Radiated Waves from a Cabin Antenna at 100 MHz

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1. Introduction

Nowadays, situations of communicating from a car are becoming very common. Here, radiation intensities from an antenna are very important. Radiation intensities may depend on frequencies, antenna orientations and positions. Radiation characteristics were preliminary investigated at 314 MHz by the Method of Moments simulator (IE3D) [1]. Dependencies on antenna positions and polarizations were studied and accuracies of simulation were ensured through experiments [2],[3]. In 314 MHz where wavelength was comparable to the car window size, radiation intensities were not seriously affected by a car body shielding.

In this paper, radiation characteristic dependences on antenna orientations and positions are studied at 100 MHz. First of all, a small antenna of a meander line structure was designed. At 100 MHz where wavelength became sufficiently larger than the car window size, radiation intensities were affected appreciably by a car body shielding. Radiation intensities were strongly decreased in the horizontal polarization. Current distributions on a car body and radiation patterns were also studied.

2. Calculation models

2.1 Small antenna mounted in a cabin

At 100 MHz, the dipole antenna length becomes 1.5 m. This size is not convenient in order to install in a car. As a small antenna, a meander line antenna was investigated. An antenna configuration is shown in Fig.1. Meander shapes were very important to cancel the capacitance of the antenna input impedance. Antenna input resistance of about 20 Ω was achieved. The total length of the small antenna was 600 mm. In the case of a horizontal antenna, the small antenna is placed in the X-Y plane as shown in Fig.1. In the case of a vertical antenna, the small antenna is placed in the Y-Z plane.

Calculated radiation patterns of horizontal and vertical antennas are shown in Fig.2 (a) and (b), respectively. Radiation patterns are shown in the plane form that a radiation sphere is developed into a plane. The center point indicate the direction of θ=0 degree. The outermost circle indicate the direction of θ=180 degrees. In Fig. 2 (a), the horizontal antenna axis coincides with the ϕ=0 direction. In Fig. 2 (b), the vertical antenna axis coincides with the θ=0 direction. Fig. 2 (a) and (b) show typical radiation patterns of a dipole antenna. Cross polarization levels were very small. As a consequence, a small antenna that works in a linear polarization is achieved.

2.2 Antenna setups

Antenna setups are shown in Fig.3. Antennas are placed beneath the front edge of the car roof. Heights of antennas were high (H=1000mm) and low (H=574mm). And antenna positions are in the centerline of a car. Power conditions are also shown. P_0 indicates the power of an oscillator. Pr and Pin indicate the reflected power from an antenna and the incident power to an antenna, respectively. Prad indicates the radiated power.

3. Calculated results

3.1 VSWR characteristics and radiated intensities

VSWR characteristics of horizontal and vertical antennas are shown in Fig.4 (a) and (b), respectively. When the horizontal antenna is placed in a car as Fig. 2 (a), VSWR levels are awfully increased. In the lower height, increase of VSWR levels becomes large. Oscillator power seems to be pushed back. On the other hand, VSWR levels are decreased in the case of the vertical antenna as Fig.2 (b). This phenomenon was not expected. Oscillator power is smoothly conducted to an antenna.

The balance sheet of antenna related powers is shown in Table 1. η (Prad / P_0) indicates the radiation efficiency. In the case of a horizontal antenna, η becomes around 10% due to the increase of VSWR values. However, η of about 90% is achieved in the case of a vertical antenna. As a reference, power conditions at 314MHz are shown in Table 2. At this frequency, η becomes more than 80% in a horizontal and a vertical polarization. In this case, antenna VSWR levels were not affected when an antenna was installed in a car.

Judging from above results, the cut off occurs in the case of a horizontal polarization. However, there is no cut off in a vertical polarization. The cut off condition is considered that the half wavelength exceeds the height of the window aperture.

3.2 Induced currents on a car body

Induced currents on a car body of a horizontal and a vertical antennas are shown in Fig.5 (a) and (b), respectively. Antennas were placed at the low height (H=574 mm). In the case of calculations, a car body was converted into a mesh configuration. Mesh sizes of 1/10 wavelength was selected. In the horizontal antenna, strong currents are appeared at the circumferences of the front window. Induced currents on the car body seem rather small. The reason is considered because output power from the antenna becomes very small. In the vertical antenna, strong currents are appeared at pillars and lower sides of a window. So, large horizontal polarizations (cross polarizations) are likely to be produced.

