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Bandwidth Extension of Ultra Low Profile Inverted L Antenna by Modification of Conducting Plane

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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 an infinite conducting plane was proposed to solve the impedance matching issue [4 - 5]. A half-wav dipole is excited at the offset points from its center. Therefore the reasonable impedance can be obtained even with a conducting plane in proximity to the dipole. The maximum gain of 8.4 dBi is obtained. The authors applied the unbalanced feed to the ultra low profile inverted L antenna on the rectangular conducting plane [6]. When the size of conducting plane is 0.245 λ (λ: wavelength) by 0.49 λ and the antenna height is λ/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. In order to miniaturize the size of conducting plane, the meandered inverted L antenna was proposed [7]. The size of conducting plane becomes 70 mm by 350 mm (0.0735 λ by 0.3675 λ) at the 315 MHz band.

In this paper, the meandered inverted L antenna on a modified conducting plane is proposed and numerically analyzed. In the numerical analysis, the electromagnetic simulator WIPL-D based on the method of moment is used [8].

2. Analytical Model

Figure 1 shows the meandered inverted L antenna on a rectangular conducting plane. The antenna element 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 radii of outer and inner conductors of coaxial cable are 1.095 mm and 0.255 mm, respectively. Parameters of inversed L antenna are determined so as to satisfy the return loss less than -10 dB at the frequencies from 312 MHz to 315.25 MHz of the keyless entry system in Japan. The size of conducting plane is 70 mm by 350 mm. The horizontal element is meandered one turn. One or two slots are located on the conducting plane.

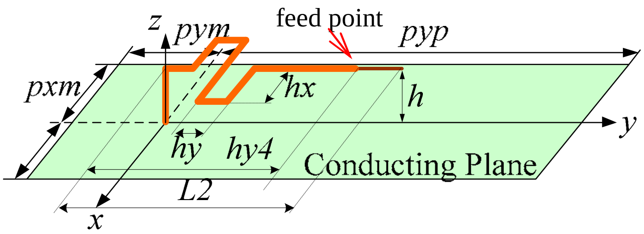


Figure 1: Analytical model
h=31.74mm(λ/30), $hy4$=107mm, $L2$=196.2 mm, hx=20mm, hy=10mm, pxm=100mm, pxm=pxp=35mm, pym=50mm, pyp=300mm

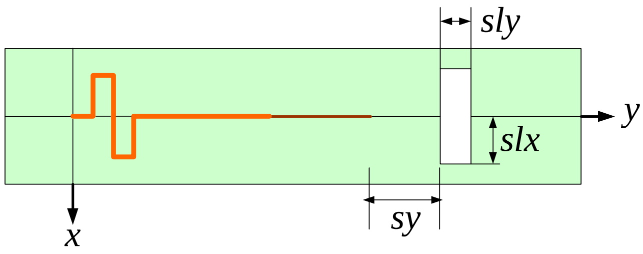


Figure 2: Rectangular slot.

3. Results and Discussion

(a) Rectangular slot

Figure 2 shows the conducting plane with a rectangular slot. The distance between the antenna end and the slot is *sy*. Table 1 shows the return loss bandwidth less than -10 dB and the directive gain at 315 MHz as a function of the slot position *sy*. Figure 3 show the current distributions at 315 MHz for sy is -50 mm and 50 mm. Since the current path length on the conducting plane is almost same in both cases, the return loss bandwidth and the directive gain are almost same.

