A Solution to Speeding Related Problem in Road Vehicles Using Passive RFID Tags

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***Abstract*—In today's world with the increasing number of vehicles on road traffic security has become an important global issue. Despite different measures from government and other authorities the safety and security in road traffic has not yet been ensured. Among the many safety threats in road traffic is the reckless driving. Although different speed limit related regulations are imposed in road vehicles, they are often susceptible to negligence either intentionally or unintentionally. But with the help of available technologies there are several solutions for such problems. A cost effective simple solution is based on the use of RFID technology with passive RFID tags. Here we have presented comprehensive model of implementing such technology in electronically controlled road vehicles for following proper speed limit specified for a particular road. We have also discussed the advantage, limitations and future prospects of this technique.**

Keywords: RFID systems, Passive tags, Speed limit following, Traffic security.

I. INTRODUCTION

According to many government and non-government organizations working on traffic security, their norms and regulations most of the traffic accidents and caused by the speeding of vehicles. According to NHTSA (National Highway Traffic Safety Organization, USA) 13040 fatalities have been reported which is 31% of all severe crashes in 2007. This problem of speeding becomes more dangerous in rainy season due to lesser friction on road or when a car approaching some crests in the hilly region. Also the roads which are full of turns are more prone to such fatalities. There are also some behavioral factors like drivers who fall in teenage group are likely to drive faster than others and often violating the speed regulations. Drunk driving also instigates the speeding problem. There are some other issues also with the drivers, like the eye sight problem. If a driver having comparatively poor eyesight or indifferent during driving can fall under speeding problem [1][2]. All the facts mentioned above upholds the significance and graveness of the issue and we feel the need of some system that would give the drivers a carefree way of dealing with the speeding problem and also give the traffic authorities to control the increasing number of fatal crashes and loss of life. Here we have shown the application of not a very old technology to solve such problem. This is the RFID or Radio Frequency Identification technique. This comprises of a RFID tag, (could be active or passive) and a RFID reader. The tag gives a unique identity to any object or quantity and the reader reads this identity for further processing. We made the first prototype of RFID based speed limit follower system in December, 2011 and uploaded the demonstration on social media YOUTUBE [4]. Later on November 2012, Hasbi APAYDIN, Şükrü KİTİŞ used RF transmitter and receiver system to automate the speed limit in road vehicles [3]. But in our case the solution is cost effective because we have used passive RFID tags which doesn't require any internal power supply to operate and only responds when the tag is interrogated by the transceiver. The objective and the overview of the system is given below.

II. OBJECTIVE

The objective of this paper is to discuss the basic architecture and functionality of the prototype we have developed. We will also highlight some of the performance issues of the system and its applicability. The focus would also be on its further enhancement to incorporate some other traffic safety related problems.

III. OVERVIEW OF THE ARCHITECTURE

In a one-way or two-way traffic scenario often there are some speed limits imposed on such roads due to various reasons like the rush of traffic on that road, the vicinity of any school or hospital or any restricted place. It can also be imposed due to some areal profile of the road or some weather conditions. Before entering such roads the speed limit is displayed on some hording or display plates like in Fig.1, which shows driver the speed limit in that lane is 50 km/h or 50 m/h. Here we are replacing this indicator with a passive RFID tag embedded on the road itself. So there is no need of any traffic stuff or office or any transmitting station to transmit the speed limit information for a particular road. Moreover as they are passive there is no need to deploy a battery in the road. The tags are well protected in a case so there is no chance of any mutilation due to environmental or other effects as long as they are embedded inside the road. These tags only transmit the information regarding the

