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Design and performance evaluation of vehicle in-front obstacle detection & Safety alert system

Md. Hasibul Jamil [1], Prasenjit Mazumder [2], Tamjid Hossain [3] and Pranab Chakma [4]

[1-4] Dept. of Electrical & Electronic Engineering, Chittagong University of Engineering & Technology, Chittagong-4349, Bangladesh

[1]hasibjamil113@gmail.com, [2]prasenjit.eee.69@gmail.com, [3]t.hossainarko.10@gmail.com, [4]pranab.chakma017@gmail.com

Abstract*-In today's world safety and security plays an important role, hence we tend to provide a good safety and security system while travelling. Vehicles are important in today's fast-paced society. Hence, acquiring a vehicle now-a-days is considered as a necessity, compared to the past where it was considered as a luxury. In this thriving society, more and more vehicles are produced to meet the increasing demands of people and business from all corners of the world. Here comes the necessity to provide more and more safety and security features to them. Hence this project aims to design an embedded system for vehicle cabin safety and security by modifying and integrating the existing modules. This monitors the level of the toxic gases such as CO, LPG and temperature inside the vehicle and provides alert information in the form of alarm during the critical situations. An sonar sensor is used to detect the static obstacle in front of the vehicle and the vehicle gets stopped if any obstacle is detected within 1.5 meter . This may avoid accidents due to collision of vehicles with any static obstacles.*

Keywords*:* ADC, GSM, Embedded System, Microcontroller, Sensors.

1. INTRODUCTION

Vehicles are something that we need every day in our life. Safety for the vehicles is most important fact for our transportation system. We must try to equip vehicles with the latest technologies for safety arrangement. As a matter of fact, this safety arrangement should be cost effective perspective to our economical condition. Warning alerts and alarms are security systems incorporated in the cars and trucks to alert us about various factors like exceeding speed limit or smoke alarms. This features are designed to aware the passengers & driver of the vehicle about crossing the limitations which is important in most of the time & in most cases. This project's main motto is to provide more efficiency in car security system in low cost.

2. PROBLEM ANALYSIS & TECHNOLOGY SELECTION

Vehicle accidents are very common problem in our daily life. An estimated 1.2 million people lose their lives in road traffic crashes every year, and another 20 to 50 million are injured [6]. This problem of road traffic crashes and resulting injuries and fatalities is however more acute in a developing country like Bangladesh. Each year as reported to police, more than 3,300 individuals lose their lives in road traffic accidents in Bangladesh and many more sustain disabling injuries. Almost 2% of Gross Domestic Product (GDP) is lost in road traffic accidents in our country which itself demonstrates the severity both in terms of deaths and injuries as well as in monetary terms [4]. With the number of vehicles rapidly rising in developing countries, this epidemic is quickly worsening in low and middle-income countries and is on its way to becoming the third leading cause of death and disabilities by the year 2020 (WHO 2000)[6]. According to the official statistics, there were at least 48,631 fatalities and 25,437 injuries in 29319 reported accidents during eight years study period (2005-2012) in Bangladesh. But it is estimated that the actual fatalities could be 10,000-12,000 each year [4]. Lack of concern & lack of skill are two major causes for these terrible accidents. If the safety measures are opened to the passengers rather than the driver only, the concern about the car safety increases which will prevent a major number of accidents. For our economical conditions this safety arrangement should be as economical as possible.

This projects main objective is to design & implement a system that will notify the drivers & passengers about the up-coming dangers. To achieve this goal, three parameters are taken which will be continuously checked while driving a vehicle. These parameters are distance

between in front obstacle, engine and cabinet temperature & presence of any LPG (Liquid Petroleum Gas) & toxic gases in the cabinet.

3. METHOLODGY & SYSTEM DESCRIPTION

For obstacle detection & distance measurement, it is possible to use an ultrasonic sensor, using a temperature sensor LM35 it is possible to measure temperature, for detecting any presence of LPG & CO (Carbon-mono-oxide) it is possible to use a MQ5 gas sensor which can also be used in smoke detection. A microcontroller can be used for signal processing, a 16×2 LCD (Liquid crystal display) is used to display the selected data as temperature, distance & presence of any kind of toxic and combustible gases. An alarm system is designed to alert driver & passengers if any parameter exceeds a certain level. The control mechanism of our proposed system consists of three main blocks as shown in Figure 1.

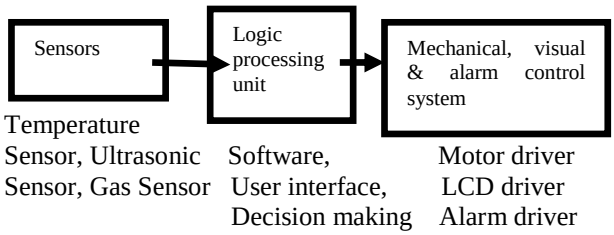


Figure 1: Basic Block Diagram.

