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Bi-Convex Patch Antenna with Probe Feed for 5.9 GHz WLAN Application

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***Abstract*— In this paper, the analysis of bi-convex patch antenna has been done. some perturbation made in the Rotman lens which resulted a biconvex lens structure and that structure has been implemented in the patch geometry.Then co-axial probe feed technique has been implemented. The proposed antenna has been designed to operate at the frequency 5.9 GHz which is assigned to the IEEE standard 802. 11p.The simulation was done using HFSS software and the S-parameter,VSWR, Gain and Directivity has been analyzed.**

***Index Terms*—Bi-Convex Patch, Rotman Lens, 5.9 GHz WLAN, S_{11},VSWR.**

I. INTRODUCTION

To take the advantages of small size and wide band there are many applications which have been developed in the modern era. Beam forming lens antenna was developed on a high resistive silicon wafer for 60 GHz WPAN taking the Rotman Lens into consideration. [1] The design geometry of Rotman Lens was varied from designer to designer

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The basic structure consists of a circular arc in one side another perturbed circular arc which can be modified to parabolic or elliptical arc. [2]. In this perturbed circular arc is kept as circular keeping the maximum width between the two arcs as the wavelength corresponding to the design frequency which is 5.9 GHz. [3].

Different feeding techniques will yield different result. In this paper the feeding techniques named as coaxial probe feed has been implemented. The IEEE802.11p is an approved amendment of the IEEE 801.11 Standard to add wireless access in vehicular environments (WAVE), a vehicular communication system.It defines enhancements to 802.11 (the basis of products marketed as Wi-Fi) required to support Intelligent Transportation Systems (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure in the licensed ITS band of 5.9 GHz (5.85-5.925 GHz). IEEE 1609 is a higher layer standard based on the IEEE 802.11p.[4].

II. ANTENNA DESIGN

The actual lens geometry parameters depend upon the positions of the beam ports, receiving ports and the transmission line lengths. The design of the lens is governed by the Rotman-Turner design equations that are based on the geometry of the lens, shown in Fig 1.[2] The left contour of the lens is a circular are. Based on Gent's equations for optical path length equality the co-ordinates of the points of positions of the antenna ports on right inner ' array curve' are derived with respect to

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three perfect focal points (G, F1 and F2)[2] . The lower case letters represent their upper case variable normalized to the focal length F and w is the phase delay in wavelengths between the antenna port on inner lens contour∑1 and antenna on outer contour∑2. Some of the predefining parameters of the Rotman lens are the internal scan angle a, focal length F, distance of on axis focal length from origin G. From Fig.1 the two symmetrical off-axis focal points F1 and F2 have coordinates (-Fcos α, Fsin α), (-Fcos α, -Fsin α) and on-axis focal point G has (-G,0) relative to point O_1 All parameters of Rotman lens are defined as n=N/F, w=(W-W_0)/f, x=X/F, y=Y/F, g=G/F, a_0= cos α, b_0=sin α.[2]

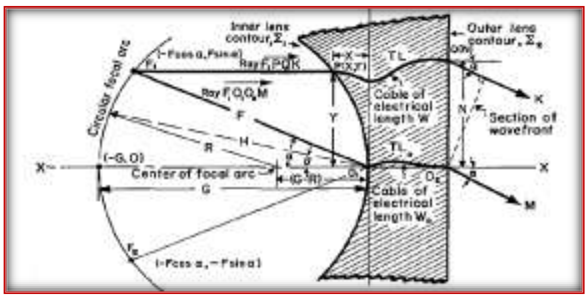

Figure.1 Geometry of a Rotman Lens[2]

Now after getting the overall idea of the rotman lens structure the design has been done in such a way that the patch structure will have a bi-convex lens structure and the maximum distance between the two arcs will be equal to the wave length λ=50.8475 mm obtained from the design frequency 5.9 GHz [3].

