Design of a Smart Alcohol Detection System with Engine Locking Mechanism

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Abstract

This project presents the design and simulation of an alcohol sensing system integrated with an engine locking mechanism to mitigate accidents caused by drunk driving. The system employs an MQ-3 alcohol sensor interfaced with an Arduino Uno microcontroller to monitor the driver's breath for alcohol concentration. When the detected level exceeds a defined threshold, the system prevents the engine from starting or shuts it down to restrict further vehicle operation. Supporting units include a display for user feedback, indicator LEDs, and an alarm to alert passengers. Circuit simulations conducted in Proteus software confirmed the system's ability to accurately detect alcohol levels, respond within acceptable timeframes, and reliably trigger the locking mechanism. The design prioritizes accuracy, dependability, low power consumption, and user-friendliness. Results demonstrate that this technology can significantly reduce the risk of drunk-driving incidents, enhance road safety, and encourage responsible driving behavior. Furthermore, the study contributes a practical framework for future advancements in intelligent vehicle safety systems.

Key words: Alcohol sensing system, MQ-3 alcohol sensor, Arduino Uno and Intelligent Vehicle safety

1. Introduction:

Road traffic accidents remain a critical global challenge, with drunk driving identified as one of the leading contributors to fatalities and injuries. Alcohol consumption impairs essential driving abilities such as judgment, reaction time, and vision, thereby increasing the likelihood of accidents. Although strict laws and enforcement measures exist, it is impractical for authorities to monitor every driver, making alcohol-impaired driving a persistent safety concern.

Technological interventions, particularly in-vehicle alcohol detection systems, offer a proactive solution by preventing drivers under the influence from operating vehicles. Alcohol sensing systems analyze breath samples to determine ethanol levels and can be integrated with vehicle control units to restrict ignition or shut down the engine when alcohol exceeds a defined threshold. Such systems not only enhance driver and passenger safety but also protect other road users.

This project focuses on designing and simulating an alcohol sensing system with an engine locking mechanism using an Arduino Uno microcontroller and an MQ-3 alcohol sensor. The system continuously

monitors the driver's breath, provides real-time feedback through indicators and alarms, and immobilizes the engine when intoxication levels are detected. In doing so, it seeks to reduce alcohol-related accidents, encourage responsible driving behavior, and contribute to the advancement of intelligent vehicle safety technologies.

2. Literature Review:

2.1 Arduino UNO

The Microchip AT mega 328P microcontroller serves as the foundation for the Arduino UNO, an open-source microcontroller board. It is made so that learning how to use a microcontroller is relatively simple for beginners. The connectors on this board, in particular, are quite simple to manage. It contains 6 analog input pins, a 16 MHz frequency, a USB connection, a power jack, and a reset button. It also has 14 digital input/output pins, of which 6 can be used as PWM outputs. It comes with everything required to support the micro-controller; to get started, just use a USB cable to connect it to a computer, or an AC-to-DC adapter or battery to power it [3]. (Davis, 2018)

Table 1: Arduino specifications (Source: Microcontroller's lab, 2022)

Microcontroller	ATmega328P
Activation Voltage	5V
Voltage Of Inputs (Recommended)	7-12V
Control Voltage (Limit)	6-20V
Computer I/O Pins	(Of the 14, six produce PWM output)
Digital I/O Pins for Pwm	6
Pins For Analog Input	6
Dc Current Pin Per I/O	20 mA
Dc Current for A Pin At 3.3v	50 mA
Quick Memory	32 KB (Atmega328P), of which the bootloader uses 0.5 KB.
Clock Speed	16 MHz
Led_ Built-in	13

2.2 Alcohol sensor

The MQ-3 alcohol sensor is a cost-effective semiconductor device capable of detecting ethanol in the air, commonly used in breathalyzers to measure alcohol in human breath [1] (Collins, 2022). Its sensitive component, SnO_2, exhibits low conductivity in clean air, which increases proportionally with the concentration of alcohol vapors, allowing for rapid and highly sensitive detection. The sensor can detect alcohol concentrations between 0.05 mg/L and 10 mg/L and is resistant to interference from smoke, mist, and gasoline. It provides both analog and digital outputs, making it easily interfaced with microcontrollers, Arduino boards, Raspberry Pi, and similar devices. Operating similarly to a standard breathalyzer, the MQ-3

outputs an analog resistive signal corresponding to alcohol concentration, requiring only a simple resistor in the drive circuit, with a 0–3.3 V ADC serving as a straightforward interface.

