

# Ultra Low Profile Inverted L Antenna on a Finite Conducting Plane

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## 1. Introduction

The input resistance of a horizontal dipole located very close to a perfect electric conducting plane becomes lower due to the existence of a metallic structure, and it approaches zero as the distance is decreased toward zero [1] - [3]. Most people tend to consider that the electromagnetic fields from the antenna and its image cancel out each other due to 180 degree phase difference. An “ultra low profile dipole (ULPD) antenna”, which is a dipole very closely located to a conducting plane was proposed to solve the impedance matching issue [4]. A half wavelength dipole is excited at the offset points from the center, so that reasonable impedance can be obtained even with a conducting plane in proximity to the dipole. The maximum gain of 8.4 dBi, which is higher than that of a half-wave dipole with a quarter wavelength distance between the dipole and the reflector, is obtained. The return loss bandwidth for 10 dB is about 2%.

In this paper, an inverted L antenna located very close on a finite conducting plane is proposed and numerically analyzed. This antenna is excited on the horizontal element. The input impedance of this antenna is matched to 50 ohms and its gain becomes more than 4 dBi. In the numerical analysis, the electromagnetic simulator WIPL-D based on the method of moment is used [5].

## 2. Antenna Structure

Figure 1 shows the inverted L antenna located very close to a finite conducting plane. The coaxial radiator is mounted on the conducting plane. This antenna consists of a horizontal arm in the y-direction and a small leg in the z-direction. The inner conductor of the coaxial cable is extended from the end of outer conductor, that is, this antenna is excited at the end of outer conductor. The horizontal length of antenna  $L$  is adjusted the resonant frequency, and the length of inner conductor  $L-L_1$  is adjusted for the impedance matching. The height of horizontal element is  $h$ . The design frequency is 2.45 GHz. The wavelength at 2.45 GHz is 122.45 mm.

## 3. Numerical Results and Discussion

Table 1 shows the return loss bandwidth less than 10 dB and the gain at the frequency of 2.45 GHz for the different antenna height  $h$ . The parameters of the conducting plane are as follows;  $p_{xm} = p_{xp} = 15$  mm,  $p_{ym} = 10$  mm, and  $p_{yp} = L+18.4$  mm. The parameters of horizontal element  $L$  and  $L_1$  are optimized to have maximum return loss bandwidth around the center frequency of 2.45 GHz. The return loss bandwidth is 2.71 % and the gain is 4.14 dBi when the antenna height is 4.0 mm (one thirtieth of wavelength). The gain increases when the antenna height  $h$  becomes lower than one thirtieth of wavelength. On the other hand, the return loss bandwidth becomes narrower. This is because the mutual coupling between the horizontal element and the conducting plane becomes strong when the antenna height becomes smaller.

Table 2 shows the return loss bandwidth and the gain at the frequency of 2.45 GHz for the different size of

conducting plane in the x direction  $p_{xm} = p_{xp}$ . The parameters of the conducting plane in the y direction are  $p_{ym} = 10$  mm, and  $p_{yp} = L+18.4$  mm. Even the length of the conducting plane in the x direction becomes narrow (5 mm), the return loss bandwidth becomes 13.63 % and the gain is 3.48 dBi. Figure 2(a) and (b) show the return loss characteristics for different  $h$  and  $p_{xp} = p_{xm}$  given in Table 1 and 2, respectively.

Figure 3 shows the input impedance characteristics of the antenna No. 1 in Table 1. Figure 4 shows that of the antenna No. 2 in Table 2. Figure 5 and 6 show the electric field radiation patterns of the antenna No. 1 and No. 2 at 2.45 GHz, respectively. The gain of antenna No. 1 is 4.14 dBi and that of antenna No. 2 is 3.48 dBi. Figure 7 and 8 show the current distribution on two antennas at 2.45 GHz. In this antenna, due to the strong coupling of the horizontal element and the conducting plane, the current of the horizontal element and y component of current on the conducting plane mainly contribute to the radiation.

Figure 9 shows the photograph of the fabricated antenna for measurement. Figure 10 shows the return loss characteristics of the antenna No. 1. The good agreement of measured and calculated return loss is obtained.

## 4. Conclusion

The unbalanced fed, ultra low profile inverted L antenna on a finite conducting plane has been proposed and analyzed numerically. The antenna height is around one thirtieth of wavelength. Due to the strong coupling between the horizontal element and the conducting plane, the gain more than 4 dBi has been obtained. The measured return loss agrees well with the calculated result. This antenna may be promising for the base station antenna of the wireless LAN.