3.3 Radiation patterns

Radiation patterns of the horizontal antenna in a plane and a cross-sectional forms are shown in Fig.6 (a) and (b), respectively. The outermost circle corresponds to the bottom direction of a car. Radiated power pattern of Fig.6 (a) shows axisymmetric characteristics around the z-axis. And most power is concentrated in the upper side of a car. Radiated powers in the lower side are less than -10 dB. In Fig.6 (b), antenna co-pole components are dominant and cross-pole components are very weak.

Radiation patterns of the vertical antenna in a plane and a cross-sectional forms are shown in Fig. 7 (a) and (b), respectively. Radiated power pattern of Fig.7 (a) shows that strong radiations exist in the front and the rear directions of a car. And rather strong radiations exist in the horizontal plane of a car. In Fig.7 (b), antenna co-pole components are dominant in the longitudinal direction (ϕ=90) of a car. In the side direction (ϕ=0) of a car, cross-pole components become large. These cross-pole components seem to be produced by current distributions on pillars and lower sides of a window as shown in Fig. 5 (b).

4. Conclusions

Radiation intensity from a cabin antenna at 100 MHz was studied. First of all, a small antenna of a meander line structure was designed. The meander line shape was very important to achieve the pure resistance. Antenna input resistance of about 20 Ω was achieved. From radiation characteristics, it was shown that the horizontal polarization became cut off. The cut off condition seemed to occur when the half wavelength exceeded the height of the window aperture. The vertical polarization components were radiated sufficiently. Induced currents on a car body and radiation patterns were also shown.

References

[1] H.Taguchi et al, “ Radiation characteristics of a Dipole Antenna Mounted in a Car ”, The 3rd International Symposium on Wireless Personal Multimedia Communications, pp.291-295, November 2000

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[3] H.Nagatomo et al, “ Radiation from Multiple Reflected Waves emitted by a Cabin Antenna in a Car”, IEICE RTANS, FANDAMENTALS, Vol.E85-A, No.7, July 2002 (to be published)

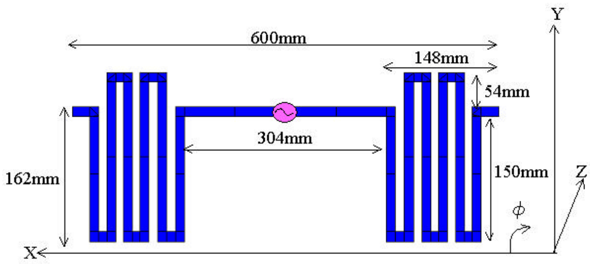


Fig.1 Small antenna configuration
(Horizontal antenna)