Table 2: Technical Specifications for Alcohol Sensors (Source: ElectroDuino, 2022)

Parameter Name / Sensor type	Detection gas	Concentration	Voltage	Load resistance (RL)	Heater resistance	Sensing resistance (Rs)	Slope	Temp humidity
Semiconductor	Alcohol gas	0.04-4mg/l alcohol	±5.0V	Adjustable	31Ω ±3 Ω	2KΩ20 KΩ (in 0.4mg/l alcohol)	200–1000 ppm	20±2; 65%± 5%RH

2.3 Light-emitting diode (LED)

When an electric current flow through a semiconductor device called a light-emitting diode (LED), the LED emits light. It functions as an indicator to demonstrate the presence of current flowing across the output USB terminals. LEDs come in a variety of hues, but in this instance, Green and Yellow LED will be used [12]. (Robert Karlicek, 2017)

2.4 LCD display (Liquid Crystal Display)

The 16×2 Liquid Crystal Display (LCD) panel, with two lines of 16 characters each, is commonly used with microcontrollers to display letters, numbers, and symbols [9] (Lueder, 2010). Designed for low power consumption, the LCD uses 16 pins for power, data, and control. Display content is managed by placing data into the data registers and instructions into the instruction register. The module supports both 4-bit and 8-bit control modes, with Arduino requiring seven I/O pins for 4-bit mode and eleven for 8-bit mode; for most text display applications, the 4-bit mode is sufficient.

Table 3. Shows Liquid Crystal Display specifications

D4 – D7	Pin A2, A3, A4, A5
Enable	Pin A1
RS	Pin A0
RW	GND
VEE	10k (Middle Leg) POT
VSS	GND
VCC	+5V
LED+	+5V
LED-	GND

2.5 Breadboard

Breadboards allow electronic circuits to be built and prototyped without soldering by inserting components into interconnected holes on a plastic board [10] (Monk, 2016). Typically arranged in a grid of rows and columns, breadboards support a wide range of circuits, from simple LED setups to audio amplifiers and microcontroller projects. They are commonly used in educational settings to teach electronics and circuit design due to their flexibility and ease of use.

2.6 Jumper wires

Jumper wires are electrical wires with connector pins at each end, used to connect components on a breadboard or prototype circuit without soldering [13] (Thompos, 2020). They facilitate easy modifications and reconfiguration of circuits during testing and development. The most common types are male-to-male, male-to-female, and female-to-female, distinguished by the configuration of their connector ends.

2.7 DC Motor

A DC (Direct Current) motor converts electrical energy into mechanical rotational motion through interactions between the magnetic fields of the stator and rotor [11] (Nasar, 2018). Widely used in applications such as industrial machinery, robotics, and electric vehicles, DC motors can be controlled by adjusting the input voltage, current, or frequency. In this project, a DC motor connected to pin 9 of the microcontroller is used to demonstrate engine locking, stopping when alcohol is detected and resuming operation when no alcohol is present.

2.8 Buzzer

Buzzers are electrical devices that produce sound, typically classified as piezo or magnetic types and powered by DC voltage [14] (Williams, 2022). They are compact and suitable for use on breadboards or PCBs, making them common in many electronic projects. Buzzers come in simple and pre-made varieties: simple buzzers emit a continuous beeping sound when powered, while pre-made buzzers contain an internal oscillating circuit to generate sound. Operating typically between 4–9 V DC, they are often powered by a 9 V battery or a regulated 5–6 V DC source and can be controlled via a switching circuit to sound at specific intervals.

2.9 A transformer

A transformer is a piece of electrical equipment that uses electromagnetic induction to move electrical energy across circuits. It is made up of wire coils (windings) that are coiled around a magnetic core. It alters voltage levels for effective power distribution and utilization in electrical systems, either stepping up or down the input voltage [7]. (Jr., 2012)

2.10 Touch-based Driver Alcohol Detection System

Touch-based alcohol detection technology estimates a driver's blood alcohol concentration (BAC) by directing near-infrared light through the skin when a finger is placed on a sensor, typically built into the gear shift or ignition button. Since alcohol absorbs light at specific wavelengths, the system can rapidly and precisely measure BAC, generating multiple readings in under a second [2] (dAdds, 2018; DADSS, 2019). However, the technology faces notable limitations, including potential false readings caused by alcohol-containing substances like medications or mouthwash, high installation costs that hinder widespread adoption in resource-limited settings, and the need for regular calibration and servicing, which increases operational complexity and long-term expenses.

