Miniaturized UWB Antenna using Half Printed Monopole with Ground Side Coupled Patch

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1. Introduction

Since the Federal Communications Commission (FCC) has allocated the frequency band from 3.1 GHz to 10.6 GHz for Ultra-wideband (UWB) application, UWB systems have been widely investigated because of low power and high data rate for wireless communication applications [1], [2]. An antenna can cover the whole UWB band for UWB applications. Recently, the new methods have been reported such as a half monopole scheme [3], [4] and a metamaterial (MTM) loading technique [5] for size reduction. Printed monopole antennas have been drawn to much attention due to wideband matching characteristic, omnidirectional radiation, high radiation efficiency, and compact size [3]. A coupled ground plane is loaded on the bottom of a substrate [6].

In this paper, a miniaturized UWB antenna using a half printed monopole with a ground side coupled patch is proposed. By halving the monopole antenna with loading a coupled extended ground [6] and tuning a microstrip feed line, the proposed antenna is miniaturized and covers the UWB bandwidth.

2. Antenna Design

Fig.1 shows the geometry of the proposed UWB antenna. The proposed antenna is printed on FR-4 substrate with relative permittivity of 4.4 and thickness of 0.8 mm. The dimension of the substrate is $35 \times 17\ mm^2$. The black dashed line in Fig.1 is the ground patch of the bottom plane, while the red dash dotted line is a cutting line for halving. The proposed antenna is halved from a monopole antenna with loading a coupled extended ground for size reduction. As the perfect magnetic conductor (PMC) is assumed to along the cutting line, the image theory can be applied to the halved proposed antenna. Consequently, the operation of the proposed antenna is similar to that of a monopole antenna.

The return loss of the half monopole antenna, which is the half of the full monopole antenna, is not acceptable for UWB application as shown in Fig. 2(a). In order to improve impedance match, a linearly tapered feedline is utilized and a narrow ground plane is added on the cutting side of the half monopole antenna. The added ground plane width, W_a, is 2 mm. Also the inductive thin shorting strip line width, W_s, is 0.15 mm, which is the same as the full monopole antenna. The input 50-Ω microstrip line has a width of 1.52 mm, and the narrow microstrip line width, W_t, is 0.4 mm. The parameters of the proposed antenna are listed in Table 1.

Two size reduction techniques are adapted to this proposed antenna. One is the extended coupled ground on the bottom side, which is acted like a loading MTM and improved in the low frequency characteristic [6]. The other is the halving technique using the image theory. The printed rectangular patch size of the proposed antenna is only $9 \times 6\ mm^2$.

3. Simulated and Experimental Results

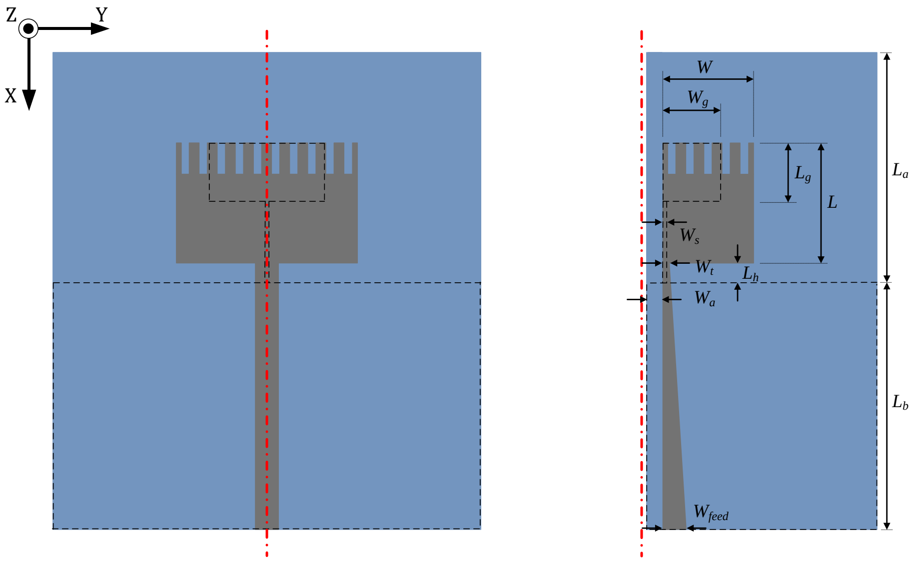
Fig. 2(a) shows the return losses of the exactly halved monopole antenna and the proposed antenna with the tapered microstrip feedline. In Fig. 2(a), the exactly halved monopole antenna doesn't cover the whole UWB band, especially at 6 GHz, 8 GHz, and 10 GHz. But, the impedance matching is enhanced at the whole UWB band with tapered-fed line. So, the proposed antenna can cover the bandwidth from 3 GHz to 11.68 GHz. Fig. 2(b) shows the comparison between the simulated and measured return losses of the proposed antenna. Results of simulation and measurement satisfy the UWB bandwidth.