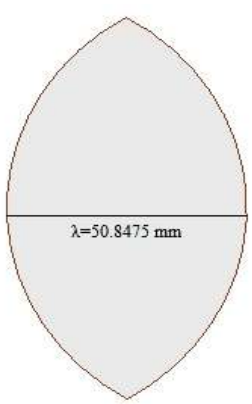

Figure2: Bi-Convex Patch Structure

The proposed antenna is designed on FR4 epoxy substrate having a dimension 100mm×100mm with relative dielectric constant of 4.4 and loss tangent of 0.02. To meet the actual design requirements, i.e. operating frequency, bandwidth, radiation pattern, and some approximations are considered. The calculations are based on the transmission line model. The effective dielectric constant of the substrate is given as [5]

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The position of the co-axial probe feed is calculated as [6]

$$X_f = \frac{L}{2\times\sqrt{\epsilon_{reff}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$Y_f = \frac{W}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Then the simulation was done by using HFSS (High Frequency Structure Simulator) software which is one of the prominent software for all electromagnetic simulations. The S-Parameter, Voltage wave standing ratio (VSWR) and Gain are analyzed.

III. SIMULATION AND RESULTS

The Simulation was carried out with the help of HFSS software and the desired frequency range has been given for the analysis. The dimensions of Co-axial probe feed are calculated and it has been implemented as the feed.

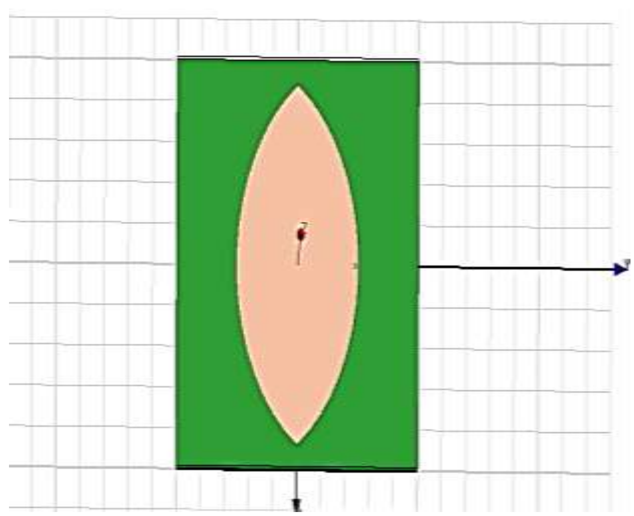

Figure3. Upper view ofthe Bi-convex Patch Antenna designed using HFSS

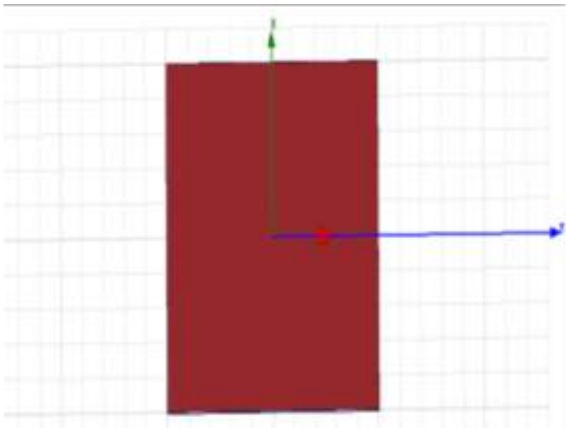

Figure4. Lower view ofthe Bi-convex Patch Antenna designed using HFSS , showing the Probe feed