2.11 Laser based alcohol detection in cars

An external laser system can be installed on the side of the road to monitor passing vehicles for alcohol vapors. When alcohol is detected, the system sends a message with a photo of the car and its license plate to

a police officer stationed further along the route, who then pulls over the vehicle for standard alcohol testing. While this method allows for automated monitoring, it faces significant challenges, especially in developing countries like Tanzania, where installing such devices on enough roads to cover at least 50% of major routes would be difficult and costly [5] (Gianinetto, 2014).

3. Methodology

3.1 System design and implementation

This section displays the block diagram and circuit diagram used in designing and implementing the alcohol detection system with engine locking mechanism.
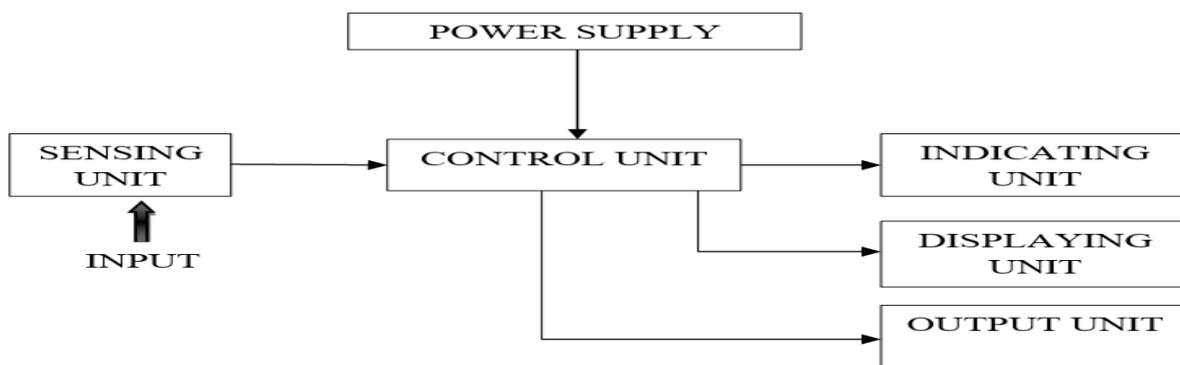

Fig 1. Block diagram of alcohol sensing system with engine locking

The proposed system's mechanism and component placement are illustrated in Figure 1. It consists of several units, including the power supply, alcohol detection, control, display, engine locking, and alarm/signaling units. An LCD display is installed in the car to provide visual feedback to the driver and passengers. A DC motor is used to simulate the vehicle's engine and demonstrate the engine locking concept. The Arduino Uno ATmega328 microcontroller continuously monitors the output from the alcohol sensor, with programming carried out in the Arduino IDE to write, compile, and upload the code onto the microcontroller.
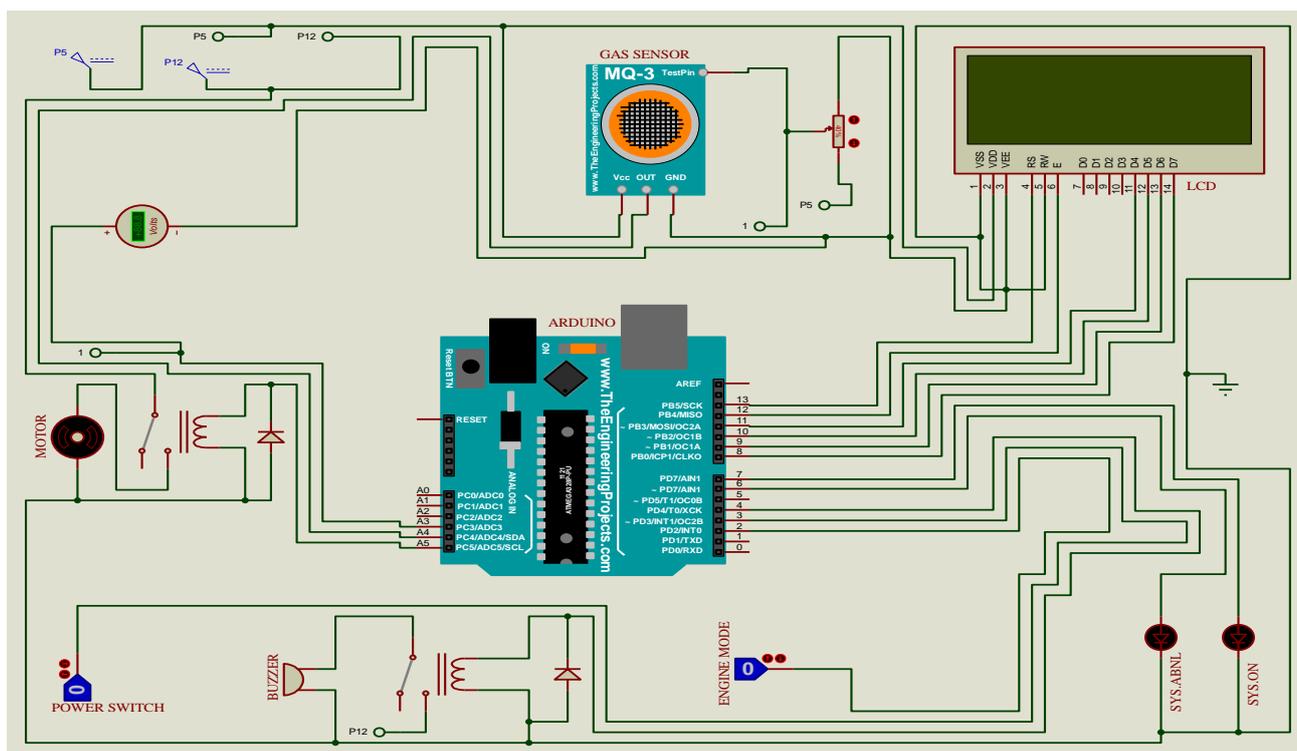

