Development Of Microcontroller Based Vehicle Alcohol Detection System

Aluko O. A.,   Ibiyomi M. A.,   Oyebiyi A.J.,

Department of Computer Engineering, The Federal Polytechnic, Ile-Oluji, Ondo State

abbeylinka41@gmail.com

Abstract

The vehicle accidents on most of high ways in Nigeria which had caused a lot people to lost their life and many sustained injuries that made them to become handicapped has become worrisome over the years. In the recent times, roadworthy report presented early in 2021 by Federal Road Safety Corp' data and information unit recorded that 80% of the fatal accidents which claimed life resulted from drunk driving. This problem necessitated the technical attention to alleviate this severity to bare minimum. The project presents the development of a vehicle alcohol detection system using ATmega328P Microcontroller. The section include; input section, control section and the output section, the input section consist of MQ-3 alcohol sensor which continuously monitor the Blood Alcohol Content (BAC) to detect the existence of alcohol in the exhalation of a driver. The control unit consist of ATmega328P microcontroller that interfacing and control the input response from MQ3 sensor and relay output through the LCD. A DC motor of the vehicle was actively working and alerted the green indicator showing that the system is working perfectly and there was no alcohol detected from the user. Upon detection of alcohol content from the driver, the red indicator switches on automatically along with the buzzer sound a warning alarm for 60 seconds delay and display 'drunk text' on the display unit to allow the driver to park before the ignition of vehicle is automatically switched off. The system was tested for continuity test and evaluated for sensitivity, specificity and the accuracy. This system will reduce accident and loss of life caused by drunk driving on our roads.

 Keywords: BAC: Blood Alcohol Content, LCD: Liquid Crystal Display, DC: Direct Current

1.   Introduction

Vehicle transportation is the most patronized means of transportation in commuting people and products from one location to another. It is therefore expected to witness more road carnages than any other means of transportation such as rail, sea and air transport, Deepa et al., (2015) Drink driving is one of the major causes of road accidents all over the world, Raiana et al.,(2019). According to the Bureau of Transportation statistics, every 2 hours, three people are killed in alcohol related highway crash. A major method for testing level of alcohol is the Blood Alcohol Content (BAC) test using breath analyzers at check points. Minonu et al., (2010) and Toshiyuki et al., (2011) A 0.05% blood alcohol is enough to impair the sense of judgment when driving but mg/L was introduced in the design, .Nirosha et al., (2012) and Pratissha et al., (2015) This method lacks credibility due to unavailability of required manpower, compromise on the part of inspection officers and the cost of maintaining check points over a wide geographical location. Even with this great technology, people still bypass some check points by passing other roads that lead to their destination. For more secured and effective method to couple or reduce car accident based on the influence of drunk driving, that is the main reason why Alcohol detection system is invented, Mohammed et al (2018). This device can detect the amount of alcohol or sense the intake of alcohol through the help of the sensor (MQ-3 alcohol sensor) by senses the surrounding environment. This sensed information is fed to an ATmega328 Microcontroller that processes the sensed data by comparison with a preset threshold value. If alcohol is detected, the microcontroller takes effect on the buzzer and red LED. The red LED and buzzer will be triggered, the system will be delayed for 60 seconds delay time for the driver to park and if the driver fails to park for that interval, the vehicle will be turn off and will not move further.

1.1   Statement of the problem

The high rate of road accident in most of our high-ways in Nigeria resulting from drunk-driving which has claimed many lives and many sustained high injuries which has made them to be handicap in fact, Traffic survey shows that driver fatigue may be a contributory factor in up to 20% and due to alcohol drinking it is about 50% of all road accidents. Radha and Patel (2019). Also, data and information unit of Federal Road Safety Corps reported that more than 80% fatal accidents caused by this outrageous manner of drunk-driving from vehicle users which has become worrisome and issue of concerned which need an urgent of technological wise to reduce this problem to bare minimum.

2.   Literature Review

Rajana et al. (2019). Developed a system to detect the alcohol content level of a driver titled "vehicle engine lock system for theft and alcohol detection" its uses MQ3 sensors embedded in the steering the vehicle to content of alcohol taken by drivers. This proposed explores the possibility at very first using technology. It's also use to track the theft of vehicle if there is using fingerprint recognition technique. It's involved certain inherit error.

