Microcontroller-Based Alcohol Detection and Vehicle Immobilization System

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Bachelor of Science in Instrumentation and Control Engineering

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CHAPTER 1: INTRODUCTION

1.1 Background of the Project

Road accidents due to drunk driving remain a big concern across everywhere, involving the deaths and injuries of countless people annually. Notwithstanding tough rules, sanctions, and educational initiatives, plenty of individuals continue to drive under the influence of alcohol, posing a substantial risk to road safety. Traditional enforcement tactics, such as roadside breathalyzer testing administered by law enforcement, are frequently reactive and incapable of preventing accidents before they occur.

To overcome this issue, an Microcontroller-Based Alcohol Detection and Vehicle Immobilization System is proposed. This system combines alcohol detection sensors with vehicle control mechanisms to prevent inebriated individuals from driving. The technology works by analyzing the driver's breath for alcohol levels, and if they exceed the permitted limit, the vehicle's ignition is turned off or the speed is gradually reduced to avoid potential accidents.

This initiative focuses on creating a system that can detect alcohol levels in drivers and control the vehicle accordingly using the ESP32 microcontroller. The system will incorporate an alcohol sensor, GPS module, GSM module, and vehicle control mechanisms to detect intoxicated drivers and prevent them from operating the vehicle. If alcohol is detected above a permissible level, the system will:

1.2 Statement of the Problem

Despite current legislation and enforcement efforts, drunk driving is a leading cause of traffic accidents, injuries, and fatalities. Existing techniques, such breathalyzer testing, are frequently reactionary and don't stop people with impairments from starting or driving a car. A proactive technology that can automatically determine a driver's alcohol content before or during driving and intervene quickly to stop collisions is required. In order to improve road safety and stop drunk driving occurrences in real time, this project uses the ESP32 microcontroller to create a system that combines GPS monitoring, GSM notifications, alcohol detection, and car immobilization.

1.3 Project Objectives

General Objective

To lessen the risks of car accidents caused by drunk driving by integrating an alcohol detection system that can stop or prevent vehicle operation when the detected alcohol levels exceed a predefined threshold.

Specific Objectives

1. Ensure Vehicle Immobilization: Program the system to automatically prevent vehicle ignition or shut down the engine if alcohol levels exceed the predefined safety limit.
2. Enable Real-Time Alerts and Tracking: To incorporate a GSM module for sending SMS notifications to predefined contacts and a GPS module for tracking real-time vehicle location.
3. Integrate User-Friendly Display and Controls: To use an OLED display for real-time feedback, showing alcohol detection status and system alerts for the driver and authorized personnel.
4. Test and Validate System Performance: Conduct tests to ensure reliability, accuracy, and responsiveness of the system in various land vehicle different conditions, such as:

1.4 Scope and Delimitation

This project focuses on the development and implementation of a Microcontroller-Based Alcohol Detection and Vehicle Immobilization System using the ESP32 microcontroller. The system is designed to detect the presence of alcohol in a driver's breath using an MQ-3 alcohol sensor. If the detected alcohol level exceeds a predefined threshold, the system activates a relay to disable the vehicle's ignition, thereby preventing the driver from operating the vehicle under the influence. The system also integrates a SIM800L GSM module to send SMS alerts to emergency contacts, and a NEO-6M GPS module for real-time location tracking of the vehicle. An OLED display is used to provide visual feedback on alcohol levels and system status, enhancing user interaction and awareness

The scope of this project is limited to the detection of alcohol via breath analysis and immobilization of a land-based vehicle's ignition system. It does not include blood alcohol concentration (BAC) analysis or other biometric authentication methods. The system is tested under controlled conditions and may not account for all environmental variables such as sensor drift due to humidity, temperature, or external alcohol sources. Additionally, the implementation is intended for prototype demonstration purposes and does not involve integration into actual automotive ignition systems for commercial or mass production use. The system's override mechanism is limited to basic methods such as password input or authorized key access, and does not yet include encryption or advanced security protocols. Moreover, while the GPS and GSM modules provide communication and tracking features, their reliability is subject to signal availability and network coverage.

This project is designed for educational and proof-of-concept purposes within the framework of ECE 415 – Microprocessor and Microcontroller Systems and Design. Its main goal is to demonstrate how embedded systems can enhance road safety by integrating sensing, control, and communication technologies in a single functional system.

CHAPTER 2: REVIEW OF RELATED LITERATURE

In this chapter previous research materials that are related to the present study have been reviewed and presented to provide insights into the investigated problems. These are studies conducted by other researchers in the past that are relevant and considered related to the current study.

Alcohol Detection and Vehicle Controlling. Worldwide, driving while intoxicated continues to be a major cause of traffic accidents (National Highway Traffic Safety Administration [NHTSA], 2009). As a result, scientists have created systems that combine sensors and microcontrollers to identify alcohol content and stop cars from operating in dangerous situations.

Bhuta, Desai, and Keni (2015) proposed an alcohol detection and vehicle control system using an Arduino Uno microcontroller and an MQ-3 sensor. Their study provides detailed technology that broadcasts the location of the vehicle via GPS, shuts the engine, and notifies emergency contacts by GSM when the alcohol content reaches a predetermined threshold. A DC motor to mimic ignition control and an LCD for real-time alerts are also included in the arrangement. The MQ-3 sensor is favored for its high alcohol sensitivity and quick response (SparkFun, n.d.). GSM and GPS modules enhance the system's emergency responsiveness by ensuring location tracking and communication. This integrated approach presents a reliable, low-cost solution to reduce drunk-driving incidents and improve vehicle safety systems. This study includes the practical integration of sensors and communication modules via the Arduino platform that provides a compact, cost-effective, and highly reliable method to enforce driving safety.

The study by Sundararajan, Ponkarthikeyan, and Bowman (2022) titled, Alcohol Detection and Vehicle Stopping System presents a microcontroller-based system aimed at reducing alcohol-related road accidents. The design utilizes an Arduino UNO as the central processing unit, connected to an MQ-3 alcohol sensor, SIM900A GSM/GPS module, buzzer, LED, LCD display, and a DC motor to simulate vehicle ignition. The system continuously monitors alcohol levels in the vehicle cabin, and when the concentration exceeds the legal threshold, it initiates a series of safety responses to prevent operation of the vehicle. The MQ-3 sensor, which is the brains behind the device, uses a tin dioxide (SnO_2) layer to alter its electrical resistance in response to the presence of alcohol fumes. The resistance of the sensor decreases when alcohol is detected, enabling current to flow and generating a signal that the Arduino can understand. The microcontroller responds by turning off the ignition, turning on an LED and buzzer to warn oncoming traffic, and using the GSM/GPS module to send an SMS with the position of the car to an emergency contact that has been pre-registered. The researchers chose components carefully to optimize the system's effectiveness and practicality. The MQ-3 sensor was favored over the less reliable MQ-2, which has a tendency to produce false alarms. The Arduino UNO was selected in place of more expensive or outdated microcontrollers like the PIC16F877, offering better performance and compatibility with four-wheeled vehicles. Additionally, the SIM900A module ensures reliable communication over mobile networks and provides real-time location tracking.

All things considered, the study shows a dependable and reasonably priced way to improve car safety. This integrated design provides a scalable solution that can assist prevent accidents and shield drivers and the general public from the risks associated with drunk driving by integrating alcohol detection, vehicle control, public alert systems, and emergency communication.

According to Sarvesh D. 's research, they have developed integrated vehicle safety systems using microcontroller-based platforms like the Arduino Uno to improve road safety and prevent vehicle-related crimes. Patel and Shah (2021) focused on drunk driving prevention by designing a system that uses the MQ3 alcohol sensor, LCD, buzzer, and motor control to detect alcohol in a driver's breath and immobilize the vehicle when limits are exceeded. Singh and Verma (2020) addressed rash driving by employing accelerometers and gyroscopes to monitor abrupt driving patterns, triggering alerts and vehicle shutdowns to reduce accident risks. Kumar and Reddy (2022) contributed to vehicle security through an anti-theft system that integrates motion sensors, ESP32 CAM for surveillance, and a GSM module (SIM800L) to notify users of unauthorized access. Additionally, Rao et al. (2019) enhanced emergency response and tracking using GPS and GSM technologies to provide real-time location updates. Collectively, these studies demonstrate the effective use of components such as the MQ3, LCD, buzzer, motor, GPS, GSM, and ESP32 CAM to build multifunctional systems capable of detecting alcohol, monitoring reckless driving, preventing theft, and improving situational awareness.

Furthermore, Sunil, Kumar, Yaswanth, Hossain, and Vardhan (2023) proposed a comprehensive vehicle safety system titled, Vehicle Safety System with Alcohol Detection and Accident Recognition that integrates alcohol detection and accident recognition features using sensor-based technology. Their project utilizes an Arduino Uno as the core processing unit, interfaced with an alcohol sensor, flame sensor, GPS and GSM modules, an accelerometer, and an LCD display. The system aims to proactively identify signs of impaired driving and respond to potential threats, such as fire hazards and collisions, while simultaneously providing real-time updates to emergency services.

