Automated Power Window Opening on Carbon Monoxide Detection

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ABSTRACT:

This paper presents an embedded system for car cabin safety. A number of sudden deaths happened due to inhaling of carbon monoxide (CO) gas inside car cabin in the past years. The designed embedded system keeps on sensing the accumulated CO gas inside the car cabin. If the value of CO exceeds the predefined threshold value and the motion sensor installed in embedded system detects the presence of any occupant inside the car cabin, a warning text message gets displayed on LCD installed in car cabin and buzzer alarm is generated. The warning text message is sent by GSM kit to occupant cell phone. After receiving response from occupant, DTMF kit generates a preset sequence number and sends a signal to the microcontroller. On receiving this signal, control unit immediately sends signals to power window control circuit of the car to open the power windows to let fresh air come in the car and as the amount of CO reaches below predefined threshold value, power windows of car are rolled up again automatically.

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1. Introduction

Cars are found everywhere and anywhere. Every car has an air conditioning system embedded in it and the exhaust engine of almost every car or vehicle produces Carbon monoxide (CO) gas which may enter into car cabin through AC vents. Exhaust engine discharges CO fumes which are sucked by air conditioner [1]. Car air conditioner gathers the CO gas when engine is idle [2]. CO is a gas that can build up to dangerous concentrations indoors when fuel-burning devices are not properly vented, operated, or maintained. In high concentrations, it may even kill a human being within a few minutes [3]. CO is a colourless, odourless and tasteless gas and potentially lethal. Many of people in each year die due to CO gas because they are not aware that they breathe in poison. CO is invisible and smell less gas [4]. CO at different concentration levels has harmful effect on human body. At low concentration, CO causes fatigue in healthy people and chest pain in people with heart disease where as at moderate concentrations, angina, impaired vision and reduced brain function. At higher concentrations, CO causes impaired vision and co-ordination, headaches, fatal, dizziness, confusion, nausea and also causes flu like symptoms [5].

In the proposed and implemented work, an embedded system is designed and used inside the car cabin such that the carbon monoxide (CO) sensor can sense the high concentration of CO gas and protect occupant's life. The embedded system is developed by using arduino mega micro controller board, gas and motion sensors, GSM (Global System for Mobile Communications) kit, DTMF (Dual Tone Multi Frequency) module and power window control circuit. As the level of CO gas inside the car cabin gets increased above predefined threshold value as sensed by gas sensor, the motion sensor starts detecting the presence of any occupant inside the vehicle. An alarm is generated when CO exceeds the threshold level and a warning text message gets displayed on LCD display embedded on the dashboard of car for the occupants present in the car. GSM kit module sends a warning text message to occupant's cell phone also. Occupant makes a call to DTMF circuit which on receiving the mobile tone, generates a binary sequence number and sends control signals to the control unit of the embedded system. In turn, the control unit sends its control signals to the power window control circuit of the car for providing immediate ventilation.

2. Hardware description

Arduino mega is microcontroller board based on AT mega 2560. Arduino mega having 54 input output pins. The arduino board is inexpensive as compared to other microcontroller. Mega is extensible board. The mega board is compatible with shields designed for arduino diecimila. Arduino mega can easily powered by USB connection or external power supply and power source is selected automatically. Arduino mega provides 256KB of flash memory for storing code. The main idea of using arduino mega is that it is programmed with arduino

software. Basically arduino mega contains everything needed to support the micro controller and can also easily connect to computer with USB cable. CO is colourless, odourless and tasteless gas. It is also known as invisible gas or acute poisoning gas [6]. CO is undetectable gas. Its presence cannot be detected without sensor. A gas sensor is used to sense the increased level of CO inside the car cabin.

Ultrasonic HC-SR04 sensor is used to detect the presence of any occupant inside the car cabin. It is compatible with arduino. Its module contains transmitter, receiver and control circuit. The transmitter end of ultrasonic sensor generates high frequency sound waves and evaluates the echo which is received by receiver end. Sensor calculates the time interval between sending and receiving the echo and determines the distance to an object. An alarm system is designed to detect the danger inside car cabin. As the level of CO gets increased above threshold value, an alarm is generated immediately [7]. Alarm in embedded system is used to alert the occupant against the increased CO level in the car. The alarm generates beep like audio sound to alert the occupant. The alarm is continuously generated until the value of CO goes below threshold value. It provides safety and security to the occupant and is an important component of embedded system. LCD is liquid crystal display. It is a 16 pins electronic device and used in wide range of applications. A 16*2 LCD display is an electronic device and is used to display text message. There are two lines and it displays 16 characters per line. Command and data are the two registers used by LCD display. LCD of embedded system is used to generate a warning message as level of CO increases. LCD screen is used to display the warning message when value of CO exceeds threshold value.