## References

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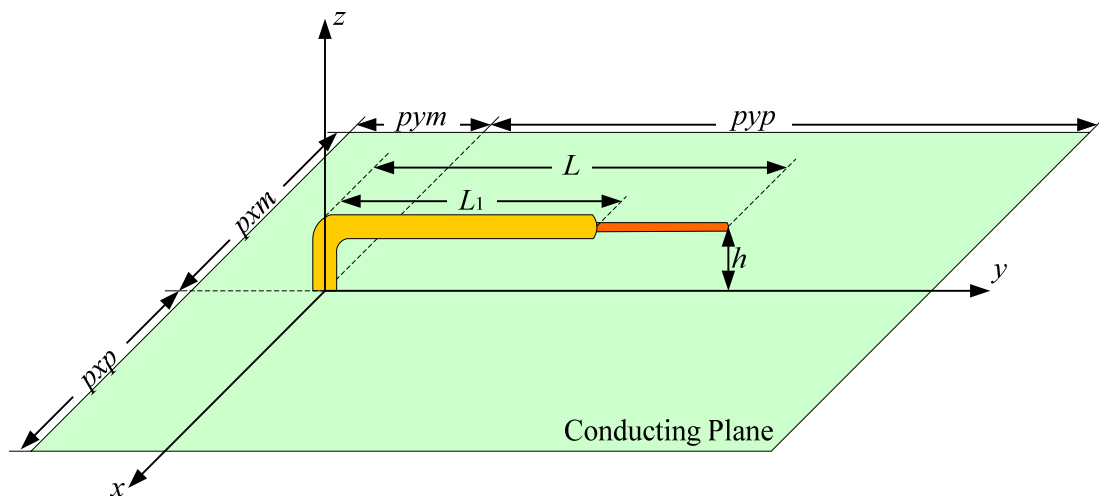


Figure 1: Structure of analytical model.

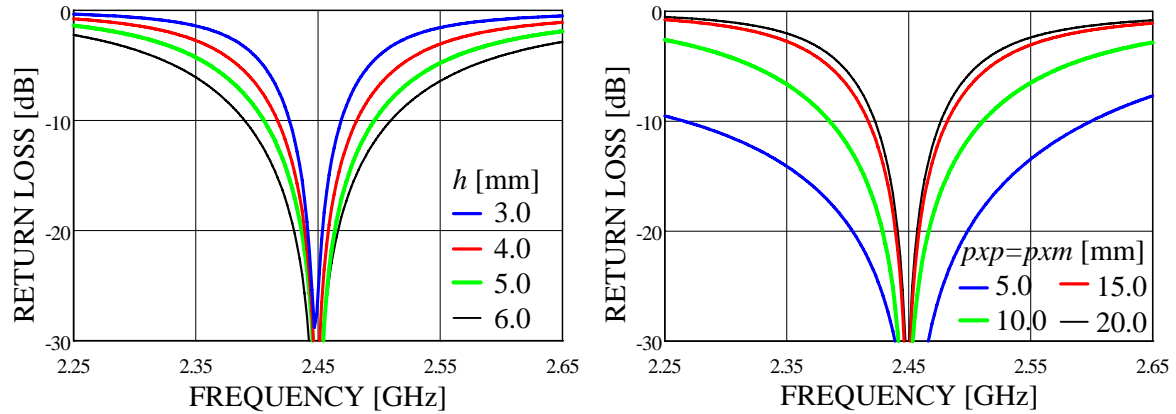
Coaxial cable: Radius of outer conductor = 1.095 mm, Radius of inner conductor = 0.255 mm.

Table 1: Antenna characteristics for different  $h$ . ( $p_{xp} = p_{xm} = 15$  mm,  $p_{ym} = 10$  mm,  $p_{yp} = L + 18.4$  mm)

$h$ [mm]	$L$ [mm]	$L_1$ [mm]	Bandwidth [%]	Gain [dBi] (2.45GHz)
3.0	32.4	25.1	1.72	4.27
4.0 ( $\lambda/30$ ) (No.1)	31.6	22.8	2.71	4.14
5.0	30.9	20.7	3.69	4.06
6.0	30.4	18.7	4.92	4.00

Table 2: Antenna characteristics for different  $p_{xp} = p_{xm}$ . ( $h = 4.0$  mm,  $p_{ym} = 10$  mm,  $p_{yp} = L + 18.4$  mm)

$p_{xp} = p_{xm}$ [mm]	$L$ [mm]	$L_1$ [mm]	Bandwidth [%]	Gain [dBi] (2.45GHz)
5.0 (No.2)	34.7	16.4	13.63	3.48
10.0	32.6	20.9	5.09	3.92
15.0	31.6	22.8	2.71	4.14
20.0	30.9	22.9	2.21	4.40



(a)  $p_{xp} = p_{xm} = 15$  mm,  $p_{ym} = 10$  mm,  $p_{yp} = L + 18.4$  mm (b)  $h = 4.0$  mm,  $p_{ym} = 10$  mm,  $p_{yp} = L + 18.4$  mm

Figure 2: Return loss characteristics.

