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Investigation and Simulation Of Rectangular Microstrip Patch Antenna Array for Wireless Acess for Vehicular Environment(WAVE).

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ABSTRACT
The Internet of Vehicles(IOV) is an important part of communication system with the development of internet of things.A novel automobile antenna is proposed,which can cover frequency bands for wave.The wireless access for vehicular environment (WAVE) is a recently developed wireless communication technology that enables the instant update of traffic information of vehicles.Vehicular communication systems can be effectively used to enhance the traffic efficiency and reduce traffic congestion.The ubiquitous intelligent system is used to develop an intelligent vehicle communication technology on the basis of the advanced WAVE wireless vehicle communication technology for improving the functionality and reducing the risk of accidents.Typically,WAVE communication systems operate in 5.75-5.925 GHz frequency band assigned by the federal communication commission(FCC).

This paper describes the design of antenna with high efficiency vehicular roof mounted for wave coummunication system used for ubiquitous intelligent systems.To enhance the connectivity among vehicles by providing seamless communication and to reduce intial access time using high performance antenna systems is the purpose of the ubiquitous intelligent systems.Wave communication efficiency depends on the antenna efficiency used for ubiquitous intelligent systems.

We are proposing rectangle array patch antenna structure to increase the performance of the antenna by enhancing gain or Bandwidth.

Keywords—*Automotive Communication,Antenna,Beam Pattern, WAVE communication systems,HFSS tool.*

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I. INTRODUCTION

In wireless communication technology the wireless access for vehicular environment(WAVE) permits the instant update of traffic information to vehicles.Vehicular communication systems reduce the traffic congestion and enhances the traffic efficiency effectively.vehicle communication technology is developed by ubiquitous intelligent system on the basis of the WAVE wireless vehicle communication technology which reduces the risk of accidents and improves the functionality.Ubiquitous intelligent systems having efficient WAVE antenna provides alternative routes to vehicles during high traffic conditions on the basis of obtained traffic information which increases road efficiency.for vehicle to vehicle(V2V) communication and vehicle to infrastructure (V2I) communication can have by WAVE communication with high frequency range and are likely to achieve high communication rate.

To achieve high speed data rates WAVE communication systems adopt the advanced orthogonal frequency division multiplexing(OFDM)scheme.these characteristics make the WAVE communication system an attractive physical layer scheme with a high efficiency antenna for a ubiquitous intelligent system.And to maintain smooth communication among vehicles,the antennas usually exhibit an elliptical beam pattern in vertical cross section of azimuth.If it doesn't exhibit elliptical beam pattern then unnecessary radiations will occur leading to poor communication.therefore,it is important for the OBU antennas to exhibit an elliptical pattern with a suitable bandwidth.Mostly antennas for WAVE communication systems consider the frequency band and the omni directional beam pattern of on-board unit WAVE antennas placed on vehicles.These OBU antennas exhibit an omnidirectional beam pattern suited to a WAVE communication systems.

In radio correspondence, an omnidirectional antenna is a class of antenna which transmits radio wave control consistently every which way in one plane, with the emanated control diminishing with rise point above or underneath the plane, dropping to zero on the antenna axis. This radiation example is regularly depicted as "donut formed".Take note of this is not quite the similar as an isotropic antenna, which transmits level with power every which way and has a "circular" radiation design.Omni directional antenna situated vertically are broadly utilized for an non-directional antenna on the surface of the Earth since they emanate similarly in every single level bearing, while the power transmitted drops off with rise edge so minimal radio energy is pointed into the sky or down toward the earth and squandered.Omni directional antenna are generally utilized for radio telecom antenna, and in cell phones that utilization radio, for example, PDAs, FM radios, GPS and in addition for base stations that speak with mobile radios, for example, police and taxi dispatchers and air ship communications.

Printed antennas were represented with an omni directional beam pattern.Additionally other research showed the pattern characteristics of the printed antennas using a micro-strip patch and an etched-upon microwave substrate layer;from the results of their study it was found that printed antennas exhibit an omni directional pattern suited global postioning system(GPS) satellite receiving systems.Anyhow, it should be noted that printed antennas are not most suitable antennas for our purpose,which require V2V/V2I communication.

II. RELATED WORK

Antenna array is defined as it consists of multiple elements and is a radiating system in which several antennas are speed properly so as to get radiating system by combining radiations at point from all the antennas in system. In general, array performance improves with added elements; therefore arrays in practice usually have more elements.Based on the spatial variation of the signals present array has the ability to filter the electromagnetic environment it is operating in.According to the wavelength the spacing between the elements and the length of the elements are also considered while designing these antennas.Usually antennas radiate individually while in array the radiation of all the elements sum upto form the radiation beam,which has high gain,high directivity and better performance with minimum losses.