GSM is basically global system for mobile communication. It is a circuit switch network which can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. GSM module can provide RS232 port to communicate and develop an embedded application. GSM module is a kind of mobile Terminal Equipment (TE), and also needs the SIM card like the mobile phone, which can control the calling service, short messages and telephone book, the data business, the complementary business, and faxing and so on via RS232 to send AT commands [8]. Applications like sending and receiving of SMS, data transfer, remote control and logging also develop. GSM has low-cost implementation of the short message service (SMS), also called text messaging, which has since been supported on other mobile phone standards as well [9]. GSM kit module can be easily connected with PC serial port or microcontroller. Also provide standard AT command interface to users; provide fast, reliable and safe transmission of data, voice, short message and fax [10]. It can also make and receive voice call. It can also be used as GPRS mode by connect to internet and perform many applications for data logging and control. GSM is directly integrated with RS232 applications [11]. GSM kit of embedded system sends short service message by using AT commands to occupant's cell phone about the exceeded value of poisonous gas inside car [12]. Micro controller and GSM kit communicate

with each other. AT command for message sending is received by RX pin (Receiving Pin) and then information is sent by TX (Transferring Pin) pin. TX pin is responsible for message sending. When value of CO exceeds threshold value, a warning message gets displayed on LCD screen as shown in Fig. 1. Table 1 shows all the AT commands along with the functions performed by them.
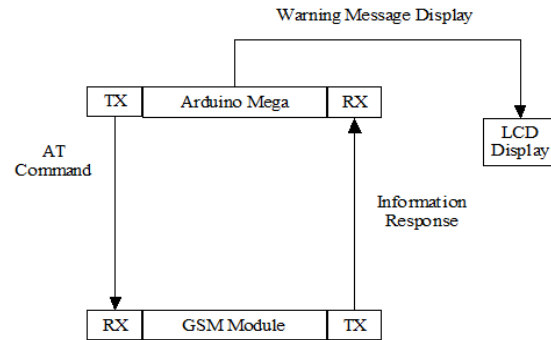

Fig. 1: Arduino mega microcontroller & GSM module

Table 1: AT Commands and their functions

AT commands	Command function
AT+CSMS	Select short message services
AT+CMCF	Set short message encoding mode (1 for text and 0 for PDU mode)
AT+CMGS	Send short message
AT+CMGR	Read SMS message
AT+CSMS	Select message service

Power window control circuit provides the window opening functionality for ventilation [13]. As the windows start moving in downward direction, the fresh air enters inside the car cabin. The main idea for using power window control circuit in embedded system is to provide immediate ventilation to the car occupant. Gear DC motor is an extension of DC motor. It has gear assembly attached to motor which helps in increasing the torque and reducing the speed. Motor speed is calculated in term of rotations of shaft per minute or in RPM. Gear DC motor can be throttled by adjusting its supply voltage. Gear DC motor is very simple to use. It has various characteristics such as form factors, strength and linear performance [14]. A relay is an electrically operated switch. Relays in embedded system are used to provide 12 Ampere current to gear DC motor. Basically relay is used to control the high voltage. Internally relay contains a coil. Relay provides isolation between the controller and the gear DC motor. In relay, as the coil rotates, the current is generated. Relay in embedded system receives signals from microcontroller and hence relay is required to bridge the gap. Relay is extremely useful and needed to control a large amount of current or voltage with small electrical signal.

Window switch is the major part of power window [15]. By the use of this switch, the two operations of opening the window and closing the window are possible. It makes windows safer and convenient for occupant's use. It provides direction to window glasses by moving them upward and downward. DTMF is dual tone multi frequency circuit. DTMF circuit in embedded system detects the mobile tone which is generated by

occupant and generates binary sequence corresponding to 6th number key pressed in mobile. It works on 5 Voltage. Therefore DTMF circuit in embedded system is used to detect the occupant response on SMS sending by GSM kit. In Table 2, the binary sequence generated for each key pressed on a mobile is shown.

