

Fractal Antenna Design for Overtaking on Highways in 5G Vehicular Communication Ad-hoc Networks Environment

Abdul Rahim, Praveen Kumar Mallik, V. A. Sankar Ponnappalli



Abstract: Vehicular Communication is designed for enhancing road safety and support autonomous driving becoming very popular in the present scenario. The proposed system aims to design a suitable and secured system for overtaking on highways. The main problem faced while driving vehicle on highways is to overtake a larger vehicle on narrow roads, where the driver visibility is limited and it is very risky to overtake from right side as there is a high probability of colliding with the vehicles coming in opposite direction. The proposed system solves the problem by establishing ad-hoc connection in 5G environment with the vehicle to be overtaken. The system consists of a communication unit designed with a controller along with various options which are used to decide when the vehicle can safely overtake. In this way the driver can safely overtake the larger vehicles without any risk of road accidents. The proposed system uses fractal geometry to design the antenna which is used for the vehicle to vehicle communication at 5G frequencies up to 20GHz.

Keywords: vehicle to vehicle communication, Fractal Antenna, 5G, Ad-hoc networks, Controller, Antenna

I. INTRODUCTION

The goal of Vehicular Communication is to provide safety and comfort while driving on the roads. The present system consists of communication between vehicles to detect the acceleration and deceleration of nearby vehicles using ad-hoc network or using available communication network [1,6]. Long Term Evaluation (LTE) and dedicated short range communication (DSRC) are used for communication between the vehicles using 3G network. The connection is established using the frequencies of 2.4GHz range end to end communication [2,3]. Intelligent transport system (ITS) uses ad-hoc network VANET when the communication network is offline [7]. The VANET uses network access points (APs) to establish connection between the vehicles for communication [8]. Existing systems uses any of the above communication which is limited in the terms of applications, security, efficiency, and connection establishment and safety measures [4]. The proposed system uses the frequencies in 5G spectrum to overcome the drawbacks of existing system [9-14].

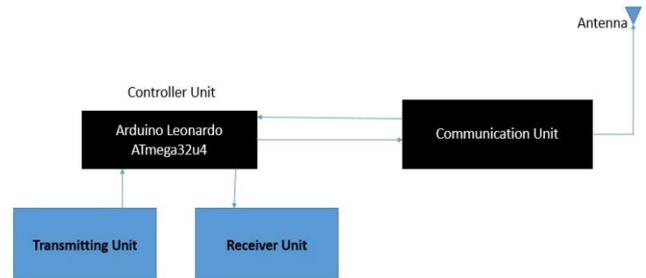
The death rate due to road accidents are increasing every year worldwide, and many efforts are made to avoid the accidents and in this process this paper is one of the effort to avoid accidents while overtaking the vehicles. The proposed system aims to communicate with the vehicle in front to get the information related to safely overtake the vehicle[5].



The rest of the paper is organized as follows. The proposed system is illustrated in section II. In section III, methodology is described. Applications, advantages, limitations and scope for future work are presented in section IV and finally concluding remarks are provided in section V.

II. PROPOSED SYSTEM

The Proposed system consists of an 8-bit microcontroller which is the heart of the system. This microcontroller consist of a processor ATmega32u4 (Arduino Leonardo) with a 8-bit CPU working at the frequency of 16MHz clock speed. The micro controller consist of 20 digital I/O pins and 12 pins for connecting analog devices. As shown in the block diagram controller unit consists of two sub units, out of which one is a transmitter unit and the second is receiver unit.



Transmitter unit consist of overtake switch which can be used when the vehicle needs to overtake. The driver uses this option which generates and interrupt to the controller. In turn the controller send the information to the communication unit which is used to transmit the request to the near-by vehicle using 5G ad-hoc network. Receiver unit upon receiving the information from the 5G ad-hoc network, passes the information to the micro-controller which intern generates the control signals which are connected to the LED'S which indicates accept and reject options.

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Along with controller unit, block diagram consist of communication unit which is used for communication between two vehicles in vehicular communication ad-hoc network. This unit works as a trans receiver which converts the micro controller signals into 5G signals while transmitting and vice versa at the receiver. Ad-hoc network discover the nearby service vehicles that are willing to collaborate with the request vehicle. Once the connection is established the request vehicle transmit the signals in the 5G range of frequencies. The connection remains available till any or both the vehicles select end of the session option.

