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HARDWARE REALISATION OF SELF PROPELLED SAFETY MONITORING SYSTEM USING CAN PROTOCOL

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Abstract

The automotive vehicle is the most importance in transportation. This paper discussed various safety measures that can be implemented in vehicles for safe travelling. The drawbacks that are observed in the existing system are glaring effect due to the opposite vehicle light illumination, gas leakage, short circuit in electrical wiring, high volume in horn causing noise pollution. Distance between two vehicles should be maintained certain meters to avoid accidents, unequal wheel pressure may lead to accidents, inaccurate fuel level in analog meters and high engine area temperature may cause damages to the engine. The GSM (Global System for Mobile communication) and GPS (Global Positioning System) are used to access the location during fault occurred (or) during cause of accident, it will send the information to the rescue people. These sensors are connected through Master and Slave modules and it is communicated using CAN (Controller Area Network) protocol. The simulation and experimental results show that the vehicle with a safety monitoring system provides a better safety to the persons in the vehicle and thereby accidents can be avoided. This proposed work was simulated and implemented through hardware. The observed results closely match with simulation and hardware results.

Keywords: Control area network, Global positioning system, Global system for mobile communication, Vehicle, Hardware.

1. Introduction

The controller area network is most commonly used in the automotive vehicle communication. The proposed work provides monitoring of various sensors to provide safety and gives alert to the persons in the vehicle and to the rescue team. Automotive electronics is a rapidly expanding area with an increasing number of

Abbreviations

ADC	Analog to Digital Converter
AFHAS	Automatic Front Headlight Adjustment System
CAN	Controller Area Network
DC	Direct Current
DCMs	Digital Clock Manager
ECU	Electronic Controller Control
EEPROM	Electrically Erasable Programmable Read Only Memory
GPS	Global Positioning System
GS	Ground-Scattering
GSM	Global System for Mobile communication
IR	Infra-Red
LCD	Liquid Crystal Display
LDR	Light Dependent Resister
MCU	Microcontroller Unit
MPPT	Maximum Power Point Tracking
OW	Optical Wireless
PIC	Programmable Interface Controller RMS
RMS	Root Mean Square
RTU	Remote Terminal Unit
SUV	Sports Utility Vehicle
TPMS	Temperature Pressure Monitoring Systems
VCN	Vehicle Control Networks

safety, driver assistance, and infotainment devices. Current vehicles generally employ a number of different networking protocols to integrate the systems into the vehicle. The introduction of large numbers of sensors to provide driver assistance applications and the associated high-bandwidth requirements of these sensors has accelerated the demand for faster and more flexible network communication technologies within the vehicle. This proposed system includes seven safety measures.

These safety measures are the most common reasons for road accidents during day and night time driving. In this proposed system, the included measures are, the first one is to reduce night time driving accidents due to opponent headlight illumination by AFHAS (Automatic Front Headlight Adjustment System). Because most of the accidents arise at night time driving. The second one is to reduce the short circuit faults at the vehicle wiring connections. The third one is to detect gas leakage and prevention. The fourth one is to monitor the temperature near engine location. The fifth one is to automatically adjust horn volume for respective surroundings. The sixth one is to display accurate fuel level and the seventh is monitoring the wheel pressure. Here some literature review is made for implementing proposed work. Kim et al. [1] reported a new methodology for the optimal Vehicle Control Networks (VCN) design. The VCN design was rest denned as the temporal and spatial joint optimization problem, and some of the challenges in solving the problem were presented. To tackle the challenges, an analytical model for examining the fundamental characteristics of the problem was derived. A repeated matching-based fast solution method was next provided to optimize the VCN design. Yim designed a preview controller method for rollover prevention has been proposed. Differential braking and active suspension have been adopted as actuators. Under the assumption that the steering input is preview able, the rollover prevention controller has been designed with LQ SOF preview control [2].

Hock et al. [3] developed a wireless controller area network using low cost microcontroller. The system is low cost and low power consumption for CAN application in order to receive data such as velocity, temperature and batteries power from Maximum Power Point Tracking (MPPT). Jankovic et al. [4] approached the CAN based monitoring the vehicles mechatronics systems which can significantly reduce time for vehicle instrumentation and enable development engineers to conduct testing in already existing vehicle before making the prototype of the new vehicle or system under development. Guo and Yue [5] investigated a control design for the platoon of automated vehicles whose sensors have limited sensing capability. A novel hybrid platoon model was established, in which actuator delay (e.g., the fuelling and braking delay) and the effect of sensing range limitation are involved. Ramya and Palaniappan [6] designed an embedded system for a vehicle cabin, which senses the gases like carbon-monoxide and oxygen and displayed at each and every second. If the level of the CO increases than the normal level (30 ppm) or the level of the oxygen decreases than the normal level (19%), an alarm strikes automatically and also ventilation is provided immediately. A warning message is sent to the authorized user via GSM.