Table 2: DTMF frequency tone and decoded binary number

Key press on cell phone	Generate binary sequence			
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	1	0	1	0
*	1	0	1	1
#	1	1	0	0

3. Software description

Arduino IDE is an open source environment and makes it easy to write and upload a code into arduino mega 2560 board. It provides convince by running on windows, Mac OX S and Linux. Arduino development environment has many attributes like text editor for writing code, message area, text console, toolbar with buttons for common functions and a series of menus. IDE is written on Java language and based on processing, avr-gcc and other open sources. The source code for the Java environment is released under the GPL and the C/C++ microcontroller libraries are under the LGPL. Arduino is used to develop the interactive objects. Generally it takes input from a variety of sensors, switches and controlling variety of lights, motors and other actuators [16]. Arduino software also includes serial monitor which allows text to be sent to and from the board. The RX, TX and LED on the board will flash when the data is being transmitted. Arduino provides an environment through which Arduino hardware and software can communicate with each other [17]. Arduino mega 2560 can be allowed to reset by software running on a connected computer. The embedded code (see Fig. 2) is developed in a very short period of time because IDE contains inbuilt libraries.
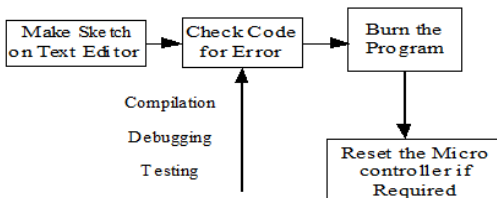
Fig. 2: Embedded code development

4. Implementation and results

Fig. 3 shows the flowchart for the developed automated window opening for CO detection. The complete embedded system architecture is shown in Fig. 4. CO sensor and ultra violet motion sensor of embedded system always keep sensing inside the car cabin. As the

level of CO gets increased from its threshold value (normal exceeded level of CO is 35ppm), motion sensor detects the presence of any occupant inside car, a warning message is displayed on LCD display and alarm circuit generates a warning alarm. GSM kit module sends a warning message to occupant's mobile number by using AT commands. Occupant makes a call on embedded SIM card number for opening the window of car and the reply from occupant is received in DTMF circuit. DTMF circuit generates a binary sequence based upon the key pressed by occupant on the mobile phone as shown in Figs. 5 and 6. In Fig. 5, DTMF generates 0110 sequence number against the 6th key pressed by occupant on his cell phone. Arduino mega receives control signals from DTMF circuit. The DTMF circuit is shown in Figs. 6 and 7. Now controller sends these control signals to ULN IC and as a result, the coil of relay gets triggered and starts rotating. Relay is responsible for providing 12 volts power supply to gear DC motor. At last, the power window gets switched on and window is free to move in downward direction as shown in Figs. 8 and 9.
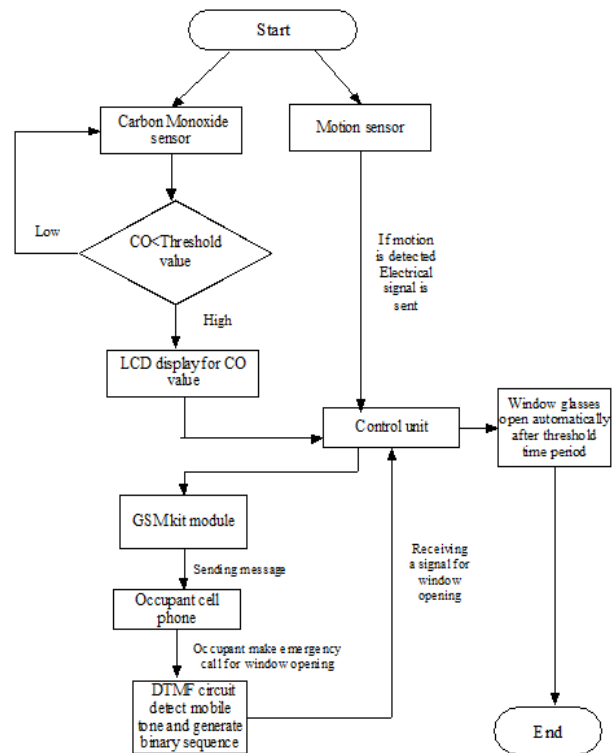
Fig. 3: Automated window opening on CO detection