The alcohol sensor is designed to monitor the driver's breath for signs of intoxication. If the alcohol concentration exceeds a preset threshold, the system restricts engine ignition, effectively preventing the driver from operating the vehicle under unsafe conditions. Additionally, a flame sensor is included to detect fire risks that may arise due to accidents or negligence associated with alcohol consumption. The GPS module tracks the vehicle's location, ensuring it remains on the designated route and under the speed limit, while the GSM module enables communication with a central monitoring system. In the event of an accident, the accelerometer identifies abnormal impacts or collisions and triggers an alert to emergency responders, thereby facilitating a quicker response time.

This study demonstrates a practical integration of multiple sensors to enhance vehicle safety. By combining alcohol detection, fire hazard monitoring, route tracking, and crash recognition in one embedded system, the researchers provide a holistic solution aimed at reducing traffic accidents and improving emergency response. The system not only prevents intoxicated driving but also assists in minimizing the consequences of road incidents, contributing to overall road safety.

Kadu, Laddha, Waghmare, Badani, Patel, and Awere (n.d.) proposed an intelligent vehicle tracking and safety system that integrates various sensors and modules using an Arduino UNO R3 as the central controller. The study focuses on minimizing road accidents caused by careless driving and enhancing emergency response, particularly in remote areas. Key components include the MQ-135 alcohol sensor, which detects alcohol levels in the driver's breath, and the ADXL345 accelerometer, which senses sudden vehicle movements to identify possible collisions. The GPS NEO 6M V2 module enables real-time location tracking, while the GSM SIM800C module sends automatic alerts to pre-registered contacts when sensor thresholds are exceeded. The L298N motor driver and gear motor support system actuation. Their approach ensures prompt emergency response and provides a cost-effective, programmable solution that can be widely adopted in various automotive safety applications. This study highlights the utility of integrating Arduino UNO, GPS, GSM, accelerometers, and alcohol sensors in building smart vehicle systems capable of real-time monitoring, accident detection, and driver safety enforcement.

Additionally, Sulthana et al. (2024) introduced the Smart Alcohol Detection and Vehicle Security System with Owner Alert (SAVES), a comprehensive system designed to address two major road safety challenges: drunk driving and unauthorized vehicle access. The proposed system integrates alcohol detection technology with advanced vehicle security components, creating a multi-layered approach to prevent both accidents and theft. Central to the SAVES design is the use of an alcohol sensor placed near the driver's seat, which detects breath alcohol concentration. If the detected level exceeds the permissible threshold, the system locks the vehicle's doors and disables the engine, preventing operation until sobriety is confirmed.

Anil Kadu, Ayush Laddha, Apurv Waghmare, Hriday Badani, Amay Patel, and Janhavi Awere (2024) proposed a safety-focused vehicle control system aimed at reducing road accidents caused by drunk driving. Their model uses the Arduino UNO as the central controller, along with an MQ-3 alcohol sensor to detect alcohol concentration in the driver's breath. If the alcohol level crosses the permissible limit, the system automatically deactivates the DC motor, effectively preventing the vehicle from starting. Additional components such as LED indicators, buttons, and a GSM module are used to alert concerned authorities in real time. This cost-effective system combines automation and communication to enhance vehicle safety and limit alcohol-impaired driving incidents.

Effectively on the other hand, Oloyede Mukhtar Abiodun, Michael David, and Waheed Moses Audu (n.d.) developed an alcohol detection system aimed at reducing drunk driving through a cost-effective and automated approach. The system uses an MQ3 gas sensor mounted on the steering wheel to detect alcohol from the driver, with readings processed by an ATMEGA 16 microcontroller. Upon detecting alcohol levels above a predefined threshold, the system simultaneously activates three modules: a relay module that interrupts the fuel supply to momentarily halt the vehicle, an LCD that displays an alert message, and a GSM module that sends notifications to a next-of-kin or law enforcement. Designed using a toy car prototype, the system demonstrated the potential for real-life implementation, providing an affordable alternative to traditional Blood Alcohol Content (BAC) testing. This research emphasizes the importance of automated safety responses—especially the relay's role in directly disabling the vehicle—to combat the risks of alcohol-impaired driving.

SAVES's Owner Alert System is a noteworthy feature that uses a GSM module to transmit real-time notifications to the owner's mobile device in the event of suspicious activity or unwanted access attempts. This provides an extra degree of protection, allowing for quick action in potentially hazardous or illegal circumstances. Additionally, the system has an LCD display for the user interface, actuators for locking doors, and an Arduino Uno microcontroller for interpreting sensor data and initiating the proper actions. Compared to conventional alcohol sensing systems, SAVES provides a more reliable solution by integrating detection, prevention, and alarm processes.

CHAPTER 3: DESIGN METHODOLOGY

This chapter presents the design constraints, considerations, concept, and cost analysis involved in the development of the Alcohol Detector with Vehicle Controlling System. It provides an overview of the various factors that influence the system's design and development, ensuring that each component meets the required specifications for optimal performance.

DESIGN CONSTRAINTS

Sensor Accuracy and Sensitivity: As a means to recognize alcohol vapors in the driver's breath, the system uses an MQ3 alcohol sensor. The sensor needs to be calibrated and maintained correctly to prevent missed detections or false positives. Determining if the alcohol content surpasses the allowable limit is crucial for accurate measurements, as this has a direct impact on system activation (such as ignition lock or alert transmission). Programming logic for the microcontroller (such as the Arduino or ESP32) must incorporate calibration procedures and environmental noise filtering.

System Reliability: The system must operate consistently under various environmental conditions, including changes in temperature and humidity—particularly in vehicle environments where such fluctuations are common. Hardware components like the ESP32, relay modules, and

LCD/GSM modules should be tested for durability and stability. This ensures the system will not fail in critical scenarios, such as during real-time alcohol detection or GSM alerting in emergency situations.

Power Efficiency: Given that microcontroller-based systems may run off the vehicle's battery or an independent power source, power consumption must be optimized. The ESP32, known for its low-power modes, should be configured to reduce energy usage when the system is idle. Components such as sensors and displays must also operate with minimal current draw to prolong operational lifespan and avoid unnecessary power drain, especially in parked or inactive vehicle states.

Controlled Override Access: To keep the system secure, only trusted or authorized people (like police officers or vehicle administrators) should be able to turn off or bypass the system. This prevents drivers from disabling the alcohol detection or engine lock feature on their own. A simple password system, key switch, or RFID tag connected to the microcontroller (like an ESP32) can be used to control access to this override function.

DESIGN CONSIDERATIONS

3.1 Materials and Components Used

In the Microcontroller-Based Alcohol Detection and Vehicle Immobilization System, the materials and components refer to the essential electronic hardware used to build and implement the system. These components work together to detect alcohol presence, control vehicle functionality, alert authorities, and display relevant information. Each part serves a specific role in ensuring the system is functional, responsive, and reliable for real-time safety monitoring. The key components include:

Materials/Components	Definition
ESP32	The ESP32 is a semiconductor that gives embedded devices, or Internet of Things devices, Wi-Fi and (in certain models) Bluetooth connectivity. Although ESP32 is only the chip, the company frequently refers to the modules and development boards that house it as "ESP32."
MQ-3 Alcohol Sensor	The MQ-3 is a gas sensor used for detecting alcohol concentration in the air. It is commonly used in breathalyzers. In this project, it detects alcohol from a driver's breath and sends the signal to the microcontroller.
SIM800L GSM Module	The SIM800L is a GSM/GPRS module that allows microcontrollers to send and receive SMS, make or receive calls, and connect to the internet via cellular networks. It is used in the system to alert authorities or guardians if alcohol is detected.
NEO-6M GPS Module	The NEO-6M is a GPS module used to track the location of the vehicle in real-time. It helps in monitoring and possibly alerting emergency contacts with the vehicle's coordinates in critical situations.

Relay Module	The relay module acts as an electrically operated switch. In this system, it is used to control the vehicle's ignition system — disabling it when alcohol is detected to prevent the vehicle from starting.
DC Motor	A DC Motor converts electrical energy into mechanical motion; used here to simulate or control mechanical vehicle parts.
LCD I2C	An OLED Display is a screen that shows real-time information such as alcohol levels, GPS data, or system status.
Battery	The battery powers the components in the system, ensuring the portability and uninterrupted function of the device.

3.2 Material/Components Specifications

1. **MICROCONTROLLER**

- ESP32 - Controls the entire system, processes sensor data, and sends alerts.

ESP32 SPECIFICATIONS	
Parameter Name	**Parameter Value**
Operating Voltage	3.3 V
DC Current on 3.3V Pin	50 mA
DC Current on I/O Pins	40 mA
Maximum Operating Frequency	240MHz
Timers	2 x 64-bit Timers, 1 RTC Timer

2. **SENSORS AND INPUT MODULES:**

- MQ-3 Alcohol Sensor - Detects alcohol levels in the driver's breath.

MQ-3 ALCOHOL SENSOR SPECIFICATIONS	
Parameter Name	**Parameter Value**
Operating voltage	5V
Load resistance	200 KΩ
Heater resistance	33Ω ± 5%
Heating consumption	<800mw
Sensing Resistance	1 MΩ – 8 MΩ
Concentration Range	25 – 500 ppm
Preheat Time	Over 24 hour

3. COMMUNICATION MODULES

- SIM800L GSM Module - Sends SMS or call notifications to emergency contacts.