Higgins et al. [7] implemented a simple linearly scalable 1-W infrared (IR) transmitter, which is centrally located on the ceiling of a sports utility vehicle (SUV), and for 15 passenger configurations, an analysis into the received power, power deviation, minimum bandwidth, and maximum root-mean-square (RMS) delay spread is provided for the regions of the vehicle most likely to benefit from the deployment of intra vehicle optical wireless (OW) communication system. Kwon et al. [8] proposed a new geometry-based channel model for wide-band polarized body area network channels consisting of four propagation modes: cylindrical-surface-scattering (CSS) for above ground off-body scattering, body-scattering (BS) for body diffracted and on-body scattering, ground-scattering (GS), and line-of-sight [8]. Raibagi et al. [9] focuses on building a user-friendly device that specializes in detecting intrusions besides doing close range obstacle detection. Automobile safety can be improved by anticipating a crash before it occurs and thereby providing additional time to deploy safety technologies.

Reddy et al. [10] developed an advanced Automobile Safety Information System (SMART). By using MEMS accelerometer and GPS tracking system we can get the information of accidental occurrence through GSM module. MEMS is a Micro electro mechanical sensor which is a high sensitive sensor and capable of detecting the tilt. The device is capable of performing all the tilt functions like forward, reverse, left and right directions. Elbert et al. analysed the globally optimal engine ON/OFF conditions are derived analytically [11]. It is demonstrated that the optimal engine ON/OFF strategy is to switch the engine on if and only if the requested power exceeds a certain non-constant threshold. By iteratively computing the threshold and the power split using convex optimization, the optimal solution to the energy management problem is found. Joerer et al. [12] defines a collision probability estimation scheme that allows assessment of the criticality of an intersection approach based on exchanged beacons, such as CAMs or BSMs. Given information about two approaching vehicles (such as their current position and speed), we are able to derive potential future trajectories and calculate the probability of a crash.

Kachroo presents the overall framework for high performance vehicle streams that integrates the transportation and the communication layered architectures together [13]. It shows the process in establishing an infrastructure for high-performance vehicles and the theoretical development and deployment of cooperative adaptive cruise control (CACC) for heterogeneous vehicles that is integrated with lateral control. Song proposed a feature points are extracted using an improved Moravec algorithm [14]. A specially designed template is used to track the feature points through the image sequences. Then, trajectories of feature points can be obtained, whereas unqualified track trajectories are removed using decision rules. Finally, the vehicle behaviour analysis algorithms are applied on the track trajectories for traffic event detection. Deng and Zhang focuses on technologies still can't prevent the traffic accident very well; this brings new study on the active safety technology based on various factors of traffic accidents [15]. It focuses on how to prevent the collision and accidents and look on the human condition and road condition monitoring.

Kim et al. [16] developed a novel tire-road friction coefficient estimation method based on 6-DoF acceleration measurement was proposed and validated under longitudinal emergency braking manoeuvres. Experimental results indicated that tire-road friction coefficient could be estimated by the proposed method accurately in real-time during longitudinal emergency braking, and its relation to tire slip was consistent with the anticipated physical trends. Liu et al. focused on improving positioning accuracy in vehicular networks using GPS pseudo range measurements [17]. Two algorithms, namely WLS-DD and DLEA, are proposed to enable the cooperative positioning. An extensive simulation study demonstrates that the proposed solutions can effectively improve the positioning accuracy under a variety of conditions. Belyaev et al. [18] proposed a low-complexity unequal packet loss protection and rate control algorithms for a scalable video coding based on the three-dimensional discrete wavelet transform. IEEE 802.11p communication technology makes it possible to introduce new automotive applications, which make use of broadband vehicle-to-vehicle and vehicle-to-roadside connectivity. We have developed and evaluated a new surveillance system aimed at improving public transport security and road traffic control.

Shih and Tsai proposed a convenient indoor vision-based parking lot system using wide-angle fish eye-lens or catadioptric cameras [19]. This is easy to set up by a user with no technical background. Easiness in the system setup mainly comes from the use of a new camera model that can be calibrated using only one space line without knowing its position and direction, as well as from the allowance of convenient changes in detected parking space boundaries. Căilean, and Dimian [20] focused on the design of the VLC sensors intended for vehicular communication applications, offering a review of the solutions found to mitigate the effect of the problematic conditions. Furthermore, summarizes these solutions and proposes an environmental adaptive VLC receiver that would be capable to optimally adjust its settings in order to maximize the communication efficiency, but without affecting the communication robustness to noise. The literature survey reviles some recent papers related to area of work on automotive safety and monitoring system.

