DESIGN OF DOUBLE-RECTANGULAR DIELECTRIC RESONATOR ANTENNA FOR VEHICULAR APPLICATIONS

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***Abstract*: A Dielectric Resonator Antenna (DRA) for wideband vehicular applications is proposed here. Two rectangular dielectric resonator antennas (RDRA) are placed on asymmetrical slots which are aperture coupled from ground. The antenna configuration described here combines the offset aperture coupled and rectangular DRA. The parameters obtained for RDRA are suitable for vehicular applications in the range of 5.8 GHz to 18 GHz. The maximum achieved gain is 16.01 dBi. Further the design parameters and the results of the proposed antenna are compared with cylindrical dielectric resonator antenna (CDRA). In this paper HFSS 13 is being used.**

***Index Terms*- aperture coupled, asymmetrical slots, dielectric resonator antenna.**

I. INTRODUCTION

Antennas are the crucial components in today's wireless network. An antenna is a device which is used to transform a radio frequency (RF) signal to an electromagnetic wave travelling on a conductor. The mostly used antennas in the last two decades are Microstrip Antenna and Dielectric Resonator Antenna (DRA) [1]. Microstrip Antenna consists of patch on one side and ground on the other side. The patch is placed on the substrate and excited using any of the feeding technique. The main advantages of Microstrip Antenna is it can operate at microwave frequency, light in weight, small size, any shape can be etched, etc. The disadvantges are, it consists of dielectric and conductor losses, offers low gain, lower impedance bandwidth, radiates from narrow surfaces like feeds and other junction points [2]. In order to overcome the disadvantages of Microstrip antenna, the dielectric resonator antenna (DRA) has been developed [3]. For the efficient operation of the system the idea of using dielectric material as radiator is proposed. Until then the dielectric resonators are used as energy sources. The DRA is also used to reduce the conduction losses which are observed in Microstrip Antenna. The advantages of DRA are light weight, low cost, small size, and high radiation efficiency, larger bandwidth. In DRA the radiation takes place through whole surface whereas in microstrip the radiation takes place only through narrow slots [4]. And also DRA has wider impedance bandwidth than Microstrip. The DRA have special feature like it can be built in any shapes on the top of substrate like rectangular, cylindrical, spherical, triangular and many more. Here double-rectangular dielectric resonator antenna is used. In the design of DRA we have a ground plane on which dielectric resonator is placed. The dielectric resonator antenna can be excited using the excitation methods [5]. In aperture coupling method, the DRA is excited through an aperture in ground plane upon which DRA is placed. In probe coupling a probe is used to excite DRA which consists of a centre pin that extends to ground plane. In Microstrip Line coupling it can be done either in Direct-coupling or side coupling. Aperture coupling to DRA offers good impedance matching [6]. Vehicular Communications systems are networks in which vehicles and roadside units are communicating nodes providing each other information like safety warnings and traffic conditions [7]. The frequency range 5.8 GHz to 18 GHz is applicable for wideband applications. The scope of vehicular applications is vehicle to vehicle and vehicle to infrastructure communications, congestion control, routing in vehicular networks, safety and driver assistance applications, mobility and handover issues. The main challenge of designing double rectangular dielectric resonator antenna (RDRA) is its flexibility [8] and [9]. The scope of vehicular communication is improving day by day the majority of antenna are having rigid structures and are not flexible. So the idea of using double RDRA for wideband applications is proposed.

II. DESIGN OF DOUBLE-RECTANGULAR DIELECTRIC RESONATOR ANTENNA

A. HFSS Ansoft Simulator

The design of double-rectangular DRA is done using HFSS (High Frequency Structural Simulator) Ansoft Simulator.

Here HFSS V13.0 simulator is used for simulation of double-rectangular DRA. Figure 1 shows the steps for designing RDRA in HFSS Ansoft simulator.