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speed limit when interrogated by the RFID reader. Now coming to the reader side, the RFID card reader is installed at the bottom chassis of the car. While the car is being passed over the tag, the transmitter will radiate a particular radio frequency which will interfere with the tag. The tag will then generate a small amount of electricity out of that radiation and activate its internal circuit. This circuit consists of a chip where a 10 digit number is there representing the proper speed limit for that road, and a modulator. The tag will retransmit the radio frequency after modulating it with the id number. This id is then decoded by the reader end attached with the car and speed information would be extracted. Now the internal control circuit installed inside the car would use the information to decelerate the car to achieve proper speed on in some case if it is below the speed limit accelerate it to get the speed. The acceleration thing is optional because we know in some countries like India there is no legal bound to go under speed but in countries like America it is mandatory to achieve proper speed. Similarly when the car goes to the end of the lane from where there is no restriction on speed is there, a relief tag would be there bearing a certain unique code which would intimidate the car that speed restrictions are over. If it is a two way lane then the car coming from opposite side, while encountering the relief tag would not respond. The relief tag would make the car respond only when previously a restriction tag is encountered. This rule would be embedded in the microcontroller at RFID reader end. Now there is a possibility that the car misses the tag to read. For that not just one but several such tags would be embedded on the road on regular interval to update the car about the speed limit restrictions. As the price of the tags is very less therefore it will not be a burden in installation cost. The installation of the tags on the road is shown in Fig.2. The tags marked as Res stands for Restriction tags, ones which imposes speed limit and Ref tags stands for relief tags, ones which releases the speed limit. We also see in the picture that the Restriction tags are placed before the starting of the speed restricted area. This is because the car cannot decelerate as a step function. It needs some time to decelerate and by that time it would cover some of the distance. Therefore it is to ensure that before the entry into the restricted zone the car must come to the specified speed. Suppose a vehicle is coming with the speed of ‘u’ m/s and it needs to be decelerated to the speed ‘v’ m/s with application of deceleration ‘f’ m/s^2 and thereby it achieves a distance, ‘s’ m then the value of ‘s’ can be determined from the following relation by Newton’s laws of motion:

$$v^2=u^2-2fs \tag{1}$$

Where,
v=final speed,
u=initial speed,
f=deceleration,
s=distance achieved.

Fig.1. Speed Limit indicator on road.

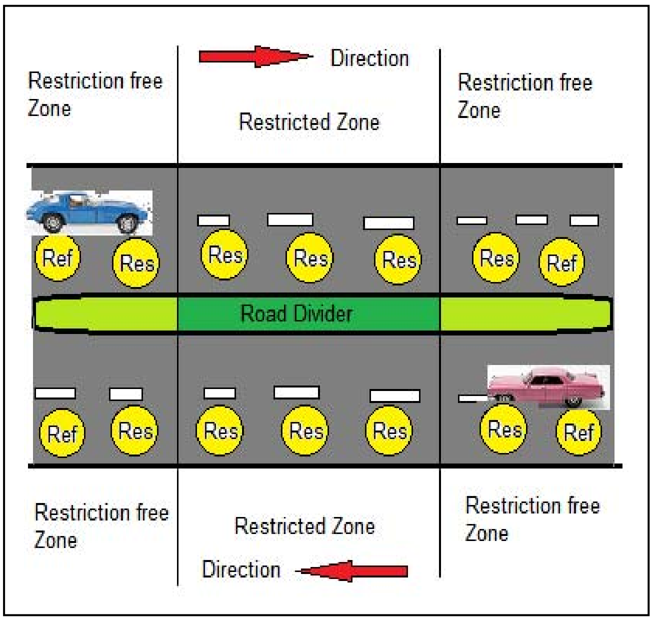

Fig.2. Installation of tags in roads

The speed profile of the vehicle as it enters into the restricted zone with different initial speed is shown in the following Fig.3. In the above curve the distance between 50 m to 100 m is the restricted zone. The area below the lower limit of this range and the above the upper limit of this range is unrestricted. The speed limit here is 50 Km/h. Here we have shown typically how a car above the speed limit is decelerated up to the speed limit and then brought back again to the original speed after the restricted zone is over. Similarly the acceleration and the deceleration profile are shown for a vehicle having initial speed below the speed limit restriction. The algorithm following which the reader module accepts the tag information is shown Fig.4. To avoid the confusion between two consecutively read tags we use the above algorithm to determine whether it is a new tag. After that the further processing is done on that. If it is a restricted tag then the difference between the current speed and speed limit is determined and according to that the car is accelerated or decelerated. The schematic of the control system acting to control the wheel speed of the car is shown in Fig.5.

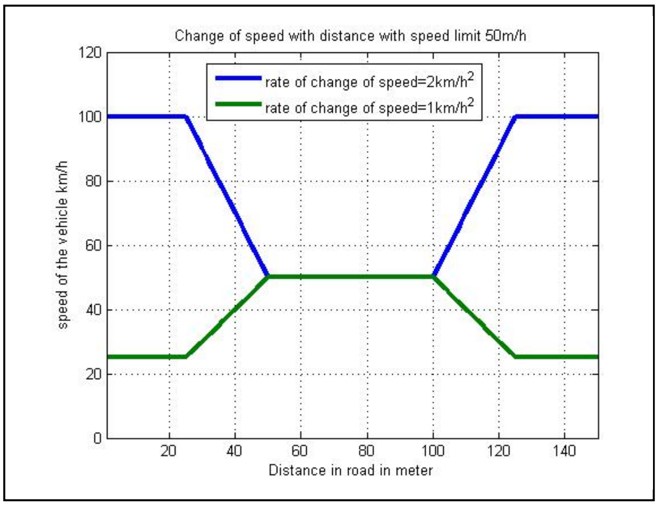

Fig.3. Velocity profile of the vehicle with distance.