2. CAN Architecture and Protocol

The Controller Area Network is a method of communication between various electronic devices like lighting control, air conditioning, central locking, gas monitoring, and distance monitoring etcm embedded in automobile. Robert Bosch in 1983 discussed how to improve the quality of automobiles and thereby making them more reliable, safe and fuel efficient. CAN provide a mechanism which is incorporated in the hardware and the software by which different electronic modules can communicate with each other using a common cable. Figure 1 shows the CAN protocol architecture and Fig. 2 shows the Bus architecture of CAN protocol.

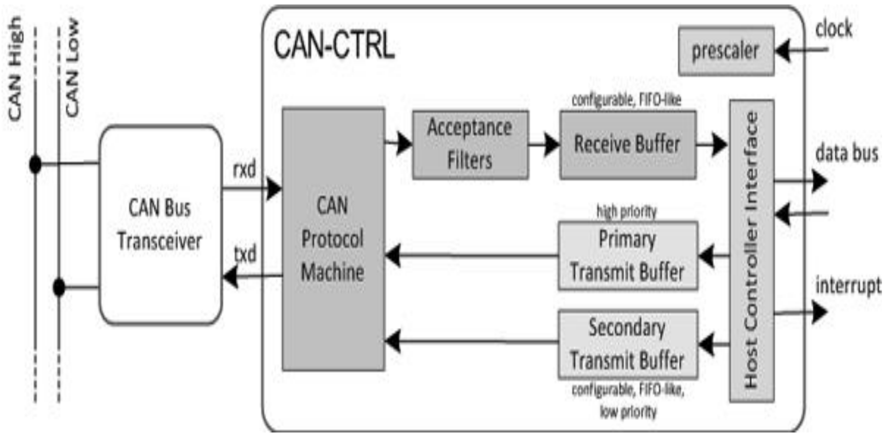


Fig. 1. Controller area network architecture.

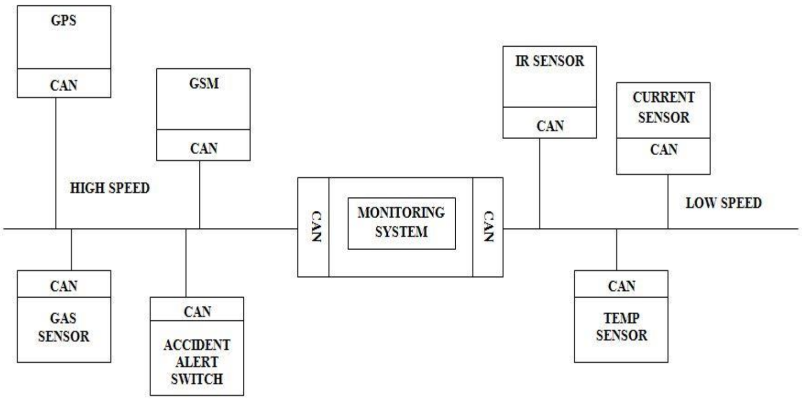


Fig. 2. Controller area network bus.

3. Master and Slave Module

In this proposed work the automotive vehicle safety measures are monitored and alerts the user through message during abnormal conditions and during emergency periods like accidents. The proposed system contains PIC 16f877A microcontroller, various sensors and CAN Protocol that communicates with the PIC microcontrollers. The sensors are connected in two microcontrollers and it is named as Master and Slave. The two microcontrollers are communicating using CAN protocol which is a two-wire serial communication.

The various sensors used for measuring the parameters are

a) Temperature sensor for monitoring engine temperature.
b) Digital fuel level sensor for monitoring accurate fuel level.
c) RFID for automatic horn volume adjustment.
d) Tire pressure monitoring sensor (TPMS) for monitoring pressure in the tire.
e) Current sensor for monitoring short circuit fault detection.
f) Gas leakage detection using gas sensor.
g) LDR for automatic headlight brightness adjustment during night time travelling.
h) IR sensor for distance monitoring to maintain a safer distance.
i) GPS and GSM used for sending alert message to the rescue persons during accident and emergency situations.

Figure 3 shows the block diagram of the proposed work. The PIC microcontrollers are named as Master and Slave. All the sensors are connected to master and slave unit. These systems provide the monitoring and alert system for automotive vehicles. The LCD and Buzzer are used to display the current sensor information and buzzer during abnormal conditions.

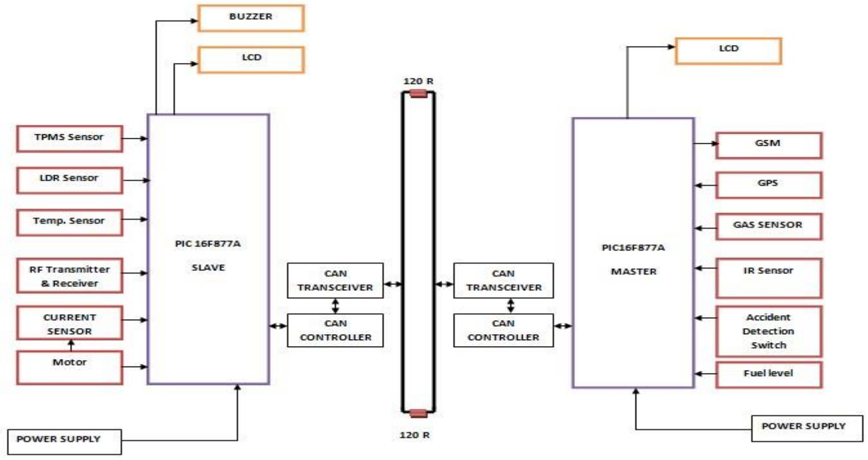


Fig. 3. Proposed block diagram.

