International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 01 | Jan 2019 www.irjet.net p-ISSN: 2395-0072

Design of an Embedded System for Vehicle Fault Diagnosis and Safety using I2C Protocol

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Abstract - *In Recent years, factors influencing the increased number of road accidents are due to careless driving, drunk driving and due to the unexpected problems occurring in the vehicles. Road transport department is taking necessary actions to prevent accidents by displaying message on LED screens at road sides but many drivers do not pay attention and continue to be the same. So this work aims at developing an embedded system for vehicle fault diagnosis and safety system at low cost. This system checks health status of vehicle such as condition of brake, seat belt, ignition system, fuel tank, engine temperature, as well as whether driver has consumed alcohol before driver starts the vehicle. If any one of these test is failed, the system does not allow the driver to turn on vehicle engine. If all the tests are passed, then only the driver is allowed to start the engine. The major advantage of this system is that, it monitors status of vehicle continuously even it is moving, while driving, in case of occurrence of any faults, driver will be warned first and then vehicle speed will be reduced gradually and then the engine will be turned off.*

Key Words: Road transport Department, I2C protocol, Microcontroller ATmega 328P, PCF8591, GPS, GSM.

1. INTRODUCTION

There is one death every four minutes due to road accidents in India. In Recent years, factors influencing the increased number of road accidents are due to careless driving, drunk and driving and due to the unexpected problems occurring in the vehicles. Road transport department is taking necessary actions to prevent accidents by displaying message on LED screens at road sides.

Drivers are considered to be alcohol-impaired when their blood alcohol concentrations (BACs) are 0.8 grams per decilitre (g/dL) or higher. Thus, any fatal crash involving a driver with a BAC of 0.8 g/dL or higher is considered to be an alcohol-impaired-driving crash, and fatalities occurring in those crashes are considered to be alcohol-impaired-driving fatalities. In the 5 years before 1987, more than 110 drivers and motorcycle riders who lost their lives each year had a BAC greater than 0.05g/100ml. This has reduced to an average of 28 drivers and riders who lost their lives each year with a BAC greater than 0.05g/100ml from 2011-2015. In 2016, there were 34 drivers and riders who lost their lives with a BAC greater than 0.05g/100ml.The proportion of drivers and motorcycle riders who lost their lives with a BAC greater than 0.05g/100ml has declined from 38% in 1987 to 19% 2016.

Present Automobiles are being developed by more of electrical parts for efficient operation. Generally a vehicle is built with an analogue driver-vehicle interface for indicating various vehicle statuses like speed, fuel level, Engine temperature etc. For the improvement of reliability, safety and efficiency advanced methods of supervision; fault-detection and fault diagnosis became increasingly important for many technical processes. This holds especially for safety related processes like aircraft, trains, automobiles, power plants and chemical plants. The classical approaches are limited to trend checking of some measurable output variables. Because they do not give a deeper insight and usually do not allow a fault diagnosis, model-based methods of fault-detection were developed by using input and output signals and applying dynamic process models. Vehicles are undergoing dramatic changes in their capabilities and how they interact with the drivers. Although some vehicles have provisions for deciding to either generate warnings for the human driver or controlling the vehicle autonomously, they usually must make these decisions in real time with only incomplete information. So, it is important that human drivers still have some control over the vehicle. Advanced in-vehicle information systems provide vehicles with different types and levels of intelligence to assist the driver.

Vehicle fault diagnosis and safety system is an essential function required for fault tolerance, reliability and fail-safe techniques. It can be used to detect faults, diagnose and identify failures, and assess the severity of the consequences. Based on the monitoring results, malfunction management or hazard reduction control can be performed. Self diagnosis and safety systems are used to observe the entire operation process of the system to be monitored and to detect any fault or combination of faults before the specified functions are significantly impaired.

1.1 Motivation

The Rapid growth of technology and infrastructure has made our lives easier. The advent of technology has also

increased the traffic hazards and the road accidents take place frequently which causes huge loss of life and property because of the poor emergency facilities. Increased number of accidents leads to loss of many lives. Due to hindered emergency services and unawareness of driver about the vehicle condition, rate of lives loss increased. To help middle class people who can't afford high profile vehicles, who couldn't manage to feel secure due to high cost of safe vehicles, we ended up with the thought of self-fault diagnosis and safety system for low/medium profile vehicles.

