A simple model for calculating the radiation patterns of antennas mounted on a vehicle roof

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1. Introduction

Recently, there has been an exceeding increase in number of radio communication systems for vehicles. An antenna for a vehicle radio communication is set on an appropriate location according to its system. It is to be desired that a radiation pattern of an antenna mounted on a vehicle could be predicted accurately so as to obtain a radiation pattern suitable for the system.

The moment method and the FDTD are numerical calculation methods widely used, which are capable of calculating arbitrary structure of an antenna. The numerical methods are practically used in the region where the size of the antenna is of the order of wavelengths. In the 900MHz band, it is difficult to calculate radiation characteristics of an antenna mounted on a vehicle since a length of a vehicle is more than ten wavelengths.

The geometric optics (GO) and the uniform geometric theory of diffraction (UTD) [1] are applicable to an antenna that is large in terms of wavelength. It has been reported that a radiation pattern of an antenna mounted on a vehicle could be calculated by the GO [2]. However, there have been few efforts to find out significant waves in order to simplify the calculation.

This paper proposes a simple and accurate calculation model for an antenna mounted on a roof of a vehicle. At first, experimental study was carried out to determine a simple model, whose radiation pattern agrees with that of an actual vehicle. In the second step, a calculation model, which is composed of a direct ray and some diffracted rays, is derived from the simple experimental model. By contract with the measured results, the calculation model is capable of accurately representing radiation characteristics of an antenna mounted on the vehicle.

2. Experimental model

Figure 1 shows the geometry and dimensions of an experimental model of a vehicle. A vehicle model, shown in Fig. 1, is constructed of metal plates and sharp wedges, not equipping any side mirror and windows, for simplicity. The model is made to a scale of a quarter of an actual vehicle. A monopole antenna is mounted at the center of the roof. A distance from the antenna to the forward and backward edges of the roof is 155mm,which is 1.86 wavelength at 3.6GHz.

The length of the monopole antenna is determined to be 1/4 wavelength at 3.6GHz in order to examine radiation characteristics of an actual vehicle at 900MHz.

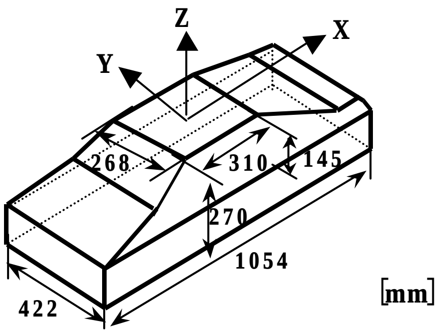
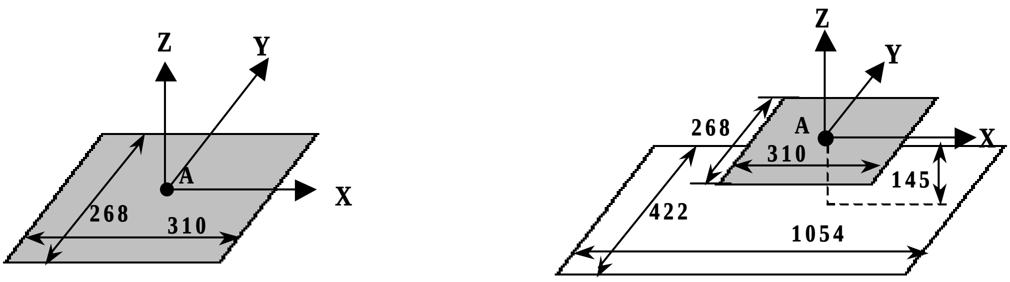


Fig. 1 Vehicle model

Figure 2 illustrates two simplified experimental models of the vehicle. The models are made up of metal plates. Figure 2(a) shows the one plate model. This model represents the roof of the vehicle, regarded as the simplest model. It is considered that the roof has a much stronger influence on the radiation pattern than any other part of vehicle.

Figure 2(b) shows the two plate model, which is the second simplest model. The upper and lower plates represent the roof and body of the vehicle model, respectively.