3.1. Master module

In Master module, PIC 16f877A microcontroller and sensors are connected through I/O ports. The data are transferred using serial communication. The types of sensor used in the master module are (a) GSM, (b) GPS, (c) IR Sensor, (d) Gas leakage sensor-MQ4, (e) Fuel level sensor, and (f) Accident detection switch.

(a) GSM

The GSM is the Global System for Mobile Communication. It is commonly used for transmitting the messages from one device to other mobile devices. GSM is used to send the alert message during abnormal conditions and during occurrence of accident to the rescue persons. Figure 4 show the GSM module.

Fig. 4. GSM module.

(b) GPS

GPS is the Global Positioning System which is mainly used to detect the latitude and longitude of the particular location. During the abnormal changes in sensors and on the accident period, it detects the location and sends the information to the PIC microcontroller. This information is used by rescue persons to easily finding the exact location. Figure 5 shows the GPS module.

(c) IR sensor

The IR sensor is operating during the object detection when the IR signal reflects back to the sensor. The distance between two vehicles should maintain 10 m and above, if it is lesser there may be chance of accidents or damage to the vehicle. Figure 6 shows the IR sensor. The IR sensor placed in the vehicle continuously monitors the distance and it alerts when the distance is below 10 m in range.

(d) Gas sensor MQ4

Many of the vehicles use GAS as an alternative energy for driving the vehicle. GAS leakage in vehicle may cause severe damage to the vehicle. Figure 7 shows the MQ4 gas sensor. The MQ4 gas sensor is used to monitor the leakage of gas and if there is any leakage it alerts the driver and sends the message to the rescue person during the abnormal condition.

(e) Fuel level sensor

The analog fuel level sensors which are commonly used in automotive vehicle are inaccurate and it does not show exact fuel value. This can be overcome by using digital fuel level sensor.

(f) Accident detection switch

The emergency or accident situation can be occurred any time, during this period the persons inside the vehicle cannot access the outside rescue persons for help so this can be overcome by placing an accident alert switch which sends the accident alert along with the location of the vehicle to the rescue persons.

Fig. 5. GPS module.

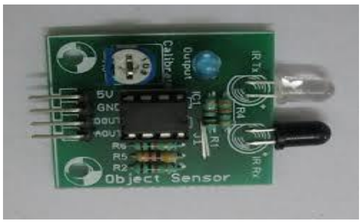


Fig. 6. IR module.

Fig. 7. Gas sensor module.

3.2. Slave module

The slave module contains PIC 16f877A microcontroller and sensors, which are communicating using serial communication. The sensors that are used are

(a) TPMS, (b) LDR, (c) Temperature sensor - LM35, (d) Current sensor - CT1270, and (e) RFID - EM18.

(a) TPMS

The Tire Pressure Monitoring Sensor is used to monitor the air pressure in the tires. The uneven air pressure may cause the performance poor and increase the heat in the wheel, Due to this it may leads to accidents.

(b) LDR

The LDR is the Light Dependent Resistor which is used to adjust the brightness of the light so that the vehicle can be easily driven in night time. The brightness of the light is adjusted by varying the LDR value.

(c) Temperature sensor- LM35

The temperature sensor used here is LM35.It is used to monitor the temperature of the engine. The operating range of LM35 is from 0'C – 100 'C. In this proposed work the temperature limit for normal value is set to 35'C.If the temperature exceeds the limit it warns the driver by indicating a beep sound through buzzer and sends the message to the rescue person about the abnormal changes in the temperature. Figure 8 shows the LM35 temperature sensor.

(d) Current sensor - CT1270

The current measurement is more important in the electrical wirings in the vehicle. Figure 9 shows the current sensor. If there is any fault in wiring it may cause damages to the circuit in vehicles. The current sensor used in this proposed work is used to monitor the current level of a DC motor which is 1 Amps in rating. If there is any change or no power supply is detected in current sensor it alerts the driver.

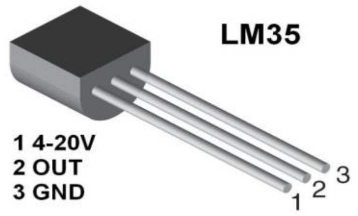


Fig. 8. Temperature sensor.