Fig 2: Complete Alcohol sensing and engine locking mechanism design

3.2 Circuit simulation

The initial stage will just have the LED indication illuminated, the alarm turned off, and the car's motor turned on.
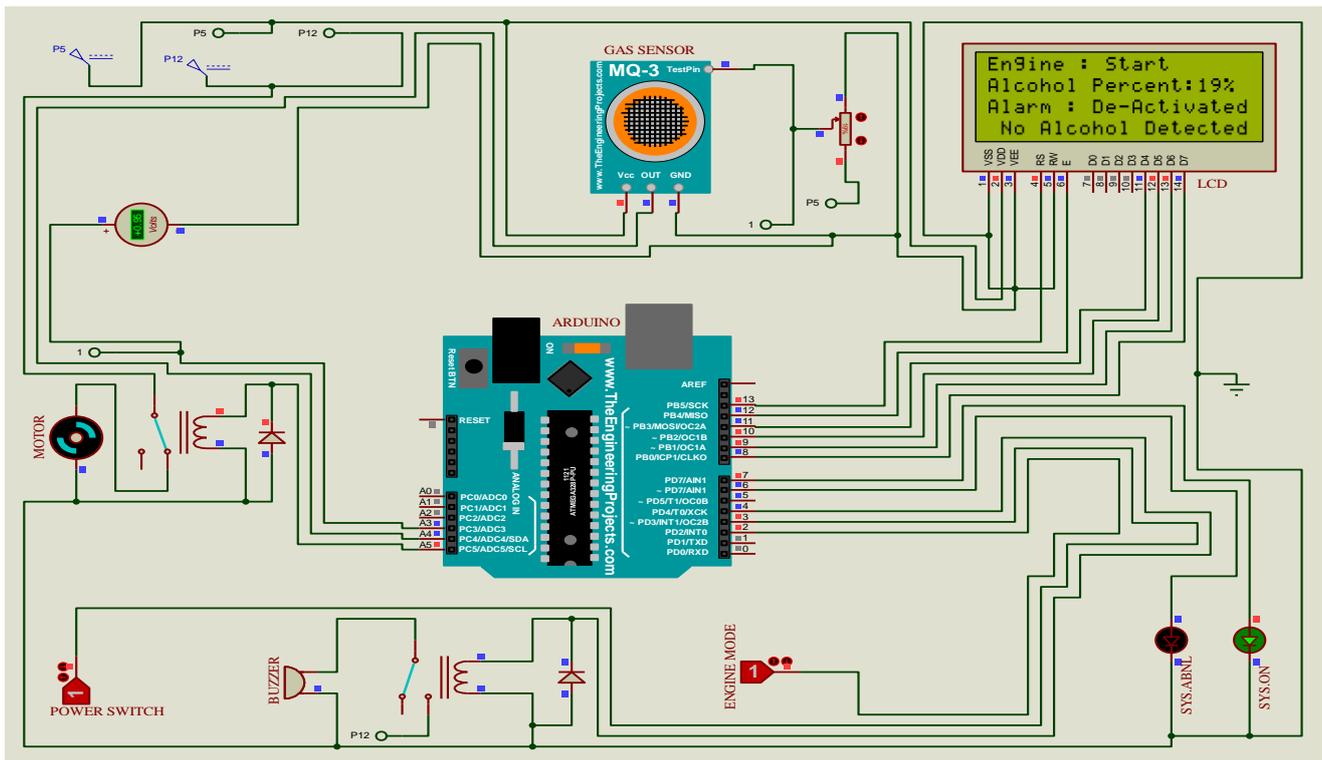