Rajesh et al. (2014) and Sudharsana et al. (2014). Came up with a Design which was titled, Drunk-Driver Detection and Alert System (DDDAS) for Smart Vehicles. Their design is Based upon the recent smart gas sensing and integration of satellite and cellular wireless communication technologies, their device has the ability to quickly sense the drunken state of the driver during start-up/driving by estimating the equivalent breath alcohol concentration level corresponding to the legally permissible state's threshold blood alcohol concentration level. On detection of such situation, on-vehicle siren/audio alarm is activated to warn the persons on road and vehicle control system is triggered to lock ignition or stop the fuel inflow to the vehicle. Additionally, 'alert SMS' indicating drunk driver location, tracked by onboard GPS receiver, along with vehicle number is communicated remotely to authorized (family members, traffic police) mobile user using GSM cellular network to take appropriate action. The system is very effective and response time is very high. And the limitation to the design was that it uses GSM module which is network dependence.

Absar et al. (2018) and Mohamad, (2013) also designed drunken driver detection and system with automated braking system. Its uses eye blink detector to detect and the system will generate warning signal to alert the driver, GPS and GSM technology we track the exact location of the accidental vehicle. When the driver didn't response to the warning signal, an automated pneumatic brake system is used to stop the vehicle within a distance.

Keerthan et al. (2018).and Dada et al (2017) Construct an alcohol sensor which is integrated with the directing wheel, titled "Drunk Driving Detection using Car Ignition Locking" this framework is meant for making vehicle driving more secure than previously and shield the mishap from happening due to the liquor utilization of the driver. This work proposed the detection of alcohol utilizing alcohol sensor associated with arduino. Its uses arduino processor to check drunk driving and work a bolt on the vehicle with embedded system which mixes both programming and equipment which can play out some particular capacities. It has the ability to respond fast. Vaishnavi et al. (2014) Intelligent Alcohol Detection System for car using Microcontroller 16F877A and MQ-2 sensor, it has ignition system which will produce spark plugs, it acts as ignition starter over the vehicle's engine. It involved certain inherit errors.

3. Methodology

This chapter described the methodology used for the design of the hardware and software part, the main hardware part is the MQ-3 sensor and how it interfaces with the microcontroller, display unit, and the DC motor, the methodology consideration and specification of alcohol detection system and its functional components were recorded. The development stages and mode of operation of the software application, simulation develop for the hardware were also reported

3.1 System Design Steps

The design steps involve in the development of the system will be aimed to operate off a 9volt power system. The system is development of alcohol detection with at least one programmable integrated circuit in this case Atmega 328P microcontroller used which is programmed using Arduino programmer. The microcontroller is program to receive signal from MQ-3 sensor once it senses or detect the presence of the alcohol at above 2.9mg/L from the users of the vehicle, the alert unit will be activated by indicating red light emitting diode and as well activate the alarm unit to sound a warning for 60seconds time delay to allow the driver to pack the vehicle at a reasonable place before the ignition of the vehicle automatically off.

The system architecture consists of mechanical, electrical and electronics components which are integrated to complete the system design as listed below;

i.	ATmega 328P microcontroller	v.	MQ-3 sensor	ix.	Dc motor
ii.	LCD	vi.	LED	x.	Battery (9volt)
iii.	Crystal oscillator	vii.	Resistor (10kiloohms)	xi.	Capacitor(25pf)
iv.	Voltage regulator (LM7805)	viii.	Buzzer		

