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Antenna Design Strategies for DSRC Radar

Sathya Ganesh Sharma R[1], Nihal R Mandi[1], Mayank Hasmukh Bhai Patel[1], K Kaushik Devaiah[1], Thyagaraj T[1]
[1]*(Electronics and Communication Department, BMSIT&M, Bengaluru, India)*

Abstract: DSRC (Dedicated Short Range Communications) is a two-way short- to- medium-range wireless communications capability that permits very high data transmission critical in communications-based active safety applications. In Report and Order FCC-03-324, the Federal Communications Commission (FCC) allocated 75 MHz of spectrum in the 5.9 GHz band for use by Intelligent Transportations Systems (ITS) vehicle safety (V2V) and mobility applications (V2I). A conformal design is one that follows any prescribed shape. Hence our antenna design can be mounted in any small part like the bonnet, car manufacturer logo, etc. Thus, by combining the conformal nature of an antenna with DSRC, a robust system for V2V communication can be created and explored.

Keywords: Conformal, DSRC, Front grill, Intelligent Transport Systems, Vehicle-to-Vehicle Communication.

I. Introduction

DSRC based communications is a major research priority of the Joint Program Office (ITS JPO) at the U.S. Department of Transportation (U.S. DOT) Research and Innovative Technology Administration (RITA). The cross-modal program is conducting research using DSRC and other wireless communications technologies to ensure safe, interoperable connectivity to help prevent vehicular crashes of all types and to enhance mobility and environmental benefits across all transportation system modes.

The U.S. DOT's commitment to DSRC for active safety communications contributes to safer driving. Vehicle safety applications that use vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications need secure, wireless interface dependability in extreme weather conditions, and short time delays; all of which are facilitated by DSRC.

1.1 Vehicle to Vehicle Communication (V2V)

V2V applications utilizing DSRC may have the potential to significantly reduce many of the most deadly types of crashes through real time advisories alerting drivers to imminent hazards–such as veering close to the edge of the road; vehicles suddenly stopped ahead; collision paths during merging; the presence of nearby communications devices and vehicles; sharp curves or slippery patches of roadway ahead.

1.2 Vehicle to Infrastructure communication (V2I)

Convenience V2I services like e-parking and toll payment are also able to communicate using DSRC. Anonymous information from electronic sensors in vehicles and devices can also be transmitted over DSRC to provide better traffic and travel condition information to travellers and transportation managers. It also helps in providing information on the nearest gas stations and also the price of the fuel automatically when the fuel is less. It also provides information on the nearest garages when the check engine light is ON while driving.

II. Advantages

1. **Designated licensed bandwidth:** For secure, reliable communications to take place. It is primarily allocated for vehicle safety applications by FCC Report and Order FCC 03-324.
2. **Fast Network Acquisition:** Active safety applications require the immediate establishment of communication and frequent updates.
3. **Low Latency:** Active safety applications must recognize each other and transmit messages to each other in milliseconds without delay.
4. **High Reliability when Required:** Active safety applications require a high level of link reliability. DSRC works in high vehicle speed mobility conditions and delivers performance immune to extreme weather conditions (e.g. rain, fog, snow, etc.).
5. **Priority for Safety Applications:** Safety applications on DSRC are given priority over non-safety applications.
6. **Interoperability:** DSRC ensures interoperability, which is the key to successful deployment of active

safety applications, using widely accepted standards. It supports both V2V and V2I communications.

7. **Security and Privacy:** DSRC provides safety message authentication and privacy.

III. DSRC Standards

TABLE 1: Frequency Allocation in US

Application	Frequency Band (GHz)
Intelligent Transportation Systems	5.850 to 5.925
Industrial, Scientific, and Medical	5.850 to 5.875

TABLE 2: Frequency Allocation in EU

Standard	Application	Frequency Band (GHz)
ITS-G5D	Future ITS Applications	5.905 to 5.925
ITS-G5A	ITS road safety related	5.875 to 5.905
ITS-G5B	ITS non– safety related	5.855 to 5.875

IV. PLACEMENT STUDY

The conformal antenna design strategy gives us the flexibility to design antennas of different shapes so that it fits in a particular location. There are several places where the antenna can be mounted like vehicle roof top, bonnet, front grill, etc. The advantages and disadvantages of placing the antenna in different places is discussed.

4.1 Bonnet

Figure 4.1 Bonnet of a Car

Advantages: The major advantage in using bonnet antenna is effective space utilization and the availability of more area for antenna design.

Disadvantages:
It is more prone to damage.
It is directly above the engine, which leads to the antenna getting heated up quickly Surrounding metal might hamper the performance of the antenna

4.2 Roof Top

Figure 4.2 Roof Top of a car

Advantages: The major advantage in using rooftop antenna is that it has a large surface area and also good view of the horizontal plane for radiation.

Disadvantages:
- It is exposed to the environment. So the metal present in the antenna might get corroded fast.
- It becomes a problem for convertible vehicles.
- Surrounding metal might hamper the performance of the antenna.