There are different types of antenna arrays but the one which we are designing is a planar array.It is 2 dimensional geometrical arrangements of individual array elements. This type of arrangement has several advantages over linear array which gives high gain, directivity; decreased side lobe levels and the beam orientation can be done any possible direction which gives symmetrical radiation pattern. One of the basic form of planar array is shown in the figure where the antenna is oriented along x and y directions which shows the lattice structure.

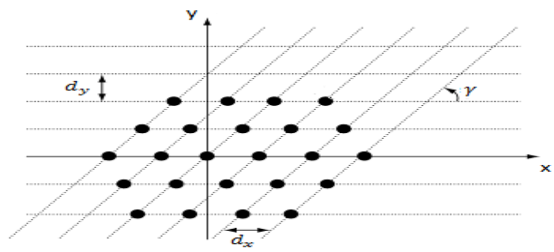

Figure 1. Basic Lattice Structure.

The rectangular array is nothing but many linear arrays arranged in a particular order forms a rectangular planar array as shown in the figure. The array factor for planar array antennas is given by

$$AF_{pR} = \sum_{n=1}^{N} A_{1an} \left[\sum_{x=1}^{X} A_{xa1} e^{j(x-1)(kd_{ax}\sin\theta_a\cos\varphi_a+\beta_{ax})} \right] e^{j(n-1)(kd_{ay}\sin\theta_a\cos\varphi_a+\beta_{ay})}$$

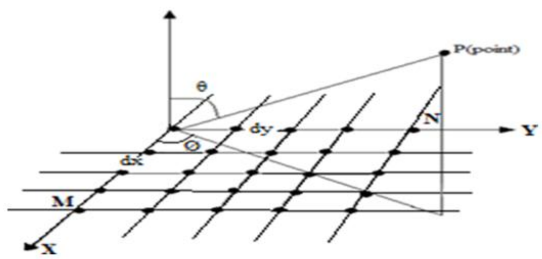

Figure 2. Rectangular array

Where A represents the amplitude level and β_{ax} ,

β_{ay} represent phase angle variation among the individual elements along x and y axis respectively.
Hence in simpler case array factor is multiplication of linear array factors along x and y axis.

$$AF_{aR} = AF_{xL} * AF_{yL}$$

Similarly for a constant amplitude level the normalized form of array factor is given by.

Characteristic	Parameter
Base Material	Teflon
Permittivity [ε]	2.1
Thickness	0.8mm
Width	11.6mm
Length	169mm

$$AF_a(\theta_a,\varphi_a)=\frac{1}{N_a}\left[\frac{\sin\left(\frac{N_a}{2}\psi_{ay}\right)}{\sin\left(\frac{1}{2}\psi_{ay}\right)}\right]\frac{1}{M_a}\left[\frac{\sin\left(\frac{M_a}{2}\psi_{ax}\right)}{\sin\left(\frac{1}{2}\psi_{ax}\right)}\right]$$

Where M,N denotes the elements total along X and Y axis respectively and

$$\psi_{ax}=kd_{ax}\sin\theta_{ax}\cos\varphi_{ax}+\beta_{ax}$$

$$\psi_{ay}=kd_{ay}\sin\theta_{ay}\cos\varphi_{ay}+\beta_{ay}.$$

The maximum of the above equation is

$$0.5(kd_{ax}\sin\theta_{ax}\cos\varphi_{ax}+\beta_{ax})=\pm m_a\pi........m=0,1,2,...$$

$$0.5(kd_{ay}\sin\theta_{ay}\cos\varphi_{ay}+\beta_{ay})=\pm n_a\pi........n=0,1,2,...$$

Similar to the element analysis, the planar array grating lobes can be analyzed as follows

$$\varphi_a=\tan^{-1}\left[\frac{\sin\theta_{as}\sin\varphi_{as}\pm n_a\lambda_a/d_{ay}}{\sin\theta_{as}\sin\varphi_{as}\pm m_a\lambda_a/d_{ay}}\right]$$

III. ANTENNA DESIGN

In WAVE communication it is important for vehicular antennas to exhibit a high gain over the field of view(FOV) of the beam pattern,with a low return loss.To satisfy these two conditions we designed an rectangular array antenna structure consists of four small rectangular segments that operates at the required resonant frequency.

