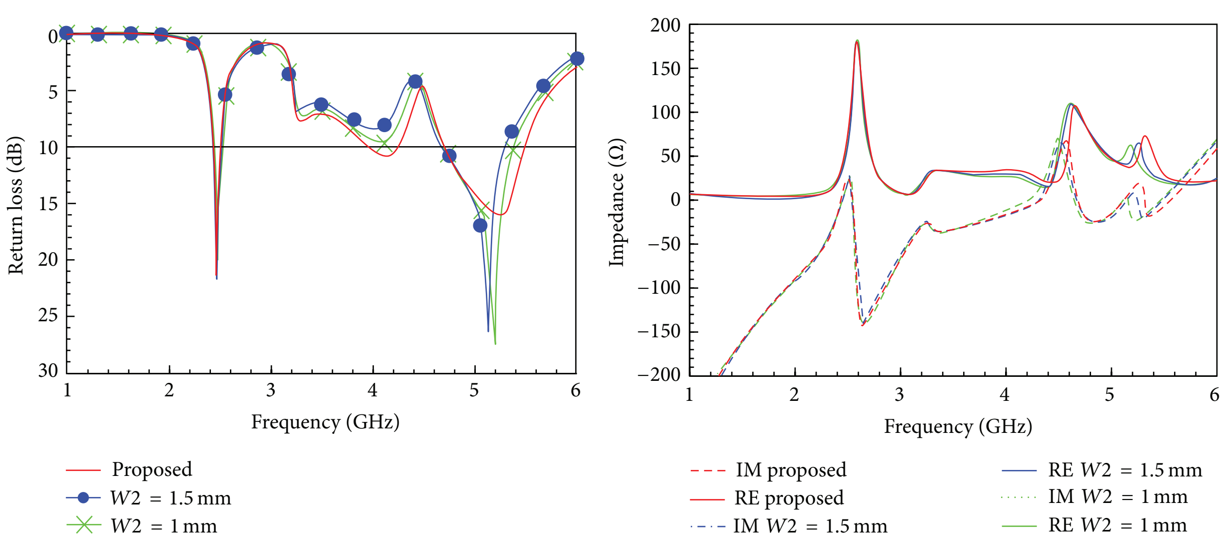


FIGURE 7: Simulated return losses and impedance of the proposed antenna for different lengths of W2.

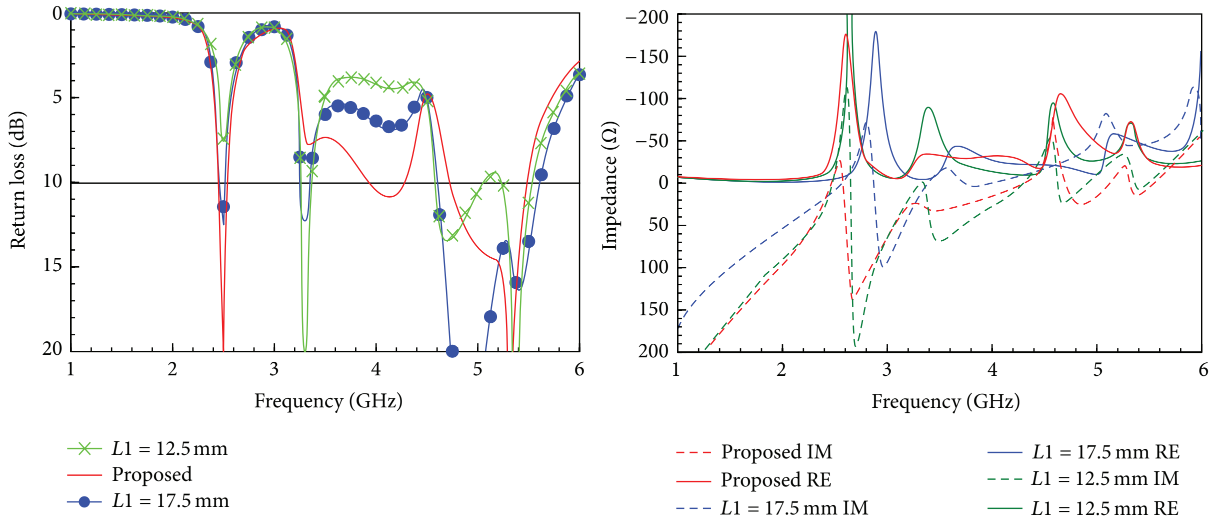


Figure 8: Simulated return losses and impedance of the proposed antenna of L1.

