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A Co-Operative Driving for Safer Travel Using Vehicle to Vehicle Communication

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Abstract: Vehicular communication is one of the most advanced technologies used in Intelligent Transport Systems (ITS). Vehicle to Vehicle (V2V) communication is one of the most durable ways to get rid of accidents than the automated vehicles, which tends to be annoying and unreliable when the vehicles stop, while the drivers have their own plans. This V2V communication is solves the problems by cooperative driving. In co-operative driving, the information about the nearby vehicles is displayed in the LCD display - like their acceleration, steering wheel angle and braking style. Alerts will be sent to the driver by buzzering during emergency situations. Not only to avoid crashes, this can also be used for many purposes like communication between vehicles by radio transmitter and receiver, to identify special vehicles like Ambulance, Police vehicles, etc. We can make sure that the path we are going is safe or accident free by the instant message from the damaged vehicle to the vehicles nearby and to them those are coming by that way and also to help people change the way we drive vehicles.

Keywords: Vehicle-to-Vehicle (V2V) Communication, RF Communication, Intelligent Transport System (ITS), LCD Display.

I. Introduction

Today the average accident rate in the world is 17.4 per 100,000 people. This is due to the fact that the people are unaware of the vehicles around them while driving. The main reasons causing accidents are distracted driving, Tailgating and sudden lane changes, traffic congestion, etc. These problems can be solved by only one way, which is to make the vehicles to communicate with each other. This communication between the vehicles would help the vehicle itself in helping the driver to avoid accidents. This technology is called Vehicle to Vehicle (V2V) communication. According to this, the driver will be warned by the vehicle itself about the vehicles around their speed, acceleration and position. In peak hour, 60% of people get stuck in road due to traffic jam. Researchers found that 57% of the accidents were due to driver factors, his behavior, alertness, speed, etc. These driver-related accidents can be avoided by alerting the driver 0.5 seconds earlier than he actually notices to avoid collision.

For this communication, 2.4GHz band wifi signal is used, which can communicate to other devices using a radio transmitter and a receiver. This radio transmitter and receiver are designed in such a way that the system transmits the basic values of the vehicle to the other vehicles using the radio transmitter and receiver. Sudden brake indication can be sent to other vehicles, which is detected and transmitted by the RF waves. This indicates other vehicles that sudden brake has been applied in this vehicle. The vibration sensor senses the vibration in the vehicle, which is amplified by an amplifier. If the intensity of the vibration is greater than the pre-set value, then this vibration intensity and time will be sent as a signal to other vehicles to indicate that the place has a speed breaker, pit or even if the vehicle has met an accident. Direction of the vehicle can be predicted by measuring the angle of the steering wheel and sends the corresponding values to other vehicles. The steering wheel value can be predicted by the value of the voltage from the potentiometer output.

V2V communication represents an additional step in ITS. This system helps to warn drivers through on-board dedicated short range radio communication devices used in V2V communication system. This is uses to transmit messages about a vehicles speed, acceleration rate, brake status and other exchange information to the vehicle from the vehicles within a range(line-of-sight).A V2V communication protocol for collision control is used in Vehicular Ad-hoc Network (VANET). Here the number of accidents in VANETs is reduced among the large number of vehicles travelling on highways. This system delivers warning messages in different road situations. The Periodic Safety Message (PSM) gives information about the position, speed, and direction of the vehicle. And Event driven Safety Message (ESM) occurs during emergency situations like hard braking, sudden lane change, accidents, etc.

A small scale prototype module called Li-Fi technology is used in V2V communication system. It comprises mainly Light Emitting Diode (LED) for sending data through light spectrum. The need of complex wireless networks and various protocols is eliminated by using Li-Fi technology..The overall system is designed to transmit basic safety information between vehicles to facilitate warning to drivers.