3.2 Hardware implementation of the design

Hardware of the system consist of ATmega328P, MQ-3 sensor, LED, LCD capacitor and other components with it design was carried out on the manufacture Veroboard, mainly surface components in system programmer. The sensor unit comprises of an integrated circuit module such as MQ-3 alcohol sensor which is place in from of the design. The integrated circuit is powered using 9-volt dc power source. A signal is sent to the microcontroller each time alcohol is detected from the user of the vehicle and necessary action are taken based on the program written on the microcontroller. The power source will be obtained from a 9-volt battery. The microcontroller and other digital integrated circuit used 5-voltage for their operation and source a voltage regulator will be used to regulate the 9-volt power supply to 5volt for the use by the circuit. The block diagram of the design is shown in Figure 3.1
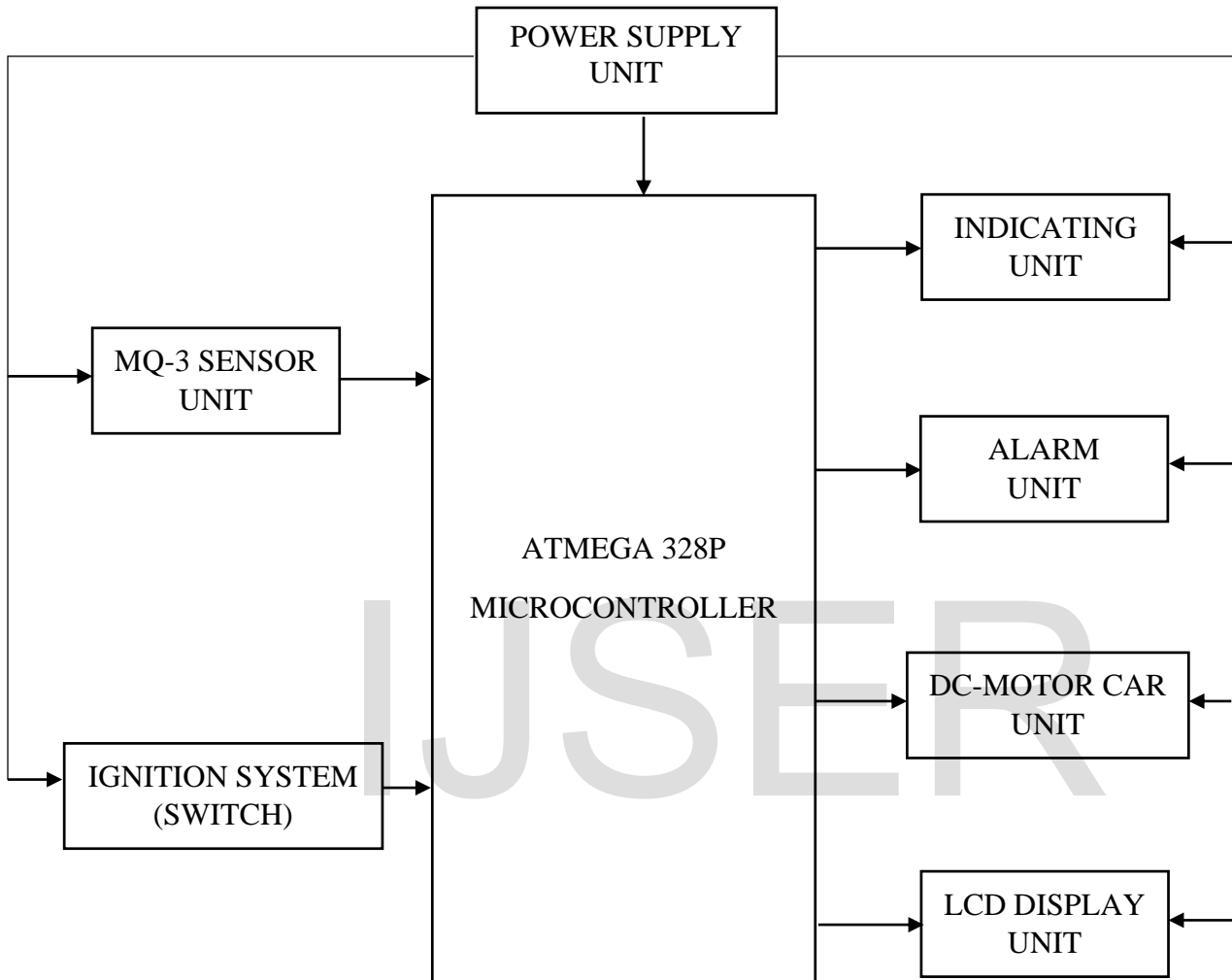
Figure 3.1: Block diagram of the Alcohol detection system.

Block diagram in Figure 3.1, shows how the following unit are integrated

i.	The tension unit / Power supply unit	iv.	Microcontroller unit
ii.	Display unit	v,	Indicating unit
iii.	Alarm unit	vi.	The ignition unit / Dc motor unit

3.2.1   Power supply unit

A stable source of voltage (between 2.0volts to 5volts) was used to drive the ATmega328P microcontroller as specified by the manufacturer. This was achieved through the use of an LM7805 voltage regulator which gives an output voltage of +5volts as

shown in Figure 3.2. This is made of rectifier diodes configured in a bridge arrangement as shown in fig below Figure 3.2. This is necessary because integrated circuit as well as ATmega328P microcontroller can only run on D.C voltage.

U1 (7805) LM78xx voltage regulator specifications from datasheet:

- o Input voltage range for 7805: V_{in} = 7.5v~20v
- o Output voltage range for 7805: V_{out}= 4.75v~5.25v

The 9v battery is enough to supply the minimum input voltage for the system. C_3 is transient capacitor and its rating as stipulated in the 78xx voltage regulator's datasheet as 0.1uf [reference]. These capacitors help for smoothening of the output from the voltage regulators.

