Vertically Polarized Antenna on a Finite Conducting Plane

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Abstract

As a vertically polarized antenna, an unbalanced fed inverted L antenna on a vertical rectangular conducting plane located on the edge of the horizontal rectangular conducting plane is proposed and numerically analyzed. The directive gain of 2.98 dBi is obtained in the horizontal direction.

Keywords : Vertical polarization Unbalanced fed inverted L antenna Numerical analysis

1. Introduction

The input impedance 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]. An “ultra low profile dipole (ULPD) antenna”, which is a horizontal dipole very closely located to a infinite 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 less than -10 dB is about 2%. In order to realize ULPD, however, a 3 dB coupler and a 90° phase shifter are needed. The authors have proposed an unbalanced fed inverted L antenna located very close on a rectangular conducting plane [5]. This antenna is excited on the horizontal element. 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 ohms and its directivity becomes more than 4 dBi. The ULPD and the inverted L antenna are horizontally polarized ones. The main beam direction of a vertically polarized antenna such as a monopole antenna on a finite conducting plane tilts upward due to the mutual coupling between a monopole and a conducting plane. Therefore, higher directive gain is desired for the vertical polarized antenna on the finite conducting plane.

In this paper, as a vertically polarized antenna, an unbalanced fed inverted L antenna on a vertical rectangular conducting plane is located on the horizontal rectangular conducting plane. The design frequency is 2.45 GHz. In the parameter study, the structure of inverted L antenna and the position of vertical plane on the horizontal plane are optimized to obtain the high directive gain in the horizontal direction. The size of horizontal rectangular plane is fixed to 200 mm by 200 mm. In the numerical analysis, the electromagnetic simulator WIPL-D based on the method of moment is used [6].

2. Antenna Structure

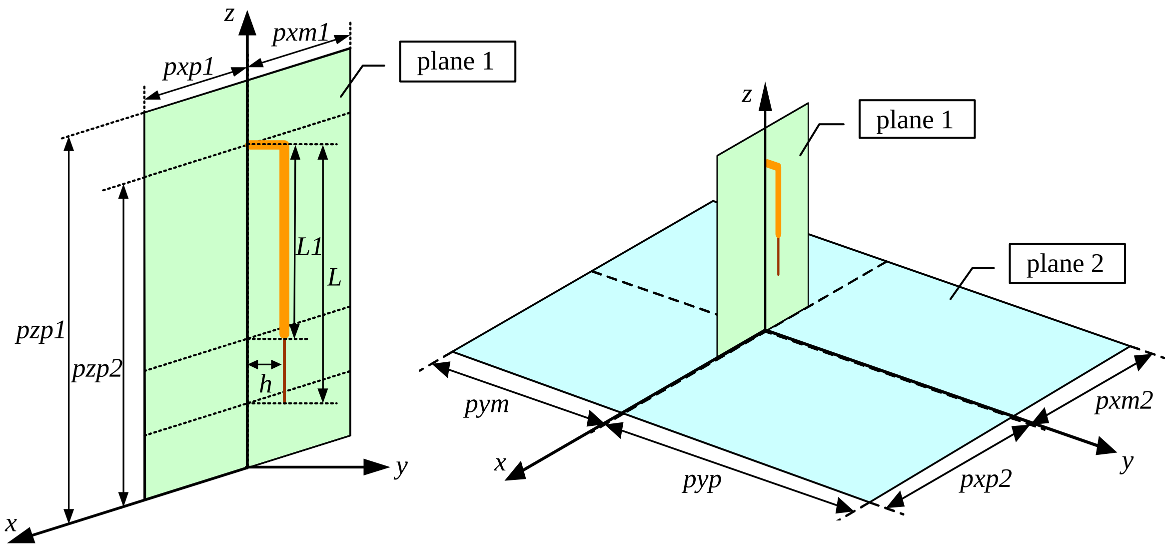
Figure 1 shows the structure of the proposed antenna. The unbalanced fed inverted L antenna is mounted on the vertical conducting plane 1. The antenna is composed of a semi rigid coaxial cable. The inner conductor of the coaxial cable is extended from the end of outer conductor, that is, this antenna is excited at the end of outer conductor. The distance between the vertical element of antenna and the plane 1 is h = 4 mm. This is around λ/30 at the design frequency of 2.45 GHz. The rectangular plane 1 is located on the vertical conducting plane 2. Two planes are connected each other.