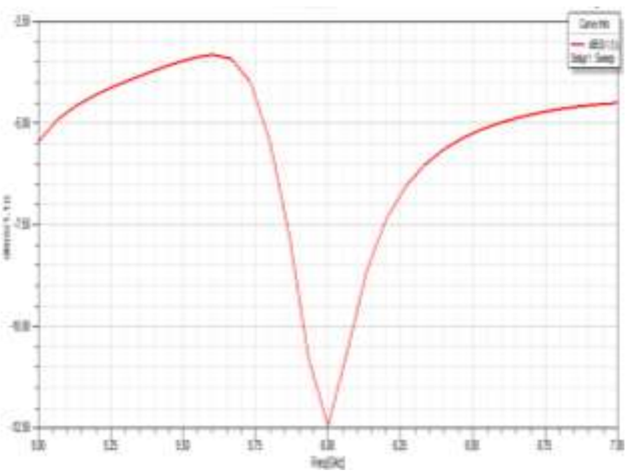

Figure5. S_{11} of the proposed antenna

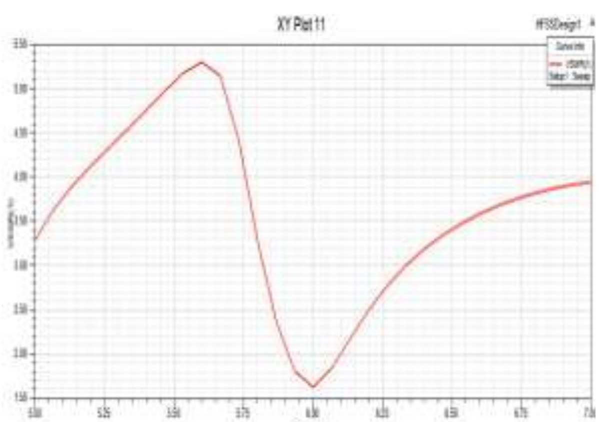

Figure6. VSWR of the proposed antenna

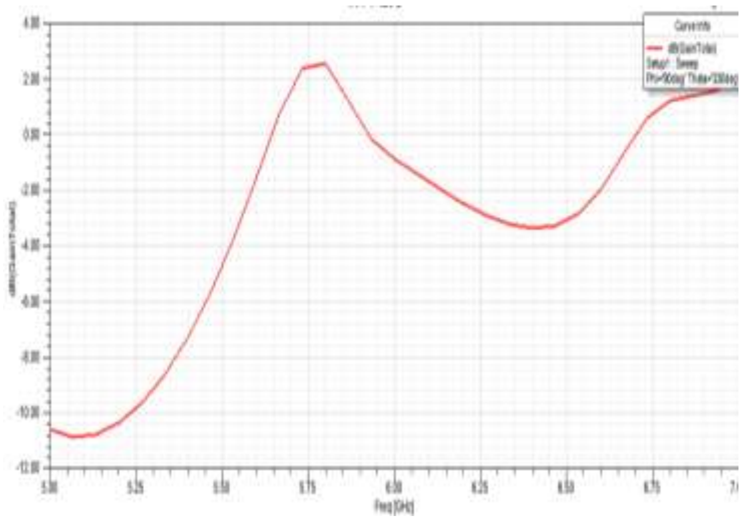

Figure7. Gain vs Frequency Curve

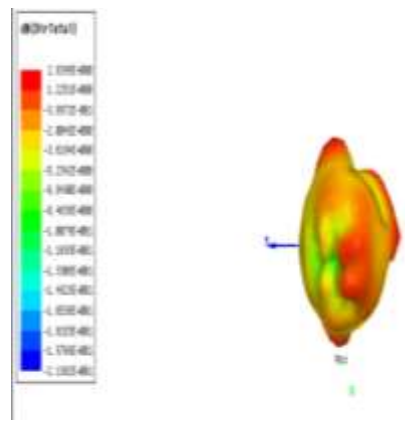

Figure8. 3D Directivity Plot

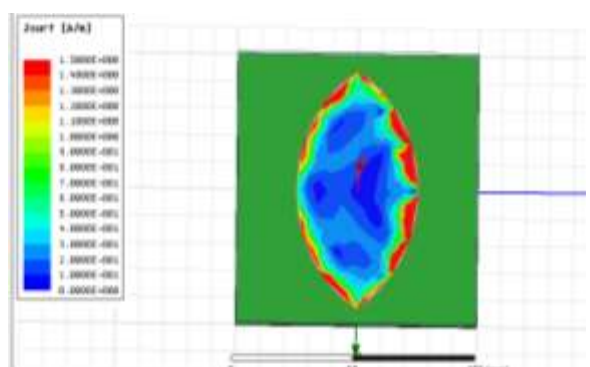

Figure9. Current Distribution of the patc

IV. ANALYSIS OF RESULT

From the return loss plot it can be analyzed that the resonant frequency is in the desired range and it can also be observed that the VSWR is nearly equal to 1 which is a good agreement to the desired value.

TABLE 1

Parameters measured for the proposed patch antenna	**HFSS**
Resonant frequency	5.99 GHz
Return loss	-12.3575 dB
VSWR	1.6481
Gain	0.5 dB

V. CONCLUSION

The design and simulation of the proposed antenna provided the result in which the resonant frequency is5.99GHz which is in the desired frequency for the 5.9GHz WLAN for wireless access in vehicular environments (WAVE). The results have been successfully analyzed.

VI. REFERENCES

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