Design of Ultra Low Profile Inverted L Antenna Composed of CPW Printed on PET Sheet for IoT Application

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***Abstract*—The ultra low profile inverted L (ULPIL) antenna on a rectangular conducting plane is located above the lower conducting plane and numerically analyzed for the application of IoT. The coplanar waveguide (CPW) is inserted within the antenna element. The antenna element is printed on the polyethylene terephthalate (PET) sheet. The shift of the resonant frequency of this antenna is small due to the existence of lower conducting plane. The influence of the existence of the lower conducting plane can be neglected when the distance between the ULPIL antenna and the lower conducting plane is longer than 6 mm (0.049 wavelength). Therefore the ULPIL antenna may be promising for the IoT application.**

***Keywords*—inverted L antenna, IoT, low profile antenna, printed antenna, polyethylene terephthalate sheet.**

I. Introduction

In the antennas closely located on a conducting body for the IoT application, the existence of conducting body near antenna affects to the antenna characteristics because it works as an antenna element. The authors have proposed the unbalanced fed ultra low profile inverted L (ULPIL) antenna on the rectangular conducting plane [1]. The inverted L antenna is composed of the semi-rigid coaxial cable. 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 resonant frequency is adjusted by the horizontal length of antenna, and the impedance matching is adjusted by the length of outer conductor of coaxial cable. When the size of conducting plane is 0.245 λ (λ: wavelength) by 0.49 λ and the antenna height is $\lambda/30$, and the length of horizontal element is around a quarter wavelength, the input impedance of this antenna is matched to 50 Ω and its directivity becomes more than 4 dBi. In this antenna, the electromagnetic field concentrates on the inverted L element and the ground plane under it. Therefore, when this antenna is used for the IoT application, the existence of conducting body may not affect to the antenna characteristics. In [2], the coaxial cable of the antenna of the inverted L antenna is replaced by the planar conductor and it is fed by a delta-gap generator. Then the coplanar waveguide (CPW) is inserted within a planar conductor in order to realize the feed line on the conducting plane [3]. An off-center-fed printed dipole was proposed for the Machine-to-Machine (M2M) application [4]. This antenna is constructed from a polyethylene terephthalate (PET) sheet. The antenna element is printed by a inkjet printer. The authors proposed the ULPIL antenna on a rectangular conducting plane with its inverted L element printed on the PET sheet [5]. The end of center conductor of CPW is T shaped. Then, this antenna located on the lower conducting plane is studied as an example of antennas for IoT application [6].

In this paper, an ULIPL antenna closely located on the lower rectangular conducting plane is numerically analyzed and the antenna characteristics are studied by changing the geometry of lower conducting plane. In the numerical analysis, the electromagnetic simulator WIPL-D based on the Method of Moments is used [7].

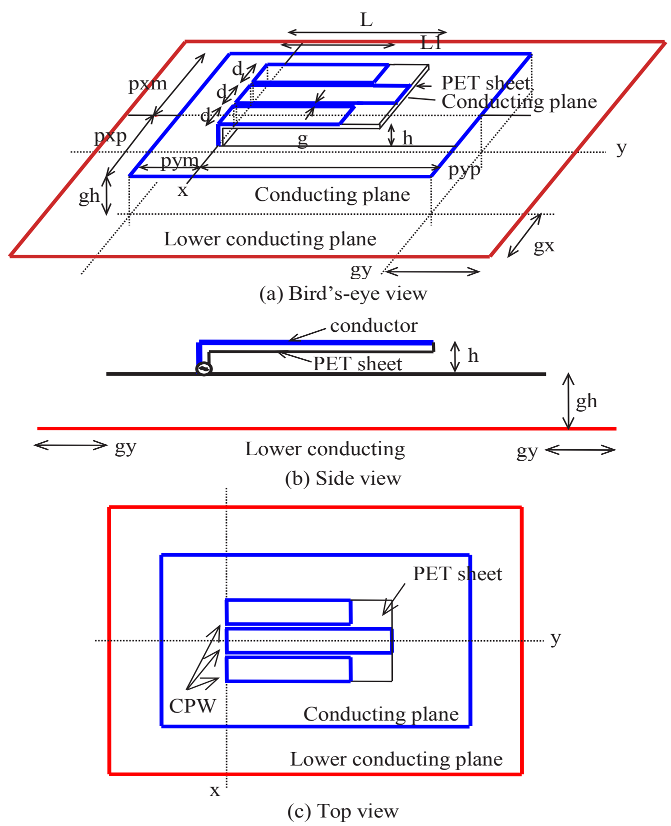

Fig. 1. ULPIL antenna located above a lower conducting plane.

II. Analytical Model

Fig. 1 shows the proposed ULPIL antenna with a built-in CPW mounted on the rectangular conducting plane. The size of conducting plane is (pxp + pxm) by (pyp + pym). This antenna is located above the lower conducting plane. The distance between the ULPIL antenna and the lower conducting plane is gh. The size of lower conducting plane is (pxp+pxm+2*gx) by (pyp+pym+2*gy). The design frequency

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is 2.45 GHz. The parameters of proposed antenna are as follows: L = 35.9 mm, L1 = 24.5 mm, pxp = pxm = 15 mm, pym = 10 mm, pyp = 50 mm, d = 4.6 mm, g = 0.3 mm, h = 2.4 mm. The relative permittivity of PET sheet = 3.0 and its thickness = 0.135 mm. The conductivity of conducting plane is assumed to be infinite.