Fig 3: Comparison between calculated and simulated values

In the third stage, when there is a high amount of alcohol detected (above threshold limit) the voltage get out from the sensor ranges about 2 to 2.5V and above. The alert and yellow LED will be on while the engine is off.
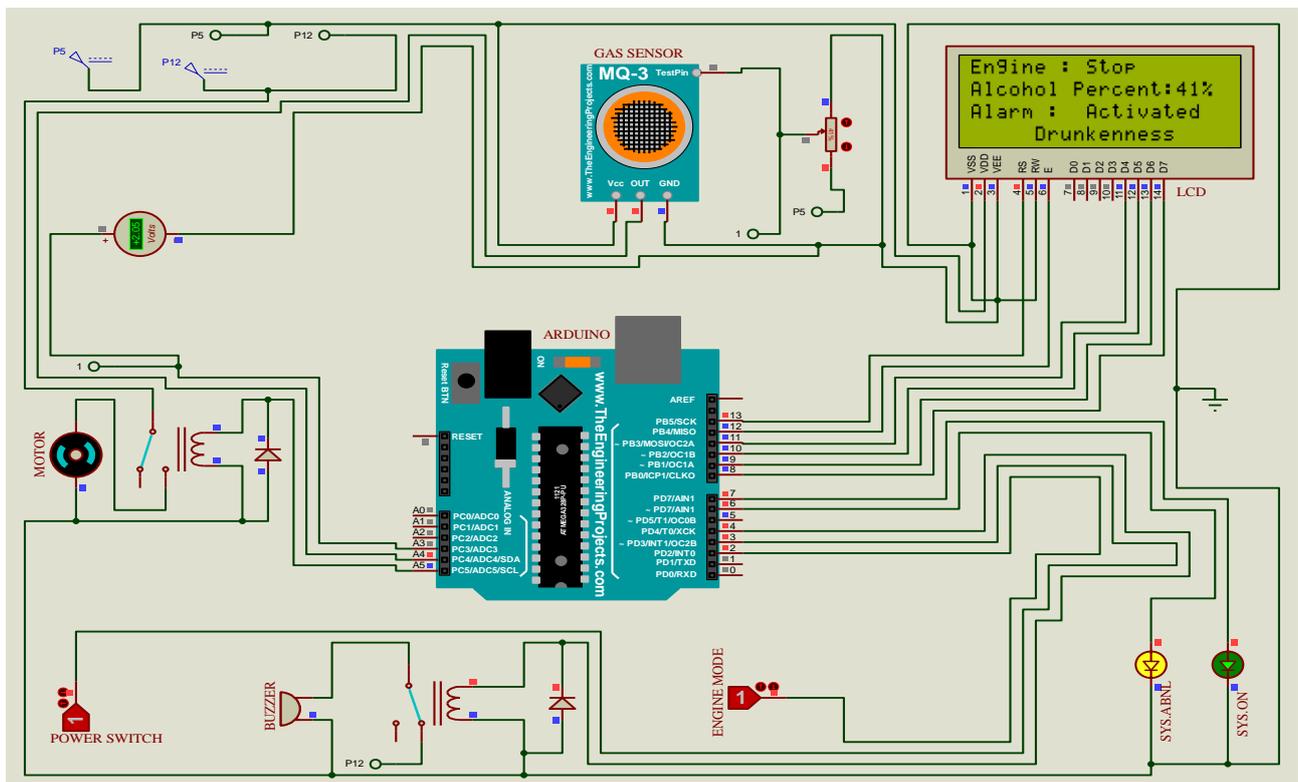