Fig 1 Design steps of RDRA in HFSS

B. Designing of Double-rectangular CDRA

The DRA in any geometry is designed to observe the factors like return loss, bandwidth, gain, radiation field and impedance. Once after the parameters are obtained they are compared with cylindrical Dielectric Resonator Antenna (CDRA).

The configuration of proposed RDRA is shown in figure 2

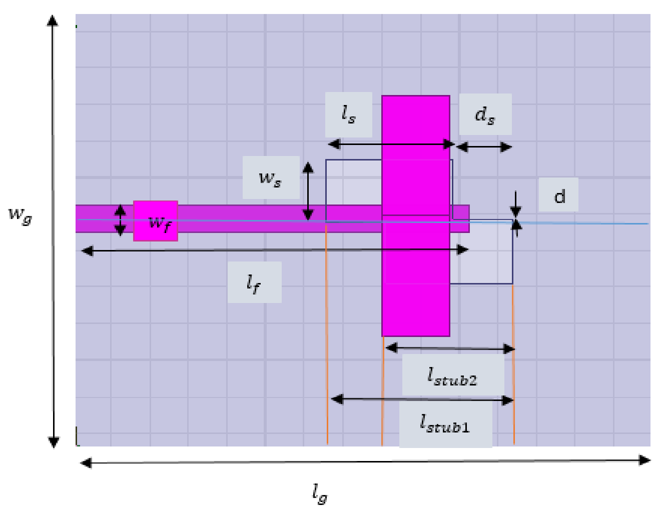


Fig 2 Configuration of RDRA (Top view)

As shown in figure 2 the configuration of the antenna consists of FR4 substrate with relative magnetic permittivity of ε_r=4.5, loss tangent = 0.017 and thickness t = 0.8 mm. The microstrip line is placed symmetrically with respect to aperture coupling with dimensions l_f and w_f. Two slots of dimensions l_s and w_s are etched in the ground plane. The DR antenna uses the alumina material with $\varepsilon_{dr} = 9.4$, length l = 6.6 mm, b = 3.5 mm, height h = 9 mm. The values of the Fig 2 as in final antenna configuration (in mm) is as follows: l_g = 30, w_g = 30, l_f = 21, w_f = 1.5, l_s = 6.6, w_s = 3.5, d_s = 3.1, l_{stub1} = 7.9, l_{stub2} = 4.8 and d = 0.2. Using the parameters the rectangular DRA is designed.

The Fig 3 shows the side view of antenna configuration.

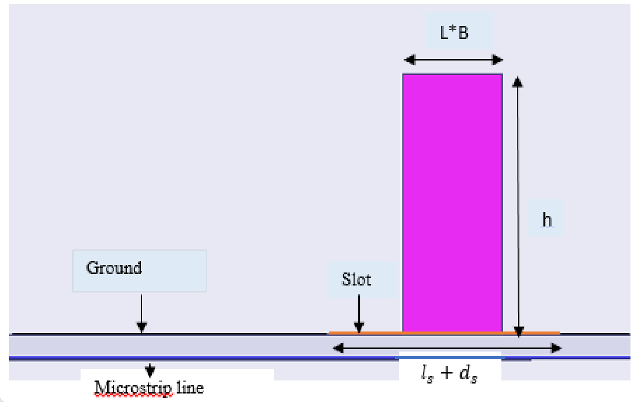


Fig 3 RDRA side view

III. RESULTS

A. Return loss characterstics

Fig 4 represents the return loss characteristics of double rectangular DRA. It is observed between two frequencies 5.8 GHz and 18 GHz. The fundamental resonance for the double-rectangular DRA is observed at 6.6 GHz.