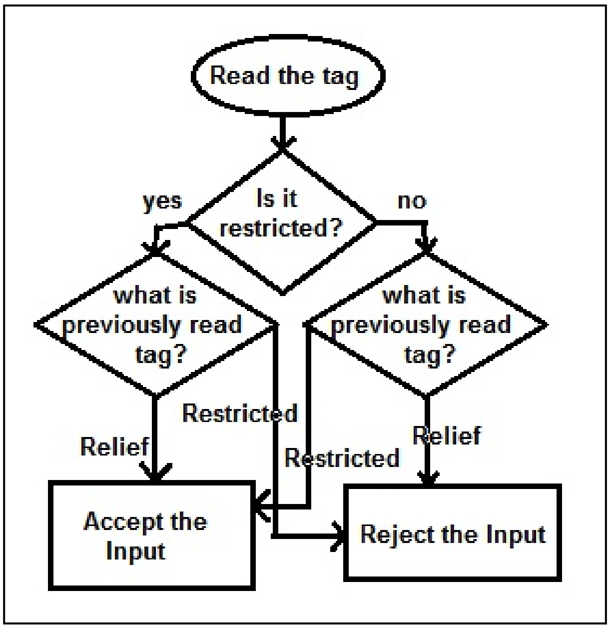

Fig.4. Algorithm for acceptance of the tag information

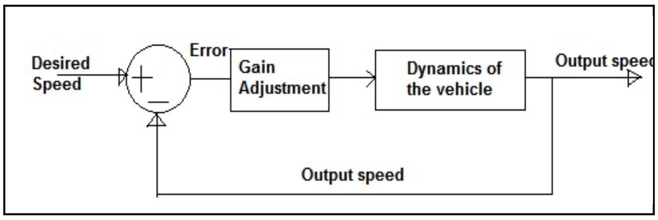

Fig.5. The Control Schematic

In the control schematic described above the vehicle dynamics plays a vital role in selection of the deceleration parameters. The control scheme starts with specifying the desired speed which is the speed limit. Now the current speed of the wheel is calculated by some mechanical or electronic instrument attached with the wheel shaft. From the difference between the two speeds, the error is calculated and then it is multiplied with the proper gains which generate the further signals to be fed to the dynamics of the vehicle to generate proper deceleration or acceleration rates for maintaining the desired output.

IV. REALIZATION OF THE SYSTEM

To realize our system we have made a small toy car which is driven by the simple D.C. geared motors and on the backside of the chassis of the car a RFID reader module is attached. The reader we have used here is the parallax RFID reader which operates in 125 KHz of frequency and ranges up to 4 inch. The reader module is connected with the microcontroller circuit. The microcontroller circuit consists of two AT89S52 microcontrollers. As there are two parallel processes to be run concurrently we have done this multiprocessing environment for enhanced efficiency. One microcontroller is totally dedicated to receiving the tag information through serial communication with the RFID reader and other module is dedicated to control the motor speed by generating the PWM signals. We have attached one L293D based motor driving unit also for amplifying the motor control signals from the second microcontroller. The detailed circuit diagram is shown in Fig.6.

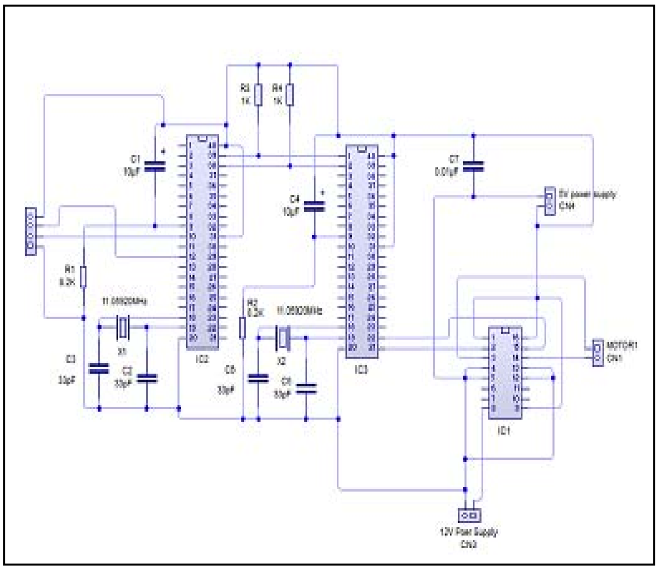

Fig.6. Circuit Schematic of the car

The circuit is connected to the RFID reader module with the 4 pin connector at the left most side. The picture of the RFID reader is shown in Fig.7.