1.2 Objective

The objective is to propose a system which is accurate, intellectual, reliable and effective means for analysis of alcohol test, smoke test, brake test, oil level test, seat belt test and accident detection test without human effort. This system makes use of the control unit consist of an embedded controller board with various sensors and GSM modem and GPS module for transmitting the location of the accident occurred to the concerned authority in the form of latitude and longitude.

2. LITERATURE REVIEW

Automated anti-collision system by detecting obstacles for automobile industry is one of the emerging technologies now-a-days [1]. An automated vehicle anti-collision system is an automobile safety system which prevents collision among cars and objects automatically. This paper discuss about implementation of the prototype of designed microcontroller based automated car anti-collision system. This system specializes in detecting obstacles by sharp distance sensor and alerts within close distance of collision and hereafter brakes automatically by actuator in critical distance without the help of driving person. If somehow driver fails avoiding the collision, this system will automatically stop the vehicle as it monitors the condition of the vehicle continuously. So it is a user friendly and versatile system which can prevent road accidents, reduce the rate of accidents as well as accidental death of human life. It can be used in any kind of automobile vehicle as it's a cost effective system.
The drawback of this system is there are chances of false collision detection. In case of sudden stopping vehicle without driver's knowledge may cause unexpected accidents.

Fault diagnosis of a circuit of vehicle system is analyzed in this paper [3]. Complex field fault modelling is used for fault diagnosis of the conditioning circuit of vehicle system. All single faults of components in the circuit are modelled in complex field. Soft fault and hard fault of single components are analyzed in detail. The problem of coincidence of fault characteristic equations is solved by changing the topological structure of circuit. The problem of intersection is analyzed by increasing the frequency of excitation source. Fault detection process and fault dictionary are given. Then the fault detection process is tested by six assumed faults. No matter soft fault and hard fault of single components, the fault detection in this paper can locate source of fault accurately.

Vehicle Health monitoring is an essential function required for fault tolerance, reliability and fail-safe techniques [3]. It can be used to detect faults, diagnose and identify failures, and assess the severity of the consequences. Based on the monitoring results, malfunction management or hazard reduction control can be performed. Because of the safety-critical nature of Advanced Vehicle Control Systems (AVCS), vehicle health monitoring will be vitally important. This paper will discuss the needs, criteria and methods for vehicle health monitoring.

The drawback this is, the vehicle health monitored results will be obtained when the driver or owner requests for it.
This paper [4] deals with design of system for automobile purposes using Zigbee protocols. The main problems faced in the existing system are inaccuracies in the calculation of speed, distance measurement, and slow response time, etc. The proposed system solves many of the problems faced by the existing systems by using a GPS module instead of the conventional speedometer and also uses sensors which are reliable in areas where human intervention is either unintended or where it puts life to risk. The problems of traffic congestion in urban arterials are increasing day by day and it is very difficult to handle it during emergencies. This system aims at communicating with the vehicle in its surrounding with the help of its location (i.e., using the latitude and longitude) to indicate their proximity. When these vehicles are very close in proximity the drivers are cautioned with the help of a message. In this way the drivers can communicate with each other and act according to the situation.

This paper[5] Proposes an advanced vehicle monitoring and tracking system based on Embedded Linux Board and android application is designed and implemented for monitoring the school vehicle from any location A to location B at real time. The proposed system would make good use of new technology that based on Embedded Linux board namely Raspberry Pi and Smartphone android application. The proposed system works on GPS/GPRS/GSM SIM900A Module which includes all the three things namely GPS GPRS GSM. The GPS current location of the vehicle; GPRS sends the tracking information to the server and the GSM is used for sending alert message to vehicle's owner mobile. The proposed system would place inside the vehicle whose position is to be determined on the web page and monitored at real time.

Remote vehicle monitoring system [6] keeps track of vehicle and also monitor the fleet level of the vehicle status. Here two problems are dealt with. First one is the anywhere any time monitoring of the vehicle status cannot be done through manual monitoring and the second one is the system behaviour change according to user changes.
As it is fully software related system, the driver/ owner will not be able to alter the system according to his needs. Monitoring might not be possible in case of absence of network.

In this paper [7] an accident prevention system is being introduced with accident identification for vehicles that will give a higher probability to reduce the accidents taking place every day on roads and at the same time if accident occurs, the system will locate its place and will automatically inform those people who will be able to take immediate actions. Here, an Arduino based system [10] has been developed by using Global Positioning.