3.1 HARDWARE SECTION

In our proposed system, an obstacle sensor i.e. the Ultrasonic Electronic Eye Telemeter Module in front of the car, such that the distance between the obstacles in front of vehicle is normally of 3 meter [6] is sensed by the ultrasonic module and instructs the microcontroller about the obstacles ahead. The microcontroller then alerts the driver with an alarm and controls the vehicle by stopping it. In the same way a gas sensor is mounted inside the vehicle such that it senses the presence of the gases inside the vehicle cabin and informs the microcontroller if there is any increase in the level of the toxic gases. The microcontroller then alerts the passengers and the driver inside the vehicle with an alarm and also sends a SMS (Short Messaging System) to the authorised user through GSM (Global System for Mobile Communication). The block diagram of the proposed system is shown in the figure 2. The proposed system is developed using PIC16F877A microcontroller. The GSM module is connected with the microcontroller through RS232 and the alarm is interfaced with the microcontroller to raise an alarm during the critical situations.

3.1.1 OBSTACLE SENSING MODULE

The obstacle sensing module is used to sense the static obstacles in front of the vehicle such that, accidents due to unwanted parking of the vehicles and collisions with trees and other objects especially during the night time could be avoided. Here in this project we use TS601 model ultrasonic electric telemeter module manufactured by Audiowell Electronics Co. Ltd. The output of TS601 is transformed data into pulse

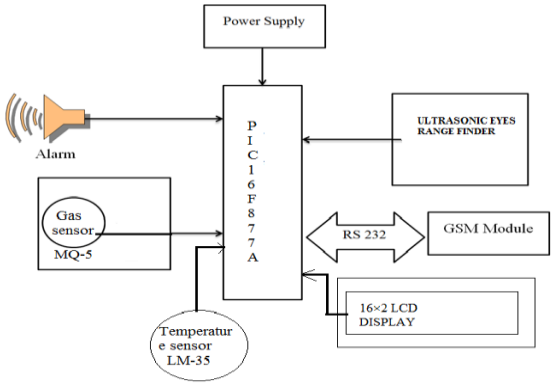


Figure 2: Block Diagram for Hardware section.

width. This width should be measure to determine the distance. The working principle of the obstacle sensor is given below.

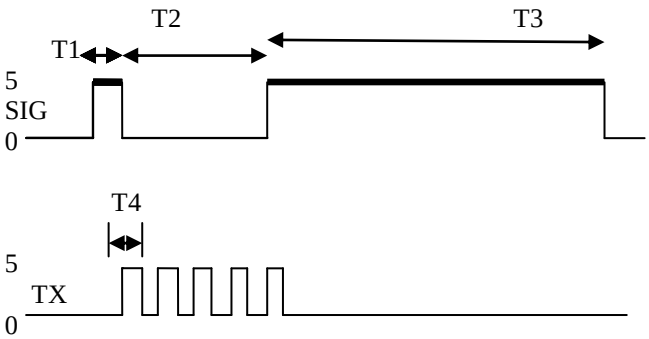
TS601 has three pins. One is +5v supply, one is for ground & last one is for signalling known as SIG. The host offers the TS601 module with an impulse through SIG, the trailing edge springs, and transmits a string of ultrasonic signal of 40 KHz when the module receives it. Then the electrical level of SIG stitch will be raised. The duration of high level T3 will be ensured by the distance between the object and the telemeter [10]. After 19.5ms, the high level descends, when no object is in a distance of 3M. The host computes the distance though the impulse width input by the electronic eye module.

$S = (V*T3)/2$ …… (1)

Computing T3 one can easily determine the in front obstacle distance in meter from Eq. (1).

V is velocity of sound at air. Characteristics of TS601 are-

- ❖ High sensitivity
- ❖ Narrow fade zone
- ❖ Quick response



T1 (Trigger) : >5µs
T2 (Postpone): 200µs
T3 (Pulse width): 0-19.5ms
T4 (Cycle): 25µs

Figure 3: Input & output Waveform for TS601 module

3.1.2 GAS SENSING MODULE

The gas sensing module is used to sense the presence of toxic gases such as CO, LPG, alcohol and other toxic gases inside the vehicles. If critical levels of gases were found, that is if the CO exceeds 20 ppm and the level of LPG exceeds 10,000ppm and the presence of alcohol is detected then the data from the gas sensing module is sent to the microcontroller which displays the information about the gas leakage inside the vehicle and produces an alarm to alert the persons inside the vehicle [2]. A MQ-5 gas sensor is used in this system to detect the presence of a dangerous LPG leak in our home or in a service station, storage tank environment and even in vehicle. This unit can be easily incorporated into an alarm unit, to sound an alarm or provide a visual indication of the LPG concentration. When the target combustible gas exist, the sensor's conductivity is higher along with the gas concentration rising. A simple electronic circuit is used to convert the change in conductivity to its corresponding output signal in this case in voltage. The features of this sensor are

* High sensitivity to LPG, natural gas, town gas
* Small sensitivity to alcohol, smoke.
* Fast response.
* Stable and long life
* Simple drive circuit.

