Radar Backscatter Modeling of Road Surfaces Near Grazing incidence at 77GHz

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Advanced Driver Assistance Systems (ADAS) have developed rapidly and become more and more popular in current and future vehicles. One of the most important component in this system is the automotive radar. The automotive radar systems available in the market mainly focus on the detection and avoidance of other vehicles on the road. The basic idea is to detect the presence and distance as well as the relative speed of other vehicles to assess the possibility of collision and issue warning or act by stopping the vehicle. This type of radar system only utilizes the ranging and speed information and other important measured radar parameters such target cross section (RCS) information or scattering coefficients from surrounding distributed targets are discarded. RCS information is very useful in remote sensing and can be used to classify different targets. One good application of using RCS information in automotive radar is to identify the road surface conditions (types, wet or dry, rough, etc.). The millimeter-wave volumetric backscattering coefficients from asphalt or concrete has been studied and modeled previously by applying radiative transfer theory (K. Sarabandi, E S. Li and A. Nashashibi, IEEE TAP., 45.11, 1679-1688. 1997). In this work, a complete backscattering model from road surface including both surface scattering and volumetric scattering is studied. The surface scattering components from random rough road surface at the automotive radar's operating frequency (77 GHz) are modeled through full wave simulations with Monte Carlo simulations using at least more than 50 realizations of the distributed target under study. Based on this data a semi-imperial model is developed.

The road surfaces are modeled as typical random rough surfaces with exponential auto-correlation function. The FEM simulating module in commercial software HFSS is applied to simulate the scattered near field distribution from rough surfaces with a planar incident wave. The full wave simulation tool FEM solver is chosen due to its high accuracy and the ability to simulated the desired targets near near grazing incident angle. The road surface is modeled as impedance boundary. In order to avoid the edge scattering of finite surface samples periodic boundary condition are applied on the sides of the finite samples. FEM solver can obtain the near field data, and applying near-field far-field transformation we can calculate the backscattered fields and the backscattering coefficients with different polarizations. After averaging the backscatter results of 50 independent simulations, the backscattering coefficients are modeled as a function of incident angle, the road's permittivity, the rms height and the correlation length of the road surface. The simulated results have been compared with other full wave solver using the method of moments, and good agreement is achieved.