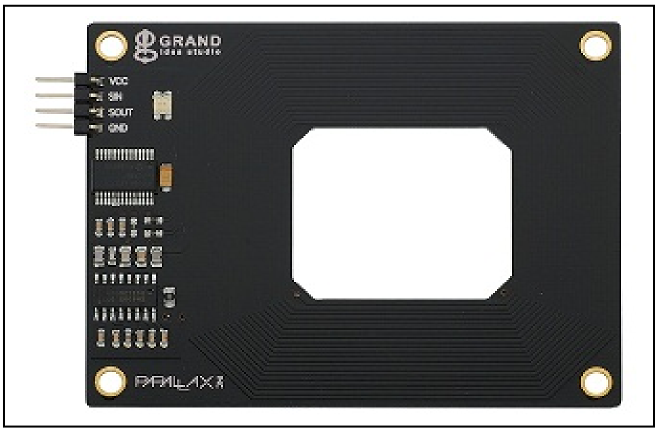

Fig.7. Parallax RFID reader module [5].

The parallax RFID reader module has four pins. Two pins are kept for VCC (=5V) and GND. And the other two pins are the serial out or SOUT and Enable pin which operates in active low mode, meaning the reader is activated when the signal is low or at logic zero. On interrogating the tag the reader gets total 12 bytes (10 bytes for each of the 10 digits and the other two are the start and stop byte). Each of these bytes has 8 data bits plus one start and other stop bit. Thus the total count of the bits becomes 120 for a particular tag [6]. The start bits are always zero and the stop bits are one. The start byte is 0X0A and the stop byte is 0x0D [7]. The reader sends the signal serially in TTL logic format with least significant bit first. The tasks the microcontroller circuit has to handle is, first extract the 10 digit number from the bit stream, then accept the tag information according to the algorithm stated earlier. There after the first microcontroller handover the task to the second microcontroller which further generates the control signal and finally changes the pulse width of the PWM wave to control the rpm of the D.C. motor. The rpm of the D.C. motor basically depends on the voltage supply. The PWM wave basically sets the voltage at a particular level to achieve the desired rpm. The relationship between the output voltage and the duty cycle of the PWM wave is given below.

$$\text{DutyCycle}=\text{on time}/\text{total time} \quad (2)$$

$$\text{OutputVoltage}=\text{Duty Cycle}*\ \text{Max.Voltage} \quad (3)$$

Where,

$$\text{Total time}=\text{on time}+\text{off time}. \quad (4)$$

The maximum voltage is the voltage supplied at the motor driver. If the rated voltage for the full rpm operation of the motor is 12v then we provide 12 V to the motor driver end then reduce the voltage using the PWM signal. If the motor is specified for a particular rpm say 300 rpm at the maximum supplied voltage 12V then at 6V it would give 150 rpm the relationship is linear between the voltage and the rpm.

V. TESTING OF THE SYSTEM

The system is tested in our lab environment on a floor mat surface we have made a lane which has a restricted zone defined by two RFID tags one acted as the restricted (TAG1) and the other acted as the relief tag (TAG2). The full rpm of our vehicle is 200rpm and we have set the restricted speed at 100rpm and normal speed at 160rpm. Therefore the vehicle has to decelerate as soon as it encounters TAG1 and come to 100rpm speed. Again encountering TAG2 it would accelerate up to its original 160rpm speed. The relationship between the motor rpm, voltage and PWM duty cycle is shown in the table I below.

TABLE I.

Motor Speed(rpm)	Voltage(Volts)	Duty Cycle (%)
160	9.6	80
100	6	50

Now from the radius of the wheel which is in our case 5cm. We can calculate the linear velocity as,

$$\text{Linear Velocity}=((\text{rpm}*2\pi)/60)*2\pi R \quad (5)$$

Where,

R=Radius of the wheel.