3.1.3 TEMPERATURE SENSING MODULE

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (or Centigrade) temperature [8]. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. In our project, we mounted two LM35, one with engine & one with cabin ceiling. The output of LM35 is in form of voltage which increases as the temperature increases. This voltage signal is fed to an 8 bit microcontroller in this case a PIC16F877A which will do the analog to digital conversion (ADC) & transfer this voltage to corresponding temperature in Celsius scale. This temperature is then shown in LCD.

3.1.3 MICROCONTROLLER

The microcontroller is the brain of any embedded system. The PIC16F877A is the microcontroller used here which is a low-power, high-performance CMOS 8-bit microcontroller. The PIC16F877A is a powerful microcontroller which provides a highly flexible and cost-effective solution to many embedded control applications. The PIC16F877A has the following features which are essential for this project.

- Up to 8K x 14 words of Flash Program Memory,
- Up to 368 x 8 bytes of Data Memory (RAM),
- Up to 256 x 8 bytes of EEPROM Data Memory
- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D) [7].

The microcontroller is always in the active mode, if the gas sensor senses a gas and founds a critical situation then the information is sent to the microcontroller. The microcontroller first provokes an alarm to alert the passengers inside the vehicle and also an alert message to the authorised user is sent in the form of SMS through GSM. The microcontroller uses 'AT+CMGS' command to send the SMS where the GSM is connected to the microcontroller through RS232 communication protocol [3].

3.1.4 GSM MODULE

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. A GSM modem exposes an interface that allows applications such as SMS to send and receive messages over the modem interface. The mobile operator charges for this message sending and receiving as if it was performed directly on a mobile phone. To perform these tasks, a GSM modem must support an "extended AT command set" for sending/receiving SMS messages, as defined in the ETSI GSM 07.05 and 3GPP TS 27.005 specifications [3]. Due to some compatibility issues that can exist with mobile phones, using a dedicated GSM modem is usually preferable to a GSM mobile phone. It should also be noted that not all phones support the modem interface for sending and receiving SMS messages. The interfacing between the GSM and the Microcontroller and the developed module is shown in the figure. 4 and figure.5.

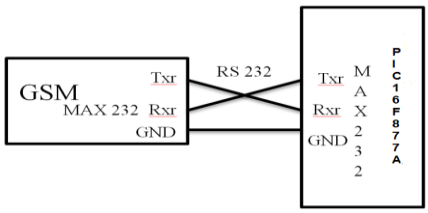


Figure 4: Interfacing GSM with

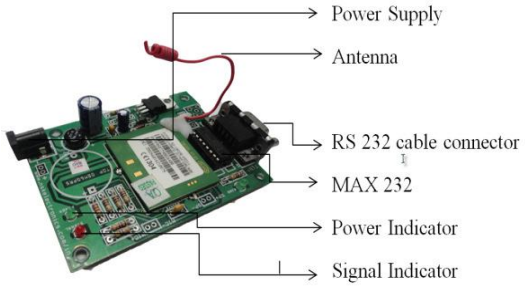


Figure 5**:** The developed GSM module

3.2 SOFTWARE DESCRIPTION

3.2.1 EMBEDDED C

An embedded system is the one which is designed to perform a specific task and the embedded software rules

the entire system. Use of C in embedded systems is driven by following advantages [6].

• It is small and reasonably simpler to learn, understand, program and debug.

• C Compilers are available for almost all embedded devices in use today, and there is a large pool of experienced C programmers.

•Unlike assembly, C has advantage of processor-independence and is not specific to any particular microprocessor/ microcontroller or any system. This makes it convenient for a user to develop programs that can run on most of the systems.

• As C combines functionality of assembly language and features of high level languages, C is treated as a 'middle-level computer language' or 'high level assembly language'.

• It is fairly efficient.