Current limiting resistor calculation:

$$R_4 = \frac{V_{out} - V_D}{I_D} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (3.1)$$

$$V_{out} = \text{Output voltage of regulator}$$

$$V_D = \text{Voltage drop across diode}$$

$$I_D = \text{Forward current of LED}$$

Light emitting diode (LED) characteristics:

Forward current of LED = 10mA and voltage drop = 2v [reference]. Therefore

$$R_4 = \frac{5 - 2}{10 \text{ x } 10^{-3}}$$

$$R_4 = 300\Omega$$

Therefore, resistor value used is: 330Ω

The power supply section is very important for all electronic circuits. The system requires 5 volts dc. This voltage level will be obtained from the 9v battery. The 9v is stepped down by to deliver a secondary output of 5V, 1 A. The 9v battery output is rectified by a full-wave rectifier comprising diodes D1 through D2, filtered by capacitor C3 and C4 regulated by IC7805 (IC) Capacitor C3 bypasses the ripples present in the regulated supply. The power supply schematic is shown Figure3.2.
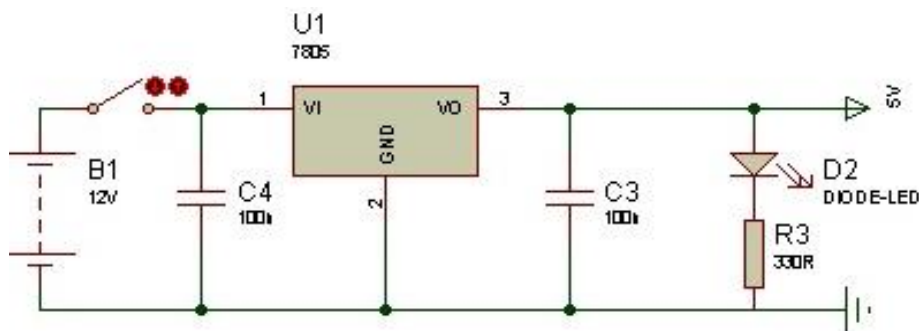

Figure 3.2: showing the interfacing Power Supply

3.2.2 ATmega328P Microcontroller unit

The Microcontroller unit as shown in Figure 3.3, can also be referred to the processing unit of the Alcohol detection system, because it interfaces with all the components or units that makes the Alcohol detection system unit function. The microcontroller has 14 pins in both side. ATmega328P microcontroller is developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. And each pin is assigned a specific task to carry out.
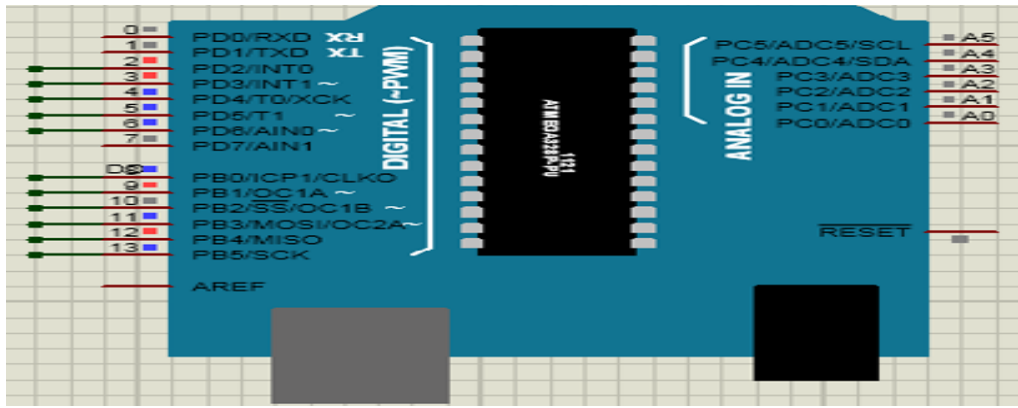
Figure 3.3: ATmega328P microcontroller unit of the alcohol detection system

3.2.3   Display unit

The display unit of the Alcohol detection system as shown in Figure 3.4, serves as part of the output unit of the design. 16x4 Character LCD Display was used for the display unit. 16x4 character-type liquid crystal display, is a kind of dot matrix module to show letters, numbers, and characters and so on. It's composed of 16row and 4colums dot matrix positions; each position can display one character. There's a dot pitch between two characters and a space between lines, thus separating characters and lines. 16x4 implies that its displays 4lines and 16characters. This LCD screen is equipped with an I2C adapter. The I2C is a type of serial bus, which uses two bidirectional lines, called SDA (Serial Data Line) and SCL (Serial Clock Line). Both must be connected via pulled-up resistors. The usage voltages are standard as 5V and 3.3V. The I2C adapter is already soldered onto the board, because of this, the wiring is quite easy. Only four pins are required to hook up. VCC, GND, SDA and SCL. The LCD display works with 5 Volts.
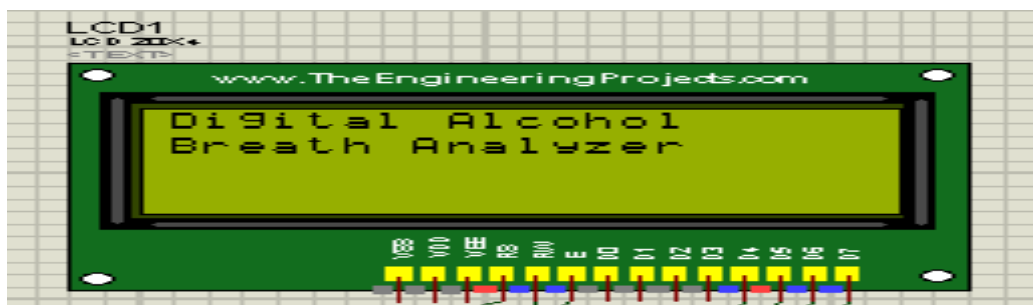
Figure 3.4: Display unit of the vehicle alcohol detection system.