II. System Design

There are two modules of the same devices, where the blocks are similar to each other. It consists of an Arduino UNO Board, piezoelectric sensor, rotary potentiometer, pedal switch, DC motor, RF transmitter and receiver, Buzzer, LCD display, acceleration control and bumper monitor. The Arduino UNO Board is the heart of the module. Piezoelectric vibration sensor senses the frequency of the vibration of the vehicle. Rotary potentiometer is used to control the voltage. The pedal switch is used in the brake pedal, which produces an output signal, when it is pressed. When the pedal switch is analog, then it can be used in the acceleration control of the real vehicle.

Fig.1. Block Diagram of Co-operative Driving Device

Zigbee is used as the radio transmitter and receiver for transmitting and receiving the signals in serial communication. Limit Switch is used for accident detection, which is mounted to the bumper of the vehicle. LCD display is connected to the Arduino UNO Board, which is used to display the values of various sensors and the vehicles. PWM is built in to the Arduino UNO Board, which is used to control the DC motor in the model of a vehicle.

A. Arduino UNO Board

Arduino UNO Board is open source hardware and it is the heart of our module. Hardware and software designs are freely available under copy left licenses making the developers easy to create many new models. It has ATmega328 processor, which has 32kb of flash memory, 2kb of SRAM, 1kb of EPROM and operates at 16MHz of clock speed. It has 14 digital pins of which 6 pins can be used as PWM outputs and another 6 analog pins. It also has a 16 MHz crystal oscillator, a power jack, a USB connection, a reset button and an ICSP header. It uses harward architecture, where the program code and program data have separate memory. It can be powered either by a computer or an external battery supply of 12Volts.Arduino has many facilities for communicating with the computer, another Arduino UNO Board or other microcontrollers. It has several software library files pre-built in to it for ease of use. Arduino Integrated Development Environment (IDE) is the software used to cross-platform the application written in java. This software supports C, C++ and also Java. Thus it is easy to program the Arduino UNO Board It can be prototyped quickly than many other processors.

Fig. 8. Arduino UNO Board

B. Power Supply

Every circuit needs a source to give energy to that circuit. The source will be a particular voltage and load current ratings. The circuit diagram of the power supply is shown in the Fig. 2. The output of the circuit is a low voltage regulated power supply of +5V, providing input voltages to the microcontroller RS232, LM311 and LCD display which requires 5 volts supply. The system is designed for two vehicles. The Vehicle Module (VM) is embedded within the vehicles. It consists of various sensors, dc motor, microcontroller and RF module.

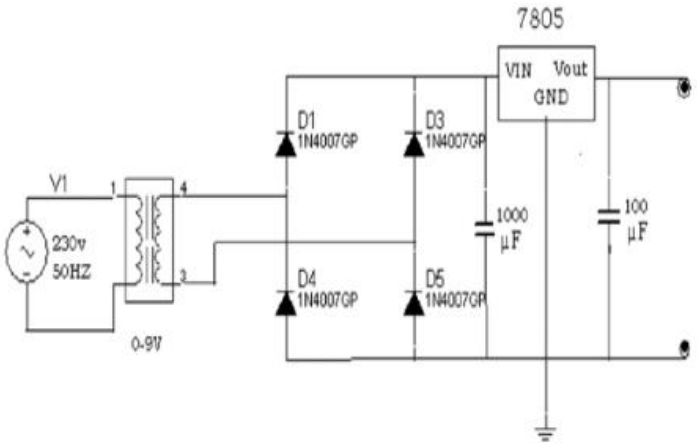

Fig.2. Circuit Diagram of Power Supply

C. Wireless Sensor Network (WSN)

WSN introduces the wireless data communication between two vehicles. Most popularly WSN is used because of its tremendous advantages such as lower data rate, long battery life, simple design, Short range and low cost communication. The pocket format of protocol is shown inTable.1.