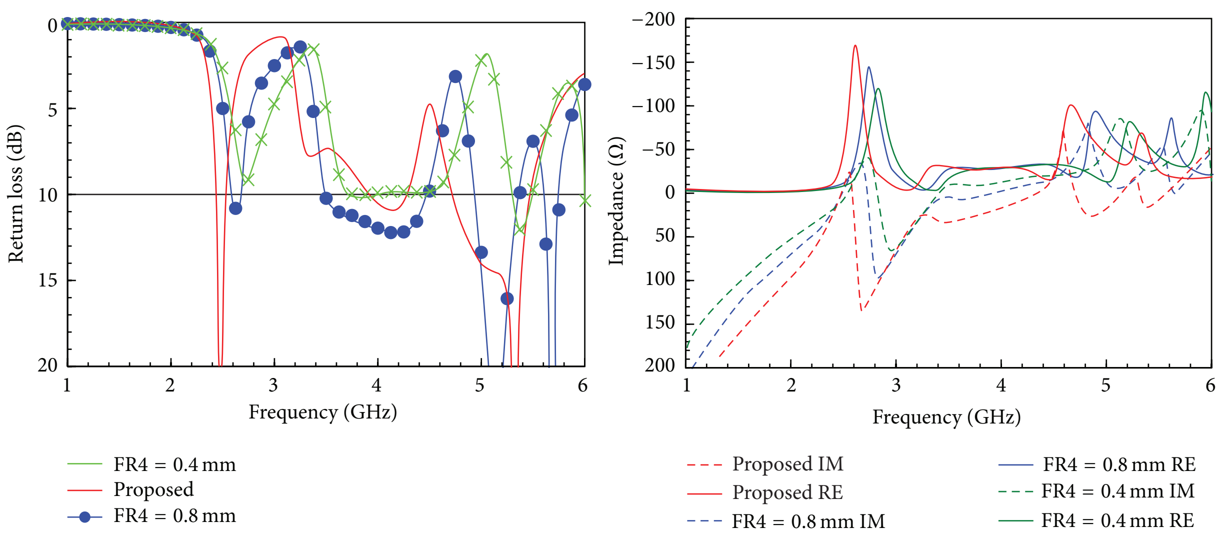


Figure 9: Simulated return losses and impedance of the proposed antenna of different thickness.

that the higher modes impedance is not matched when the length of W2 equal to 1.5 mm. Figure 8 shows the simulated return losses and the impedance of the proposed antenna with different lengths of L1. When the length of the L1 varies from 12.5 to 22.5 mm, the modes of loop are not changed too much; only the impedance changes. So we choose the system ground area length of 22.5 mm. Figure 9 shows the simulated return losses and the impedance with different thickness of the substrate of the proposed antenna. The thickness of the substrate used in 1.6 mm is most suitable for our design.

The radiation performances of an antenna are important parameters for applications. The radiation patterns and efficiency of the antenna are measured in 3D chamber at Cheng Shiu University. Figures 10(a), 10(b), and 10(c) show the measured radiation patterns at 2.4, 5.15, and 5.35 GHz. Figure 10(a) shows the radiation pattern at 2.4 GHz and the radiation pattern in *Y-Z* plane is near omnidirectional characteristic. Figure 10(b) shows the radiation patterns at 5.15 GHz and the radiation pattern in *Y-Z* plane is also near omnidirectional characteristic. Figure 10(c) shows the radiation pattern at 5.35 GHz. Figure 10 shows the measured antenna gain and efficiency of the proposed antenna. In Figure 11(a), the measured antenna gains at 2.4 to 2.5 GHz show a stable characteristic. The antenna gains are from 1.32 to 1.45 dBi with a small variation of 0.13 dBi and the radiation efficiency here is larger than 70%. Figure 11(b) shows the measured antenna gains at 5.15 to 5.35 GHz that present a stable characteristic. The antenna gains are from 2.1 to