The measured radiation patterns of the proposed antenna are shown in Fig. 3. The yz-plane radiation patterns are omnidirectional, as expected, over the whole UWB bandwidth. The xz-plane radiation patterns are similar to those of a monopole antenna. The patterns in the xy-plane are asymmetric due to the antenna geometry.

The calculated peak gain of the proposed antenna is shown in Fig. 4. The gain is about 3.3 dBi in the whole operating UWB band. Although the proposed antenna is halved and miniaturized, the proposed antenna gain is not one-half of the full monopole antenna one. The minimum peak gain is 1.95 dBi at 3 GHz and the maximum peak gain is 4.46 dBi at 11 GHz. Fig. 5 shows the photos of the top and bottom views of the fabricated proposed antenna.

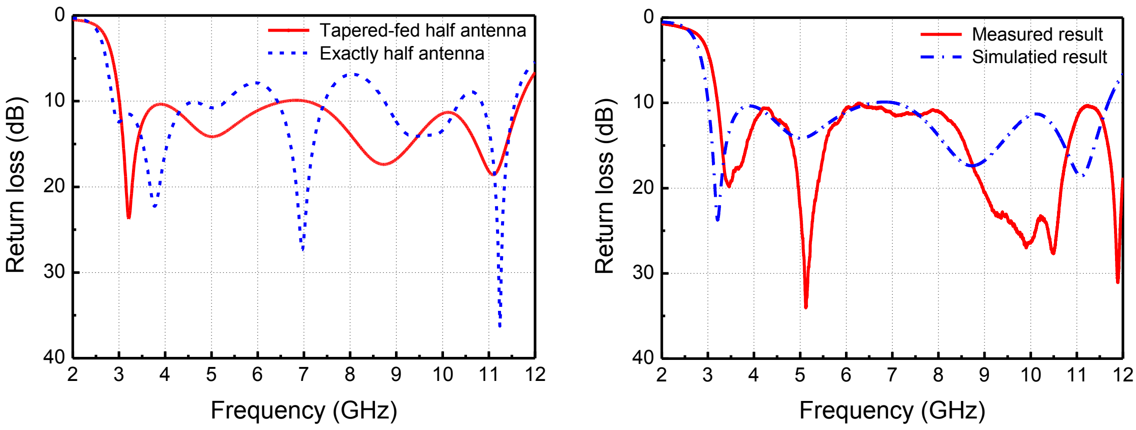
4. Conclusion

A miniaturized half monopole antenna with a ground side coupled patch for UWB applications is proposed. By halving the monopole antenna with the extended coupled ground on the bottom side, the size reduction of 43% compared with the reference antenna of the full monopole is obtained. And a broadband impedance matching is achieved with a tapered feedline. The measured result of 10-dB impedance bandwidth is from 3.2 GHz to over 10.6 GHz. The proposed antenna shows omnidirectional radiation which is similar to that of the monopole antenna. The antenna gain is about 3.3 dBi and is ranged from 1.95 dBi to 4.46 dBi in the whole UWB band.