Device_Name	Fix_id	Channel_id	Message	setting

Table1. WSN Format of Protocol

D. Acceleration Control

The acceleration control is used to monitor the acceleration rate of the vehicles which are within the range. The monitored acceleration rate is displayed on the LCD screen of that vehicle and the other vehicles. Acceleration is given in our model is by a rotary potentiometer, whereas in original vehicles, it will be given by an Analog pedal switch. It is connected to the Arduino UNO Board in the pin of A1.

E. RF Communication

WSN is used in the communication between vehicles due to high reliability and faster transmission speeds. The IEEE 802.15.4 is a simple standard in RF communication. It consists of a Media Access Controller

(MAC) and some physical (PHY) networking layers for pocket data protocol. Its frequency is about 2.4 GHz (6 channels with baud rate of 250kbps) is used for this application.

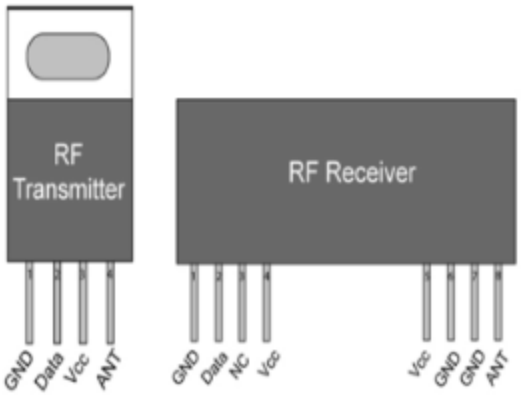

Fig.3. Pin diagram of RF Transmitter and Receiver

F. Pedal Switch

The pedal switch is mounted to the brake pedal of the vehicle. During normal condition, it is in off position, where the output is 0.In analog pedal switch, when a sudden brake is applied, the pedal switch will be closed and the output voltage is given to the comparator, which compares the voltage to the reference voltage. When the output voltage is higher than the reference voltage, the comparator produces the output value of 1V.Now, the system produces an Event driven Safety Message (ESM) to warn other vehicles. If the output voltage is lower than the reference voltage, then the comparator produces the output voltage of 0V. It is connected to the Arduino UNO Board in the pin number of 4.

G. Piezoelectric Sens

Piezoelectric sensor is used to sense the vibrations produced by the vehicle. When the vehicle passes through deep potholes, speed breakers, etc. The vibrations will be recorded and amplified, which can be differentiated by their intensities. It consumes only a little amount of power for sensing the vibrations. In fig. 4, the normal vibrations will be very low and the vibrations caused by many causes will be high and can be differentiated from normal vibrations. It has LM32 IC, which is a comparator IC. This IC compares the output of the vibration level in terms of voltage and the reference voltage. If the voltage produced by the piezoelectric sensor is greater, then the signal will be given to the processor.

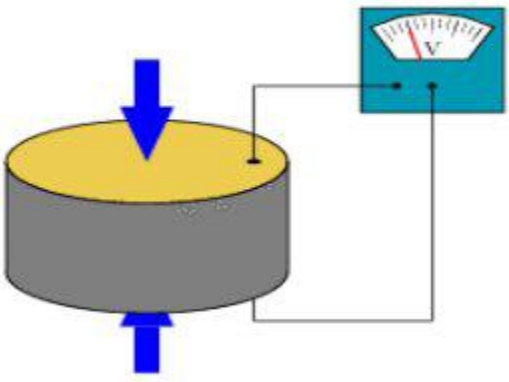

Fig.4. Piezoelectric Sensor

Fig. 4 shows the working of piezoelectric vibration sensor. Here, when the vibration is produced, there will be a production of voltage. This is represented in the diagram as measuring the voltage. The arrow marks indicate the vibration given to the sensor. Fig. 5 shows the model graph of electric signal produced in the piezoelectric sensor. Here, the graph is drawn for the frequency and time in x and y-axis respectively. When the

frequency is greater than a particular limit (We have set it to 8Hz in our model) as shown in the graph, the comparator circuit sends the signal to the arduino uno board.