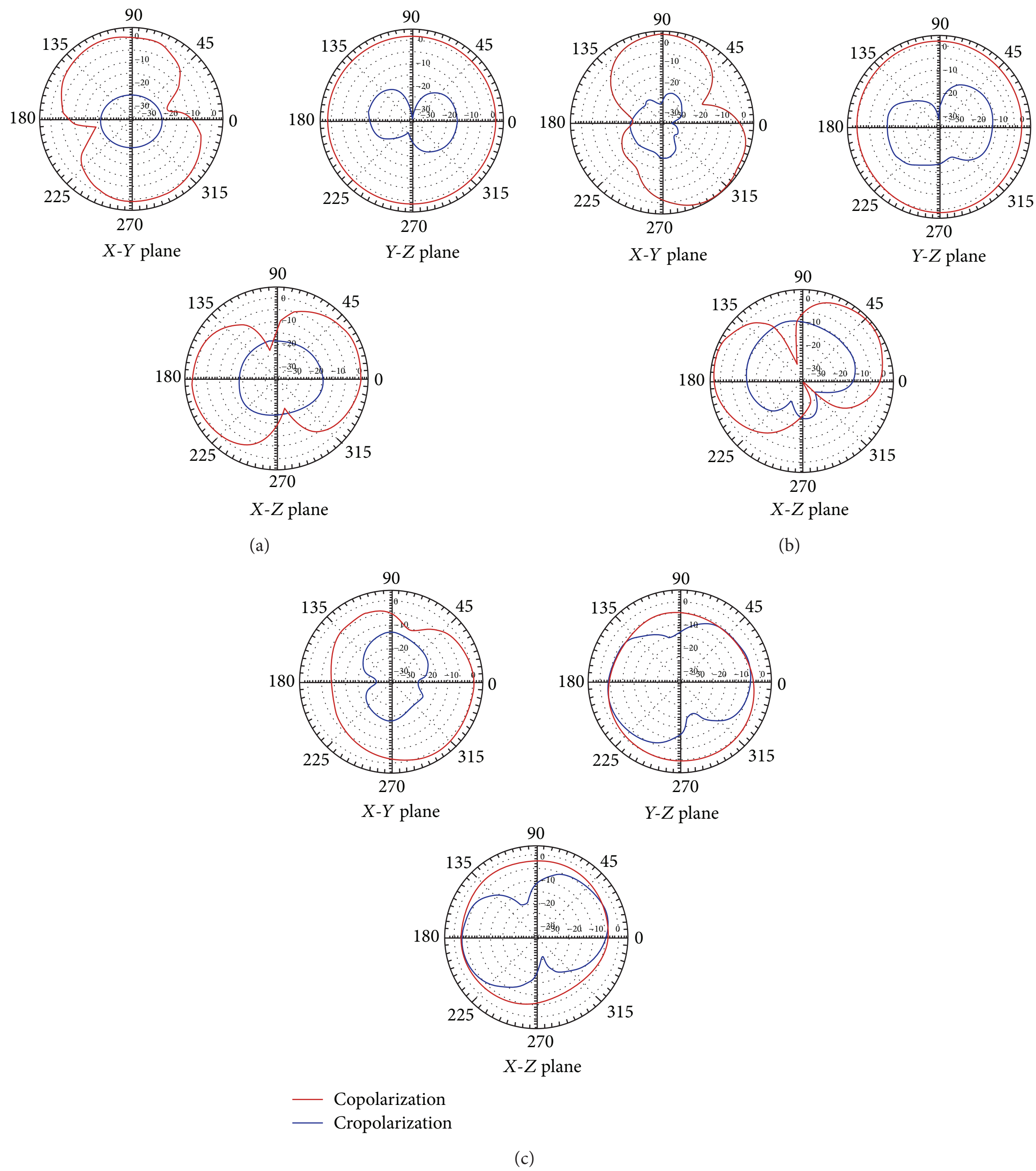


Figure 10: Measured radiation pattern of the proposed antenna at (a) 2.4 GHz (b) 5.15 GHz (c) 5.35 GHz.

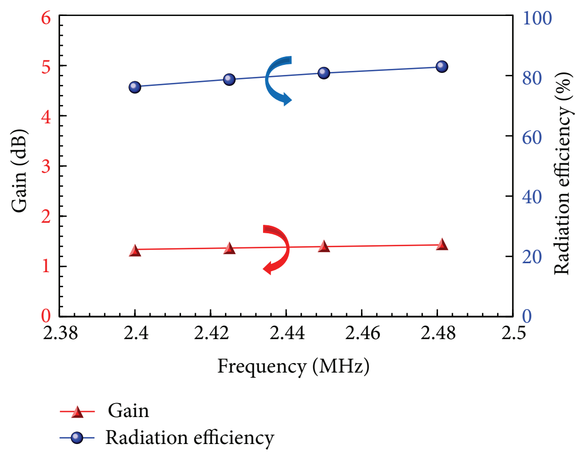
1.36 dBi with a small variation of 0.74 dBi and the radiation efficiencies from 5.15 to 5.35 GHz are all larger than 60%. The performances of the antenna are suitable for applying in portable devices with small size.