3. Results and Discussion

Figure 2 show the directive gain in the horizontal direction, the return loss bandwidth less than -10 dB, the main beam direction and the directivity as a function of the width of plane 1. Figure 3 show the antenna characteristics as a function of the position of the base of inverted L antenna on the plane 1. Figure 4 show the antenna characteristics as a function of the position of the plane 1 on the plane 2. By adjusting the length of conducting plane 2, the main beam direction becomes larger. From the parameter study, the directive gain in the y direction becomes largest when the plane 1 is on the edge of the plane 2. Figure 5 show the calculated input impedance characteristics of the proposed antenna. The parameters of this antenna are as follows; pyp = 200 mm, pym = 0 mm, h = 4.0 mm, pxp1 = pxm1 = 20.0 mm, pzp1-pzp2 = 10.0 mm, pzp2 = 37.0 mm, pxp2 = pxm2 =100mm, L=30.36mm, L1=23.45mm. Figure 6 show the calculated electric field radiation patterns at the frequency of 2.45 GHz. The directive gain in the horizontal direction becomes 2.98 dBi and the directivity is 8.15 dBi at θ = 55° .

4. Conclusion

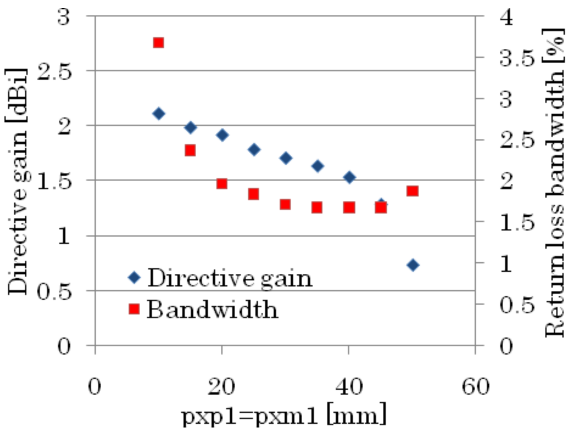
The vertically polarized antenna on the rectangular conducting plane has been proposed. The unbalanced fed inverted L antenna on the vertical rectangular plane is mounted on the edge of the horizontal rectangular plane. The width and height of the vertical plane is 40 mm and 47 mm (0.327 λ and 0.384 λ), respectively. The size of the horizontal plane is 200 mm by 200 mm (1.63 λ by 1.63 λ). The directive gain in the y direction becomes 2.98 dBi. The measured result of the proposed antenna will be the next subject. The proposed antenna may be useful for application of indoor communication.



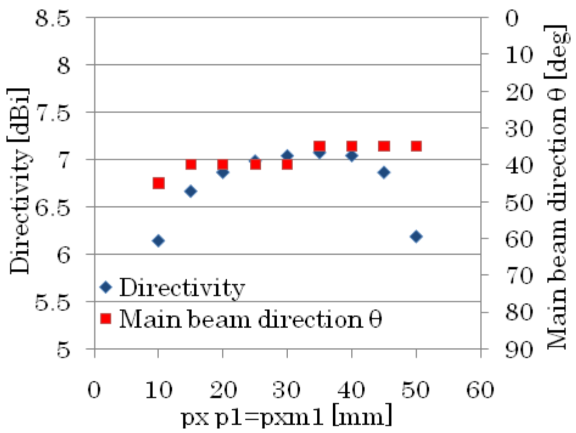
(b) Unbalanced fed inverted L antenna on a rectangular plane.

(a) Structure of proposed antenna.

Figure 1: Proposed vertical polarized antenna on a rectangular plane.

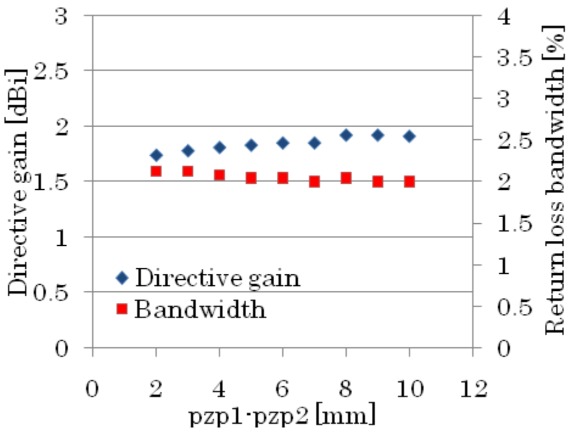


(b) Directive gain at horizontal direction and return loss bandwidth.