SIM800L GSM MODULE SPECIFICATIONS	
Parameter Name	**Parameter Value**
Power Supply	3.4 to 4.4 VDC (4.0V typical)
Current Required	1A-2.6(MAX)
Band Frequency	Quad-band
Default Baud Rate	9600bps
Working Temperature Range	-40 C ~ +85 C
SIM Interface	1.3V, 3V
Timing Functions	Use AT Commands Set
PCB Dimensions	23 mm x 25 mm

- NEO-6M GPS Module - Provides real-time vehicle location tracking.

NEO-6M GPS MODULE SPECIFICATIONS	
Parameter Name	**Parameter Value**
Receiver Type	50 channels, GPS L1(1575.42Mhz)
Horizontal Position Accuracy	2.5m
Navigation Update Rate	1HZ (5Hz maximum)
Capture Time	Cool start: 27sHot start: 1s
Navigation Sensitivity	-161dBm
Communication Protocol	NMEA, UBX Binary, RTCM
Serial Baud Rate	4800-230400 (default 9600)
Operating Temperature	-40°C ~ 85°C
Operating Voltage	2.7V ~ 3.6V
Operating Current	45mA
TXD/RXD Impedance	510Ω

4. VEHICLE CONTROL COMPONENTS

- Relay Module - Controls the vehicle ignition system, preventing the engine from starting.

RELAY MODULE SPECIFICATIONS	
Parameter Name	**Parameter Value**
Normal Voltage	5V DC

Normal Current is	70mA
AC load current Max	10A at 250VAC or 125V AC
DC load current Max	10A at 30V DC or 28V DC
Operating time is	10ms
Release time is	5ms
Maximum switching is	300 operating per minute

- DC Motor (Simulation Purpose) - This represents the vehicle engine in a prototype.

3.3 Relevance of each Component to the Final Output

ESP32

The ESP32 microcontroller is responsible for decision-making within the system, based on the signal received from the MQ-3 Alcohol Sensor. It manages the entire system by determining whether to activate or deactivate the vehicle's ignition. If no alcohol is detected, the ESP32 enables the ignition. However, if alcohol is detected above the predefined threshold, it automatically disables the ignition to prevent the vehicle from starting or continuing to operate. This real-time response enhances driver safety by continuously monitoring and controlling the system based on sensor input.

MQ-3 Alcohol Sensor

The MQ-3 Alcohol Sensor is responsible for detecting the alcohol in the driver’s breath. It continuously monitors the driver’s breath which will send a corresponding signal to the microcontroller and compare it to the predefined threshold. This Alcohol Sensor is essential for real-time alcohol monitoring to control the vehicle.

DC Motor

The DC motor is used for simulation or representation that the vehicle’s ignition is activated or deactivated depending on the alcohol level detected by the MQ-3 Alcohol Sensor. The relay is responsible to control the ignition based on the alcohol detection monitored. Once there is no detected alcohol, the ignition will be activated. However, when the alcohol exceeds the predefined threshold the ignition of the DC motor automatically turns off. The DC motor is 2djust a representation of the vehicle that turns on and off depending on the signal that was sent by the microcontroller.

Relay

The relay is responsible for controlling the ignition system based on the alcohol detection results. It works with the ESP32 microcontroller, which is programmed to activate or deactivate the vehicle's ignition depending on the alcohol level detected by the sensor. If the alcohol level exceeds the predefined threshold, the relay automatically turns off the ignition, preventing the vehicle from starting. If the level is below the limit, the relay allows normal operation. This automated switching ensures safety by minimizing the need for manual intervention and preventing drunk driving incidents.

OLED Display

The OLED Display is used to visually present important system information. It shows whether alcohol is detected or not, displays the real-time location data from the GPS Module, confirms when SMS alerts are sent via the GSM Module, and indicates the overall status of the system or vehicle. This provides clear, real-time feedback to the driver or authorized personnel, enhancing user awareness and system transparency.

GSM Module

The GSM Module enables the microcontroller to send and receive SMS messages and calls. It plays a critical role in real-time communication by notifying the driver's emergency contact when alcohol is detected above the predefined threshold. By connecting to cellular networks, the GSM Module can transmit alerts even without Wi-Fi, ensuring that authorized individuals are informed immediately. This component enhances the system's safety response by sending automatic messages to the designated emergency contacts.

GPS Module

The GPS Module allows the microcontroller to determine the real-time location of the vehicle. It becomes especially useful when alcohol is detected above the predefined threshold, enabling location tracking of the vehicle for safety and monitoring purposes. Once the location is acquired, the system uses the GSM Module to send this information to the authorized emergency contact, ensuring quick response and situational awareness.

Power Source

The power source is essential in delivering the necessary energy to all components in the Alcohol Detection and Control System. It ensures that each part receives the correct voltage for optimal performance and stable operation. A reliable power supply helps prevent system issues such as incorrect sensor readings, delayed relay actions, or malfunctioning of the ESP32, all of which could compromise system efficiency and accuracy.

Breadboard

The breadboard serves as a temporary platform for connecting components like the ESP32, relay, sensors, and other electronics used in the system. Its flexibility allows for easy placement and removal of parts, which is valuable during testing and validation. Once the setup is verified and all components function properly together, it provides confidence to transition the design to a more permanent solution like a PCB.

Jumper Wires

Jumper wires are crucial for building and testing the Alcohol Detection system. They allow easy and flexible connections between different components on the breadboard and the ESP32. These wires are especially useful during prototyping, troubleshooting, and verifying circuit functionality, enabling seamless connectivity across breadboards and within the circuit setup.

Printed Circuit Board (PCB)

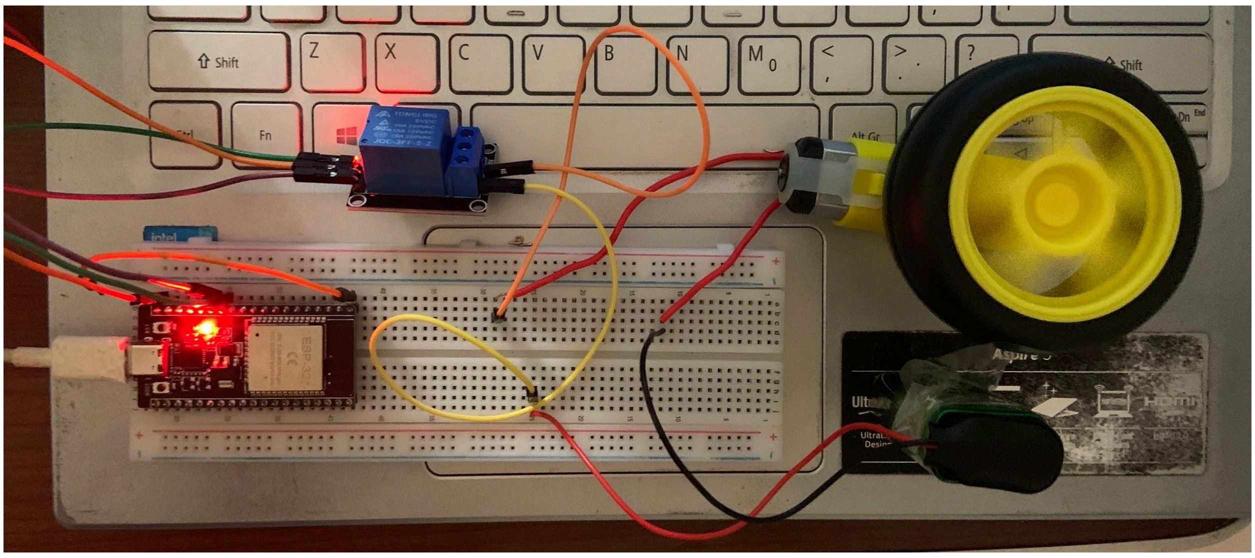
A PCB is made from a non-conductive substrate with conductive paths etched onto it, allowing for the secure and permanent mounting of electronic components such as resistors and diodes. Unlike breadboards, PCBs offer more reliable, long-term connections through soldered joints. This makes them ideal for final implementations, where consistent performance and minimal risk of loose connections are required.

3.4 Verification of Materials

This section is crucial for the development process of the system. By verifying the quality and reliability of the selected materials, the researchers could ensure that they work under specific conditions. Proper material verification guarantees that the system is under good performance, can work for a long period, and is safe for the aquatic environment. Refusing to undergo this process may result in safety hazards for the aquatic life, reduce the system's lifespan, and affect the overall performance.

DC Motor and Relay

To verify the functionality of the DC motor and relay, a test circuit was assembled using a separate 9V power source, the ESP32 microcontroller, and a basic test code uploaded to the ESP32. In the setup, the relay module was connected to a GPIO pin of the ESP32, allowing the microcontroller to control the relay's switching operation. The DC motor was connected through the relay's normally open (NO) contact and powered by the external 9V battery. The test code was designed to toggle the GPIO pin between HIGH and LOW states at timed intervals, thereby switching the relay ON and OFF. When the relay was activated, the DC motor successfully powered on; when deactivated, it powered off. This confirms that both the relay and the motor are fully functional, correctly wired, and receiving appropriate voltage and current. It also validates that the assigned GPIO pin on the ESP32 is delivering the necessary logic levels to drive the relay module. This successful response ensures the components are ready for integration into the full project system.



