Diffraction Loss Modeling for V2V Wireless Channel in Viaduct Scenarios at 5.9 GHz Band

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Abstract

In vehicular communication scenarios, viaduct is one of common road network structures, making significant impact on the characteristics of vehicle-to-vehicle (V2V) wireless channel. This paper proposes four diffraction loss models for viaduct scenarios, covering normal viaduct and ramp, viaduct and ramp with soundproof walls. It is found that the special structure of viaduct will have a significant effect on the diffraction loss of V2V wireless channel. Our analysis result shows that the normal ramp can reduce the diffraction loss by about 13 dB when the carrier frequency is 5.9 GHz band and the distance between transmitter and receiver is within 100 m. Meanwhile, the ramp with soundproof wall can reduce the diffraction loss by about 10 dB. In addition, the soundproof wall in the viaduct scenario will increase the diffraction loss by about 3.6 dB, while the additional diffraction loss caused by the soundproof wall in the ramp scenario can reach 3.6 to 6 dB. It indicates that the impact from viaduct on diffraction cannot be neglected in the vehicular channel modeling.

Description of Viaduct Scenarios

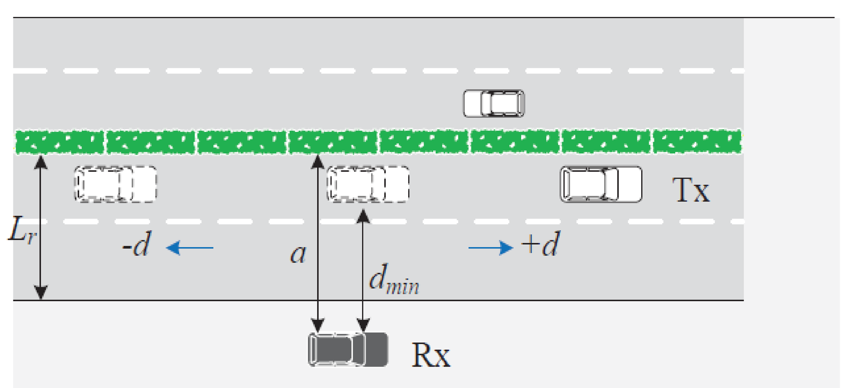
Based on the realistic traffic, viaduct scenarios are summarized into the following four types:

Method

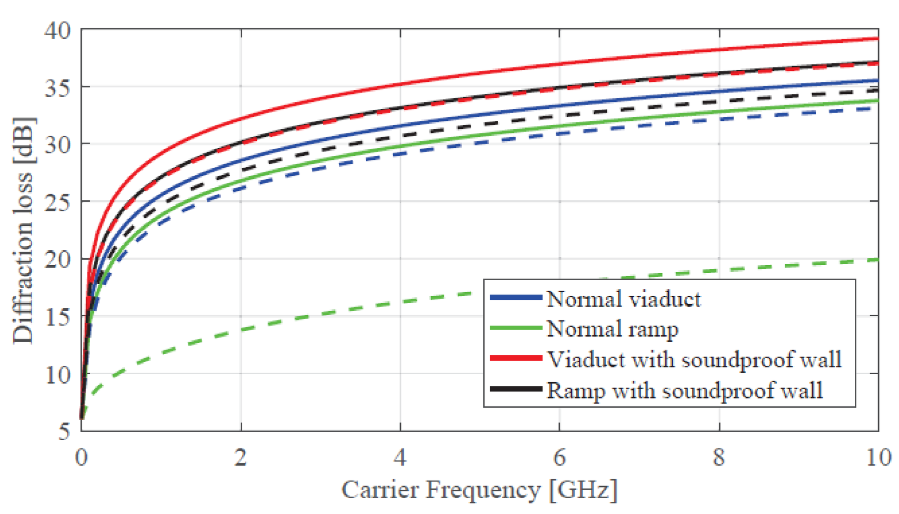
According to the analysis above, it is found that D_{tx} and D_{rx} are two key parameters for the diffraction loss calculation.

$$\theta_d = \arctan\left(\frac{h_s - h_{tx}}{D_{tx}}\right) + \arctan\left(\frac{h_s - h_{rx}}{D_{rx}}\right), \qquad v_F = \theta_d \cdot \sqrt{\frac{2D_{tx}D_{rx}}{\lambda(D_{tx}+D_{rx})}}$$

$$L(dB) = -20 \cdot \log_{10}\left(\frac{1}{2} - \frac{\exp(j\cdot\pi/4)}{\sqrt{2}} \cdot F(v_F)\right) \qquad F(v_F) = \int_0^{v_F} \exp\left(-j\cdot\pi\cdot\frac{t^2}{2}\right)dt.$$