4.3 Side Mirrors

Figure 4.3 Side Mirror of a car.

Advantages: The major advantage of placing the antenna on a side mirror is that it can be used effectively for Vehicle to Infrastructure communication since it radiates sideward towards the footpath.

Disadvantages:
- Since it radiates towards the side, it is less effective for Vehicle to Vehicle communication in the forward direction.
- Side mirrors are more prone to damage in congested environments.

4.4 Front Grill

Figure 4.4: Front Grill of a car

Advantages:
- Concealed design
- No effect on aesthetics.
- Cooled by incoming airflow even though it's placed in front of the engine

Disadvantages: The major disadvantage in placing an antenna in the front grill is that the design cannot be standardized since every car has different grill shapes.

In conclusion, it's more beneficial to choose the front grill as the position of our antenna.

V. Antenna Designs

5.1 Hyundai Elantra

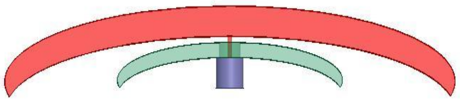

Figure 5.1: Antenna design for front grill of Hyundai Elantra

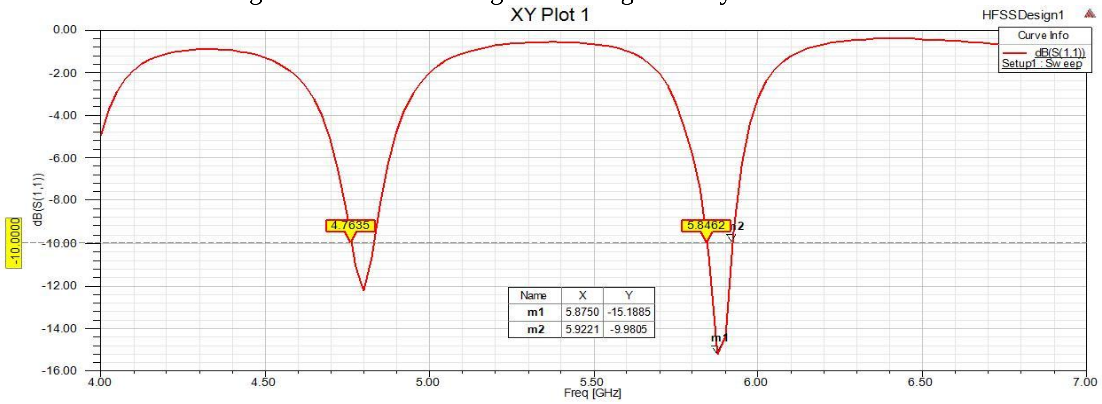

Figure 5.2: S11 plot of Antenna design for front grill of Hyundai Elantra

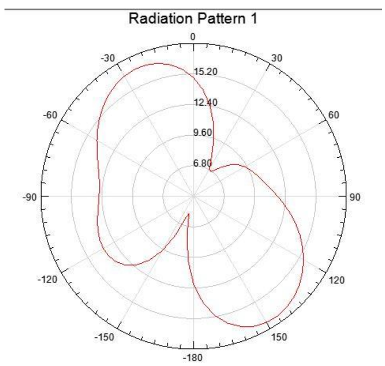

Figure 5.3 Radiation plot of Hyundai Elantra grill design

The design has a curved patch and ground material made of copper. Here air is the substrate. The patch is 100mm long and 50mm wide. The antenna resonates at 5.875GHz with a return loss of -15.19 dB. The Bandwidth is 75.9MHz.

5.2 Hyundai Getz

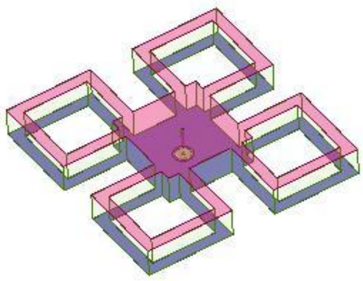

Figure 5.4: Antenna design for front grill of Hyundai Getz.

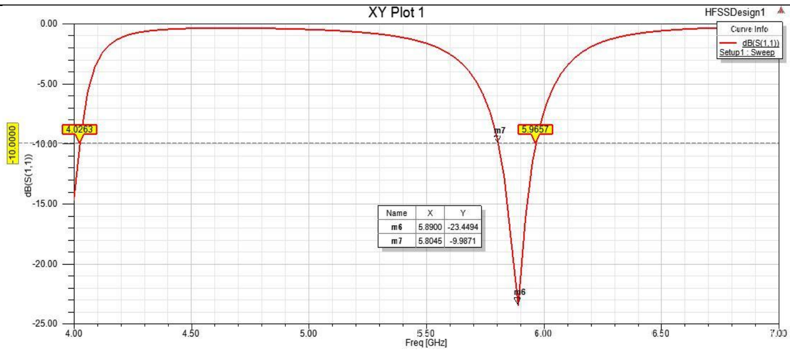

Figure 5.5: S11 plot of Antenna design for front Grill of Hyundai Elantra

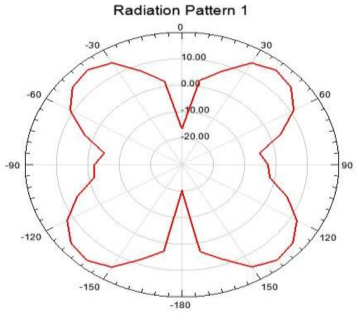

Figure 5.6 Radiation plot of Hyundai Getz front grill antenna

The design is 70mm long and 70mm wide (Without considering the gaps). It resonates at 5.89 GHz with a return loss of -23.44dB. Bandwidth obtained is 161MHz. Fr4 epoxy substrate is used. It covers all DSRC standards.