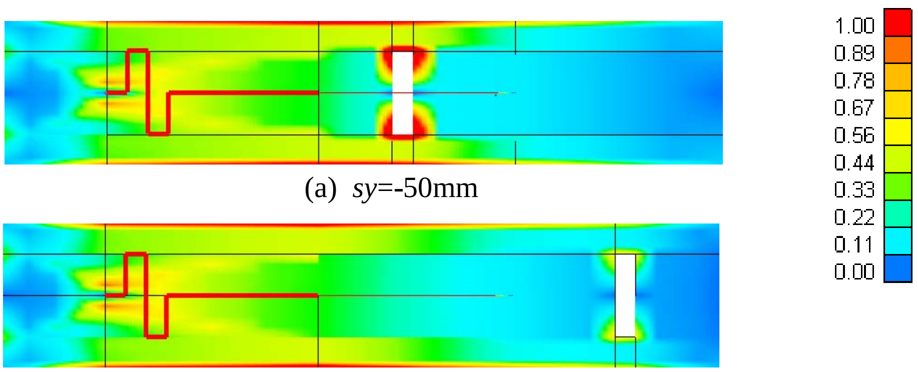
(b) H shaped slot

Figure 4 shows the H shaped slot located around the antenna end. Figure 5 shows the current distribution on the antenna shown in Figure 4. Figure 6 shows the H shaped slot located around the feed point. Figure 7 shows the current distribution on the antenna shown in Figure 6. Figure 8 shows the two H shaped slot located at the feed point and the antenna end. Figure 9 shows the current distribution on the antenna shown in Figure 8. Table 2 shows the comparison of the return loss bandwidth and directivity at 315 MHz between the antennas without slot, with one H shaped slot and two H shaped slots. By adding the two H shaped slots on the conducting plane, the return loss bandwidth is extended. The return loss bandwidth is 63.3MHz from 301.0MHz to 364.3MHz, and the directivity becomes 2.63dBi at the frequency of 315 MHz.

Table 1: Characteristics as a function of *sy*.

sy [mm]	*hy*4 [mm]	Return loss bandwidth		Directivity at 315MHz [dBi]
		low freq.[MHz]	high freq.[MHz]	
-50	103	307.4	319.4	2.72
-30	103	307.7	319.7	2.72
-10	104	307.8	319.5	2.72
10	104	308.1	319.8	2.71
30	104	308.1	320	2.72
50	104	308.1	320	2.72

Ly=199 mm



(a) *sy*=-50mm

(b) *sy*=50mm

Figure 3: Current distribution of the antenna with a rectangular slot at 315 MHz.

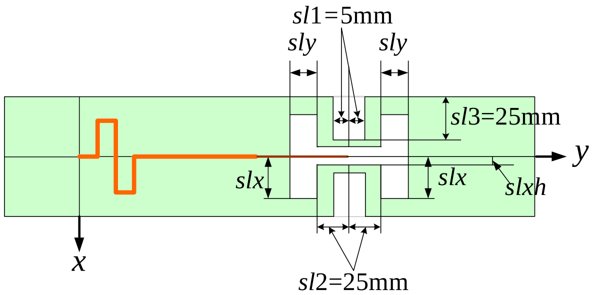


Figure 4: H shaped slot at antenna end.
=31.74mm (1/30λ), *pxm*=*pxp*=35mm, *pym* =50mm, *pyp*=300mm, *hx*=20mm, *hy*=10 mm, *slx*=25mm, *sly*=10mm, *sl*1=5mm, *sl*2= 25mm, *sl*3=25mm

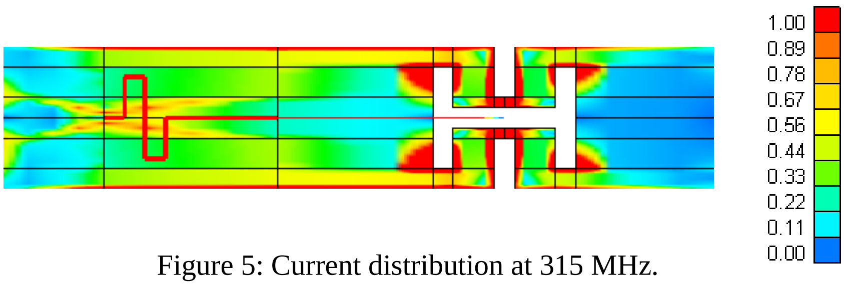


Figure 5: Current distribution at 315 MHz.
h=31.74mm (1/30λ), *pxm*=*pxp*=35mm, *pym* =50mm, *pyp*=300mm, *hx*=20mm, *hy*=10 mm, *slx*=25mm, *sly*=10mm, *sl*1=5mm, *sl*2= 25mm, *sl*3=25mm

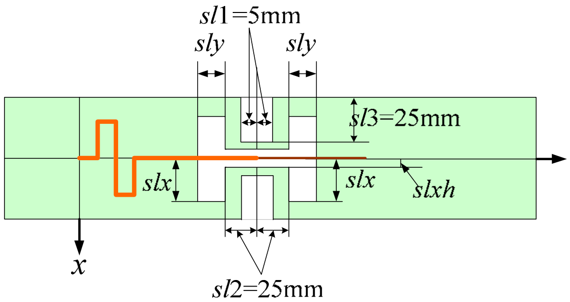


Figure 6: H shaped slot at feed point.

