



## STUDY AND ANALYSIS OF CONFORMAL ANTENNAS FOR VEHICULAR COMMUNICATION APPLICATIONS

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### ABSTRACT

The degradation of performance metrics of an antenna due to hiding multiple antennas in the vehicular body and aerodynamic drag caused due to perturbing antenna structures is overcome by using conformal antennas. Conforming the antenna causes various changes in the radiation characteristics of the antenna. Therefore it is essential to study and analyze these variations for characterizing the conformal antenna and also to counterbalance the changes in performance metrics. The various effects of parameters which contributes for superior radiation characteristics of the conformed radiating antenna which is used for vehicular communication applications is carefully deliberated in this paper.

**Keywords:** conformal antenna, aerodynamic drag, RT duroid, vehicular communication.

### INTRODUCTION

The antenna which is conformed to any prescribed shape is called conformal antenna. The shapes to which the antennas are conformed can also be a part of a fast moving vehicle. The practical issue of any antenna includes its physical size. Planar antennas can also be used in a fast moving vehicle but their Radar cross section is very high in comparison with the conformal antennas. Therefore need radomes for counterbalancing this effect. The integration of a conformal antenna in a vehicular body makes it less perturbing and also reduces the visibility to the human eye.

Another characteristic of the conformal antenna integrated in the vehicle is that the aerodynamic drag which affects the radiation characteristics is eliminated. The force which is exerted on the vehicle or any object that oppose its motion through air is called as Aerodynamic drag. The Aerodynamic drag is directly proportional to speed and mass of the medium. The shape and texture of the object also has an effect on the aerodynamic drag.

Conformal antennas have many applications especially in vehicular applications because they space and are less perturbing.

### Vehicular communication

Transfer of information between vehicles and transfer of information between vehicles or between vehicle and infrastructures like traffic signal controllers, police stations, hospitals, etc are called vehicular communication. The RF communication link established between vehicles is called Dedicated Short Range Communication. The communication standard vehicular communication application uses two different resonating frequency of 5.9GHz and 915MHz. The information carrying capacity is higher in the DSRC standard which uses 5.9GHz in comparison with the DSRC standard which uses 915 MHz.

IEEE 802.11 was extended to include the Dedicated Short Range Communication channels for intelligent transportation services which include Vehicle to Vehicle (V2V) communication and Vehicle to Infrastructure (V2I) communication. The commercially available DSRC antennas include omnidirectional antennas with gain of 6.9dBi and directional antennas like yagi antennas with the gain of 12dBi. The omnidirectional antennas are used for ordinary applications like entertainment where as directional antennas are used for special applications like safety applications. In this research paper the change in various parameters like size, materials, shape, patch which effect the radiation characteristic of a conformal antenna for vehicular communication applications is studied by simulating the conformal antenna. The inferences are made after tabulating the results.

### FFECT of changing the material for a conformal antenna

The commonly available materials used for fabrication of a DSRC antenna are RT Duroid, FR4 Epoxy. The antenna is designed using Feko Suite 7.0 and the simulation results are tabulated in Table-1 given below. It's inferred that by using different materials there is a notable change in the radiation characteristics.

The various materials commonly available for the antenna fabrication are FR4 Epoxy, RT Duroid 5870™, RT Duroid 5880™, RT Duroid 6002™, RT Duroid 6006™ and RT Duroid 6010™. Using Feko Suite the antenna is designed and simulated to find the radiation characteristics. Change in material results notable variation in the radiation characteristics.