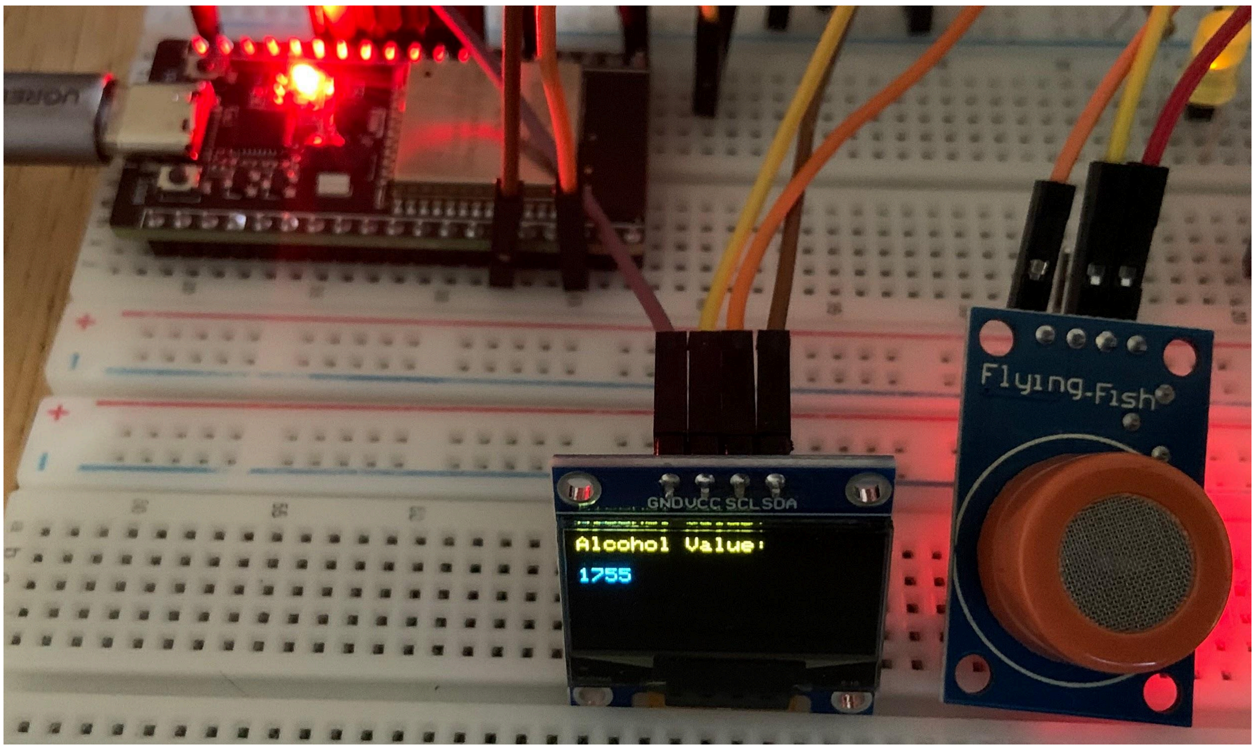
```
#define RELAY_PIN 12 // GPIO on ESP32

void setup() {
  pinMode(RELAY_PIN, OUTPUT); // Set pin as output
}

void loop() {
  digitalWrite(RELAY_PIN, LOW); // Trigger the relay (if active LOW)
  delay(2000);  // Keep it triggered for 2 seconds
  digitalWrite(RELAY_PIN, HIGH); // Turn off relay
  delay(2000);  // Wait for 2 seconds
}
```

OLED Display and MQ-3 Alcohol Sensor

To ensure the reliability of the visual output system, the OLED display module was tested using an ESP32 microcontroller. A basic test program was uploaded to evaluate the functionality of the communication interface. The OLED successfully displayed the expected text, confirming correct wiring, adequate power supply, and effective I2C data transmission. Brightness, contrast, and text size were also evaluated to ensure legibility under varying lighting conditions, a critical requirement for field operations.

The MQ-3 alcohol sensor was assessed for its ability to detect alcohol concentration. It was connected to the ESP32, and a simple analog reading was used to monitor real-time sensor output. Initially, the sensor's output was observed under normal conditions. Then, alcohol vapor was introduced near the sensor, resulting in a noticeable and consistent increase in analog values. This confirmed the sensor's responsiveness and sensitivity to alcohol presence.

The successful performance of both components validates their integration with the ESP32. The OLED display provides real-time, clear visual feedback, while the MQ-3 sensor accurately detects alcohol levels. Together, they form a dependable system suited for safety-critical applications such as vehicle access control, where real-time alcohol detection and user notification are essential.




```
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels
#define OLED_RESET     -1 // Reset pin #

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);
```

```
const int MQ3Pin = 34; // Analog pin for MQ-3

void setup() {
 // Initialize the OLED
 if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
 // Address 0x3C for OLEDs
 while (true); // Infinite loop if OLED init fails
 }

 display.clearDisplay();
 display.setTextSize(1);
 display.setTextColor(SSD1306_WHITE);

 display.setCursor(0, 0);
 display.println("MQ-3 Alcohol");
 display.display();
 delay(2000);
}

void loop() {
 int sensorValue = analogRead(MQ3Pin);
 display.clearDisplay();
 display.setCursor(0, 0);
 display.print("Alcohol Value: ");
 display.setCursor(0, 16);
 display.print(sensorValue);
 display.display();
 delay(1000);
}
```

```
// Include Libraries
#include <Wire.h>
#include <TinyGPSPlus.h>
#include <HardwareSerial.h>


// Pin Definitions
#define GPS_RX_PIN 4     // GPS TX → GPIO4 (ESP32 receives here)
#define GPS_TX_PIN 14    // GPS RX ← GPIO14 (ESP32 transmits here)


// Global Variables
TinyGPSPlus gps;
HardwareSerial SerialGPS(1);  // UART1 for GPS
```

```
float Lat = 0;
float Lng = 0;
float horizontal_speed = 0;
int16_t ax, ay, az;
float ACC_THRESHOLD = -5.0;
float SPEED_THRESHOLD = 35.0 / 3.6;


// Timing variables
unsigned long lastGpsPrint = 0;
const unsigned long GPS_PRINT_INTERVAL = 1000;


void setup() {
 Serial.begin(115200);
 delay(1000);


 // Initialize GPS on UART1
 SerialGPS.begin(9600, SERIAL_8N1, GPS_RX_PIN, GPS_TX_PIN);
 delay(3000);
 Serial.println("Initializing GPS...");

}


void loop() {
 unsigned long currentMillis = millis();


 // === 1. Process GPS Data Continuously ===
 while (SerialGPS.available()) {
   char c = SerialGPS.read();
   if (gps.encode(c)) {
     //Serial.println("GPS sentence parsed.");  // Debug line
     if (gps.location.isValid()) {
       Lat = gps.location.lat();
       Lng = gps.location.lng();


       if (gps.speed.isValid()) {
         horizontal_speed = gps.speed.mps();
       }
     }
   }
 }
```

```
 // === 2. Debug GPS Data ===
 if (currentMillis - lastGpsPrint >= GPS_PRINT_INTERVAL) {
  if (gps.location.isValid()) {
   Serial.print("Lat: "); Serial.print(Lat, 6);
   Serial.print(" | Lng: "); Serial.print(Lng, 6);
   Serial.print(" | Speed: "); Serial.print(horizontal_speed * 3.6);
   Serial.print(" km/h | Sats: "); Serial.println(gps.satellites.value());
  } else {
   Serial.println("Waiting for GPS fix...");
  }
  lastGpsPrint = currentMillis;
 }
}
```

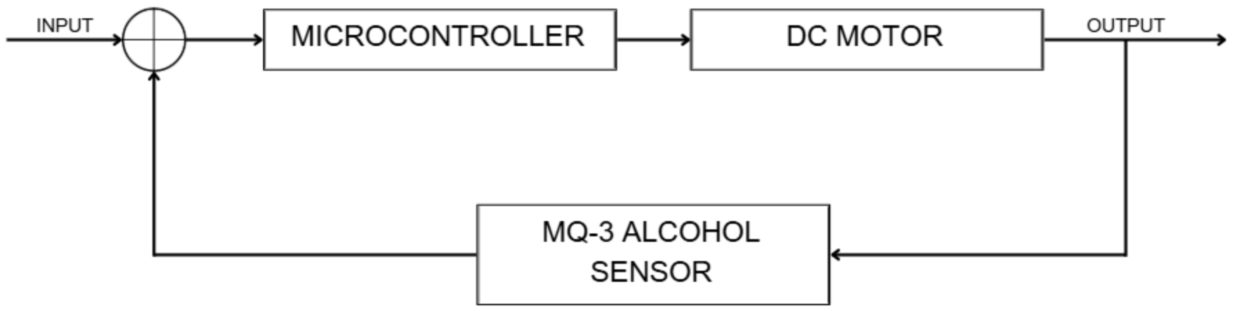
Code for Verification of the GPS Module

DESIGN CONCEPT

3.5 Conceptual Framework

This section illustrates how the different materials work together to form a complete system. It offers a visual representation that shows the flow and interaction between components. The three main elements included are the block flow diagram, the schematic diagram, and the microcontroller pinout diagram.