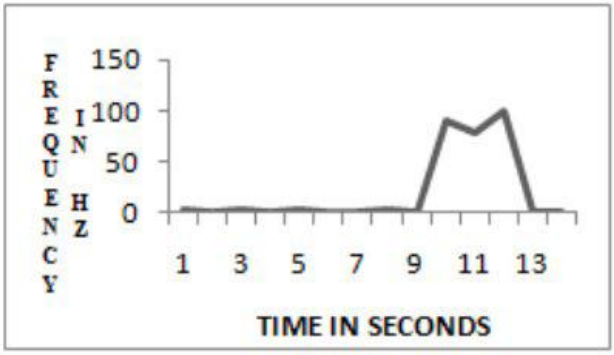

Fig.5. Model Graph of Piezoelectric sensor

H. Rotary Potentiometer

Rotary potentiometer is used for predicting the direction of the vehicle. It is mounted in the steering wheel of the vehicle. The value of potentiometer's is used to predict the direction of the vehicle. The output value of the potentiometer is in the range of (0-5)V. Where the vehicle will indicated that it will take a left turn when the range of the potentiometer output will be between (0-2.4)Volts, (2.6-5)V indicates that the vehicle takes a right turn and 2.5V indicates that the vehicle is moving straight. It is connected to the Arduino UNO Board in the pin of A0.

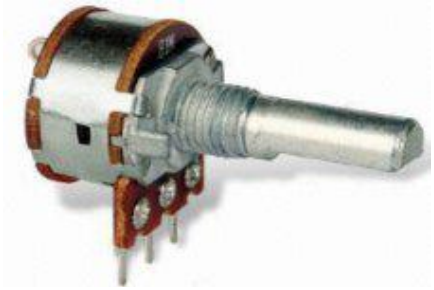

Fig. 6. Rotary Potentiometer

I. Buzzer

Buzzer is used to produce alarming sound signal, when the system receives an ESM. It makes the driver to be warned about the incident and make him attentive towards the road and vehicles nearby. It is connected to the Arduino UNO Board in the pin number of 4.

J. Liquid Crystal Display (LCD)

An LCD is a small low cost display, which is easy to interface with an embedded controller like an Arduino UNO Board. For displaying messages, Single line of code is enough for this display by including Libraries in the program. It has a built in controller KS 0066 or an equivalent one, thus having a faster duty cycle with low power consumption. It is also available with lower powered input like 3V. The speed, acceleration rate and other important messages of the vehicles which are in the range are displayed in the LCD screen. It is connected to the Arduino UNO Board in the pins: 7, 8, 9, 10, 11 and 12.

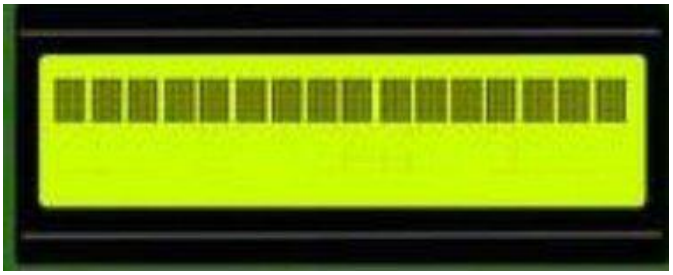

Fig. 7. LCD display

K. Bumper Monitor

The bumper monitor is used for the detection of accidents. The bumper monitor uses a limit switch, which can be attached to the bumper of the vehicle. This switch works as same as that of the pedal switch, i.e. when the switch is pressed above a particular limit (collided), the limit switch will generate 1 as output, which intern communicates that the vehicle has collided with another vehicle and creates awareness in the particular area about the collided vehicle. When the switch is below the particular limit, the switch will generate 0 as output. It is connected to the Arduino UNO Board in the pin number of 6.