**Table-1.** Variation in dimensions due to change of materials (rectangular patch).

Material	Relative Permittivity	W (in cm)	L (in cm)
RT DUROID 5870™	2.33	1.97	1.575
RT DUROID 5880™	2.2	2.01	1.618
RT DUROID 6002™	2.94	1.811	1.407
RT DUROID 6006™	6.15	1.345	0.974
RT DUROID 6010™	10.2	1.074	0.749
FR4 Epoxy	4.4	1.5472	1.1535
Wash cotton	1.51	2.2694	1.9296
Polyester	1.44	2.3017	1.9712

**Table-2.** Change in radius (circular patch).

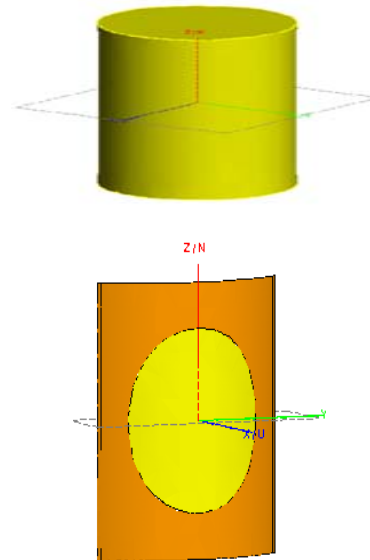
Material	Relative Permittivity	RADIUS (in cm)
RT DUROID 5870™	2.33	0.927
RT DUROID 5880™	2.2	0.9521
RT DUROID 6002™	2.94	0.8312
RT DUROID 6006™	6.15	0.5846
RT DUROID 6010™	10.2	0.4576
FR4 Epoxy	4.4	0.6865
Wash cotton	1.51	1.133
Polyester	1.14	1.2871

### Effect of change in base model

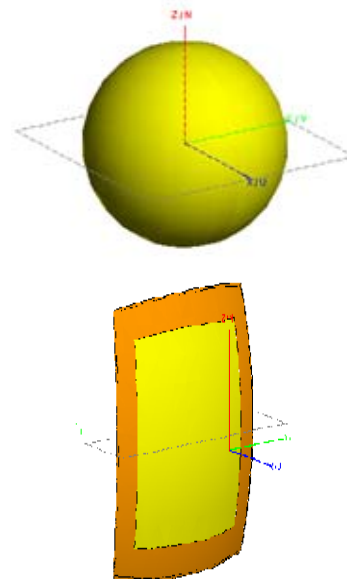
Conformal Antenna is antennas which can be conformed to a prescribed shape. The prescribed shape is a part of a base model where the conformal antenna is to be placed. The conformal antenna can be placed on base model of any shape. In this paper three different base models are used for study. Base model play a major role in conformal antennas because the characteristics of an antenna mainly depends on the platform in which it is placed.

The different base models used are cylinder, sphere and cone.

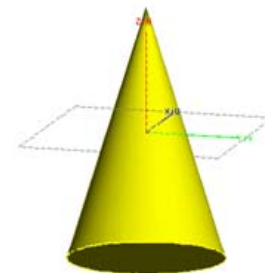
The most commonly used base model is cylinder because major real world shapes can be approximated by cylindrical surface. The conformal antenna placed on different base models is shown in Figure-1, Figure-2, and Figure-3.



**Figure-1.** Conformal antenna on a cylindrical base model.



**Figure-2.** Conformal antenna on a spherical base model.



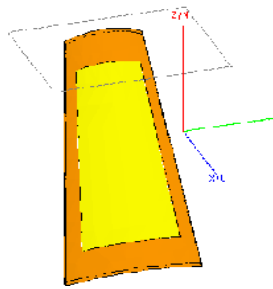


Figure-3. Conformal antenna on a conical base model.

**Effect of change in type of patch**

In this paper two different types of patch are used for the study and they are circular and rectangular patch. The most commonly used patch is rectangular patch but whereas circular patch has more advantages when compared to rectangular patch. The directivity of circular patch antenna is more when compared to that of rectangular one.

Circular patch provides circular polarization and the space occupied by circular patch is less when compared to that of rectangular. The conformal antenna placed on cylindrical base model with different type of patch is shown in Figure-4.