Fig 4: Comparison between calculated and simulated values

Table 4: Shows Comparison in parameters

Parameter	Calculated values	Simulated values
Input AC voltage	240Vrms	239Vrms
Secondary Voltage	16.97Vrms	16.3Vrms
Rectified voltage	15.57Vrms	17.5Vrms
Output voltage	12Vrms	12Vrms

3.3 Flow chart design

Figure 5 displays the system's flowchart. The algorithm for the system consists of three key phases. The device must first boot up before moving on to the measuring stage, which checks the drivers' blood alcohol content. The microcontroller will receive a predefined set limit as input; if the alcohol level exceeds the limit, the car won't start.
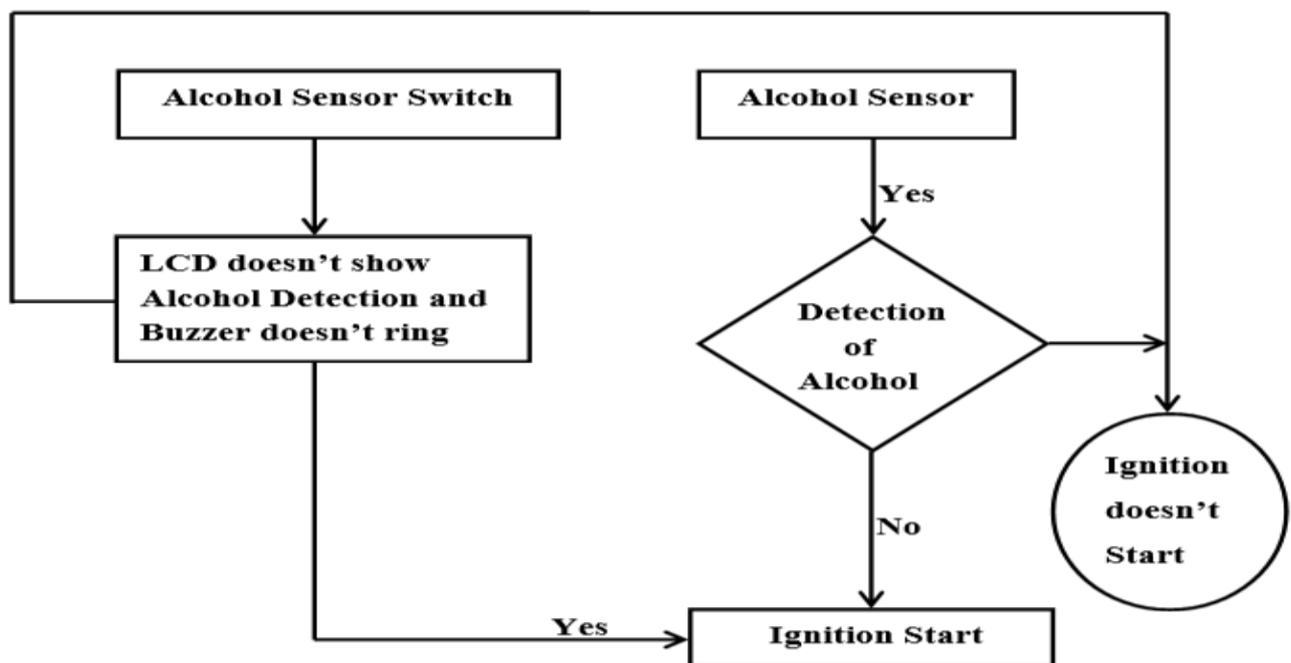

Fig 5: Flow chart

3.4 System operation

The Arduino Uno board includes an 8-channel, 10-bit analog-to-digital converter (ADC) that converts input voltages of 0 –5 V into digital values ranging from 0 –1023. The analog signals from the alcohol sensor are read by the microcontroller and scaled into percentages, corresponding to alcohol concentration in parts per million (ppm). Based on these readings, the system categorizes driver intoxication into three stages. In the first stage (intoxication), only the LED indicator is activated while the engine remains running and no alarm is triggered. In the second stage (mild inebriation), the engine, alarm, and a green LED indicator are activated simultaneously. In the third stage (drunkenness), the driver's impairment is considered severe; the engine is shut off, while the alarm and a yellow LED indicator remain on, prompting the driver to park safely at the roadside.