L. Global Positioning System (GPS)

The normal GPS module is not compatible for this type of use, since those GPS module has only an accuracy of 5meters. Thus a new type of GPS module is used here. This GPS module is a centimeter precise module, developed by 'Texas University' and a startup company 'Radiosense'. It is so accurate that they have mentioned it to be so precise, even to track lane keeping of a vehicle. It not only uses the code measurements sent by satellites, but also the carrier phase measurements to calculate a solution relative to a known reference station, so that common errors cancel with each other. The receiver is software defined, so it can be connected to the vehicle's current computing system. The system uses an external database for the lane's width and roadmap. The system computes vehicle's centimeteraccurate GPS signal and warns when the vehicle is nearing to the lane boundary in the original system. Here, it uses the same and will warn the driver about cars nearby and their abnormal behavior. This is the heart of the system, which will make the system so precise to keep the vehicles in track.

Fig. 8. Centimeter Accurate GPS module

M. Pulse Width Modulation (PWM)

PWM has duty cycle in its mode of operation. The ON-time and OFF-time of duty cycle is calculated. When the ON-time of the duty cycle is high the speed will be increased and when the OFFtime is high, the speed will be decreased. In many applications PWM is used for blinking of LED bulbs. Here the PWM is used to control the dc motor by means of a dc driver circuit using octo-coupler for enhancing the DC motor drive. It is inbuilt in the Arduino UNO Board.

III. Results and Discussion

Roadway transportation can be made safer than the current way of transportation today and can probably be made many times more reliable by this method. In this method, the system measures the different values of different sensors like acceleration, braking, steering angle and position of the vehicle and transmits the data through Zigbee module. The signal is received by the Zigbee module of other vehicles in the range. These transmitted and received values are displayed in the LCD screen of the vehicle's infotainment display. In modern world, these data can be modernized and be made to animate the vehicle icons in the display of the vehicle in a precise form. In this way, the driver will be aware of the other vehicles nearby the vehicle, in which he is in and would be so safe in the road by reducing accidents.

Fig. 9. Model of infotainment display

Fig. 7 shows the model of the infotainment display of the car, which shows the information about all the other vehicles surrounding the vehicle. This can be achieved by integrating the maps of the surroundings and various values of the sensors like data of the roadmap, location using centimeter precise GPS signal, direction, speed, dimension and the kind of vehicle.

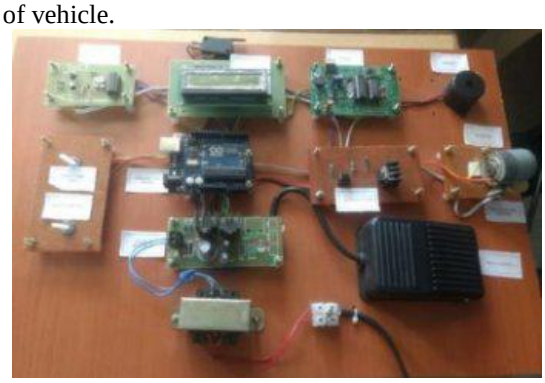

Fig. 10. Model for co-operative driving using Vehicle to Vehicle Communication

IV. Conclusion

The vehicle to vehicle communication has been completed successfully and the output results have been verified. The results are in line with the expected output. This module has been checked with both hardware and software testing tools. In this work "Transmitter, Receiver, Power supply, RF encoder, RF receiver, Display and Sensors" chosen are proved to be more appropriate for the intended application. This project is having enough avenues for future enhancement. It is a prototype model that fulfills all the logical requirements. With minimal improvements like the displayed details, on further enhancing and simulating, it can be created as a simulated form of display in the center console of the vehicle, displaying that particular vehicle and other vehicles in the animated form, which helps the driver in knowing the top view of the position of all the vehicles in his surroundings. It can be directly applicable for real time applications. Thus, this project contributes a significant step forward in the field of "PUBLIC SAFETY", and further paves a road path towards faster developments in the same field. This is further adaptive towards continuous up gradations in performance and in terms of peripheral units. This work can be applied to a variety of industrial and commercial applications in automobiles.

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