3.2.4 Engine locking unit

The engine locking unit as shown in Figure 3.5, it was built by the concept of using a DC motor to demonstrate as the car engine. The DC motor operate based on preset conditions; once the alcohol level goes above 2.9 mg/L the engine motor continuous to move for 60seconds delay time for the driver to park, and if the if the driver fails to park for that interval, the engine motor will move causing the vehicle to move further. The DC motor is connected too pin-9 on the microcontroller and it operate from 1.5volt to 6volt.

3.2.5   Alcohol detection unit

The alcohol sensor unit as shown in Figure 3.6, has four pins; test pin, vcc, dout and ground. The test pin is used to accept logic signals of 0 or 1 by using logic state pin. Two LED was used for the design (Red and Green). This LED were used to show or indicate when the system is working properly and when alcohol is detected. The green LED on automatically immediately the system is powered on, indicating that the system is on and the vehicle is moving. The red LED turns on automatically when alcohol is detected to indicate that alcohol is detected. in the simulation, when the logic state is 1 the led goes on to indicate that alcohol is present and off indicate the condition of the presence.

Figure 3.5: Engine locking unit of the alcohol detection system
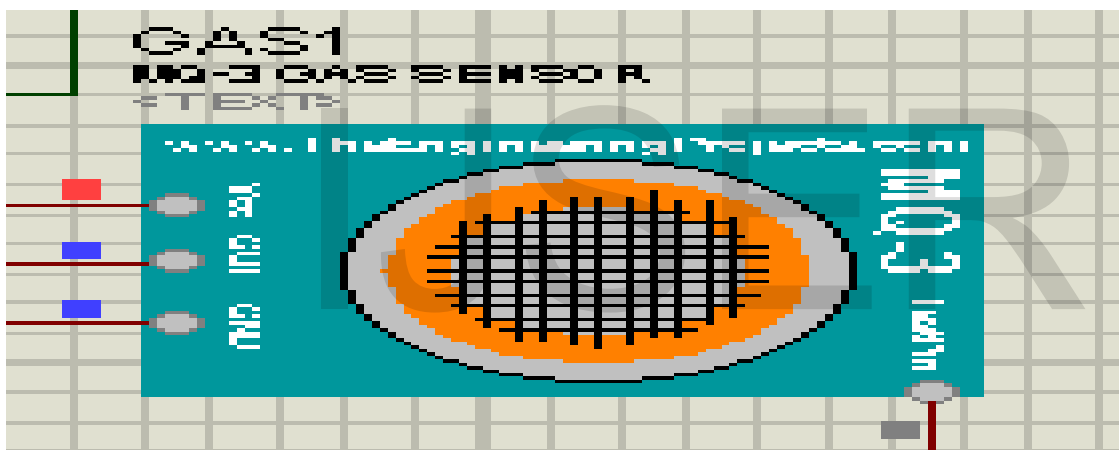
Figure 3.6: Alcohol detection unit of the alcohol detection system

3.2.6   Indicating unit

The Indicating unit as show in Figure 3.7, helped to indicate the condition of the system. Two LED were used for the design (Red and Green). This LED were used to show or indicate when the system is working properly and when alcohol is detected. The green LED on automatically immediately the system is powered on, indicating that the system is on and the vehicle is moving. The red LED turns on automatically when alcohol is detected to indicate that alcohol is detected. in the simulation, when the logic state is 1 the led goes on to indicate that alcohol is present and off indicate the condition of .
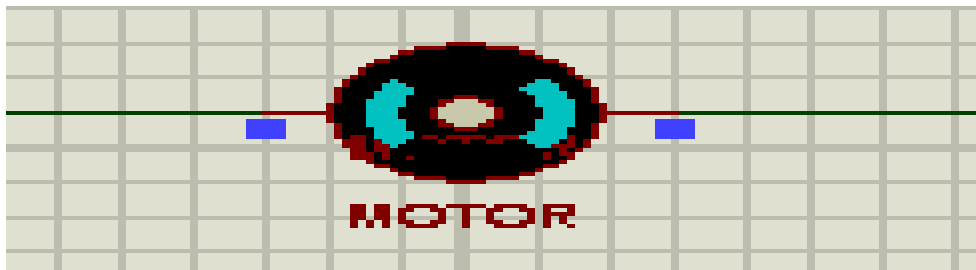
Figure 3.7: Indicating unit of the alcohol detection system