Fig. 4: Embedded system architecture

Fig. 5: Occupant cell phone making call (Left); Occupant press preset number (Right)
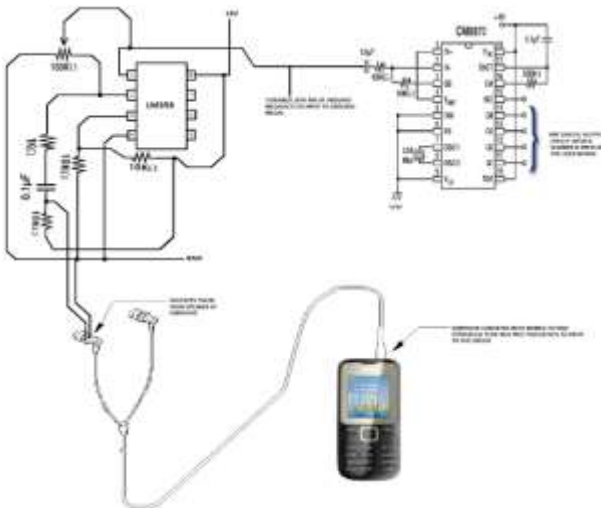

Fig. 6: DTMF circuit
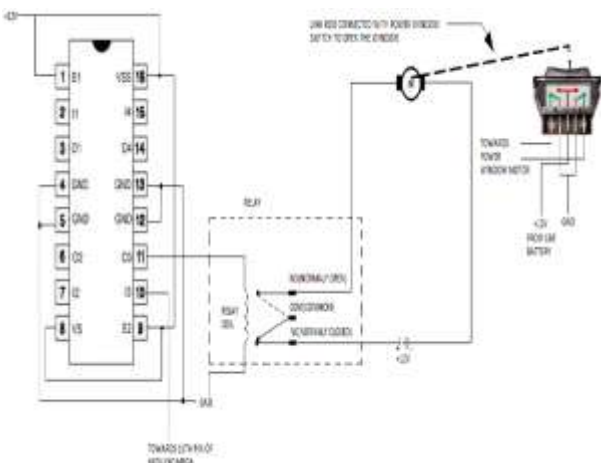

Fig. 7: DTMF circuit for response of the message

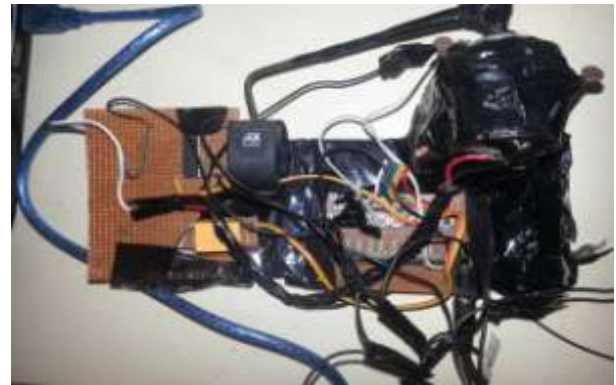**Fig. 8: Circuit diagram of power window control system**

Fig. 9: Power window control circuit

5. Conclusion

An embedded system has been designed and tested for vehicle cabin to detect the presence of harmful toxic gas (CO) using Arduino mega 2560 microcontroller. The CO gas is less sensible and invisible to human eyes which are a big threat to car occupant's life. This gas is colourless, odourless and tasteless, so the occupant inside the car cabin doesn't even realize its presence. This situation may result in sudden death of occupant inside the car. The main idea of this system is to create a simple and easy embedded system that has high sensitivity towards CO gas accumulated inside the car cabin. So that as the level of CO goes beyond the threshold value, the designed and implemented embedded system displays the value of CO gas on LCD display and provides immediate ventilation by opening the power windows of car automatically. Thus the main intention of designed embedded system is to avoid the worst and critical situation inside the car cabin.

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