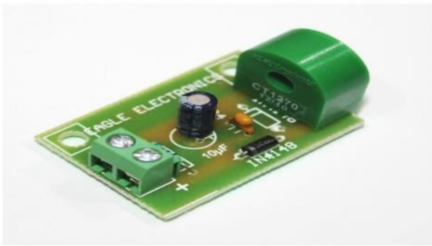


Fig. 9. Current sensor module.

(e) RFID – EM18

The RF transmitter and Receiver are the EM18 receiver and RFID tag for transmitter. Figure 10 shows RFID transmitter and receiver. The main objective of this sensor is receiving the magnetic signal whenever the tag is placed near by it and changes the mode of operation according to the condition. This sensor is used for changing the volume of the vehicle according to area zone and to reduce the noise pollution.

Fig. 10. RFID transmitter and receiver.

4. Simulation Results

The proposed work can be simulated by using proteus simulation tool. Figure 11 shows the simulated proposed work in the proteus tool.

In this simulation, the values of the sensors are taken by using ADC input and it is processed in microcontroller. The sensors which are used in simulation are temperature sensor, current sensor, luminance sensor LDR, gas sensor, digital fuel sensor and tire pressure sensor. The output of the Master and Slave modules are connected through the CAN protocol and the output is taken from the RS232 port to the virtual terminal. The simulation of the proposed work provides the required output and the proposed work can be implemented through hardware. The following parameters are used for the simulation. Output of each sensor is monitored through the LCD display. The sensors operate in two ways during normal and abnormal conditions.

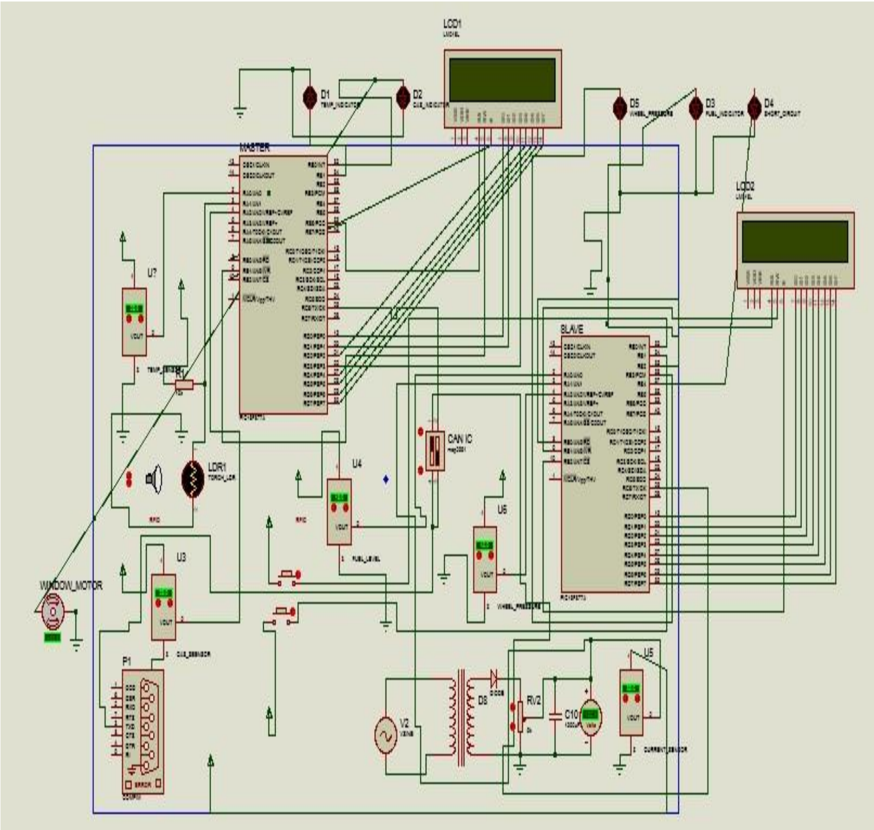


Fig. 11. Proposed simulation circuit.

4.1. Master during normal condition

Table 1 shows the simulation results of the master module under normal condition for temperature, gas and luminance variations.

Table 1. Master module during normal condition.

Sensors	Range	LED	Motor	Intensity
Temp sensor	Below 30	D1-OFF	-	-
Gas Sensor	Below 30	D2- OFF	OFF	
Luminance sensor	Below 92	-	-	Low

a) Temperature value

Figure 12 represents the temperature setting during normal condition. The sensor D1 is used to measure the temperature of the master unit.

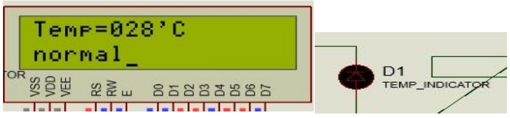


Fig. 12. Temperature during normal.

b) Front light adjustment

Figure 13 shows the front light adjustment for short range. The light dependent resistor is used to sense the distance.