• It supports access to I/O and provides ease of management of large embedded projects

Many of these advantages are offered by other languages also, but what sets C apart from others like Pascal, FORTRAN etc. is the fact that it is a middle level language; it provides direct hardware control without sacrificing benefits of high level languages. Compared to other high level languages, C offers more flexibility because C is relatively small, structured language; it supports low-level bit-wise data manipulation. Compared to assembly language, C Code written is more reliable and scalable, more portable between different platforms (with some changes). Moreover, programs developed in C are much easier to understand, maintain and debug. Benefits of assembly language programming over C are negligible when we compare about the ease with which C programs are developed by programmers.

3.2.2 mikroC PRO FOR PIC

After developing the software, it must be downloaded to the microcontroller through any on of the downloading tools such as universal programmer. Hence the program should be converted to HEX code before downloading it into the microcontroller. The microC Pro for PIC compiler comes into act at this place. The mikroC PRO for PIC is a powerful, feature-rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control [9].

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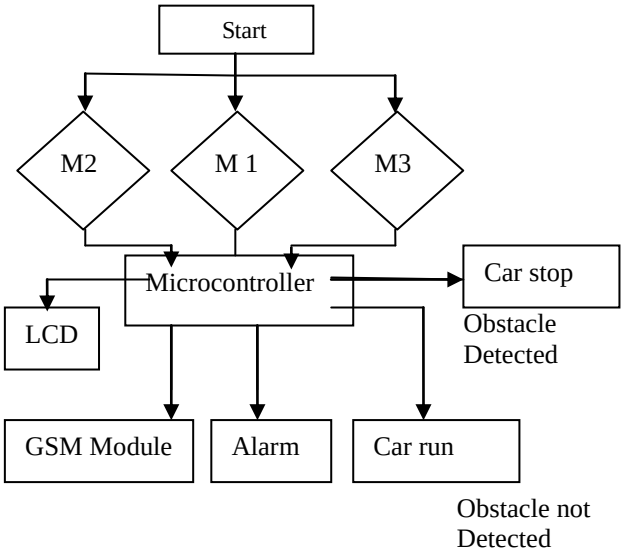
4. DESIGN IMPLEMENTATION

An embedded controller is implemented by using three set of modules, i.e. the obstacle sensing module, the gas detection module & GSM module. The obstacle detection module is mounted in front of the vehicle such that it searches for the static obstacles. The ultrasonic transmitter transmits the sound continuously to the maximum level of 3 meters. When the sound is reflected back by an object, then that is received by the ultrasonic receiver, thus the module senses the obstacle. It then sends the corresponding signals to the microcontroller which in turn provokes an alarm by the microcontroller as the first measure and stops the vehicle. The data flow diagram of the obstacle sensing module is shown in the figure 5. In the same way, the gas detection module which is placed inside the vehicle continuously senses the presence of gas in the vehicle cabin. When excess levels of toxic gases such as CO greater than 20 ppm, LPG (Liquid Petroleum Gas) higher than 10,000 ppm and the presence of alcohol are found or any smoke presents in the cabinet, then the corresponding signals are sent to the microcontroller which in turn provokes an alarm to alert the passengers in the vehicle. And in turn commands the GSM module to send an SMS to the authorised user about the alarming situation inside the vehicle using the 'AT+CMGS' command. The flow diagram of the gas sensing module is shown in figure 5.The GSM module is connected to the microcontroller by the means of RS232 cable as the communication between the GSM and the microcontroller is synchronised through the MAX232.

LM35, temperature sensors is mounted on the car cabin & on the engine and convert temperature to corresponding voltage level which is fed to the microcontroller to monitor of the engine & cabinet temperature. The system architecture is shown in fig.6.



M1=Obstacle Sensing Module
M2=Gas sensing Module
M3=Temperature sensor

Figure 6: System Architecture.

5. CONCLUSION

Traffic accidents keep with a yearly increasing of a high rate. This paper deals with an embedded system that senses the toxic gases inside the vehicle and alerts the person inside the vehicle, the system also sends an alert message to the authorised user through GSM such that remedy measures could be easily taken for the passengers inside a vehicle. The developed system can also sense the obstacles in front of the vehicle. As a

consequence, the accidents due to static obstacles could be avoided. The proposed system has been developed in a special motive that should protect not only the passengers inside the vehicle but also the persons around it and to prevent collision of vehicles with any other vehicle or obstacles e.g. trees. The developed system is especially helpful to avoid accidents in night-time. This system could be further enhanced with future technologies to provide more safety and security to the vehicle systems. Thus, we propose an intelligent car system for accident prevention and making the world a much better and safe place to live.

6. REFERENCES

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7. NOMENCLATURE

Symbol	Meaning	Unit
T	Time	(Second)
V	Sound velocity	(meter per sec)
S	Distance	(Meter)