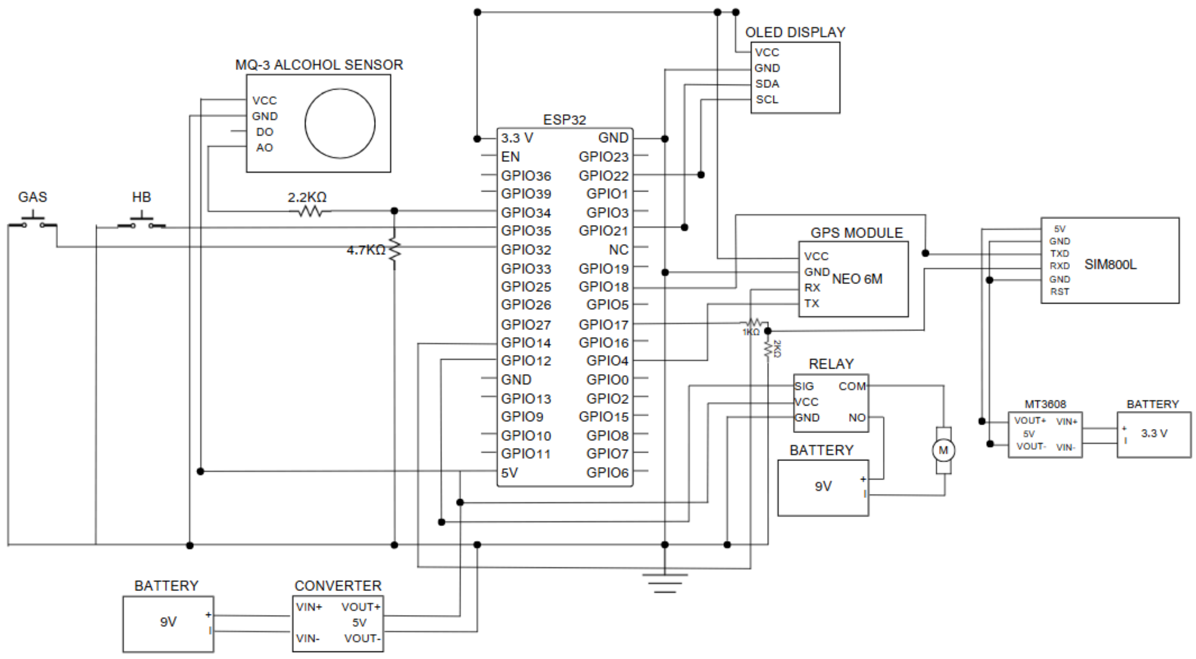
3.5.1 Block Flow Diagram



This block flow diagram illustrates the complete structure and operation of the Microcontroller-Based Alcohol Detection and Vehicle Immobilization System. It provides the step-by-step process of how data is gathered, analyzed, and used to produce outputs that help maintain proper system function. Each block corresponds to a specific component and its role within the system, with connections showing how they interact. The system operates in a continuous closed-loop, driven by three key components: the MQ-3 alcohol sensor, the ESP32 microcontroller, and the control mechanism, which includes a DC motor as its actuator.

The diagram further illustrates the real-time feedback loop between the MQ-3 alcohol sensor, ESP32 microcontroller, and the relay-controlled motor. The microcontroller processes alcohol readings, compares them to a predefined threshold, and then activates or deactivates the relay accordingly. This relay controls the vehicle's ignition system, allowing or preventing engine operation based on the detected alcohol level. Through continuous monitoring, the system can automatically disable or enable the ignition, ensuring driver safety by reducing the risk of drunk driving without requiring manual control.

3.5.2 Schematic Diagram



The schematic diagram illustrates a microcontroller-based alcohol detection and vehicle control system designed primarily to enhance driver safety. At the core of the system is the ESP32 microcontroller, which manages various input and output components. The MQ-3 alcohol sensor is responsible for detecting the presence of alcohol in the user's breath. It provides both analog and digital signals to the ESP32, allowing it to interpret the alcohol concentration. Based on the sensor's readings, the ESP32 controls several LEDs (white, red, green, and yellow) to indicate different system statuses or alcohol levels. Additionally, a buzzer is connected to the ESP32 to emit a warning sound when alcohol is detected beyond a safe threshold.

To enhance the system's functionality, a GPS module is integrated via serial communication (TX/RX), enabling location tracking that could be useful in emergency or monitoring scenarios. An OLED display, connected via the I2C interface (SDA and SCL), shows real-time information such as alcohol levels, system status, or GPS coordinates. A relay module is included to control a 9V battery-powered load, which could represent a vehicle's ignition system. When alcohol is detected, the ESP32 can deactivate the relay, effectively preventing the vehicle from starting. The entire system is powered by a 9V battery, with careful distribution to each component via appropriate power and ground connections. This integrated setup provides a comprehensive and automated safety mechanism against drunk driving.

3.6 Design Procedures

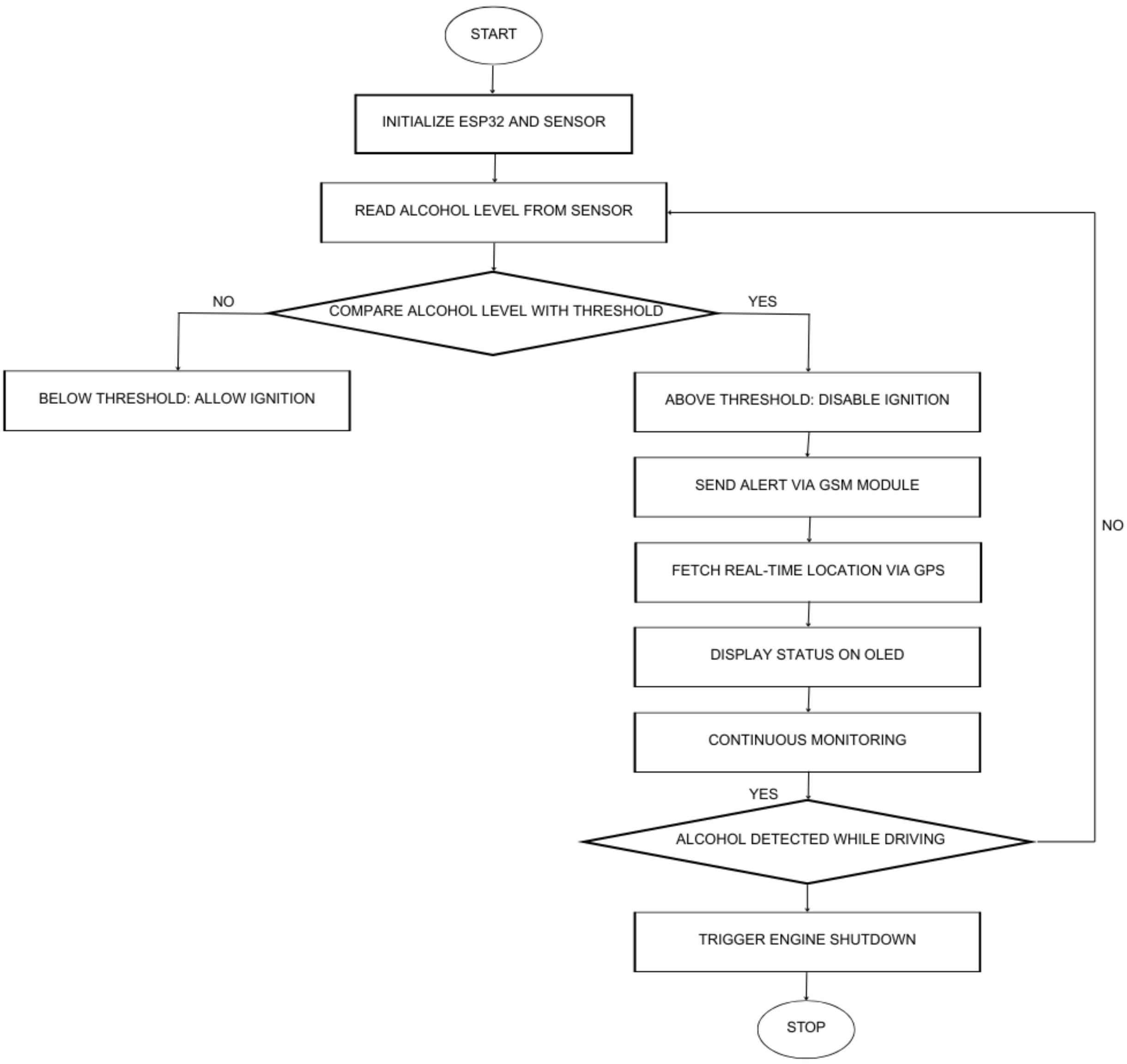


Figure: Flow Chart of Microcontroller-Based Alcohol Detection and Vehicle Immobilization System

This system is intended to prevent drunk driving by combining an alcohol-detecting method with vehicle control functions. It ensures that drunk drivers cannot operate a car and notifies emergency contacts in the event of a violation. The ESP32 microcontroller acts as the central processing unit, with GSM and GPS modules providing additional communication and tracking capabilities. The relay module enforces ignition control by turning on or off the engine.

The system works by detecting the driver's alcohol level and automating procedures to ensure road safety. The device measures the amount of alcohol in the driver's breath using an MQ-3 alcohol sensor. The data is handled by the ESP32 microcontroller, which compares the detected level to a predetermined threshold. If the alcohol level is below the legal limit, the vehicle will operate normally. If the alcohol level exceeds the threshold, the device automatically shuts the vehicle's ignition, preventing the driver from starting it. At the same time, the GSM module sends an SMS alert to designated emergency contacts while the GPS module obtains the vehicle's current location for tracking. The system also has an OLED display that shows real-time status updates. Furthermore, constant surveillance ensures that if alcohol is detected while the car is in motion, the system automatically shuts down the engine to avoid accidents.