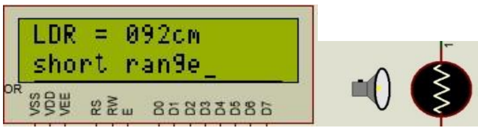


Fig. 13. Luminance during short range.

c) Gas level

The sensor D2 is used to sense the gas level. Figure 14 displays the gas level.

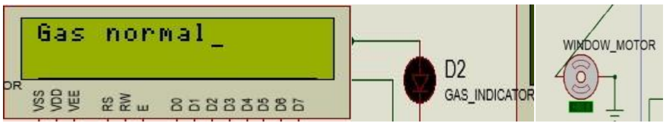


Fig. 14. Normal gas level.

4.2. Master during abnormal condition

Table 2 displays the simulation results of the master module under abnormal condition for temperature, gas and luminance variations.

Table 2. Master during abnormal condition.

Sensors	Range	LED	Motor	Intensity
Temp. sensor	Above 30	D1-ON	-	-
Gas Sensor	Above 30	D2-ON	ON	
Luminance sensor	Above 92	-	-	High

a) Temperature

Figure 15 represents the temperature setting during abnormal condition. The sensor D1 is used to measure the temperature of the master unit.

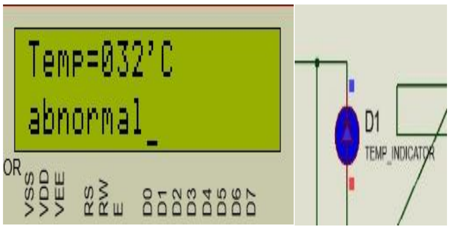


Fig. 15. Temperature during abnormal.

b) Front light adjustment

Figure 16 shows the front light adjustment for short range. The light dependent resistor is used to sense the distance. The LCD display shows the exact range of front light.

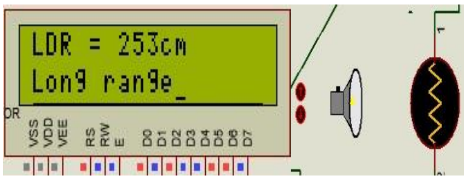


Fig. 16. Luminance during long range.

c) Gas level

The sensor D2 with window motor is used to sense the gas level. Figure 17 displays the gas level.

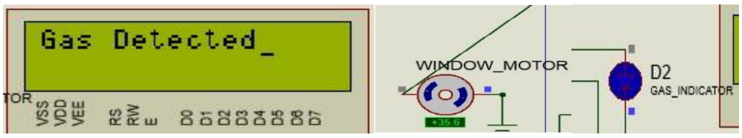


Fig. 17. Gas leakage detected.

4.3. Slave during normal condition

Table 3 shows the simulation results of the slave module under normal condition for fuel, current, RFID and Wheel pressure variations.

Table 3. Slave during normal condition.

Sensors	Range	LED	Zone
Fuel sensor	Above 15 ltr	D3 - OFF	-
Current Sensor	Above .32 Amps	D4 - OFF	
RFID sensor	Above 30 Mtr	-	General
Wheel Pressure Sensor	Above 30	D5 - OFF	

a) Fuel level

The fuel sensor D3 is used sense the level of the fuel under normal condition. Figure 18 displays the fuel sensor output.

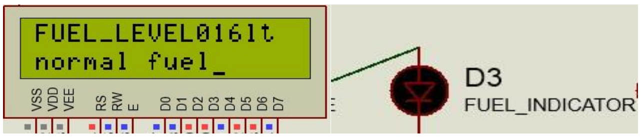


Fig. 18. Normal fuel level.

b) Current sensor

The current sensor D4 is used sense the amount of current flow under normal condition. Figure19 displays the current sensor output.

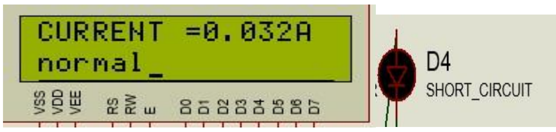


Fig. 19. Normal current.

c) RFID sensor

The RFID sensor is used sense the zone under normal condition. Figure20 shows the RFID output.

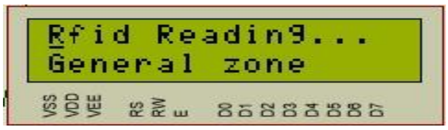


Fig. 20. General zone.

d) Wheel pressure sensor

The D5 sensor is used sense the pressure of the wheel under normal condition. Figure 21 shows the wheel pressure sensor output.