This paper[8] deals with an enhanced electronic safety system design with simulation results for teenagers and older drivers is presented in this paper. Because of their physiological characteristics that lead to multiple driving errors need monitoring to avoid their recurrence comparing to the initial design, the presented safety system in this study considers additional two parameters; the number of driving errors and the errors duration. Based on these two parameters, the total number of recorded driving errors (lower/higher than the low/high front distance limits respectively) will be considered. If this number exceeds a certain limit of error then a suitable response will be taken as a safety reaction. Simulation results are demonstrating the recognition capability among the three cases of driving conditions, which are safe front distance, short front distance alarm, and long front distance alarm [8].

The major drawback of this is as the system is designed for teenage and older drivers, it might be inconvenient for the use by other people.

A vehicle health monitoring system based on analytical redundancy is developed for automated passenger vehicles. A residual generator and a residual processor are designed together to detect and identify actuator and sensor faults of the Buick LeSabre rapidly [9].

The major drawback of this system is there is a chance of change in the vehicle health pattern which doesn't affect the condition of vehicle but doesn't match the previous patterns.

3. BLOCK DIAGRAM OF PROPOSED SYSTEM

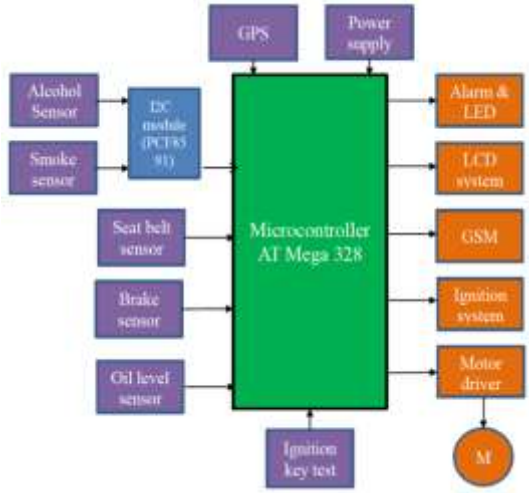

Fig -1: System block diagram

The self fault diagnosis and safety system is the connection of each module incorporated with the central control unit. A battery has been used to provide necessary power supply. For navigation a GPS module has been used and for transmitting the coordinate of the location a GSM module has been attached. Controlling of motor is performed by a relay driver circuit.

When an ignition key is inserted, alcohol test, brake test, seat belt condition test, oil level test, door test and smoke test will be conducted. If any of the tests fails, the LCD displays the particular test failure, buzzer beeps and relay circuit will not be activated. If result of all tests is a pass then, LCD displays requesting to start the engine starter motor. The tests will be continuously carried out. In case of occurrence of any faults, the driver will be alerted via buzzer and LCD.

4. WORKING OF PROPOSED SYSTEM

4.1 Accident Detection Process

Step#1: Insert ignition key.
Step#2: Ignition key insertion test conduction will be conducted.
Step#3: Alcohol test will be conducted.
Step#4: Brake test will be conducted.
Step#5: Seat belt test will be conducted.
Step#6: Door test will be conducted.
Step#7: Smoke test will be conducted.
Step#8: If all tests are passing, then it activates the relay and displays a message on the LCD asking to start the engine.
Step#9: If any of the above tests fails, then Buzzer will be activated and doesn't allow the driver to start the engine.

Step#10: Steps 2, 3, 4, 5, 6, 7 will be cyclically conducted during movement of vehicle, in case of any test failures buzzer will be activated.

4.2 Accident detection and alerting process

Step#1: Switches (force sensors) are used to sense the accidents.
Step#2: In case of any accidents, it will be detected by the switches.
Step#3: Location of the accident will be sent to the controller.
Step#4: GSM will be activated.
Step#5: "EMERGENCY" message along with the location will be sent to the pre stored numbers.
Step#6: Steps 1, 2, 3, 4, 5 will be continued.

5. RESULTS

Table -1: Ignition Key Test Result

TEST	If YES	If NO
Ignition key Test	Test conduction will be initiated.	LCD displays "Plz insert the ignition key".

Table -1: Test Results of alcohol test, brake, door, smoke seat belt.