Thus if we measure the time required to shift from normal velocity to limit velocity we will get the deceleration. The top view with circuit board and bottom view with the RFID reader attached in it is shown in Fig.8 and Fig.9 accordingly.

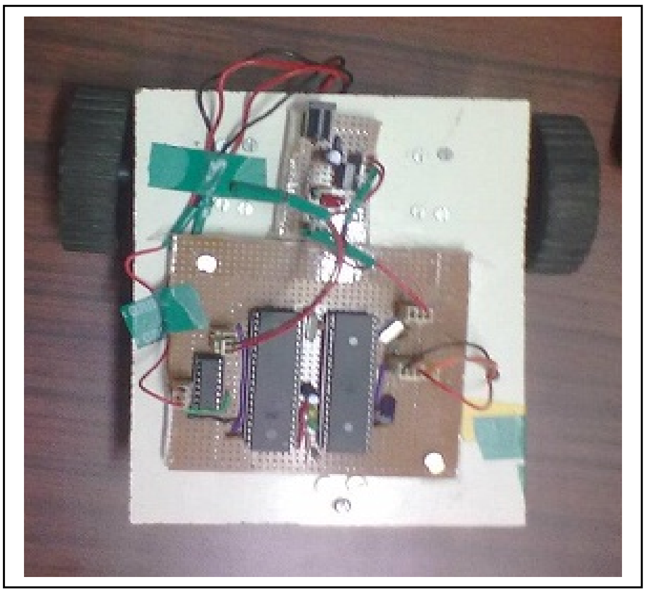

Fig.8. Top view with the circuit attached on the car.

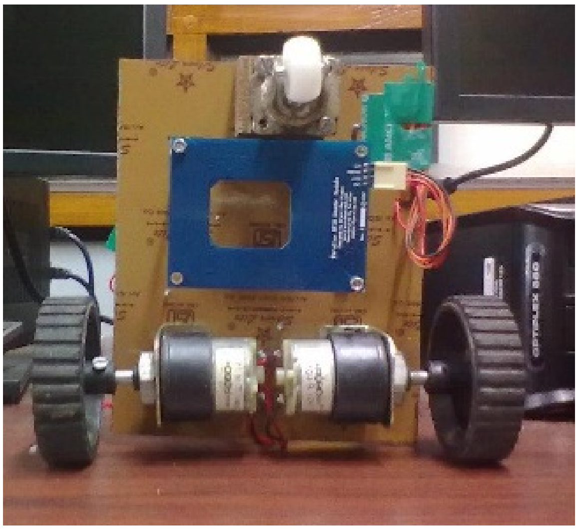

Fig.9. Bottom view of the car with motors and RFID reader

VI. COMMUNICATION PROTOCOL

There are a lot of communication protocols available at different frequency range for communication between tag and reader. They are mainly based on amplitude-shift-keying, frequency-shift-keying or phase-shift-keying. For example ISO15693 protocol is used at 13.56MHz frequency for read distance of 1-1.5metres, which uses amplitude-shift-keying for at the card end and amplitude/frequency shift keying at the reader end [8].

VII. CONCLUSION

As we have discussed above the architecture and the implementation process of the system is not much critical but there are some small issues also. Although the use of passive tags gives us much economic solution the maintenance of the roads should be taken seriously, so that the tags would not be exposed on the surface of the road, otherwise these would be smashed under the wheels of the vehicles and there are the chances of dislocation. For the roads which are very wide, may be one or two tags sufficient to ensure an encounter with the readers. Therefore more number of tags should be spread across the width of the road also. There may be other alternatives to the solution by changing the design parameters of the tag. There is also a factor that the speed limit of any particular zone is changed through the year depending on the environmental or traffic parameters. In those cases the tags can be made reprogrammable, means the 10 digit number inside the tag need to be modified for setting new speed constraints. This updating of code can be easily done by a special vehicle with programmer attached underneath of it. Besides these there is some non-functional aspect of the entire project also. As we easily comprehend that the use of 10 bytes gives us a large combination. Therefore not only speed but other information about the area or terrain or other traffic related information can be encoded in the tags which can update the driver about the area he is driving even when he is out of any network like GPS, internet etc. These extended factors are really promising which would enrich the entire system. Overall the system has fewer challenges but huge prospect for solving the speeding and other traffic related issues which would not only save car owner’s money, wasting in speed violation related fines but also save a lot of life and give the authorities a powerful tool to solve existing traffic problems and also those which would arise in future.

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