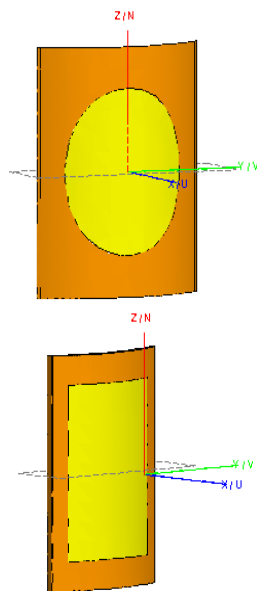


Figure-4. Cylindrical conformal antenna with different types of patches.

**Analysis of the radiation characteristics of conformal antenna**

For this study we take two materials into consideration along with three different base models and two types of patch. The materials under study are RT DUROID 5870 and RT DUROID 6002.

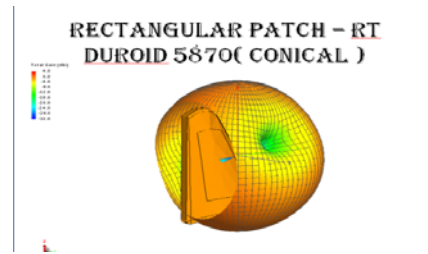


Figure-5.a.

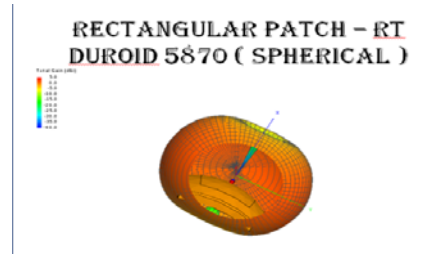


Figure-5.b.

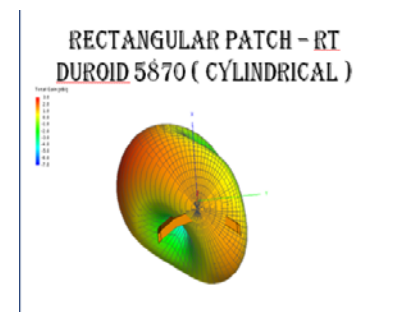


Figure-5.c.

Table-3. Variation of gain in dbi for rectangular patch.

BASE MODEL / MATERIAL	CYLINDRI CAL	SPHERICAL	CONICAL
RTDUROID 5870	3	5	4

The Figures-3.a,b and c represent radiation pattern of RT DUROID 5870 material with rectangular patch. The Table-3 represents the change in gain according to change in base model.

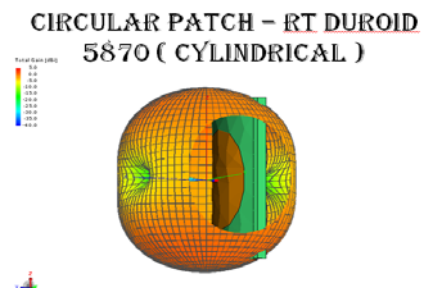
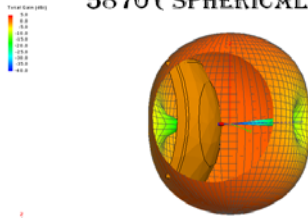


Figure-6.a.

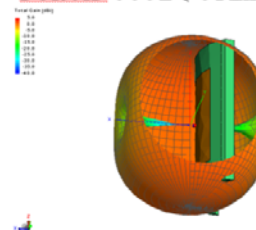


**CIRCULAR PATCH – RT DUROID 5870 ( SPHERICAL )**



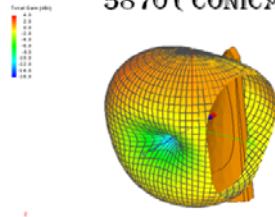
**Figure- 6.b.**

**RECTANGULAR PATCH – RT DUROID 6002 ( CYLINDRICAL )**



**Figure-7.c.**

**CIRCULAR PATCH – RT DUROID 5870 ( CONICAL )**



**Figure- 6.c.**

**Table-5.** Variation of gain in dbi for rectangular patch.

BASE MODEL / MATERIAL	CYLINDRICAL	SPHERICAL	CONICAL
RT DUROID 6002	5	5	2

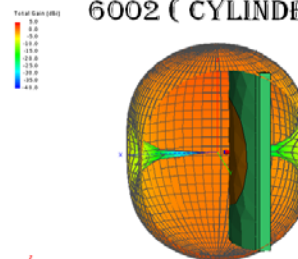
**Table-4.** Variation of gain in dbi for circular patch.