III. Results and Discussion

Fig. 2 shows the S11 characteristics of the antenna as a function of gh. The shift of resonant frequency is small by changing the size of lower conducting plane and the distance gh between the ULPIL antenna and lower conducting plane. When gh becomes longer than 6 mm, the influence of lower conducting plane to the antenna characteristics can be neglected. Fig. 3 shows the directivity characteristics in the z direction as a function of gx = gy. The distance gh between ULPIL antenna and the lower conducting plane is 2 mm. The directivity at the lower resonant frequency becomes small. Fig. 4 shows the current distribution on antenna at the lower resonant frequency of 2.33 GHz and the design frequency of 2.45 GHz. In the antenna in [6], the edge current of outer conductor of CPW becomes large. On the other hand, in the proposed antenna, the edge currents flow along the outer conductor and the top end of center conductor of CPW. The length of outer conductor L1 is small compared with the length, pym + pyp, of ground plane. Therefore the mutual coupling between ULPIL antenna and the lower conducting plane becomes small in the proposed antenna.

IV. Conclusion

The ultra low profile inverted L antenna on a rectangular conducting plane closely located above the lower conducting plane has been numerically analyzed. The CPW is installed within antenna element printed on the PET sheet. The shift of the resonant frequency of ULPIL antenna is small when the size of the lower conducting plane and distance to ULPIL antenna are changed. The second lower resonance occurs due to the coupling of ULPIL and the lower conducting plane. The influence of the existence of the lower conducting plane can be neglected when the distance between the ULPIL antenna and the lower conducting plane is longer than 6 mm (0.049 λ). Therefore the ULPIL antenna may be promising for the IoT antenna.

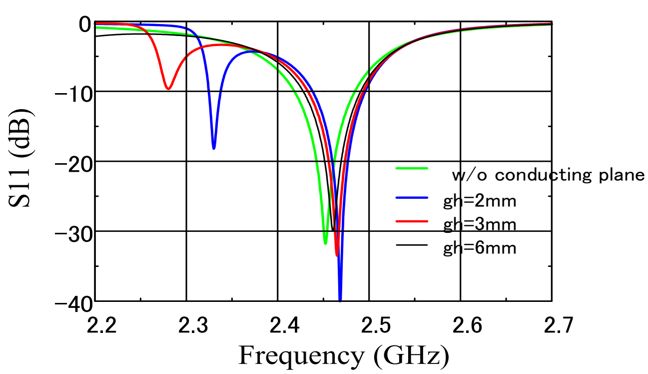


Fig. 2. S11 characteristics of proposed antenna. L = 35.9 mm, L1 = 24.5 mm, pxp = pxm =15 mm, pym =10 mm, pyp = 50 mm, d = 4.6 mm, g = 0.3 mm, h = 2.4 mm, gx = gy = 10 mm.

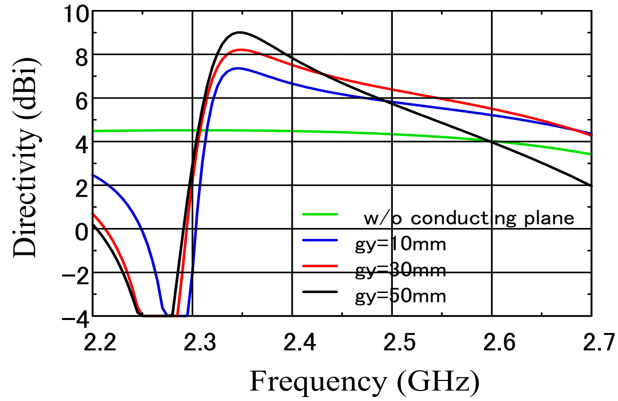
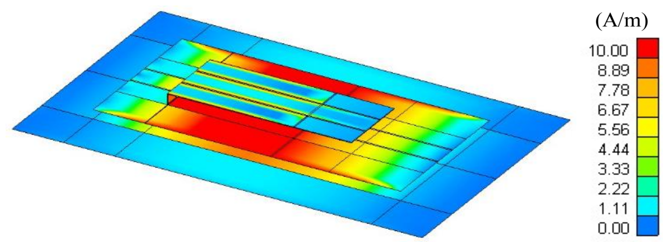
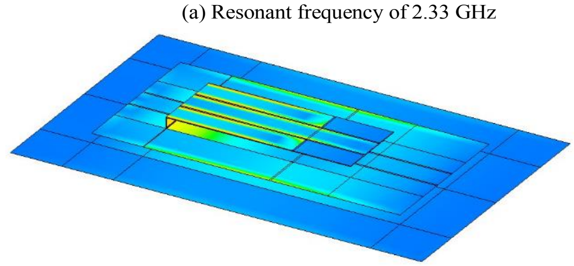


Fig. 3. Directivity characteristics of proposed antenna in z direction. L = 35.9 mm, L1 = 24.5 mm, pxp = pxm =15 mm, pym =10 mm, pyp = 50 mm, d = 4.6 mm, g = 0.3 mm, h = 2.4 mm, gh 2 mm.



(a) Resonant frequency of 2.33 GHz



(b) Design frequency of 2.45 GHz

Fig. 4. Current distributions on proposed antenna. L = 30.9 mm, L1 = 24.8 mm, pxp = pxm =15 mm, pym =10 mm, pyp = 50 mm, d = 4.6 mm, g = 0.3 mm, h = 2.4 mm, gh = 2 mm, gx = gy = 10 mm.

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