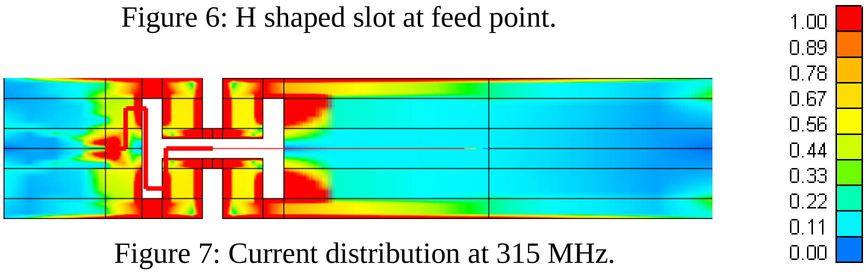


Figure 7: Current distribution at 315 MHz.

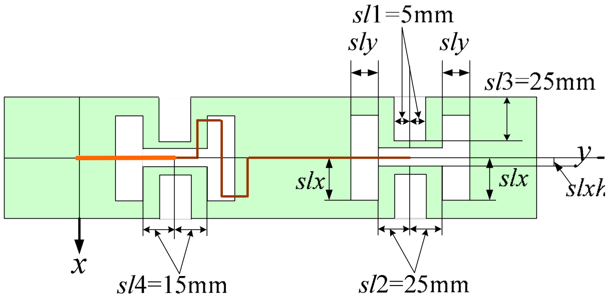


Figure 8: Two H shaped slot at feed point and antenna end.

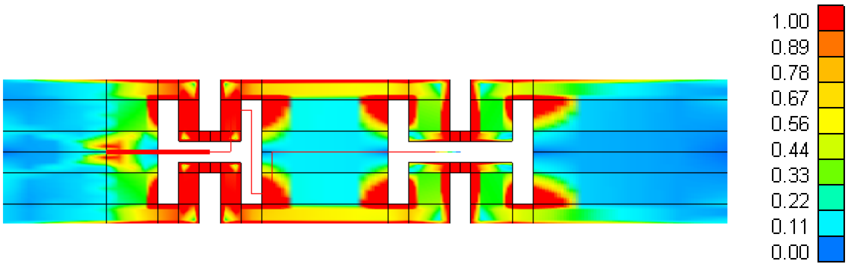


Figure 9: Current distribution at 315 MHz.

Table 2: Comparison of return loss and directivity of antenna with H shaped slots.

Slot position	*hy*4 [mm]	*L*2 [mm]	Return loss bandwidth low freq. [MHz]	Return loss bandwidth high freq. [MHz]	Directivity at 315 MHz [dBi]
w/o slot	104	199.5	308	319.6	2.70
Antenna end	85	196.5	306.6	324.3	2.76
Feed point	53	189.5	304.5	329.2	2.61
2 slots	50	171	301.0	364.3	2.76

4. Conclusion

The meandered inverted L antenna on a modified conducting plane has been proposed and numerically analyzed. In order to extend the return loss bandwidth, the rectangular slot or H-shaped slots are located on the conducting plane. The size of conducting plane is fixed as 70 mm by 350 mm (0.0735 λ by 0.3675 λ) at the 315 MHz band. When two H-shaped slots are located, the return loss bandwidth of 63.3 MHz and the directivity of 2.63 dBi are obtained.

In the next step, the size of conducting plane will have to be reduced for the practical application of the keyless entry system of car.

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. Thunvichit, T. Takano and Y. Kamata, "Ultra Low Profile Dipole Antenna with a Simplified Feeding Structure and a Parasitic Element", Trans. of IEICE, vol.89-B, no.2, pp. 576-580, 2006.
[5] 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.
[6] T. Yamashita, M. Taguchi, "Ultra Low Profile Inverted L Antenna on a Finite Conducting Plane", Proc. of ISAP 2009, pp.361-364, 2009.
[7] M. Taguchi and K. Kozaki: "Miniaturization of Ultra Low Profile Inverted L Antenna on Rectangular Conductor", Proc. of 2011 IEEE AP-S Symposium, Spokane, July 2011.
[8] WIPL-D Pro v9.1: http://www.wipl-d.com .