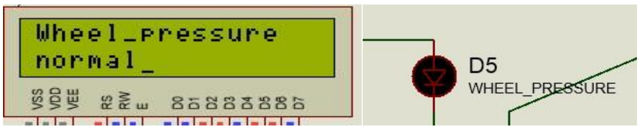


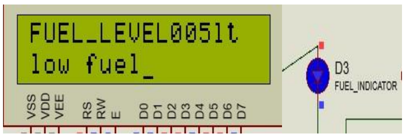
Fig. 21. Normal wheel pressure.

4.4. Slave during abnormal condition

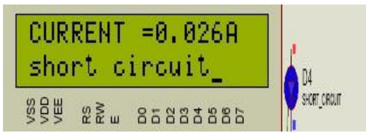
Table 4 shows the simulation results of the slave module under abnormal condition for fuel, current, RFID and Wheel pressure variations. Figures 22 (a) to (d) show the output for slave during abnormal condition.

Table 4. Slave during abnormal condition.

Sensors	Range	LED	Zone
Fuel sensor	Below15 ltr	D3 - ON	-
Current Sensor	Below .30 Amps	D4 - ON	
RFID sensor	Below 30 Mtr	-	Hospital/ School
Wheel Pressure Sensor	Below 30	D5 - ON	



a) Normal fuel level



b) Normal current

c) School zone and hospital zone

d) Abnormal wheel pressure

Fig. 22. Output for slave during abnormal condition.

5. Hardware Results

In this hardware implementation, the sensors used in the simulation along with other sensors are connected according to the block diagram along with the accident alert system GPS and GSM and also with the IR sensor for distance monitoring. The LCD and buzzer are used for indicating and displaying the sensor value information. The GSM and GPS used to send alert message during the emergency or accident period. It contains Master and Slave Modules; the sensors are connected to each module separately. Figure 23 shows the hardware diagram of the proposed work. The Master Module contains GSM, GPS for communication, sensors like Gas sensor, IR sensor and Accident detection switch are interfaced. In Slave module, Temperature sensor, RF transmitter and receiver and current sensor are interfaced. Figure 24 displays the hardware results and output of master and slave.

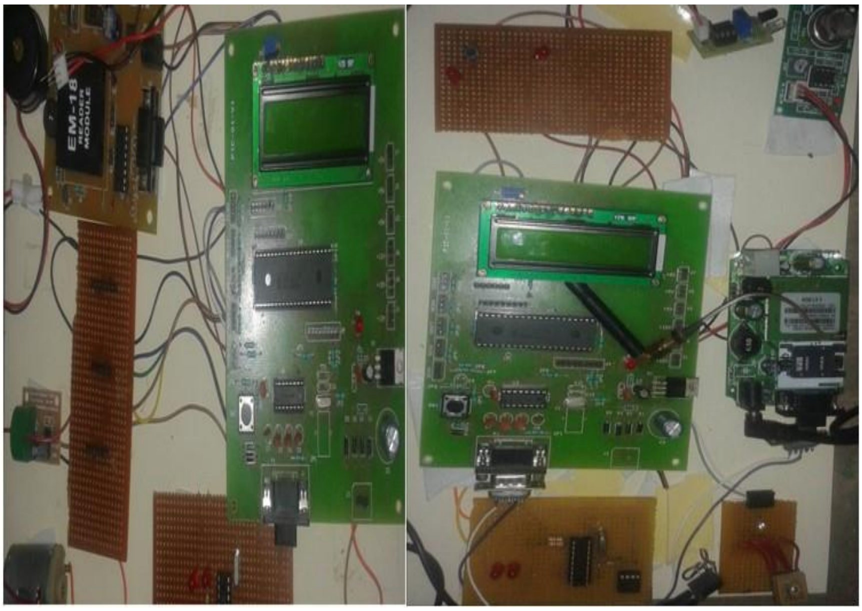


Fig. 23. Proposed hardware circuit.

The following parameters are used for the hardware implementation. Output of each sensor is monitored through the LCD display. The sensors operate in two ways during normal and abnormal conditions. Table 5 shows the comparison between CAN and Ethernet. Similarly, Table 6 displays the comparison between CAN, TTP and Flex ray.

Table 5. Comparison of CAN and Ethernet.

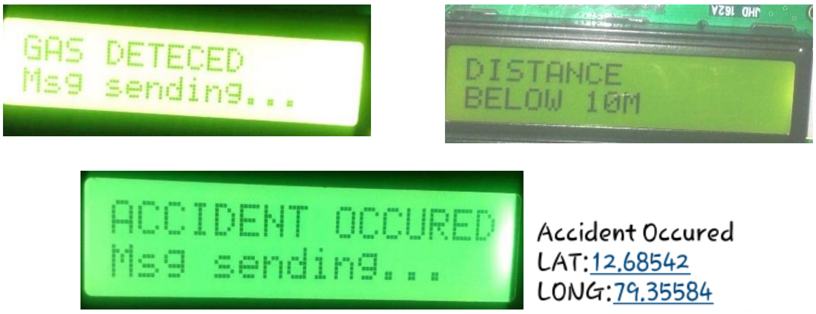
Sl. No	CAN	Ethernet
1	Secured communication	No secured communication
2	Collision-free bus arbitration	Suffer from bus arbitration collisions
3	Multi- and broadcasting are reliable	Multi- and broadcasting are not reliable
4	Data integrity is more	Data integrity is less

Table 6. Comparison of CAN, TTP and Flex ray.