3.2.7   Alarm Unit
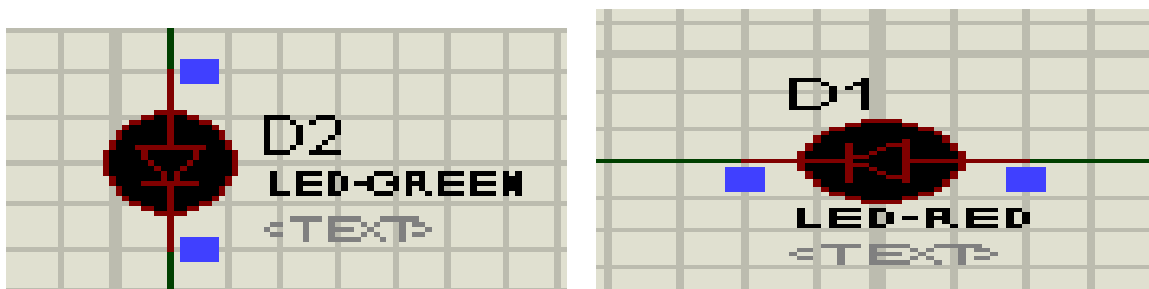
The alarm unit as shown in Figure 3.8, uses a buzzer which sounds and indicate that alcohol is detected. The buzzer used belongs to the PS series. The PS series are high-performance buzzers that employ Uni-morph piezoelectric elements and are designed for easy incorporation into various circuits. They have very low power consumption in comparison to electromagnetic units. It has a voltage requirement of 2V and is connected to pin 16 of the microcontroller. The purpose of the buzzer was to create awareness to passengers whenever alcohol is detected.
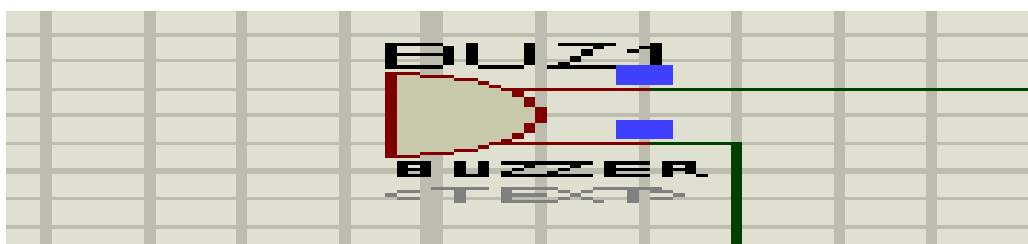
Figure 3.8: Alarming unit of the alcohol detection syst

3.2.8   Engine locking unit

The engine locking unit as shown in Figure 3.9, it was built by the concept of using a DC motor to demonstrate as the car engine. The DC motor operate based on preset conditions; once the alcohol level goes above 2.9 mg/L the engine motor continuous to move for 60seconds delay time for the driver to park, and if the if the driver fails to park for that interval, the engine motor will move causing the vehicle to move further. The DC motor is connected too pin-16 on the microcontroller and it operate from 1.5volt to 6volt.
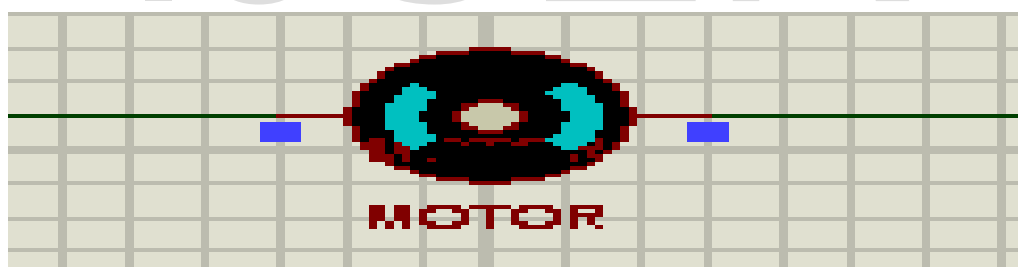
Figure 3.10: Ignition unit of the alcohol detection system

3.3   Design Analysis

The circuit diagram as shown in Figure 3.11, was designed using Proteus professional, version 7.9 software installed on PC which is running on a windows 10 Operating system. The Proteus circuit diagram design and the diagrammatical representation are shown in Fig. 3.10, The Vehicle alcohol detection system is powered on using 9volt DC battery, the 9volt DC battery is further stepdown to 5volt required by the microcontroller, sensor, display and indicating unit. The ATmega328P microcontroller has already been designed to operate without the use of transformer. While other components like DC motor require 1.5V and the LEDs need 2V.