TEST	If PASS	If FAILS
Alcohol Test	Alch<0.15 mg/L, LCD Displays " alchl test P"	Alch>0.15mg/L. LCD displays " alchl test F" Buzzer will be activated
Brake Test	LCD displays "Brake test P"	LCD displays "Brake test F" and Buzzer will be activated
Seat Belt Test	LCD displays "SB test P"	LCD displays "SB test F" and Buzzer will be activated
Door Test	LCD displays "Door test P"	LCD displays "Door test F" and Buzzer will be activated
Smoke Test	ADC Smk< 50, LCD Displays "Smoke test P"	ADC Smk> 50, LCD displays "Smoke test F" Buzzer will be activated
Oil Level Test	LCD displays "Oil level test P"	LCD displays "Oil level test F" and Buzzer will be activated
All tests	LCD displays "start the starter motor"	Buzzer will be activated and starter motor will not be initiated.

Fig -2: Information about Latitude and Longitude of the accident detected area message received in our mobile.

Fig -3: Satellite view of the accident location.

6. IMAGES OF IMPLEMENTED PROTO TYPE

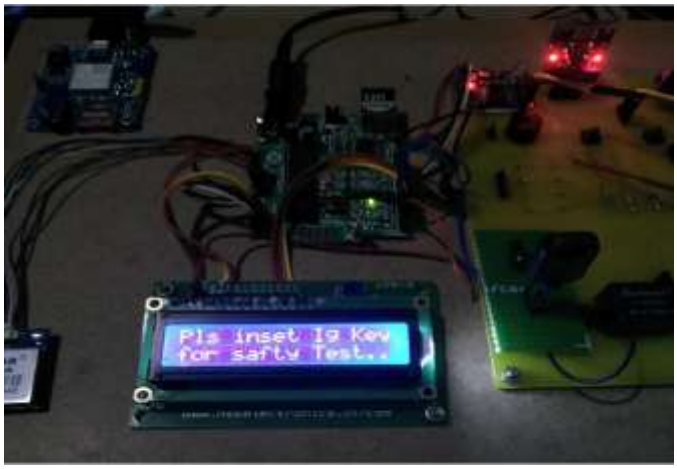

Fig -4: Ignition key test.

Fig -5: Brake condition test.

Fig -6: Smoke test

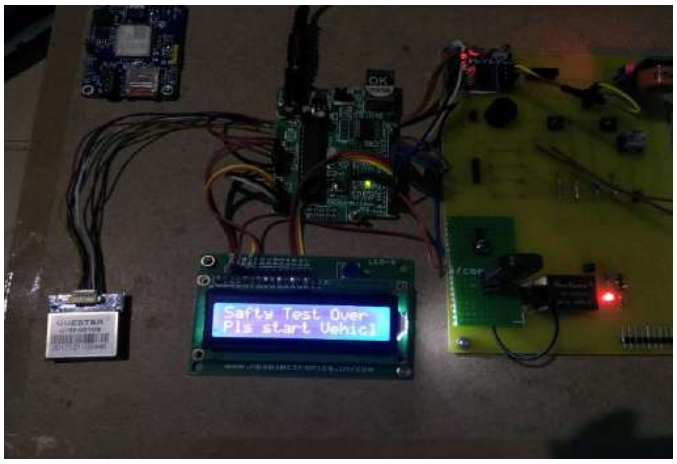

Fig -6: safety test completed.

7. ADVANTAGES AND DRAW BACKS

7.1 Advantages

1. Faults in the vehicle regarding brakes, doors, seat belt, and oil level will be successfully detected.
2. Drunk and drive fatalities will be reduced due to alcohol consumption detection of the driver.
3. Location of the accident is detected and sent to the pre stored numbers.
4. Simple and Reliable Design for low/medium profile vehicles.

7.2 Drawbacks

1. Communication problem in remote areas.
2. GPS will take few seconds to minutes' for initialisation/to establish communication with satellites.
3. Alerting system doesn't work in absence of network

8. CONCLUSIONS

This paper proposes an embedded system in order to ensure the safety of driver and co-passengers who use low/medium profile vehicles. This system avoids accidents due to faults and failure in the vehicle by detecting those at initial stages. In case, any accidents happen, it sends alert messages to respective authorities like hospital and families. The proper vehicle monitoring and maintenance can save time, financial investment and improve the ownership experience.

In future voice playback unit can be implemented with display system to help the driver and co-passengers to understand the fault condition in a much better way whenever there is a fault during the conduction of test.

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