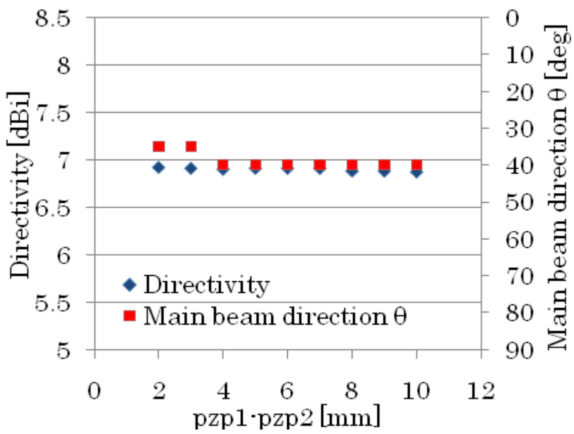


(a) Main beam direction and directivity.

Figure 2: Antenna characteristics as a function of pxp1 = pxm1. h =4.0mm, pzp1-pzp2=10.0mm, pzp2=37.0mm, pxp2=pxm2 =100mm, pyp=pym=100mm.

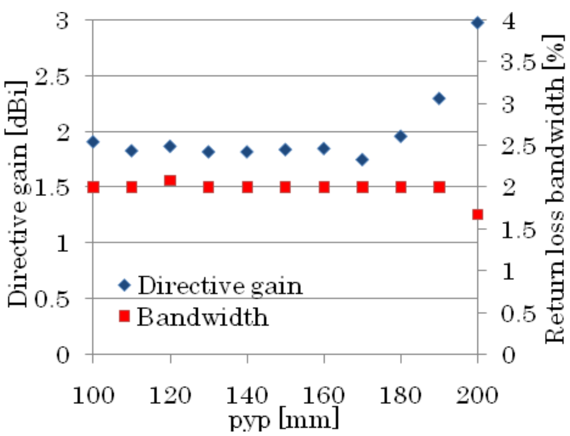


(a) Directive gain at horizontal direction and return loss bandwidth.

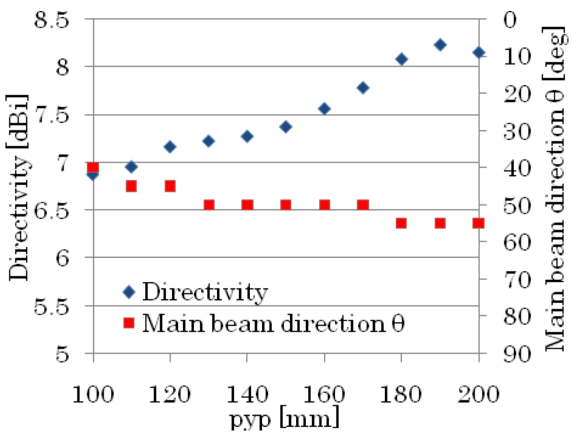


(b) Main beam direction and directivity.

Figure 3: Antenna characteristics as a function of pzp1-pzp2. h=4.0mm, pxp1=pxm1=20.0mm, pzp2=37.0mm, pxp2=pxm2=100mm, pyp=pym=100mm.



(a) Directive gain at horizontal direction and return loss bandwidth.



(b) Main beam direction and directivity.

Figure 4: Antenna characteristics as a function of pyp. h=4.0mm, pxp1=pxm1=20.0mm, pzp1-pzp2=10.0mm, pzp2=37.0mm, pxp2=pxm2=100mm.