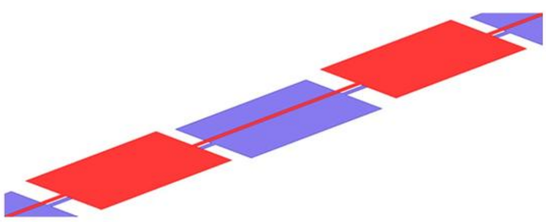

Figure 3. Proposed antenna structure.

An array structure with four elements of rectangular patch is used in the ground plane and feed plane to achieve high efficiency.

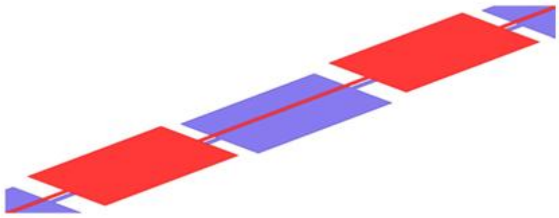

Figure 4. Structure of the proposed antenna model with a ground layer and a feed layer.

Characteristics of the proposed wireless access for vehicular environment antenna structure.

Design Equations:

$$W=\frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

$$\varepsilon_{eff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

$$L_{eff}=\frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$

$$\Delta L=0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

$$L=L_{eff}-2\Delta L$$

L_{sub}**=6h+*L***
W_{sub}**=6h+*W***

Where f_r is Frequency of operation, ε_r and h are Dielectric constant and height of substrate,W is the width of the antenna and L is the length of the antenna, f_o is the resonant frequency of the antenna. ε_{eff} is the effective dielectric constant.The radiation will be done through the air and dielectric substrate so we must calculate the effective dielectric constant.The dielectric constant of the air and substrate are different.
L_{eff} is the effective length of the patch.The radiation is done through the width of the patch so we must calculate the width of the patch.
L_{sub} is the length of the substrate.
W_{sub} is the width of the substrate.

IV. RESULTS AND ANALYSIS

Array antenna has been simulated on the roof of a vehicle.the proposed antenna E and H plane pattern performance must track in both amplitude and phase over the required FOV to achieve high polarisation efficiency.From the cross polarized response we can know that the polarisation efficiency is inversely proportional to the unwanted energy.The simulation results are

calculated using the High Frequency Structure simulator(HFSS).
Figure 5 shows the simulated near-filed radiation of the proposed WAVE antenna.

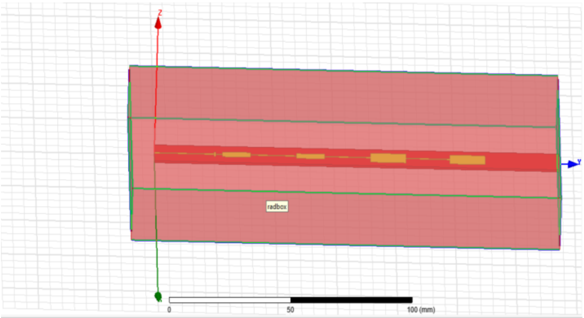

Figure 5. Simulation result of near field radiation.

Figure 6 shows the simulated return loss of the proposed WAVE antenna.From the return loss plot we will know at which frequencies our antenna will radiate.In the plot we can see the frequencies which are less than -10db are the desired ones which is Band Width of the antenna.the resonating frequency is 5.82 Ghz.

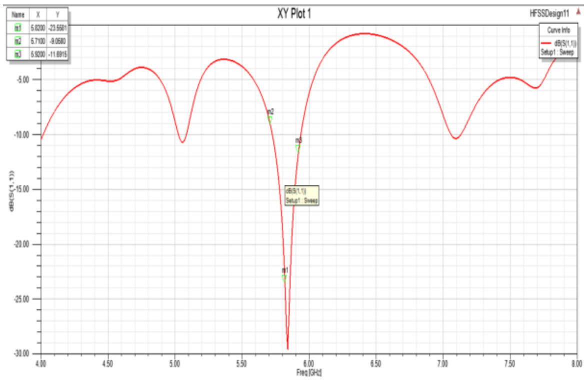

Figure 6. Simulation result of return loss.

VSWR is determined from the voltage measured along a transmission line leading to an antenna. VSWR is the ratio of the peak amplitude of a standing wave to the minimum amplitude of a standing wave, When an antenna is not matched to the receiver, power is reflected (so that the reflection coefficient, Γ, is not zero). This causes a "reflected voltage wave", which creates standing waves along the transmission line. The result are the peaks and valleys.Impedance matching means maximum power should be transferred from source to load. A perfect impedance match corresponds to a VSWR 1:1, If the VSWR = 1.0, there would be no reflected power and the voltage would have a constant magnitude along the transmission line. But in practice it is hard to achieve it. So, The VSWR is always ≥ +1, VSWR values are not more than 3.