The Arduino board is designed locally in such a way that the microcontroller is able to interact with all the units present in the design of the vehicle alcohol detector system. In designing the local Arduino board, Veroboard was used and the component listed in the system design were all used. Some pins configuration was change pins such as; SDA to 27, SCL to 28, RX to 3, AO to 23, 13 to 19, which is the LED connector, 9 to 15 which is the buzzer connector and 10 to 18 which is the motor connector, all the

component were connected and they were able to interact with each other. The connection start from the source which is the DC battery to the LM8075 voltage regulator which regulated the 9volt Dc battery to 5volt, and it was connected to pin 7 and 5 on the microcontroller were other component takes instruction for execution. A $10K\Omega$ resistor was used and connected to pin1 through pin 7 of microcontroller on port A. The two capacitors of each 22pF were connected to 12MHz crystal oscillator in parallel connection with the microcontroller on pin 9 through pin10 respectively. This was to synchronize the operation of the microcontroller and other electronics on the board. In the design, one busser was used which was connected to pin15 and other pins was grounded, the dc motor to pin pin16 and the LED pin was connected to pin19, after which they were also grounded. The physical implementation of the design was carried out on the manufactured breadboards using mainly surface mounted components. The component was then soldered into the respective component slots using a 30W soldering iron.

Figure 3.11: Complete Circuit diagram of the Alcohol detection system

3.3.1 Operation of Alcohol detection system using ATmega328P microprocessor

In the designed system, when the system is power on through the switch, signal will be send to the ATmega328P microcontroller immediately the LCD will display 'Digital Alcohol Analyzer' for few seconds before it started to analyze the Blood Alcohol Contents (BAC). The value for the Blood Alcohol Contents (BAC), usually fluctuate because of gas particle in air. During this period or interval, the green LED indicator will be on along with the dc motor and the LCD will display 'Normal' text. The green LED is used to indicate that the system is working properly and the is dc motor moving. The buzzer and the red LED will remain idle during this process, which implies that no alcohol is detected. Immediately the MQ-3 alcohol sensor senses the present of alcohol, and the concentration of the Blood Alcohol Contents (BAC) value is above 2.9 Mg/L, the sensor will send a signal to the ATmeha328P microcontroller and the Buzzer will be activated along with the RED light. At this point, the green LED will be on and the dc motor will still be moving at its normal speed but, The LCD will display 'Drunk' text. This process helps to notify the driver of the vehicle that alcohol has being detected and the process will last for 60seconds delay of time for the driver to park. And if the driver fails to park for this interval of time, the dc motor will automatically stop moving, green LED will be off and the buzzer will be deactivated to stop alarming. The red LED will remain on and the LCD will still display drunk.

3.4 Software Design approach

The software design for this project was implemented using a C compiler for ATmega microchip. This compiler consists of an optimized C compiler program as well as improved functions for many microcontroller operations. The flow chart on Figure 3.10: shows the implementation of the algorithm used in the programming of theATmega328P microcontroller. The program on starting initializes the microcontroller unit on boot up.

3.4.1   Loading of Code to ATmega328P Microcontroller

The code loading process of microcontroller is called dumping. The microcontrollers understand only the machine level language, which contains '0 or 1s'. There is need to load the Hex code into the microcontroller. There are various programmer software available in the market for loading the code to the microcontroller. Here, 'Arduino' programmer software was used to dump the code to the PIC microcontroller as shown in Figure 3.12. The programmer kit comes with the hardware kit along with the software. The ATmega328P microcontroller placed in the hardware kit, which comes with the socket. Here are the steps to load the code onto the microcontroller.

i.   Interface the hardware (programmer kit) to the computer through a serial cable.

ii.   Place the microcontroller in the socket of the hardware kit. Press the lock button to ensure the microcontroller is connected to the board.

iii.   Open the software installed in the computer. This shows the menu bar with file, functions, open, save and setting options.

iv.   Select the '**Open**' option from the drop-down menu and select the '**Load file**'.

v.   Click on the '**Load'** button so that the hex file is loaded into the microcontroller.