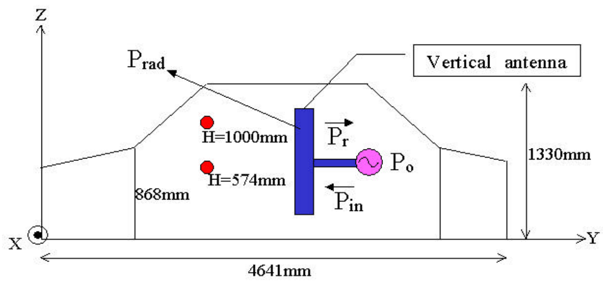
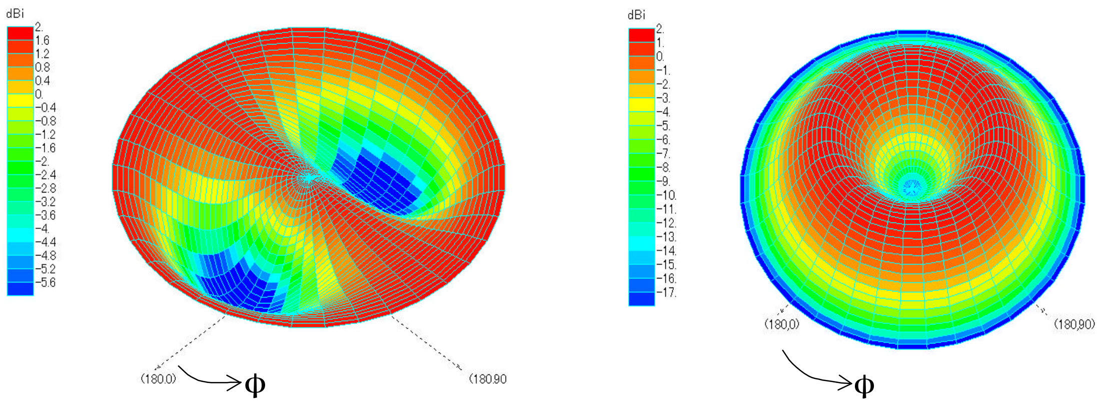
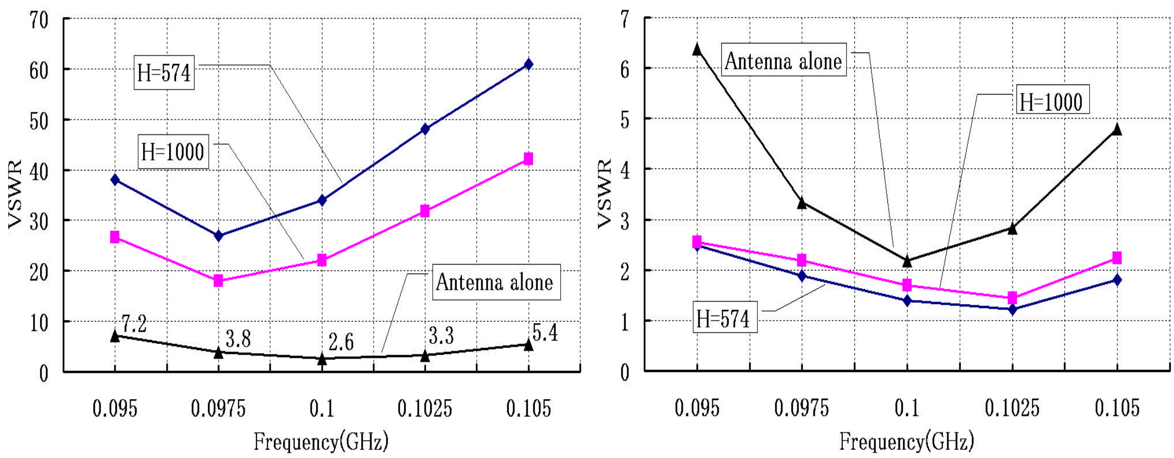


Fig.3 Antenna setup



(a) Horizontal antenna (E total)
(b) Vertical antenna (E θ)

Fig.2 Radiation patterns of small antenna



(a) Horizontal antenna
(b) Vertical antenna

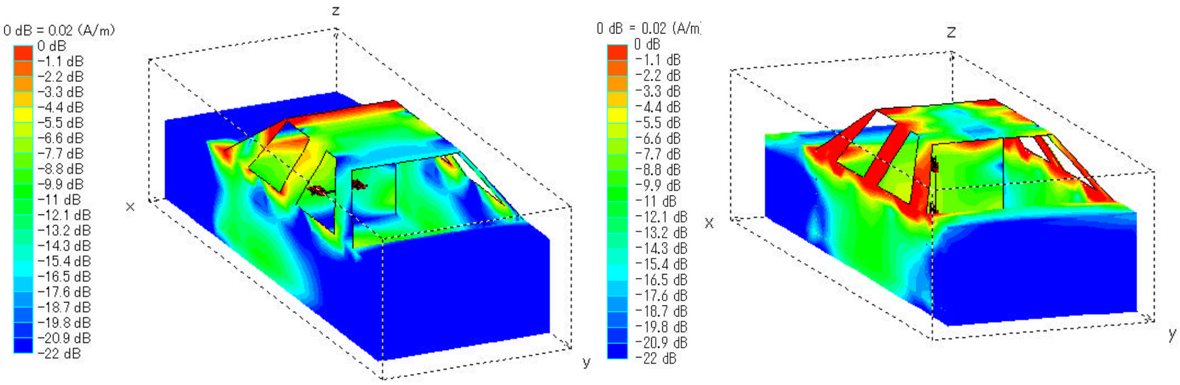
Fig.4 VSWR characteristics

Table 1 Power balance at 100MHz

	Horizontal antenna		Vertical Antenna	
	H=574	H=1000	H=574	H=1000
Po	0.01w	0.01w	0.01w	0.01w
Pi	0.00111w	0.00166w	0.00955w	0.00934w
Pr	0.000852w	0.00131w	0.00955W	0.00879w
η	8.52%	13.1%	95.5%	87.9%