3. Conclusions

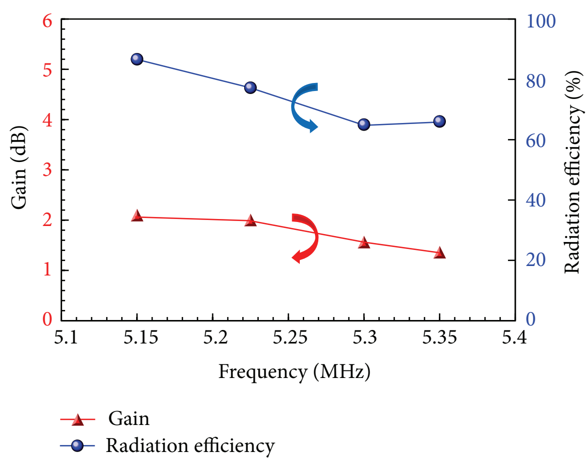
A small-size USB Dongle antenna for WLAN application has been proposed and verified. The operating frequency band is easily adjusted by changing antenna's dimensions. The measured and simulated impedance bandwidth can cover the band of 802.11 a/b/g applications. To antenna's performances, the measured radiation patterns perform an omnidirectional feature. Both antenna gains within two frequency bands are stable and good for the application of dongle devices.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.



(a)



(b)

Figure 11: Measured antenna gain and efficiency at (a) 2.4-2.5 GHz and (b) 5.15–5.35 GHz.

Acknowledgments

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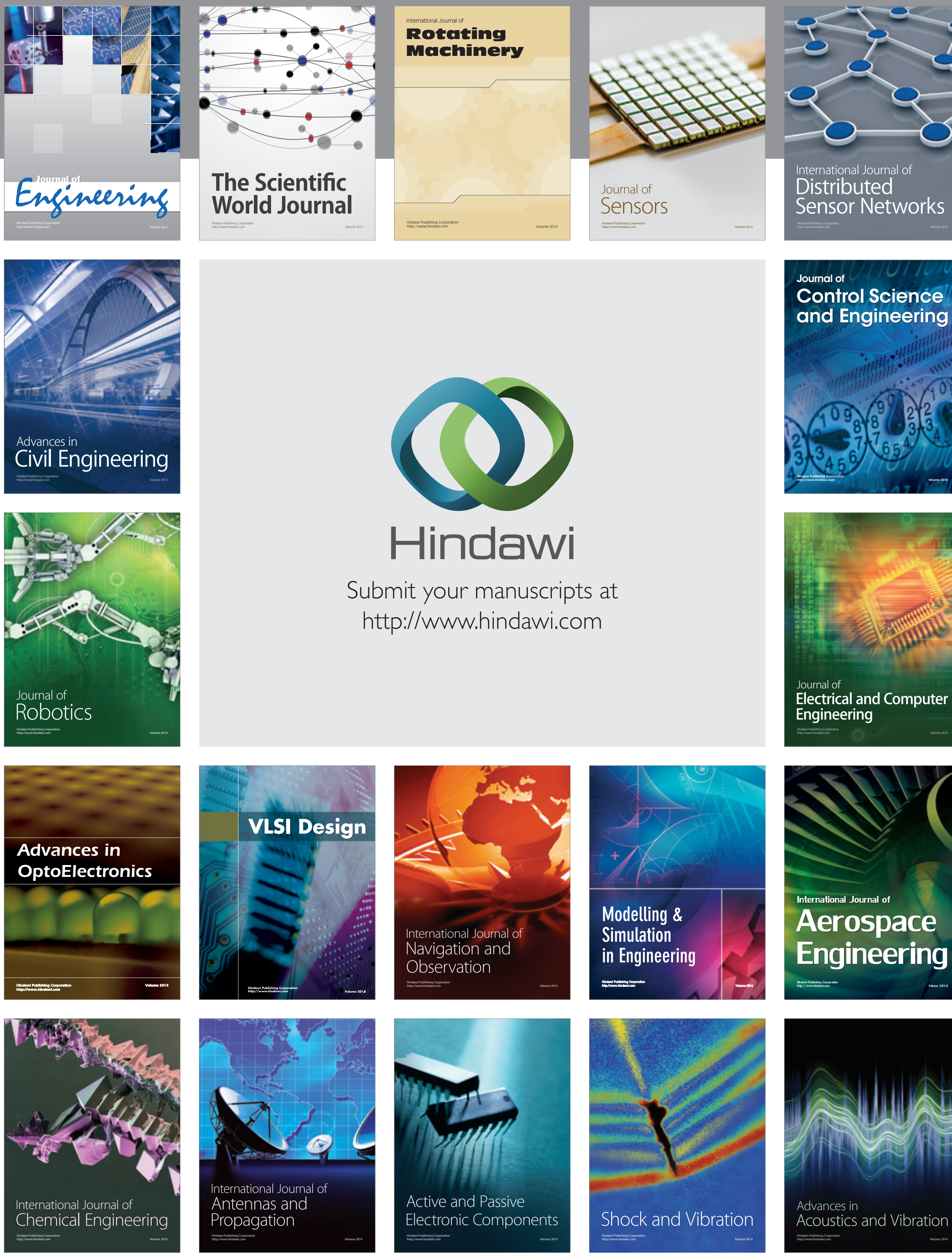

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