5.3 Fiat Linea

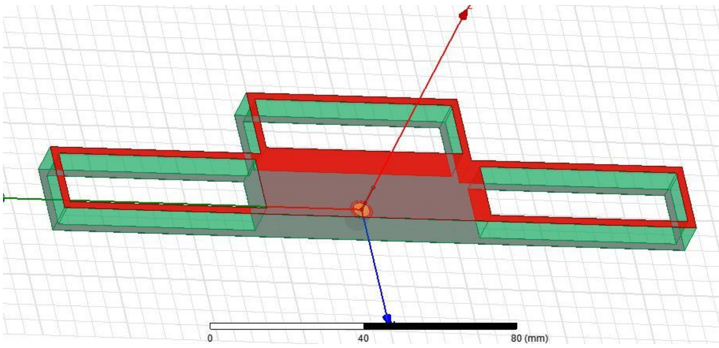

Figure 5.7: Antenna Design for Fiat Linea front grill.

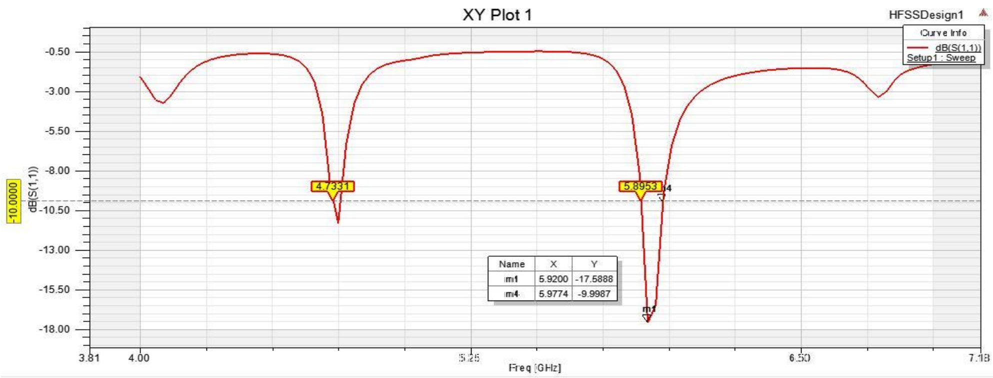

Figure 5.8: S11 plot of Antenna design for front Grill of Fiat Linea.

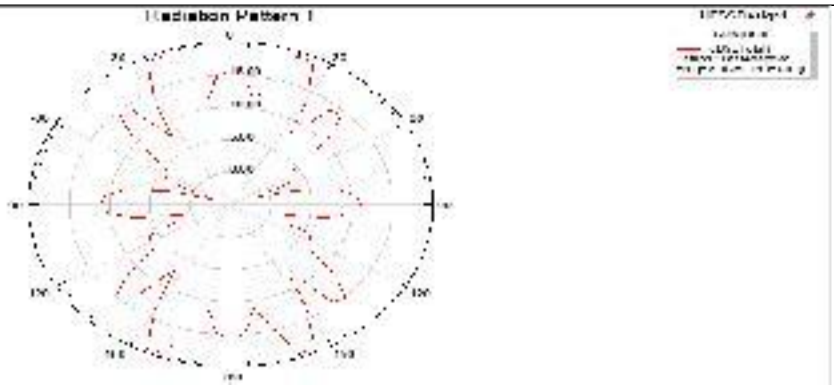

Figure 5.9: Radiation plot of Antenna design for front grill of Fiat Linea.

The substrate used is hard rubber. It has a total length of 180mm and a width of 40mm (Without considering the gaps). The antenna radiates at 5.92GHz bandwidth.

5.4 Analysis of Results

Table 5.1: Results of the Antenna designs

Sl no.	Grill Shape (Car used)	Frequency (GHz)	Bandwidth (MHz)	Return Loss (dB)
1	Hyundai Elantra	5.875	75.9	-15.19
2	Hyundai Getz	5.89	161	-23.44
3	Fiat Linea	5.92	82	-17.588

VI. Conclusion

DSRC communication uses antennas radiating at 5.9GHz with a minimum of 75MHz. Thus, we have designed three antennas that covers all the DSRC standards prescribed by the United States and the European Union, thereby covering applications which include Intelligent Transport Systems like emergency vehicle notification system, automatic road enforcement, etc. and Road Safety related applications such as collision avoidance system and other non-road safety applications.

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