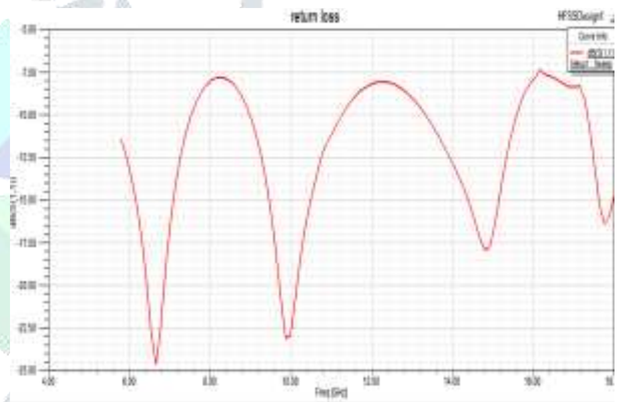


Fig 4 Return loss Characteristics (frequency verses S_{11} dB)

B. Gain and Impedance

The gain of the proposed antenna is shown in Fig 5. The simulated gain is observed between 5.8 GHz and 18 GHz. The maximum achieved gain is 16.06 dBi and minimum achieved is -0.8 dBi. The gain observed at 5.8 GHz is 3.63 dBi.

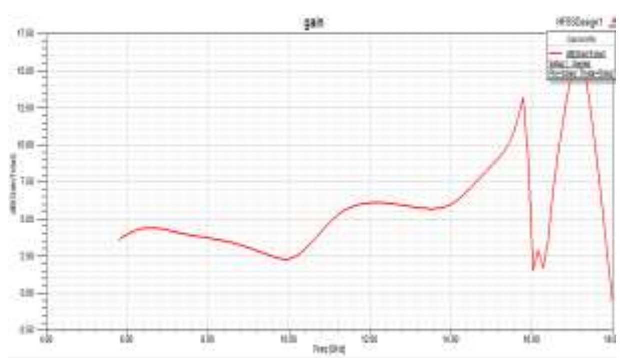


Fig 5 Gain verses frequency graph

The impedance curve is shown in Fig 6. The real parts are around 50 Ω, and imaginary parts are around 0.

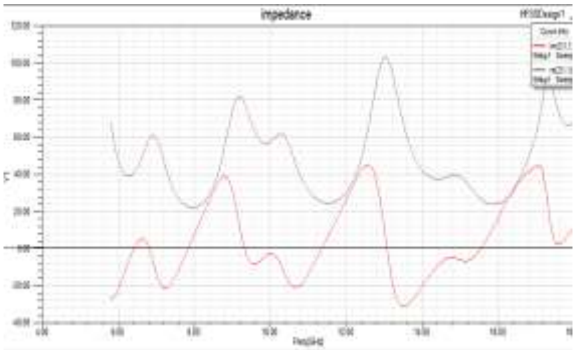
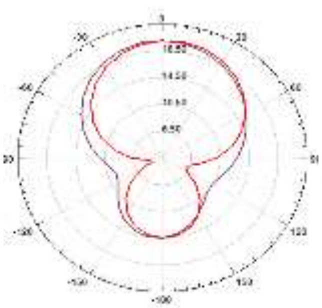


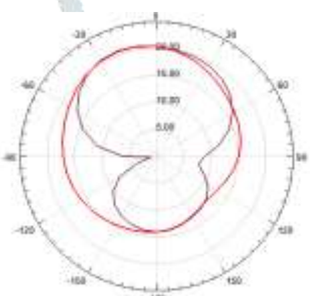
Fig 6 Impedance of the antenna

C. Radiation Pattern

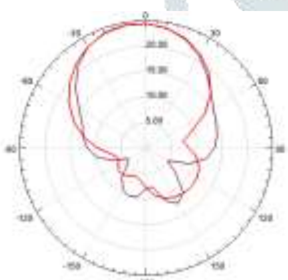
Fig 7 displays the 2-D normalized radiation patterns at frequencies 6 GHz, 10 GHz and 15 GHz. It is shown in both E-plane and H-plane, which shows the maximum radiation from antenna. Fig 8 shows the 3-D polar plots of the radiation pattern.



