

Performance of Aftermarket (DSRC) Antennas Inside a Passenger Vehicle

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ABSTRACT

A vehicle's safety system capability can be enhanced by a cooperative Vehicle-to-Vehicle (V2V) system in which vehicles communicate their driving status data, such as location and speed, using a common Dedicated Short Range Communication (DSRC) protocol. The effectiveness of the V2V applications will depend on the number of the vehicles equipped. Market penetration significantly influences the effectiveness of V2V safety applications. Previous research indicated that it could take decades to reach 95% DSRC safety device penetration in the market if only the new vehicles are equipped with the DSRC transponders during manufacturing. In order to raise the market penetration of such technology in the foreseeable future and provide a safety benefit to the early adopters, a scenario that involves retrofit and aftermarket DSRC devices is suggested by U.S. Department of Transportation (USDOT). A typical retrofit for a passenger vehicle may mean that a DSRC antenna will be installed on the roof of the vehicle and the cable will be routed to the transponder somewhere inside the vehicle. An aftermarket device installation typically means that the antenna is placed inside a vehicle on the dashboard. However, the RF signal may be impeded by glass windows, metal pillars, seats, and even the passengers. Also, there is no built-in ground plane as in the case of a roof top mount. This paper examines the performance of commercially-available DSRC antennas mounted inside of a vehicle, shows results of field trials using 0 dBi and 9 dBi horizontal gain antennas, identifies issues, and suggests possible placements of the antenna in a vehicle.

INTRODUCTION

After 2013, the U.S. government may mandate or in other ways encourage passenger and commercial vehicles to be

equipped with 5.9 GHz DSRC transponders [1]. If only new vehicles are equipped with transponders, it will take up to 40 years to reach significant market penetration [2]. For successful cooperative safety applications, high market penetration is critical. To increase the number of transponders on the road, the Vehicle Infrastructure Integration Consortium is considering several retrofit installation scenarios [3]. Some scenarios include retrofitting installations that include a roof-mounted antenna. Other scenarios include stand-alone DSRC devices that can reside on a dashboard. In-vehicle retrofit devices are easier to install since they do not need routing antenna cables from the roof to the vehicle's interior. However, communication performance of the antenna residing inside a vehicle is degraded compared to the antenna being on the roof of the vehicle. The purpose of this research was to compare DSRC communication performance with antennas placed inside a vehicle versus on the roof.

Similar research involved DSRC performance measurements with the antenna placed only on the roof of the vehicle [4, 5, 6, 7], while this research focused on in-vehicle DSRC antenna performance.

IN-VEHICLE DSRC ANTENNA PERFORMANCE

EXPERIMENT SETTINGS

This section describes the experimental equipment used for testing. We converted two ordinary passenger sedans into experimental platforms by equipping them with additional hardware. Each of the two experimental vehicles is equipped with a Denso Wireless Safety Unit (WSU) with integrated Atheros 802.11p-based DSRC radio, Novatel Global Positioning System (GPS) receiver and antenna, and a software application running on the WSU processor. The two vehicles are sending a Basic Safety Message (BSM) in

wireless short message type, as defined in the Institute of Electrical and Electronics Engineers (IEEE) 802.1p draft standard [8]. Each vehicle sends messages periodically every 100 ms. The data content of the BSM is defined in Society of Automotive Engineers (SAE) J2735 standard [9]. The over-the-air BSM size includes 51 bytes of overhead, 222 bytes of security information, and 105 bytes of data, for a total of 378 bytes. Messages are sent at 20 dBm with ~ 3 dB cable loss yielding ~ 17 dBm total over-the-air power. BSMs are sent with data rate of 6 Mbps on a continuous dedicated safety channel CH172 (5.855-5.865 GHz).

We used two commercially-available antennas: a long pole antenna with 9 dBi at horizon with embedded ground plane and elevated radiating element (Antenna A), and a ground plane dependent “hockey puck” mono-pole antenna with 0 dBi at horizon (Antenna B). Both antennas are omnidirectional at horizon. As shown in Figure 1, the experiments used the following four antenna setups:

- a). Antenna A mounted inside the vehicle below the rear mirror
- b). Antenna B placed on the dashboard
- c). Antenna B mounted on a metal sheet placed on the dashboard
- d). Antenna B mounted on the roof of the vehicle

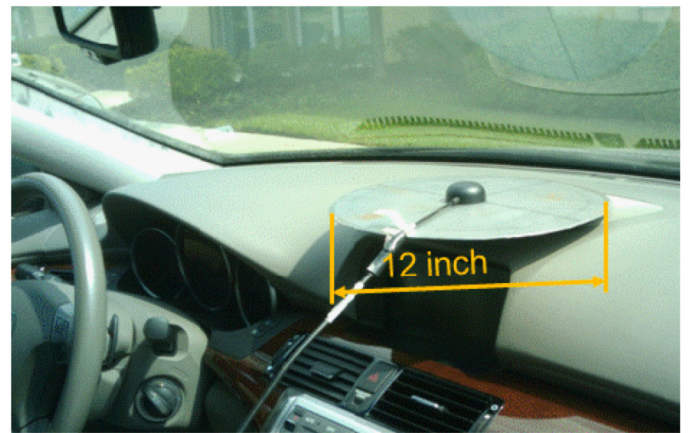


a)

Figure 1. Antenna setups: a) Antenna A mounted inside the vehicle and below the rear mirror, b) Antenna B placed on the dashboard, c) Antenna B mounted on a metal sheet placed on the dashboard, and d) Antenna B mounted on the roof of the vehicle.



b)



c)



d)

Figure 1 (cont.). Antenna setups: a) Antenna A mounted inside the vehicle and below the rear mirror, b) Antenna B placed on the dashboard, c) Antenna B mounted on a metal sheet placed on the dashboard, and d) Antenna B mounted on the roof of the vehicle.