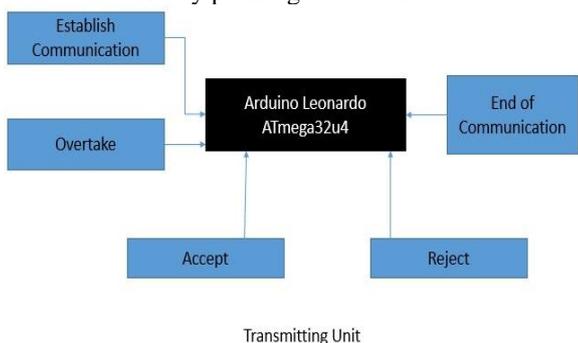
III. METHODOLOGY

The System is divided into two segments, first is controller unit and second is the communication unit
Controller Unit:

This unit is the heart of the system and is connected with all the required interfacing devices, which are helpful for communicating between the vehicles. The controller unit has transmitter and receiver unit along with a LCD display. The transmitting unit consists of switches which are as follows

1. Establish Communication
2. Request for Overtake
3. Accept
4. Reject
5. End the Communication

Considering vehicles A and B, out of which B vehicle is a large and slow moving vehicle which is ahead of the A vehicle. A vehicle is the vehicle which needs to overtake; both the vehicles have the same five options as listed above. Vehicle A driver presses the first button which is for establishing the connection, this triggers the communication unit. The communication unit will be discussed later in the paper, once the communication is established; the driver of vehicle A now presses the second switch which is for requesting the vehicle A for overtake. As the request goes to the vehicle B, the driver of vehicle B either Accept the Request or Reject the Request. Once the information is passed to vehicle A, the vehicle A driver can end the communication by pressing the fifth switch.

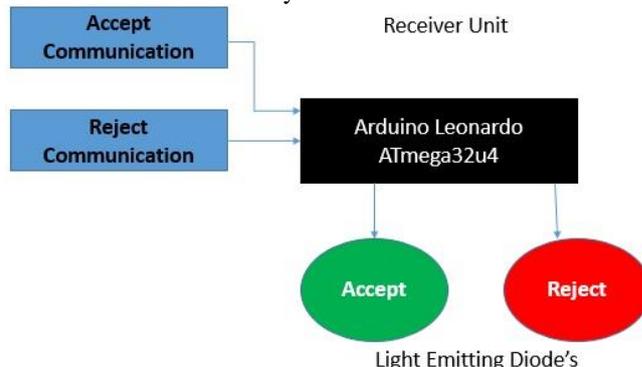


The receiving unit consists of the following interface

1. Acknowledge Communication
2. LED's for Accept and Reject

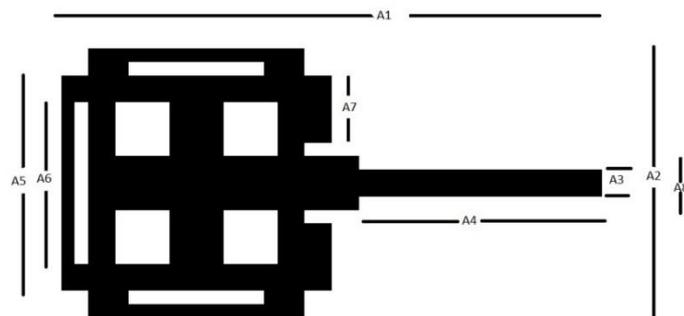
As any vehicle needs to communicate, they send request as Establish Communication which intern vehicle B acknowledge using the Acknowledge Communication such that vehicle to vehicle communication can be established. Once the communication is established the vehicle request for overtake, if overtake is possible the B vehicle will accept the request which can be seen on the vehicle A receiving unit where the accepted LED will be on. Once the Accepted LED

is on, vehicle A can easily overtake the vehicle B, and if it is rejected then Rejected LED will be on, that means at present it is very risky to overtake, upon which vehicle A will not overtake, and after some time once again vehicle A request for overtake, this process continues till the vehicle A overtakes Vehicle B Safely.



Fractal Antenna Design:

The Antenna is designed using fractal geometry which is widely used for wide band applications, and high beam width[16-21]. For the vehicular communication, this proposed antenna is very much suitable as high beam width is need for the application. The antenna is designed using the base of sierpinski square which is shown in the diagram below.