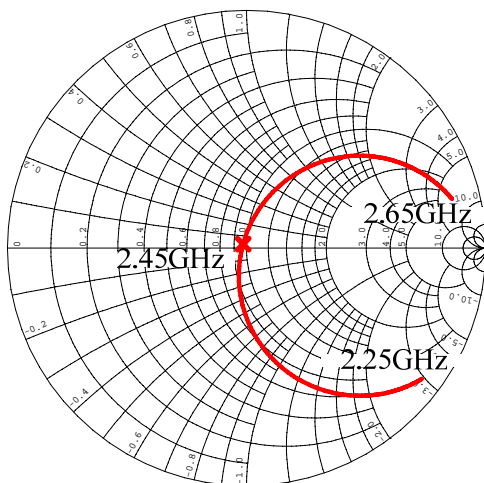


Figure 3: Input impedance of antenna No. 1.  
 $p_{xp} = p_{xm} = 15$  mm,  $p_{ym} = 10$  mm,  $p_{yp} = 50$  mm,  
 $h = 4.0$  mm,  $L = 31.6$  mm,  $L_1 = 22.9$  mm.

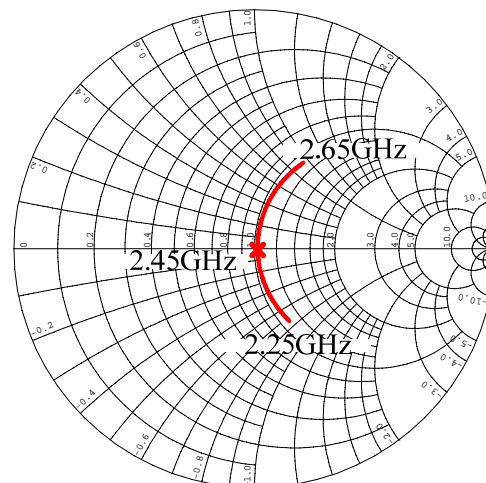
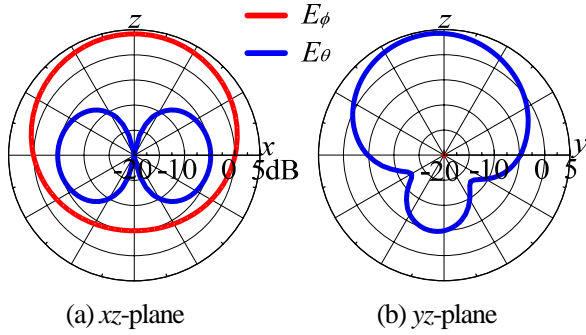
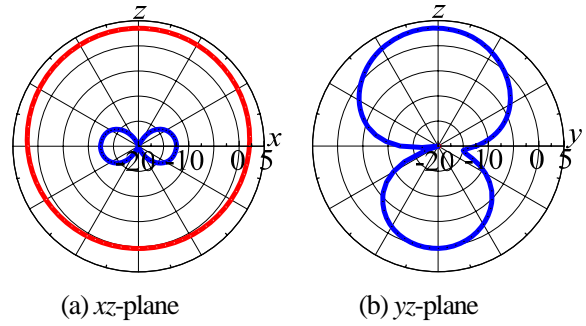