This device decreases the hazards of drunk driving and improves overall road safety by combining alcohol detection with vehicle immobilization and remote monitoring.

3.7 Design Computations

MQ-3 ALCOHOL SENSOR

$$V_{OUT} = V_{IN} \times \frac{R_2}{R_1+R_2}$$
$$V_{OUT} = 5V \times \frac{4.7\ k\Omega}{2.2k\ \Omega+4.7\ k\Omega}$$
$$V_{OUT} \approx 3.41V$$

The MQ-3 sensor uses a voltage divider formed by two resistors: **R1 = 2.2kΩ** and **R2 = 4.7kΩ**. This divides the 5V supply to a lower voltage suitable for the analog input pin of the ESP32. This voltage is within the safe range for the ESP32 analog input, which accepts up to 3.3–3.5V (with internal attenuation).

GSM MODULE SIM800L

$$V_{OUT} = V_{IN} \times \frac{R_2}{R_1+R_2}$$
$$V_{OUT} = 5V \times \frac{2\ k\Omega}{1\ k\Omega+2\ k\Omega}$$
$$V_{OUT} \approx 3.33V$$

The SIM800L module is sensitive and operates best at around **3.3V**. Using a similar voltage divider for its RX pin (to protect it from the ESP32's 5V logic), the resistors used are **R1 = 1kΩ** and **R2 = 2kΩ**. This output ensures that the signal from the ESP32 to the SIM800L's RX pin does not exceed the module's voltage limit and keeps the module safe during communication.

DESIGN COST

3.8 Trade-Off Analysis

This section focuses on assessing and comparing different component options to determine the most suitable ones for this system. Factors such as performance, cost, reliability, and lifespan are taken into account. It also includes a detailed explanation of the final component selection and the reasons behind each choice.

Mounting of components

Printed Circuit Board (PCB)	Breadboard
Components are soldered into it to provide strong and permanent connections.	Connections are temporary and may loosen easily over time, making them vulnerable to noise.
Suitable for long-term use and for repeated use in different projects.	Less durable and unsuitable for permanent installations due to wear over time.
Provides a clean and professional appearance for electrical connections.	It may appear messy, especially in complex circuits with numerous jumper wires.
Needs additional work since making	Connections are easily made, whether it be

connections requires skill in soldering components together	through solid, stranded, jumper wires, or the terminals of components themselves.
Used for finished products.	Primarily for prototyping and testing.

Table 3.8.1: Circuit Platform Trade-off Analysis

Although both boards are great for prototyping, PCB's offer a greater edge in creating the prototype. Although its only drawback is that it requires additional soldering of the components, it ensures that each component is secured in place, which makes it perfect in creating a polished and functional final prototype, unlike the breadboard that always creates room for error due to loose connections

Alcohol Sensor

MQ-3	Electrochemical	Infrared
Highly sensitive to alcohol, allowing it to accurately detect even trace amounts of alcohol gas in the surrounding environment.	Provides high accuracy and sensitivity in measuring the current generated by a chemical reaction between alcohol and an internal electrode.	Uses advanced optical technology to detect specific infrared wavelengths absorbed by alcohol molecules, allowing contactless, selective, and stable measurement without external environmental conditions or other gases.
Very low-cost sensor, typically ranging from ₱100 to ₱150. Ideal for prototyping, educational use, and low-budget projects.	Moderately priced sensor, price ranges from ₱500 to ₱1,500, depending on the brand and accuracy level. Ideal for mid to high-end applications that require greater reliability.	High-cost sensors, typically priced at ₱2,000 or more. Ideal for advanced safety systems and high-end detection applications due to its precision and non-contact functions.

Table 3.8.2: Alcohol Sensor Trade-off Analysis

While all alcohol sensors detect alcohol effectively, they differ in cost and performance. The MQ-3 is great for budget-friendly prototypes but has limited accuracy. Electrochemical sensors offer improved precision and are better for more reliable setups. Infrared sensors, though pricey, deliver the best accuracy and consistency, making them ideal for high-end and safety-focused applications.

GSM Modules

SIM800L	SIM800A	SIM900A
It has quad-band support, which allows it to work globally across various GSM networks.	Utilized in a dual-band network, that limits its use in a certain region.	Also utilizes a dual-band network that makes it suitable for regional applications but not for global deployment.
It also offers faster GPRS connectivity, supports both SMS and voice calls,	A moderate GPRS performance was provided, enough for basic data and standard SMS operation.	Among these three, SIM900A has slower GPRS speeds, which can limit its use in data-heavy applications.
Has a compact size, making it	Just like other GSM modules,	It reliably supports SMS and

ideal for space-constrained IoT applications.	it supports SMS and voice calls.	voice calls, which has made it popular in legacy GSM applications.
It requires a stable power supply between 3.4V and 4.4V.	It is a bit bigger than SIM800L but still viable for most system projects.	Compared to these three, SIM900A has a larger size, which in miniaturized applications may be a constraint.
Typically priced between ₱150 and ₱300, it is one of the most affordable options for DIY and IoT projects due to its compact size and quad-band support.	Usually ranges from ₱200 to ₱400, slightly higher in cost because it is often used in region-specific applications and offers reliable basic functionality.	Generally priced between ₱250 and ₱450, making it the most expensive of the three. Its higher cost is due to its proven stability in legacy GSM systems and its larger physical size.

Table 3.8.3: GSM Module Trade-off Analysis

All GSM modules offer basic features like SMS and call functionality, but each one fits different project requirements. The SIM800L is a compact and affordable option, ideal for global IoT projects. SIM800A is slightly larger and region-locked but works well for general use. Meanwhile, SIM900A is best for legacy systems thanks to its stability, though its slower data speed and larger size can be a drawback for modern, space-limited designs.

GPS Module

NEO-6M	NEO-7M
Suitable for low-power embedded applications because it has slightly lower power consumption.	Suitable for an application that can afford the trade-off because it consumes slightly more power than NEO-6M but it provides enhanced performance.
It is widely used and more affordable in low-budget GPS projects.	By its increased accuracy and performance, being a bit more expensive is justified.
Typically priced between ₱250 and ₱400, making it a budget-friendly option for basic GPS tracking in hobby, academic, and entry-level IoT projects.	Generally costs between ₱350 and ₱600, slightly more expensive due to its improved performance, faster satellite lock time, and better sensitivity compared to the NEO-6M.

Table 3.8.4: GPS Module Trade-off Analysis

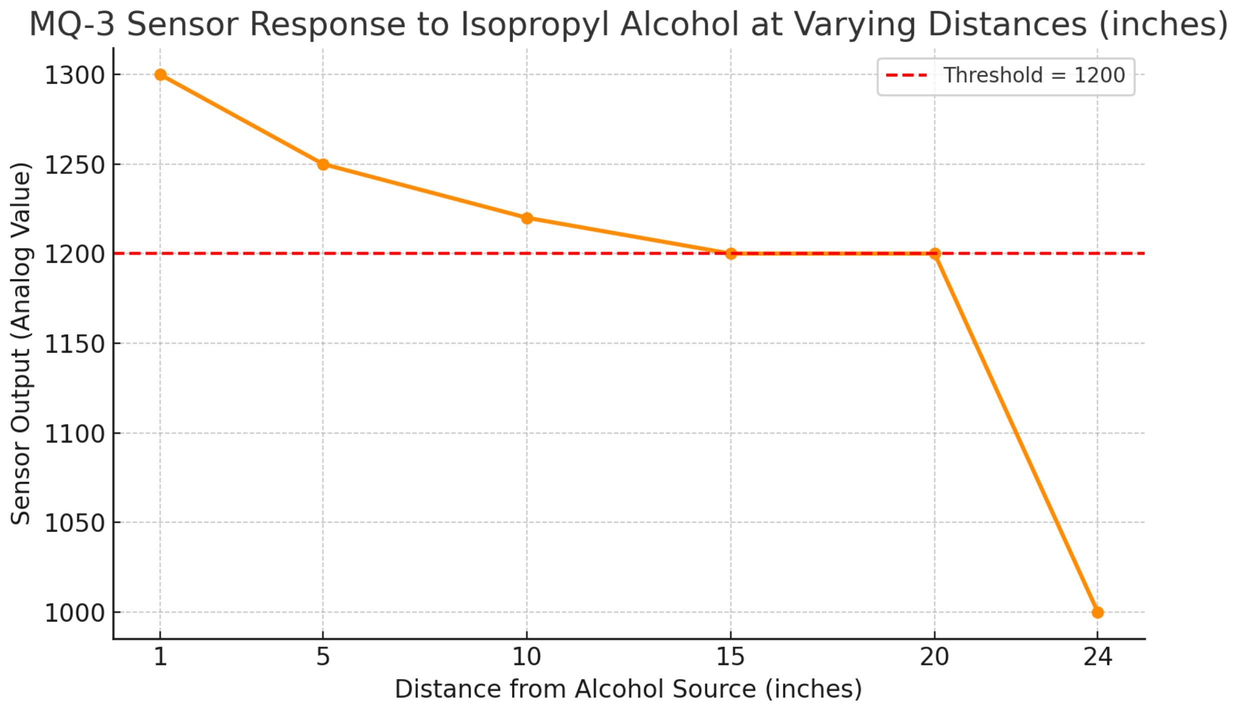
Both GPS modules perform well in tracking, but they cater to different needs. The NEO-6M is ideal for low-cost, low-power projects, making it popular in academic and beginner-level applications. In contrast, the NEO-7M offers improved accuracy, quicker satellite acquisition, and better sensitivity, suitable for more advanced projects that can manage slightly higher power use and cost. Its added features justify the price for applications that require more reliable GPS performance.