(a) At 6GHz

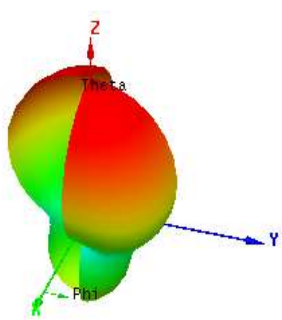


(b) At 10GHz

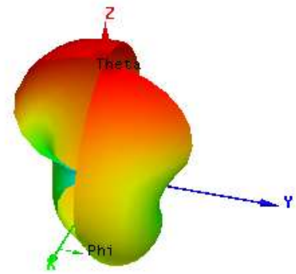


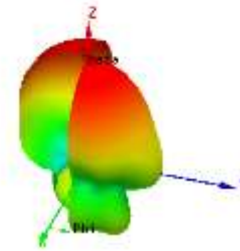
(c) At 15 GHz

Fig 7 Radiation pattern of antenna in E-plane and H-plane in 2-D



(a) At 6 GHz



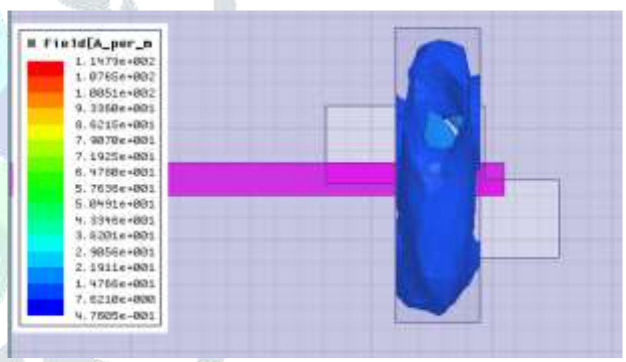


(b) At 10 GHz (c) At 15 GHz

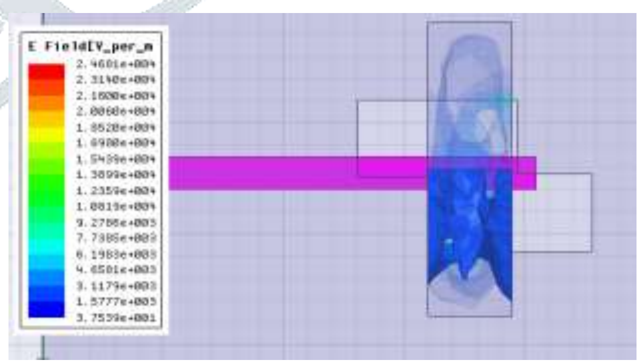
Fig 8 Radiation pattern of antenna in 3-D plot

D. Field Disrtibution

Fig 9 shows the magnetic field distribution of the Double-rectangular DRA at 5.8 GHz and 18 GHz. It is inferred that most of the coupling is generated by the aperture slots at these two frequencies. Here field distribution is done from the middle of the coupling aperture to the DRA's directly.



(a) H-field



(b) E-field

Fig 9 Magnetic field Distribution at H-field and E-field

E. Comparision of double-cylindrical DRA with double-rectangular DRA

Parameters	Existing System (CDRA)		Proposed System (RDRA)	
	At 5.8 GHz	At 18 GHz	At 5.8 GHz	At 18 GHz
Return loss (dB)	-9.79	-6.62	-14.52	-14.72
Impedance (Ω)	54.26	76.33	68.54	70.42
Maximum gain achieved (dB)	12		16.06	

Table 1 Comparision of Double-CDRA with double-RDRA

IV. CONCLUSION

A double-rectangular dielectric resonator antenna is presented in this paper. It is observed that, it covers the range between two major frequencies 5.8 GHz and 18 GHz which are applicable for vehicular applications. The parameters like return loss characteristics, impedance, and gain and radiation pattern are observed. The maximum achieved gain is 16.01 dBi. Further the antenna has a simple design structure and other feeding techniques can also be applied.

V. REFERENCES

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