Figure 3.12: Code Dumping Device

4.   Results

The result of simulation ensures that the circuit worked properly. The practical implementation of simulated circuit has been presented in Figure 4.1. In this circuit diagram ATmega328P microcontrollers was the main components used for controlling other devices (MQ-3 sensor, LCD, LED, Buzzer, Dc motor). Among the controlling devices, MQ-3 sensor was used as a sensor for determining the present status of the system.

MQ-3 sensor was used as an input device for the designed system in order to sense the presence of alcohol from drivers breath, it sends signal to the ATmeha328P microcontroller if the alcohol contents sensed is above 2.9Mg/L. Immediately the signal is sent to the ATmega328P controller, the whole process automatically kick starts, the overall working of the system is controlled by the Switch. The LEDs (Green and Red), gives the feedback of the processes taking place inside the system. Delay time was set into the system in order allow the driver to park. The delay time is the important part of the designed system because, if the delay times was not introduced, the invention of the project will not have help the society and the present generation to reduce accident due to drunk driving. The connectivity is provided based on the ATmega328P Microcontroller and then communicates with LED,

alarming and display units. The system provides a user interface as it interacts with the system. The interface helps the user to know the Blood Alcohol Contents (BAC) reading and to display text based on the condition of the designed system.

The Total attempts of 60 was carried out to determine the sensitivity, specificity and accuracy of the design system, using the following parameters; True detection (TD), Unable to detect (UD), false detection (TD). The average sensitivity and the specificity calculated are 0.77 and 0.80 respectively this value was used to calculate the overall accuracy of the designed system which was 96.25%. It is also noteworthy to indicate that the lithium batteries used were getting weak and the batteries were replaced after each successive test or number some numbers of attempts.

Figure 4.1: Shows the interior view of the design

4.1   Parameters for Evaluating the Developed System

The Indicating system of this project consists of three sub-units which are the display unit, alert unit and indicating unit. The indicating unit enables the user to know the presence condition of the design system through the green and red LED, buzzer was used in the alarming unit to sound warning sound to the vehicle driver that the presence of alcohol has being detected and there is need for parking or siren respectively, while the last unit from the three unit listed is the displaying unit, 16x4 LCD display was used for the displaying unit and it help to analyze the Blood Alcohol Contents and play the presence state of the designed system. The following parameters were used for evaluating this developed system:

i.   False Detection (FD): This is the process whereby the implemented system detects the presence of an alcohol from an undrunk drivers and the system sends or triggers alarm and indicating units.

ii.   True Detection (TD): This is the process whereby the implemented system detects the presence of an alcohol on a drunk driver and the system sends or triggers alarm and indicating units.

iii.   Unable to Detect (UD): This is the process whereby the implemented system was unable to detect the presence of alcohol from the driver's breath

iv.   Sensitivity (SE): The degree of response of the system to change in an input signal.

v.   Specificity (SP): The state of being specific for a given condition rather than general.

$$Sesitivity = \frac{Td}{Td + Ud} \qquad\qquad (4.1)$$

$$Specificity = \frac{Td}{Td+Fd} \qquad\qquad (4.2)$$

$$Accuracy = \frac{Td}{Td+Fd} \Big/ \frac{Td}{Td+Ud} \; x\, 100 \qquad\qquad (4.3)$$

4.2   Discussion

The prototype was designed and implemented. The results obtained from the combination of various alcohol detection system components and corresponding constructions are evaluated and some observations were made during the different stages of testing. Some distances were taken so as to ascertain the workability of the alcohol detection system.

The percentage error reflected was due to internal frictions within the alcohol detection system mechanism. The Specificity (SE) of the developed system was 0.80 (80%). This implies the ability of the implemented alcohol detection system correctly detect the presence of alcohol and trigger alarm, display and indicating units. The Sensitivity of the implemented alcohol detection system was 0.77 (77%). This indicates that the implemented alcohol detection system was able to correctly detect the presence of alcohol and trigger alarm, display and indicating units to notify the vehicle driver. Nevertheless, the Recognition Accuracy of the designed system was 96.25%

5.   Conclusion

In conclusion, the construction of a Vehicle Alcohol Detection System using ATmega328P microcontroller gives good response and accurate results as expected. This study designed and implemented an Alcohol Detection System Usingatmega328P to reduce accident due to drunk driving. The Microcontroller ATmega328p was programmed with C language and the sensitivity of the designed devices was accurate compared to the works and developments.

5.1   Recommendation

This future implication or scope of the research, is very great considering the fact that it alleviates accident and save lives. This system can be advanced and integrated as a wearable device which can be mandatory for every driver to wear while driving as driving jacket especially on the highways road.

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