Chapter 4: Project Deliverables (Results and Discussion)

Testing the Distance of Alcohol Detection concentration

The MQ-3 sensor is engineered to detect a variety of alcohol vapors, including ethanol, methanol, and isopropanol. Although it exhibits the highest sensitivity to ethanol, it is also responsive to isopropyl alcohol, albeit with potentially varied readings due to differences in sensitivity across alcohol types.

For testing purposes, **isopropyl alcohol** was applied to a piece of cotton to create a concentrated vapor source. This setup allowed for controlled observation of the sensor's detection range and response behavior at varying distances from the alcohol source.



Distance (inches)	Threshold (1200)
1 inch	Above threshold
5 inches	Above threshold
10 inches	Above threshold
15 inches	Above threshold, but detection begins to slow slightly
20 inches	Still above the threshold, but the sensor takes longer to register the value
24 inches	1000 below. Falls below threshold, vapor too diffuse for detection

Factors That Can Affect Alcohol Detection Accuracy

- **Ventilation**
  Open windows, fans, or air conditioning can disperse alcohol vapors, reducing concentration around the sensor.
- **Airflow Direction and Speed**
  Direct airflow may carry vapors toward or away from the sensor, influencing detection timing and intensity.
- **Distance from the Sensor**
  The farther the alcohol source is from the sensor, the lower the concentration of vapors it detects.

- **Ambient Temperature**
  Higher temperatures can increase vaporization rate but may also affect sensor baseline values or introduce thermal drift.
- **Humidity**
  High humidity may interfere with gas sensing, as water vapor can alter the sensor's response to alcohol.
- **Presence of Other People (Other Passengers)**
  Alcohol from other individuals, especially in enclosed spaces, can lead to false positives or affect accuracy.
- **Sensor Warm-Up Time**
  MQ-3 sensors require a warm-up period (~1–2 minutes) to stabilize; readings before this can be inaccurate.
- **Contamination of Sensor Surface**
  Dust, oils, or residues on the sensor can reduce sensitivity or alter response time.
- **Sensor Age or Degradation**
  Over time, the sensor's sensitivity may degrade due to aging or prolonged exposure to alcohol vapors.
- **Power Supply Fluctuations**
  Inconsistent voltage can affect analog readings and sensor performance.

Developing a sensor project

The development of the sensor project for the Microcontroller-Based Alcohol Detection and Vehicle Immobilization System involved integrating various hardware components with embedded software to create a responsive and functional safety mechanism. The goal was to construct a real-time, sensor-driven system capable of detecting alcohol in the driver's breath and immediately responding by immobilizing the vehicle and notifying concerned parties.

System Integration and Assembly

The project was developed on a breadboard during the prototyping phase to allow for flexible testing and adjustments. Key components used include:

- **ESP32 Microcontroller –** served as the brain of the system, handling all sensor inputs and controlling outputs such as the relay and display.
- **MQ-3 Alcohol Sensor –** continuously monitors the alcohol concentration in the air near the driver's seat.
- **Relay Module** – connected to the ignition system (simulated via a DC motor) to enable or disable the engine based on alcohol detection.
- **OLED Display –** provided real-time visual feedback on alcohol levels and system status.
- **GSM Module (SIM800L)** – used for sending SMS alerts to emergency contacts if alcohol levels exceed the threshold.
- **GPS Module (NEO-6M)** – provides the real-time location of the vehicle in case of emergency.

Software Development and Coding

The microcontroller was programmed using the Arduino IDE. The code was structured to:

1. Continuously read analog values from the MQ-3 sensor.
2. Compare those readings to a predefined alcohol threshold (e.g., 1600).
3. Trigger the relay to disable the motor if the threshold is exceeded.
4. Display real-time status on the OLED screen.
5. Transmit SMS and GPS coordinates through the GSM and GPS modules, respectively.
6. Modular coding was applied to ensure each feature (sensor reading, relay control, display update, communication) functioned independently and cohesively.

Sensor Calibration and Environment Handling

To improve detection accuracy:

- The MQ-3 sensor was preheated before readings were taken.
- Delays and averaging techniques were added to filter noise from the sensor data.
- LED indicators were used to visually represent system stages—initialization, detection phase, safe status, and alarm.

System Logic Workflow

1. On startup, the OLED displays a warm-up message while the MQ-3 preheats.
2. If alcohol is detected above the threshold:
   - The relay disconnects the engine (simulated with a DC motor).
   - An alert message is displayed on the OLED.
   - The GSM module sends an SMS alert including GPS coordinates from the GPS module.
3. This sensor project development provides an integrated, automated system aimed at reducing alcohol-impaired driving by using embedded electronics and real-time monitoring.

Chapter 5: SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Findings

The Microcontroller-Based Alcohol Detection and Vehicle Immobilization System successfully integrated key components to prevent drunk driving. The MQ-3 sensor reliably detected alcohol within 1 to 15 inches, triggering the ESP32 microcontroller to disable the ignition via a relay-controlled DC motor. Upon detection, the GSM module sent SMS alerts, and the GPS module provided accurate real-time location data. Visual and audio feedback through the OLED display, buzzer, and LEDs ensured clear communication of system status. Overall, the system proved effective, responsive, and reliable in detecting alcohol and preventing vehicle operation under unsafe conditions.

Conclusion

The system effectively achieved its goal of enhancing road safety by preventing vehicle operation under the influence of alcohol. By integrating the MQ-3 alcohol sensor, ESP32 microcontroller, and modules for GSM and GPS communication, the device was able to detect alcohol accurately, disable ignition, and send alerts with real-time location. The combination of visual, audible, and remote notifications ensured immediate awareness and response. Overall, the project demonstrates a practical and cost-efficient solution for reducing drunk driving incidents through automation and real-time monitoring.

Results in terms of Accuracy

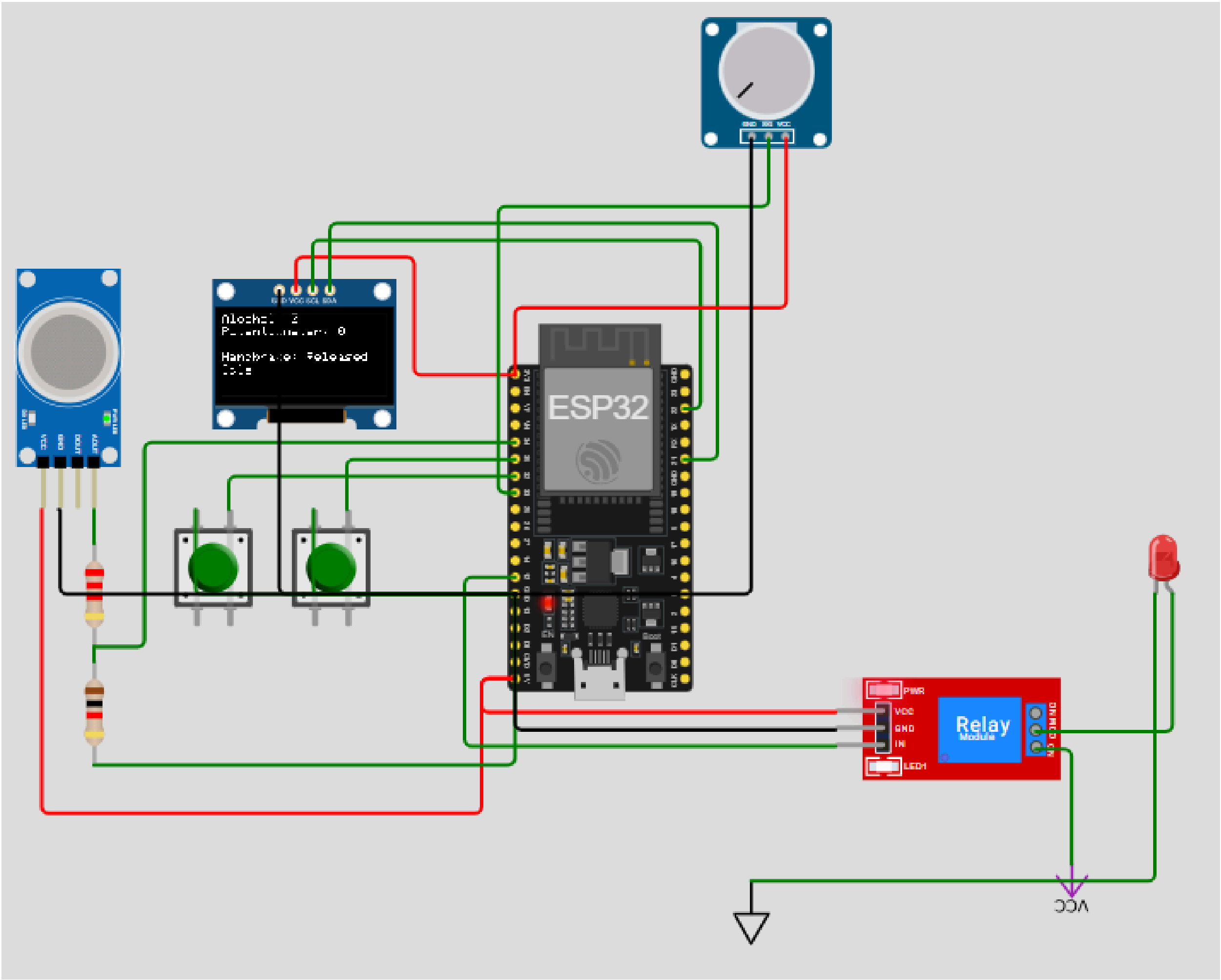
The system demonstrated high accuracy in detecting alcohol and responding appropriately. The MQ-3 sensor provided consistent readings, especially at close range, after proper calibration and warm-up. The ESP32 microcontroller processed data quickly, triggering the relay to disable the ignition within 1–2 seconds. The GPS module offered location accuracy within approximately 2.5 meters, and the GSM module reliably sent SMS alerts with minimal delay. Visual and audible indicators also responded correctly, ensuring clear and timely communication of system status.

