Characterization of Vehicle Penetration Loss at Wireless Communication Frequencies

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Abstract:
Automotive window films are widely used for heat rejection, protection from ultra-violet radiations and glare control purposes. For an increased performance, these films are usually metallized since metals effectively reflect the impinging electromagnetic radiations. The expend of metallization in these films may affect the communication of radio signals into vehicles. In this perspective, the provision of reliable in-vehicle coverage is a major goal of both wireless network providers and automotive industry. In order to quantify the effects of automotive window films on communication signals inside a vehicle, this research study was undertaken with industrial cooperation. This document presents the characterization of Vehicle Penetration Loss (VPL) at major wireless communication frequencies based on empirical and numerical evaluation and by exploiting different window coatings including a commercially available automotive window film and Aluminium metal foil. The research involved ultra-wideband (UWB) car measurement campaign for the frequency range of 0.6-6.0 GHz in an indoor industrial environment at an isolated storage facility in Helsinki utilizing a regular sized hatchback car. Several realistic measurement scenarios were considered to obtain large measurement sets. The measurement data was post-processed using fine algorithms to exploit various channel characteristics to gain sufficient understanding of associated propagation phenomenon. Window films were also exclusively measured in a specialized environment to accurately assess the associated penetration loss. Apart from measurements, numerical analysis based on Finite-difference time-domain (FDTD) method for the assessment of VPL was carried out at discrete frequencies, 900 MHz and 1.2 GHz. The numerical approach can serve as a future alternate to measurements provided that adequate computational resources are available. The results infer that the use of metallized automotive films can severely affect the communication of radio signals into vehicles.