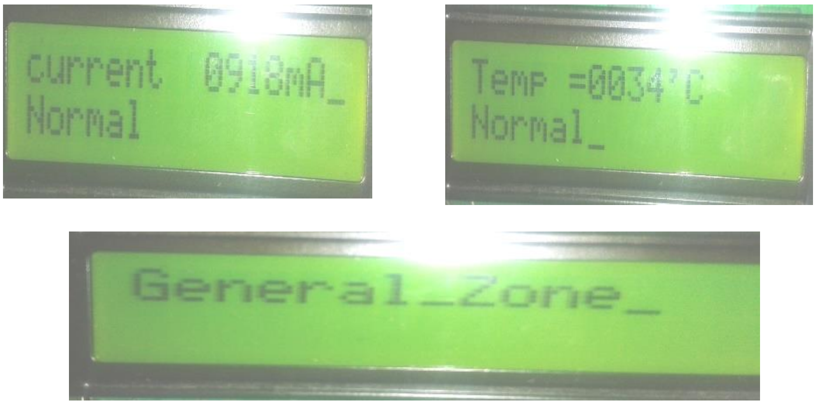
Sl. No	CAN	TTP	Flex ray
1	Low complexity	High complexity	Very high complexity
2	Very less flexible system	Less flexible system	Very flexible system
3	Ensure safety	Moderate safety	Motive safety
4	Lack of compos ability	Robust level of compos ability	High level of compos ability
5	8 bytes	Uses 2 frame	Frame supports254 bytes
6	Bandwidth - 1mbps	2mbps	10 mbps

a) b)

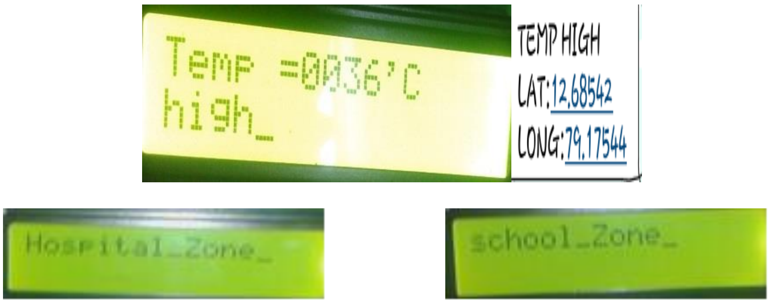
Hardware output of master during normal conditions a) normal gas level, b) normal distance



Hardware results of master during abnormal conditions



Hardware results of slave during normal conditions



Hardware results of slave during abnormal conditions

Fig. 24. Hardware results and output of master and slave.

6. Conclusions

This paper discusses about various safety measures that are needed in the automotive vehicle. The safety measures include automatic brightness adjustment, measuring engine area temperature, short circuit of electrical wirings, gas leakage detection, automatic horn volume adjustment, distance maintenance, wheel pressure monitoring, digital fuel indicating and accident alert system are provided in this safety system. The sensors are connected to the Master and Slave modules that are communicated through CAN protocol. The GSM and GPS are used to send alert message to the rescue persons during emergency situations and the simulation results and hardware implementation results are satisfactory to provide a safety monitoring system and overcome the accidents. The comparison between simulation and hardware results are shown in Table 7.

Table 7. Comparison of hardware and simulation results.

Hardware Results		Simulation Results		**Sensors**
Abnormal Condition	Normal condition	Abnormal Condition	Normal Condition	
Above35° CBuzzer ON Alert SMS	Below35°C Buzzer OFF	Above30° CD1 ON	Below30 °CD1 OFF	**Temperature sensor(LM 35)**
-	Above0.9 Amps	Above0.32 amps D4 ON	Below0.32 Amps	**Current sensor**
Leakage Alert SMS	No leakage	Above30 D2 ON	Below30D2 OFF	**Gas sensor (MQ4)**
Below30 D6 ON	Above30 D6 OFF	-	-	**IR sensor**
-	-	Above92	Below92	**Luminance sensor LDR**
Below10M Hospital/School	Above10 MGeneral	Below30M Hospital/School	Above30 MGeneral	**RFID zone EM 18**
-	-	BelowD5 ON	AboveD5 OFF	**Wheel pressure TPMS**
-	-	Below 15 Ltrs D3 ON	Above15 LtrsD3 OFF	**Fuel level sensor**
Accident Alert SMS	-	-	-	**Accident alert GPS, GSM**

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