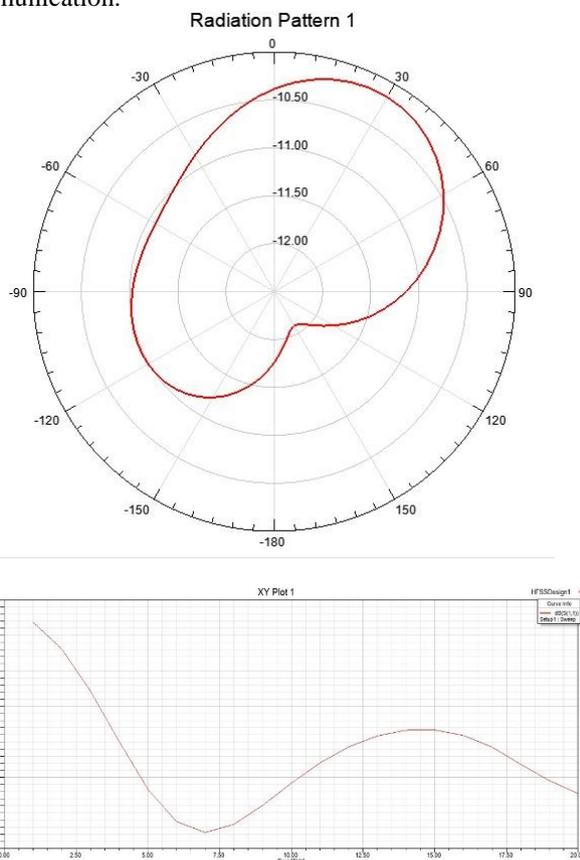
The dimensions for inner square is 2mmX2mm and the rectangles are 1mmx2mm and the remaining dimensions are provided below in the tabular column.

| A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
|----|----|----|----|----|----|----|-----|
| 30 | 24 | 2 | 12 | 20 | 16 | 4 | 3.5 |

The below tabular column shows the VSWR for the frequencies ranging from 1GHz to 20GHz. Resonant frequency is at 10GHz and the VSWR is around 50.

| | Freq [GHz] | dB(VSWR(1)) Setup1 : Sweep |
|----|------------|-------------------------------|
| 1 | 1.000000 | 55.808355 |
| 2 | 2.000000 | 54.717943 |
| 3 | 3.000000 | 53.246593 |
| 4 | 4.000000 | 51.751593 |
| 5 | 5.000000 | 50.540577 |
| 6 | 6.000000 | 49.801748 |
| 7 | 7.000000 | 49.567632 |
| 8 | 8.000000 | 49.739092 |
| 9 | 9.000000 | 50.157802 |
| 10 | 10.000000 | 50.673742 |
| 11 | 11.000000 | 51.176379 |
| 12 | 12.000000 | 51.596388 |
| 13 | 13.000000 | 51.895239 |
| 14 | 14.000000 | 52.053270 |
| 15 | 15.000000 | 52.059994 |
| 16 | 16.000000 | 51.907548 |
| 17 | 17.000000 | 51.590892 |
| 18 | 18.000000 | 51.140068 |
| 19 | 19.000000 | 50.738230 |
| 20 | 20.000000 | 50.429563 |

The below figure depicts the Radiation pattern for the proposed antenna and the radiation pattern is around 120 degrees which is very much useful for the vehicle to vehicle communication and its is having good directivity . The return losses are very much low which is very much helpful for radiating the entire energy towards forward direction. From the reported results it is clearly noticed that the proposed antenna will be suitable for real time vehicle to vehicle communication.



IV. APPLICATIONS

Vehicle Safety: Highest Priority is given to the Vehicle safety while overtaking heavy vehicles on highways as many accidents are happening due to not having proper communication with the vehicles which are ahead travelling. This method can be used for overtaking the vehicles safely.

ADVANTAGES: Collision and Accidents avoidance: with the communication established between the vehicles, the collision and road accidents can be eliminated. Night time driving will be more comfortable with the proper communication between vehicles.

LIMITATIONS: Depending upon the vehicle, complexity of the systems and various interfacing devices the estimated cost of installing vehicle to vehicle communication would be around Rs.10, 000 to20, 000.

Scope for Future work: Along with Vehicle overtake, the system can introduce warning system when the vehicle comes very much near to other vehicles. A feedback system can be used for automatically applying the brakes when the vehicle is coming close to other vehicles. Automatically change the direction of vehicle when the system senses dividers.

V. CONCLUSION

The communication between the vehicles is used for enhancing the safety while driving on the high ways. The System designed uses 5G communication with Ad-hoc network for faster establishing the communication between the vehicles. The micro controller along with the interfacing devices are used to provide the information regarding overtaking the vehicles without any collision or accidents. Fractal antenna is used for wideband band application and the design is very much suitable for the vehicle to vehicle communication.

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