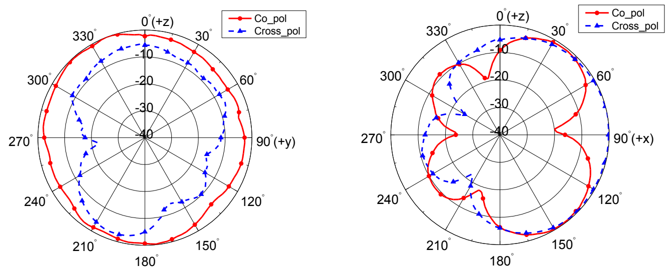
(a) (b)

Figure 1: Antenna configuration
(a) Reference antenna (b) Proposed antenna

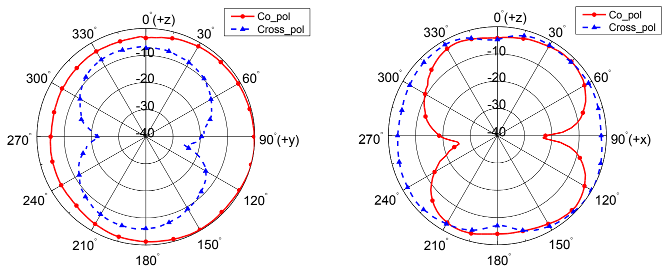


(a) (b)

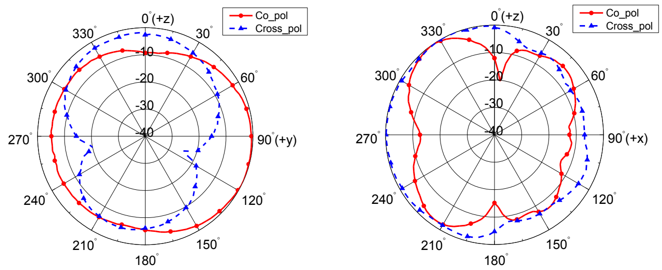
Figure 2: Results of the proposed antenna
(a) Simulated result (b) Measured result



(a)



(b)



(c)

Figure 3: Measured radiation patterns
(a) 3.2 GHz (b) 6 GHz (c) 9 GHz

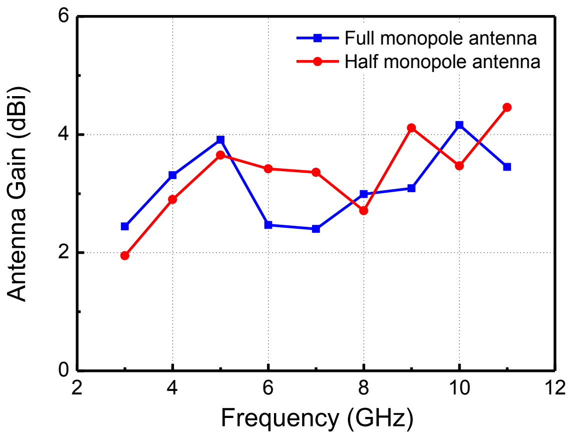
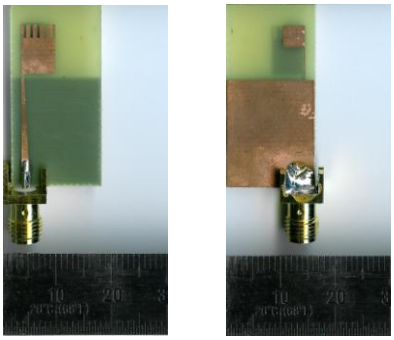


Figure 4: Gain of the proposed antenna



(a) (b)

Figure 5: Photos of the fabricated proposed antenna
(a) Top view (b) Bottom view

Table 1: Parameters of the proposed antenna

Parameter	L	L_g	L_h	L_a	L_b	W	W_g	W_a	W_s	W_t	W_{feed}
Size(mm)	9	4	1	15	20	6	4	2	0.15	0.4	1.52

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