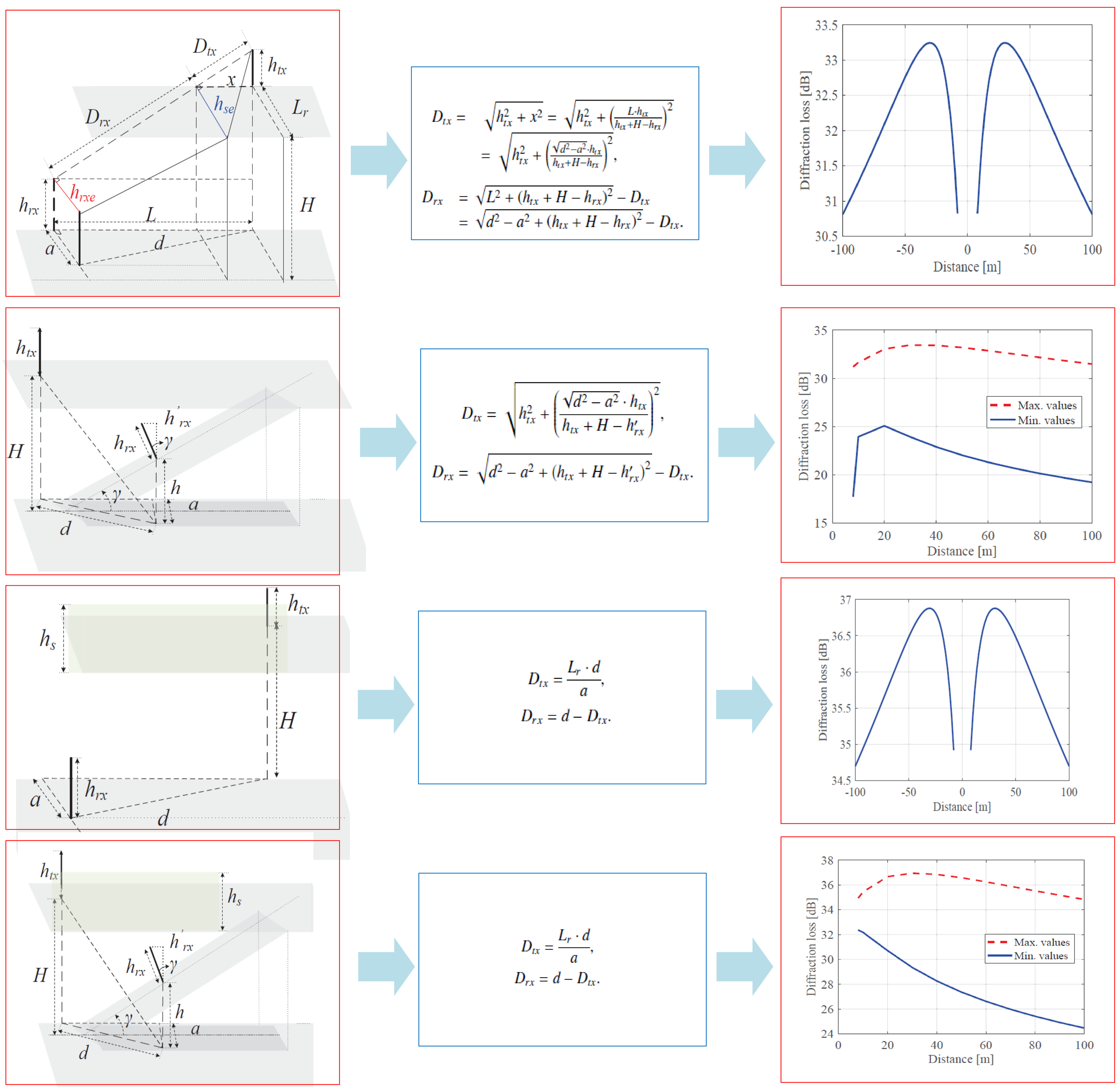
Considering the realistic traffic situation, the positional relationship between Tx and Rx can be analyzed by two cases. It is set to the origin point where the two cars have a minimum distance *d*min. The distance between Tx and Rx is set to a positive value when the Tx car is in front of the Rx car, whereas it is a negative value when the Tx car is behind of the Rx car.



Considering that carrier frequency is an important impact factor for diffraction loss, we thus firstly make an analysis of the relationship between carrier frequency and diffraction loss.

Diffraction Loss Models

Correspondingly, the geometric models can be simplified.



Conclusion

In this paper, we proposed diffraction loss models at 5.9 GHz band for four common viaduct scenarios. The numerical simulation are carried out considering the realistic traffic situation. We find that the ramp and the soundproof wall make significant impact on the diffraction loss. The existence of the ramp can reduce the diffraction loss by 10-13 dB, while the soundproof wall will cause an additional diffraction loss of 3.6-6 dB to the V2V wireless channel. Therefore, the effect of the ramps and soundproof walls on diffraction cannot be neglected in the design and optimization of vehicular communication systems.

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