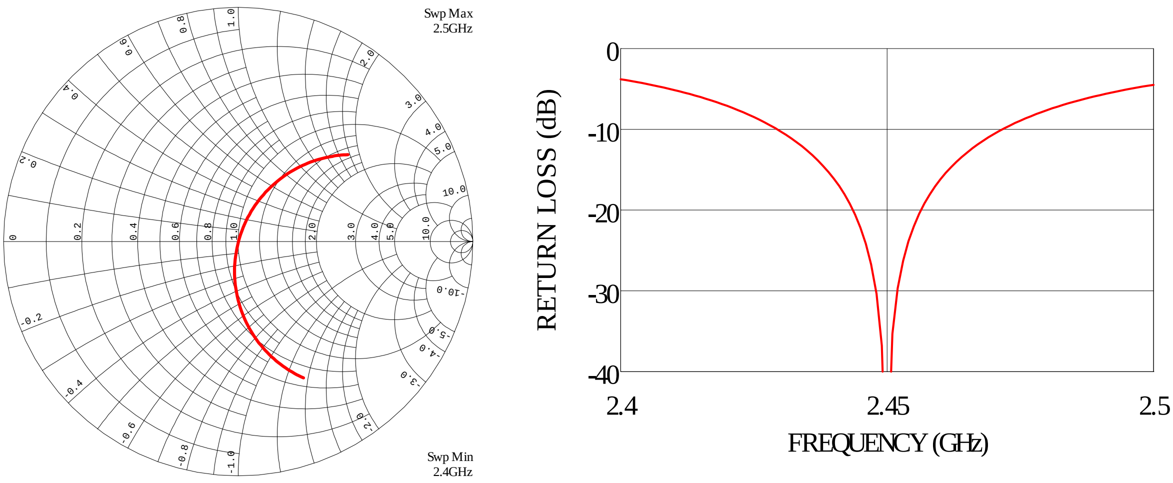
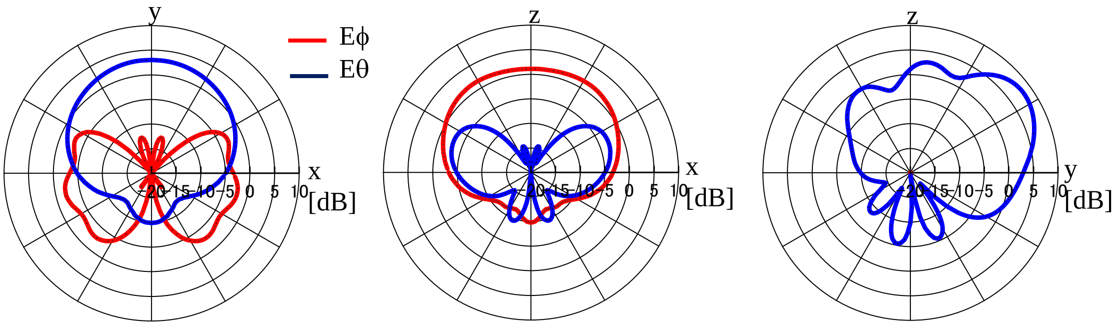


Figure 5: Calculated input impedance and return loss characteristics of proposed antenna.
pyp=200mm, pym=0mm, h=4.0mm, pxp1=pxm1=20.0mm, pzp1-pzp2=10.0mm,
pzp2=37.0mm, pxp2=pxm2 =100mm, L=30.36mm, L1=23.45mm.



(a) xy-plane (b) xz-plane (c) yz-plane

Figure 6: Calculated electric field radiation patterns of the proposed antenna at 2.45 GHz.
pyp=200mm, pym=0mm, h=4.0mm, pxp1=pxm1=20.0mm, pzp1-pzp2=10.0mm,
pzp2=37.0mm, pxp2=pxm2 =100mm, L=30.36mm, L1=23.45mm.

References

[1] J. D. Kraus, Antennas, McGraw-Hill, New York, pp. 425–427 and 461-467, 1988.

[2] C. A. Balanis, Antenna Theory Analysis and Design, Wiley, New York, pp. 175–180, 1997.

[3] S. A. Schelkunoff, H. T. Friis, Antennas Theory and Practice, Wiley, New York, 1952.

[4] A. Thumvicit, T. Takano, Y. Kamata, "Characteristics verification of a half-wave dipole very close to a conducting plane with excellent impedance matching", IEEE Trans. on Antennas and Propagat., vol.55, no.1, pp.53-58, 2007.

[5] T. Yamashita, M. Taguchi, "Ultra Low Profile Inverted L Antenna on a Finite Conducting Plane", Proc. of ISAP 2009, pp.361-364, 2009.

[6] "WIPL-D Pro v7.0 3D Electromagnetic Solver Professional Edition User's Manual", WIPL-D, 2009.