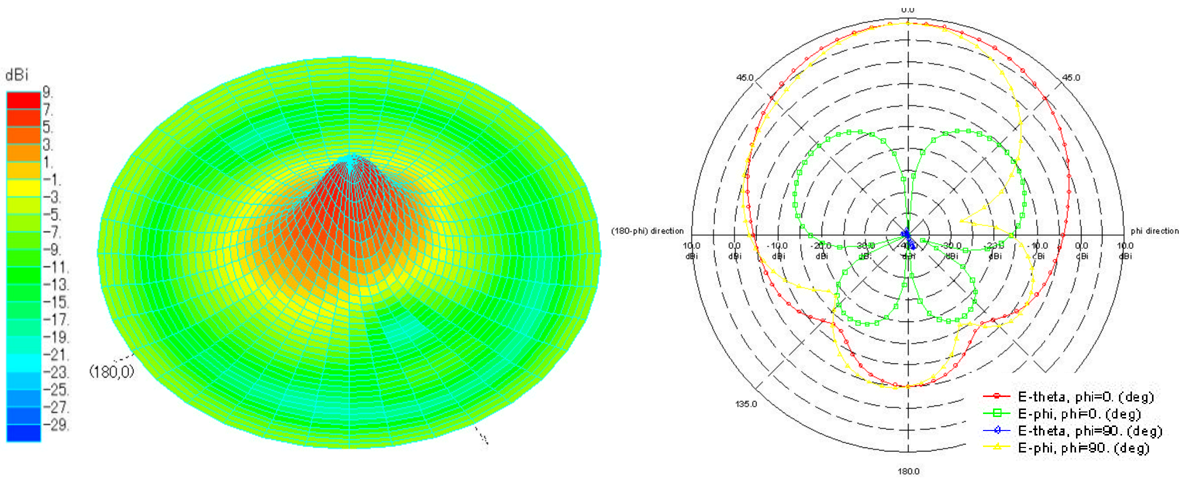
Table 2 Power balance at 314MHz

	Horizontal antenna	Vertical antenna
	H=574	H=574
Po	0.01w	0.01w
Pi	0.00883w	0.00822w
Pr	0.00797w	0.00877w
η	80%	87.8%



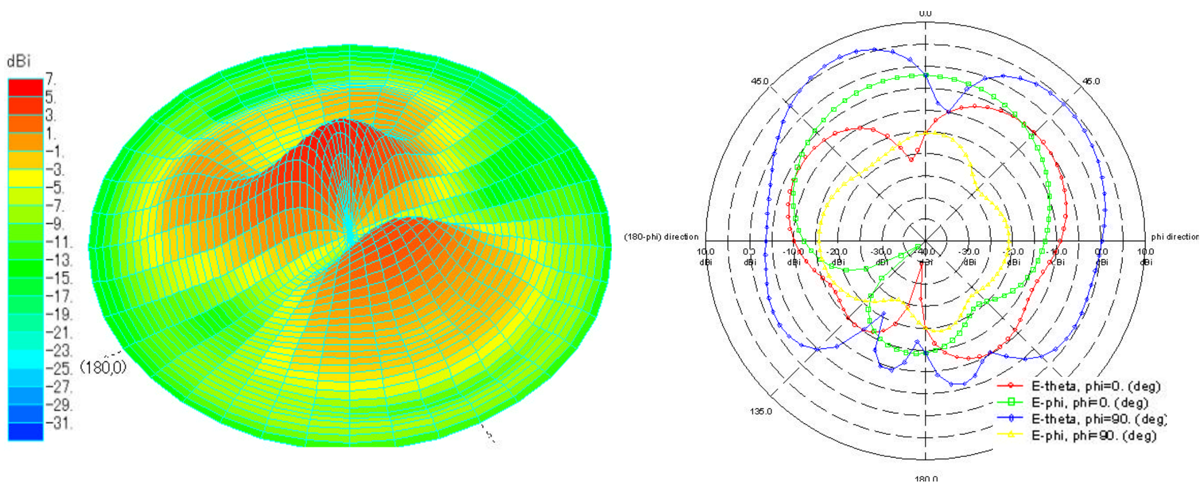
(a) Horizontal antenna (b) Vertical antenna

Fig.5 Current distributions on a car body



(a) Plane form (Etotal) (b) Cross sectional form

Fig.6 Radiation patterns of the horizontal antenna



(a) Plane form (Etotal) (b) Cross sectional form

Fig.7 Radiation patterns of the vertical antenna