3.5 Implementation of software

A free-running program that utilizes input from the alcohol sensor makes up the software design, together with programming for the LCD display, DC motor, and alarm unit. The program code is created on an Arduino sketch and imported using an Arduino Uno development board to the program memory of an ATMEGA328 microcontroller. Utilizing the Arduino sketch IDE environment, the hex file is created.
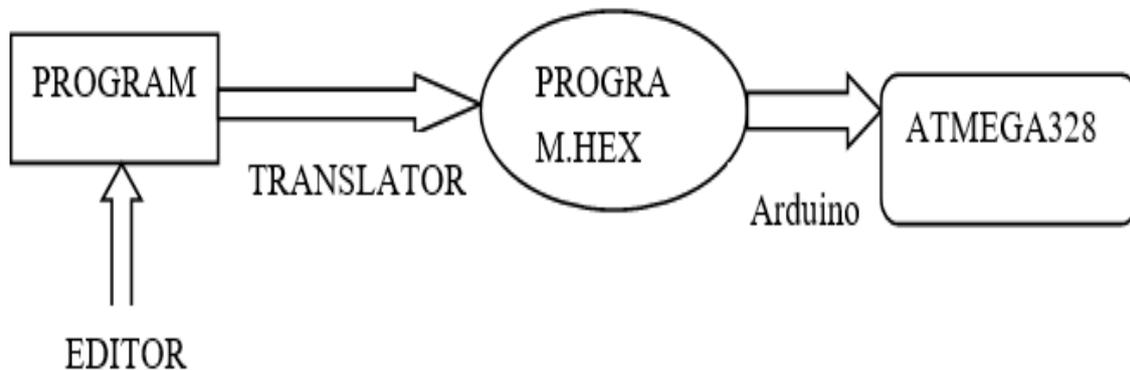
Fig 6: Device Programming

3.6 Arduino programming

The code file is imported into the controlling unit and additional instruction codes are loaded into the sensing unit after the hex file was generated using the Arduino sketch IDE environment, as illustrated in figure 7 below.
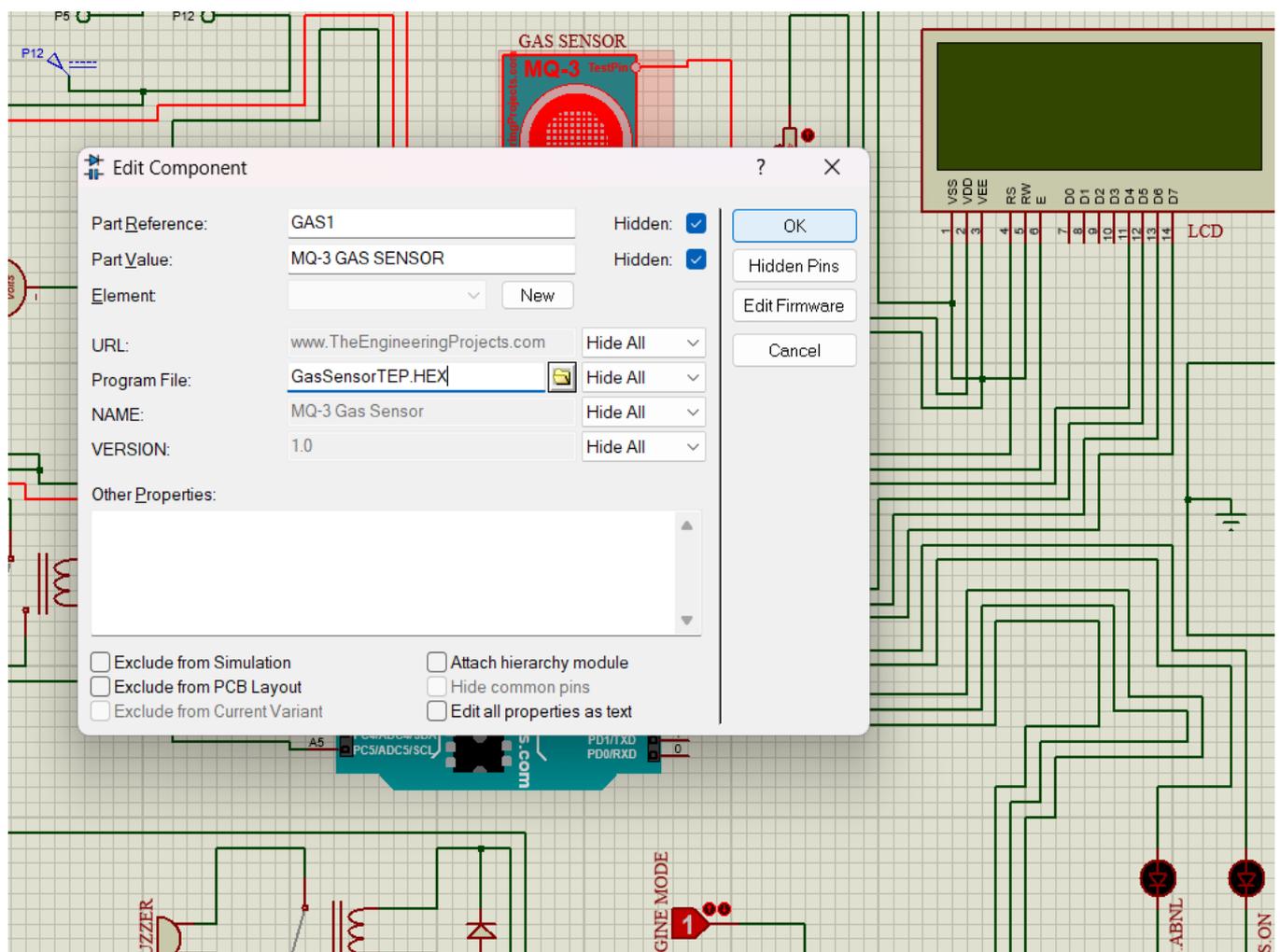
Fig 7: Location of hex file