Figure 7 shows the simulation result for the voltage standing wave ratio (VSWR) for WAVE communication systems. As shown in this figure, the array antenna model exhibits a sufficient VSWR of 1.14 for the WAVE bandwidth.

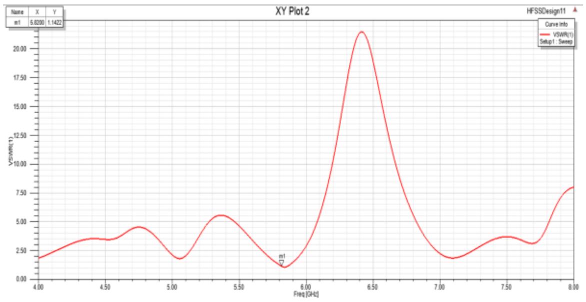

Figure 7. Simulation result of voltage standing wave ratio (VSWR).

The term Antenna Gain describes how much power is transmitted in the direction of peak radiation to that of an isotropic source.Gain of an antenna is a key performance figure which combines the antenna's directivity and electrical efficiency.

Figure 8 shows the gain of the antenna vertically located on the roof of a vehicle.The proposed array antenna exhibits a gain of upto 7dB.

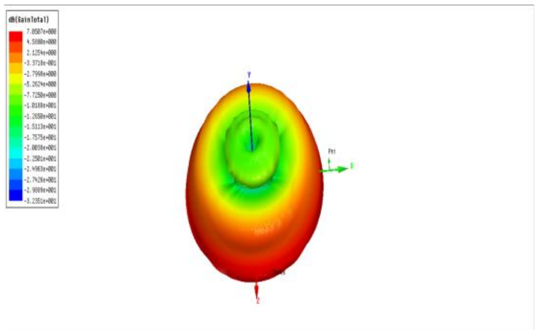

Figure 8. Simulation result showing the top view of the gain pattern.

Figure 9 shows the radiation pattern of the rectangular array antenna.We will see radiation pattern at 0 and 90 degrees which is called E-plane and H-plane of the antenna respectively.From pattern the antenna is having elliptical pattern in azimuth plane and omni directional pattern in elevation plane which is very advantageous for our application.

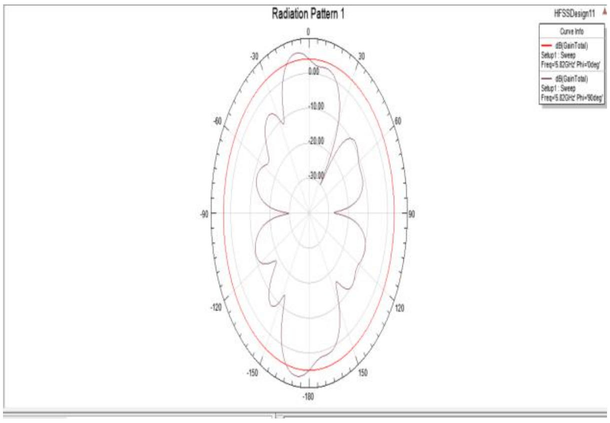

Figure 9. Simulation result of radiation pattern at 5.82GHz.

The radiation efficiency of an antenna is defined as the ratio of outward power radiated by the antenna to the input power fed to the excitation port of the antenna.Figure 10 shows the radiation efficiency of the proposed antenna.From the plot we can see the efficiency is 97% which is effective.

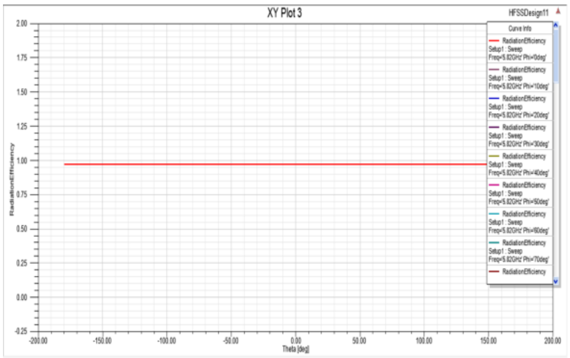

Figure 10. Simulation result of radiation efficiency.

V. CONCLUSION

The design of a high-performance vehicular array antenna for WAVE communication systems is presented. the proposed antenna exhibits an array structure to achieve an improvement in its performance in terms of its return loss, VSWR,gain and radiation pattern.Further, the simulation results show that the proposed array antenna has improved parameters like return loss and the gain with -23.55dB and 7.0dB respectively.the results of this study show that the proposed antenna for WAVE communication systems can enhance connectivity among vehicles to ensure seamless communication.

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