BASE MODEL / MATERIAL	CYLINDRICAL	SPHERICAL	CONICAL
RT DUROID 5870	5	5	4

The Figures-5.a,b and c represent radiation pattern of RT DUROID 6002 material with rectangular patch. The Table-5 represents the change in gain according to change in base model.

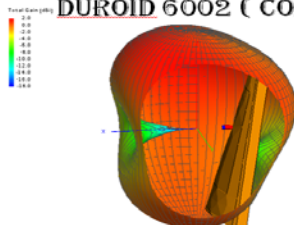
The Figures-4.a,b and c represent radiation pattern of RT DUROID 5870 material with circular patch. The Table-4 represents the change in gain according to change in base model.

**CIRCULAR PATCH – RT DUROID 6002 ( CYLINDRICAL )**



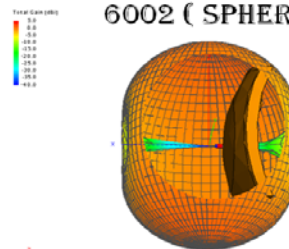
**Figure-8.a.**

**RECTANGULAR PATCH – RT DUROID 6002 ( CONICAL )**



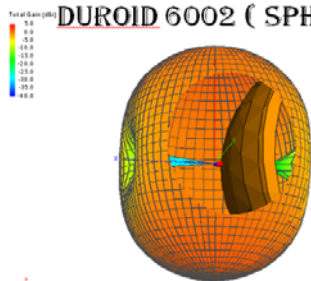
**Figure- 7.a.**

**CIRCULAR PATCH – RT DUROID 6002 ( SPHERICAL )**



**Figure-8.b.**

**RECTANGULAR PATCH – RT DUROID 6002 ( SPHERICAL )**



**Figure-7.b.**



### CIRCULAR PATCH – RT DUROID 6002 ( CONICAL )

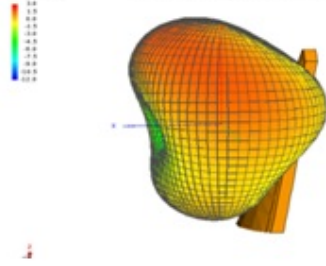


Figure-8.c.

Table-6. Variation of gain in dbi for circular patch.

BASE MODEL / MATERIAL	CYLINDRIC AL	SPHERIC AL	CONICAL
RT DUROID 6002	5	5	3

The Figures-6.a,b and c represent radiation pattern of RT DUROID 6002 material with circular patch. The Table-6 represents the change in gain according to change in base model.

Table-7. Gain when there is change in base model ( rectangular patch ) (in Dbi).

BASE MODEL / MATERIAL	CYLINDRIC AL	SPHERIC AL	CONICAL
RT DUROID 5870	3	5	4
RT DUROID 6002	5	5	2

Table-8. Gain when there is change in base model (circular patch ) (in Dbi).

BASE MODEL / MATERIAL	CYLINDRIC AL	SPHERIC AL	CONICAL
RT DUROID 5870	5	5	4
RT DUROID 6002	5	5	3

## CONCLUSIONS

Thus the gain and radiation pattern of conformal antennas are analyzed by changing the base model, patch and material used.

According to the inference above we can conclude that circular patch is the better when compared to rectangular patch.

Of the three base models, spherical base model is more reliable than that of the other two base models. When it comes to material RT DUROID 5870 is more or less having constant gain.

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