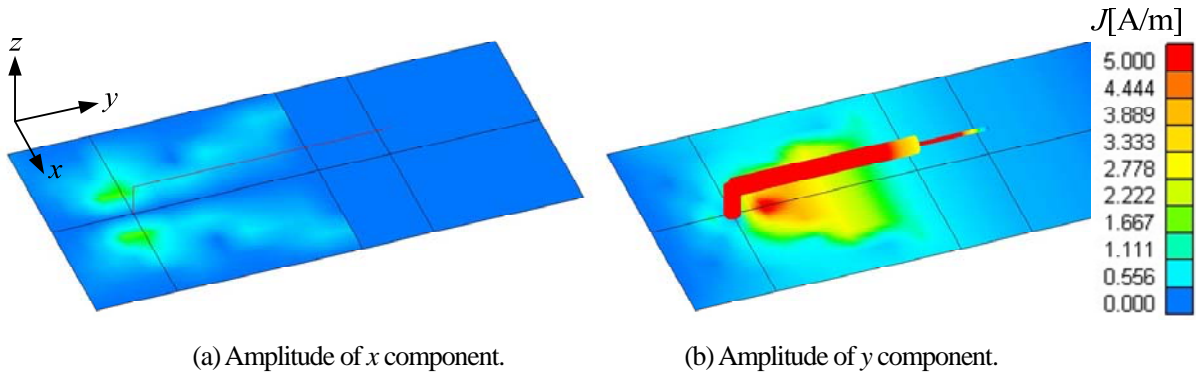
Figure 4: Input impedance of antenna No. 2.  
 $p_{xp} = p_{xm} = 5$  mm,  $p_{ym} = 10$  mm,  $p_{yp} = 53.1$  mm,  
 $h = 4.0$  mm,  $L = 34.7$  mm,  $L_1 = 16.4$  mm.



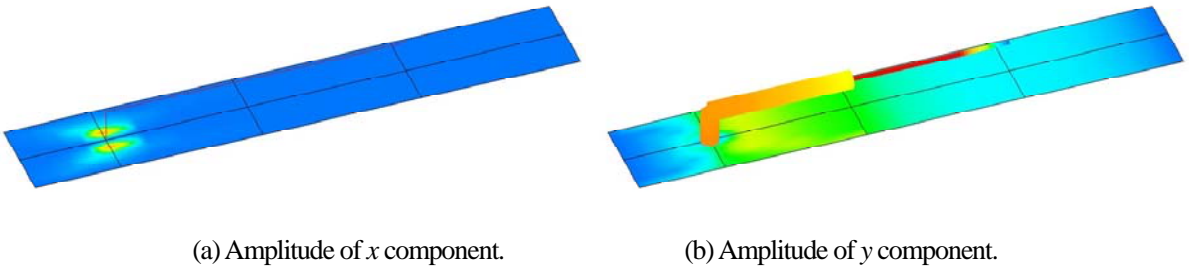
(a)  $xz$ -plane (b)  $yz$ -plane  
 Figure 5: Electric field radiation pattern of antenna No. 1 at 2.45 GHz.



(a)  $xz$ -plane (b)  $yz$ -plane  
 Figure 6: Electric field radiation pattern of antenna No. 2 at 2.45 GHz.



(a) Amplitude of  $x$  component. (b) Amplitude of  $y$  component.  
 Figure 7: Current distribution of antenna No. 1 at 2.45 GHz.



(a) Amplitude of  $x$  component. (b) Amplitude of  $y$  component.  
 Figure 8: Current distribution of antenna No. 2 at 2.45 GHz.

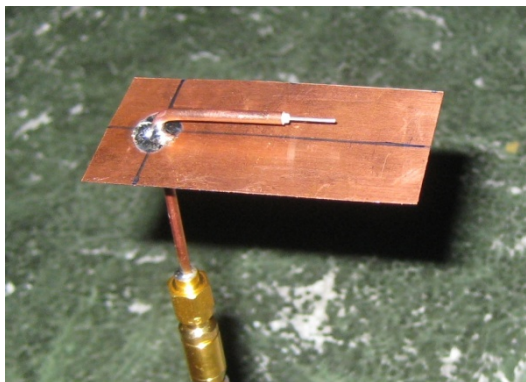


Figure 9: Photograph of fabricated antenna.

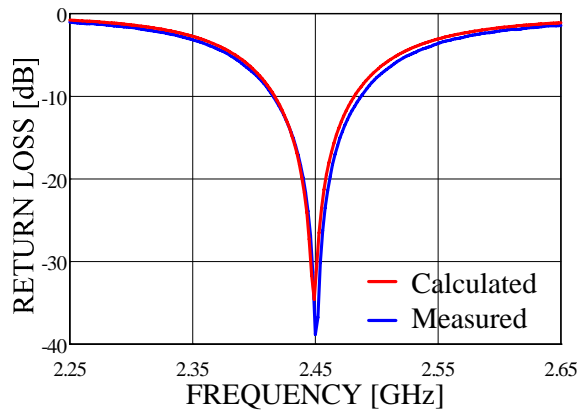


Figure 10: Return loss characteristics of antenna No. 1.