3.7 Results

Tables 5 and 6 demonstrate the outcomes of this designing.

Table 5: Features of the sensitivity level

VOLATGE (V)	PPM (PART PER MILLION)	PERCENTAGE (%)
0	0	0
0.5	100	10
1	200	20
1.5	300	30
2	400	40
2.5	500	50
3	600	60
3.5	700	70
4	800	80
4.5	900	90
5	1000	100

Table 6: Level of drunkenness

Voltage Output	200 – 300ppm 1 – 1.5V 20 – 30%	300 – 400ppm 1.5 – 2V 30 – 40%	400– 500ppm 2 – 2.5V 40 – 50%
LCD Display	Intoxicated	little inebriated	Drunkenness
Alarm	Off	Off	On
Ignition SYS	On	On	Off
Indicator	Led Green On Led Yellow Off	Led Green On Led Yellow Off	Led Green On Led Yellow On

4. Discussion

The assessment of the sensor's accuracy using ethanol to simulate how it would react to an alcohol concentration level based on the previously specified circuit simulation design. These outcomes were achieved;

4.1 Features of the Sensitivity Level

Table 6 displays the percentage, voltage, and ppm alcohol content. The percentage and voltage values are represented in ppm. The motorist can see the alcohol % level thanks to our method. The concentration level,

or BAC level, can be determined by the ppm readings. Depending on the resistance of the alcohol sensor, the voltage values rise or fall. By writing instructions to the microcontroller to lock the car engine when the alcohol sensor reading is equal to or higher than 40% using this table, the locking idea was achieved. To evaluate whether the sensor reading exceeds the predetermined limit, the microcontroller analyzes the analog voltage values coming from the sensor. In essence, the microcontroller automatically analyzes analog values received over 2V with the preset limit; if they do not match, the engine will shut down.

4.2 Alcohol Intoxication Level

On the basis of the three pre-specified conditions for intoxicated driving, experimental findings were produced. The car engine will be running while the driver is still capable of maintaining control. The technology will nonetheless permit the engine to run in a somewhat inebriated state. Finally, a drunk driver will become unstable and unable to make decisions. The engine locks off automatically in the situation. Table 6 displays the **amount of intoxication.**

5. Conclusion and Recommendations

5.1 Conclusion

The goal of the engine locking mechanism and alcohol detection system is to reduce or completely eliminate the number of fatal car accidents and injuries caused by alcohol consumption. The Arduino Uno ATMEGA328 microcontroller and MQ-3 sensor were used to successfully build and implement the system. The goal of the project is to use an engine locking mechanism and an alcohol detector to make driving in the future safer and more beautiful. The simulated circuit operates correctly, and the project has been successfully completed.

5.2 Recommendations

The researcher suggests doing the following based on the findings above.

The idea of an alcohol detection system with an engine locking mechanism might be introduced to the car manufacturing firms for the safety of drivers and the damage prevention of automobiles in order to help reduce road accidents caused drunk driving behavior. Additionally, the Tanzanian government should support engineering students from the Dar es Salaam Maritime Institute and other institutions by offering loans that would enable them to develop outstanding projects in their final year, with assistance from the education sector.

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