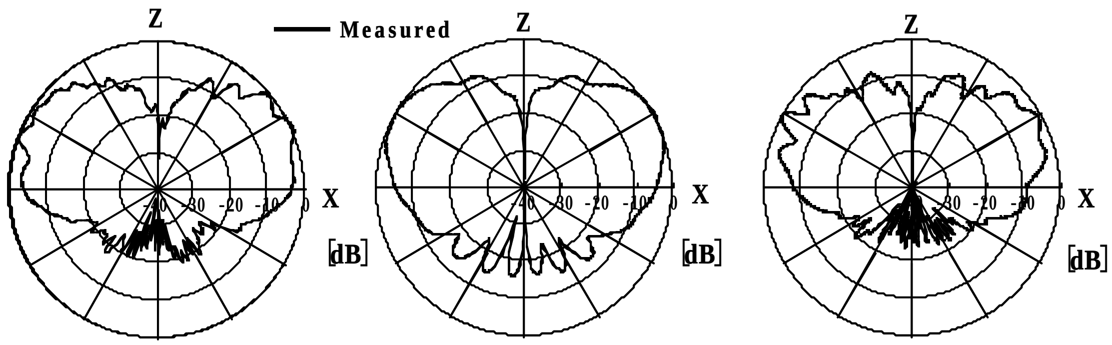


(a) One plate model **(b) Two plate model**

Fig. 2 Simplified experimental model

3. Results of experiments

Figure 3 shows the measured radiation patterns. Figure 3(a) indicates that there are a number of complicated fluctuations in the radiation pattern of the vehicle model. This phenomenon is considered to be due to rays diffracted from the edges of the vehicle model.



(a) Vehicle model **(b) One plate model** **(c) Two plate model**

Fig. 3 Measured radiation patterns of the experimental model

As can be seen from Fig. 3(b), the radiation pattern of the one plate model is different from that of vehicle model in regard to the fluctuations. Furthermore, the one plate model radiates more strongly in the region of Z<0 than the vehicle model. The radiation pattern of the two plate model, shown in Fig. 3(c), is in good agreement with that of vehicle model.

From this, the two plate model is effective in making an accurate estimate of the radiation pattern of the antenna mounted on the roof of the vehicle.

4. Calculation model

A radiation pattern is estimated from the sum of a direct ray and rays diffracted from edges of the antenna. From the result of the experimental study, we propose a calculation model. Figure 4 illustrates a calculation model, which is based on the two plate model. The calculation model consists of a direct ray (W1), two single diffracted rays (W2, W3), and two double diffracted rays (W4, W5). The diffracted rays are computed with the UTD technique [3].

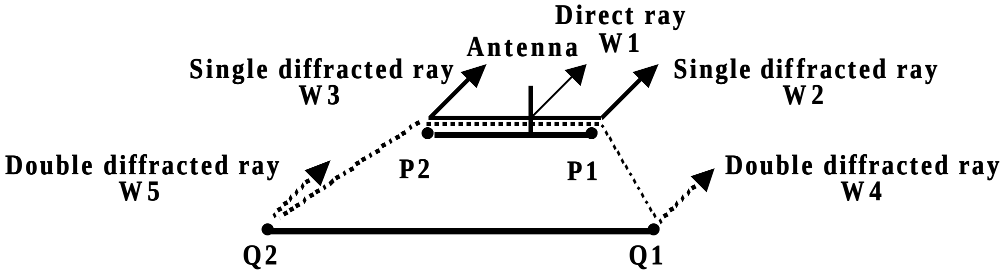
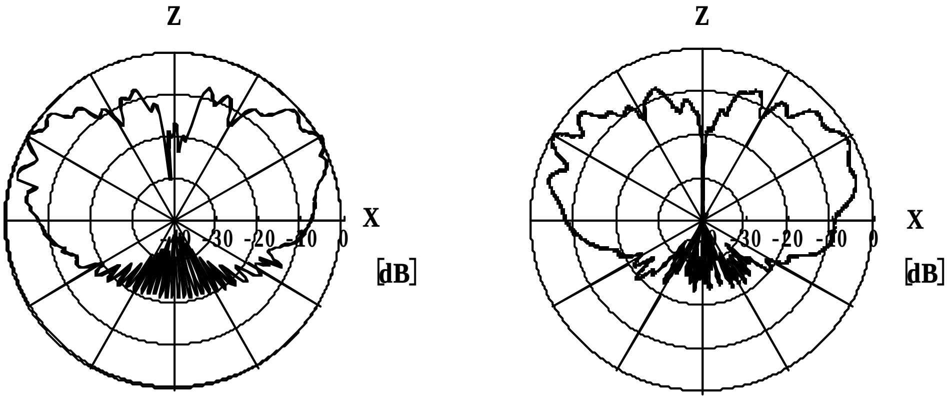


Fig. 4 Calculation model

Figure 5 shows the calculated and measured radiation patterns of the two plate model. From Fig. 5, the radiation pattern of the calculation model shows a good agreement with that of the experimental model. From this, the calculation model, which takes five rays into account, permits us to predict radiation characteristics of the antenna mounted on the vehicle.



(a) Calculated **(b) Measured**

Fig. 5 Calculated radiation pattern of the two plate model

5. Conclusion

In this paper, the calculation model applicable to the antenna mounted on the roof of the vehicle is presented. The simple calculation model, comprising a direct ray and four diffracted rays, provides an accurate representation of the radiation pattern of the antenna mounted on the roof of the vehicle.

References

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