Recommendations for Future Improvements

1. **Temperature and Heart Rate Monitoring biometric sensors** (like heart rate or temperature) to monitor driver health and detect signs of drowsiness or illness.
2. **Tamper Detection Feature.** Add tamper sensors or logs that alert the system owner if the alcohol sensor or circuit has been physically tampered with.
3. **Remote Engine Immobilization.** Allow **authorized users to remotely disable the engine** via SMS or an app if the vehicle is stolen or misused.
4. **Voice Command Integration.** Add support for voice commands to let the driver interact with the system hands-free, such as checking system status or issuing override commands.
5. **Delayed Engine Stop.** Implement a brief delay before engine shutdown to give the driver time to safely pull over and avoid abrupt stops that may cause accidents.
6. **Force Sensitive Resistor (FSR).** To improve the accuracy of detecting only the driver's breath, this sensor detects whether someone is seated in the driver's seat, allowing the alcohol sensor to activate only when the driver is present, reducing false readings from nearby passengers

WOKWI SIMULATION

https://wokwi.com/projects/431751661437496321



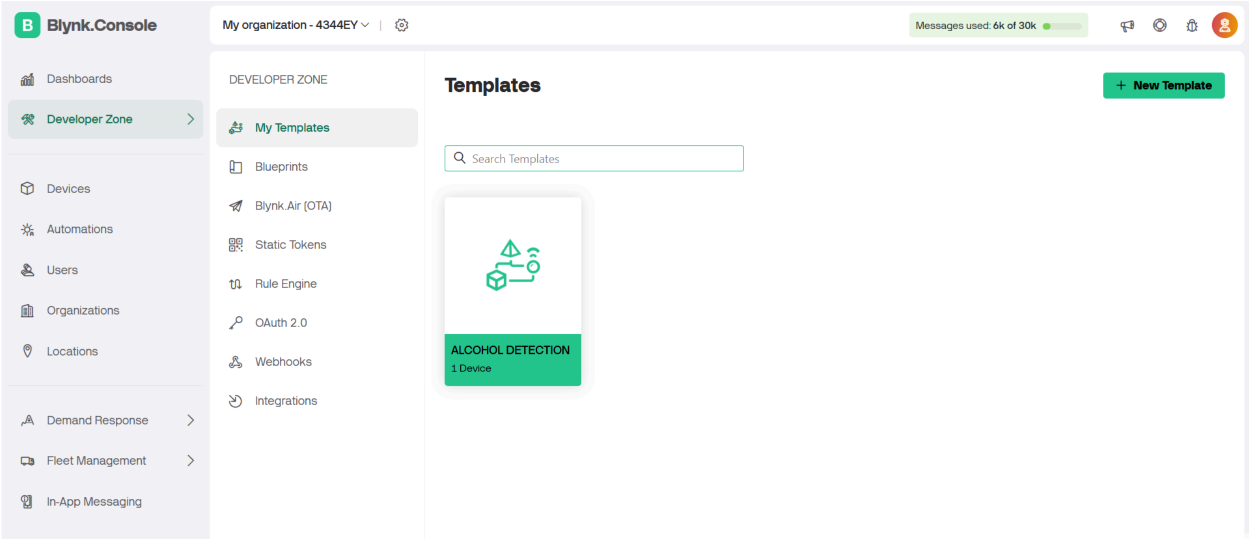
In the Wokwi simulation setup, certain hardware components from the actual prototype were replaced with virtual equivalents to facilitate proper functionality and testing. These substitutions were necessary due to the limitations of available components within the simulator.

To imitate the behavior of the MQ-3 alcohol sensor, a potentiometer was used. This allowed for manual adjustment of the analog input to simulate varying alcohol levels. By rotating the potentiometer, users could trigger the alcohol detection logic and observe how the system would respond under different simulated conditions. This substitution proved effective for verifying the alcohol threshold logic and system response without requiring a physical alcohol sensor.

Additionally, due to the unavailability of DC motors in Wokwi, an LED was used as a visual indicator to represent the motor's ON/OFF state. When the system conditions were met (i.e., no alcohol detected, handbrake released, and gas pedal pressed), the LED would turn ON, symbolizing the activation of the motor. Conversely, the LED remained OFF when any condition was unmet. This approach provided a clear and observable method to test the motor control logic and ensured the reliability of relay switching behavior.

Overall, these substitutions allowed for accurate simulation and verification of the core logic in the alcohol detection and vehicle control system. The simulation effectively demonstrated the system's intended functionality and provided a reliable platform for debugging and validation prior to physical implementation.

BLYNK IOT

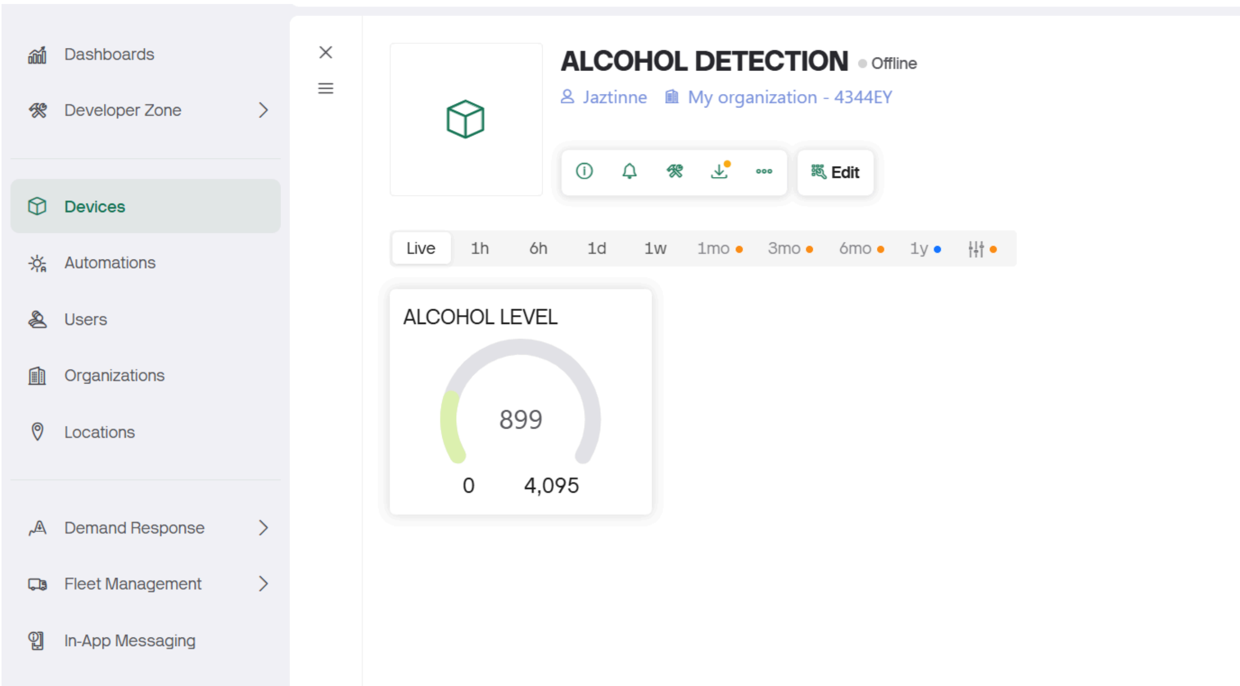


In the development of a microcontroller-based alcohol detection and vehicle immobilization system, integrating Blynk IoT offers a powerful and user-friendly approach to remotely monitor and control the system in real time. Blynk is a versatile Internet of Things (IoT) platform that allows developers to create customized dashboards and connect their hardware projects to smartphones or other internet-enabled devices. This functionality is particularly useful in applications like alcohol detection and vehicle control, where real-time data visualization and remote alerts enhance safety and user interaction.

With Blynk, the alcohol detection sensor data, such as the alcohol concentration measured by the MQ-3 sensor, can be transmitted wirelessly to a mobile device or web dashboard. This enables users, guardians, or authorized personnel to monitor the driver's alcohol levels from anywhere, increasing situational awareness and enabling quick responses.

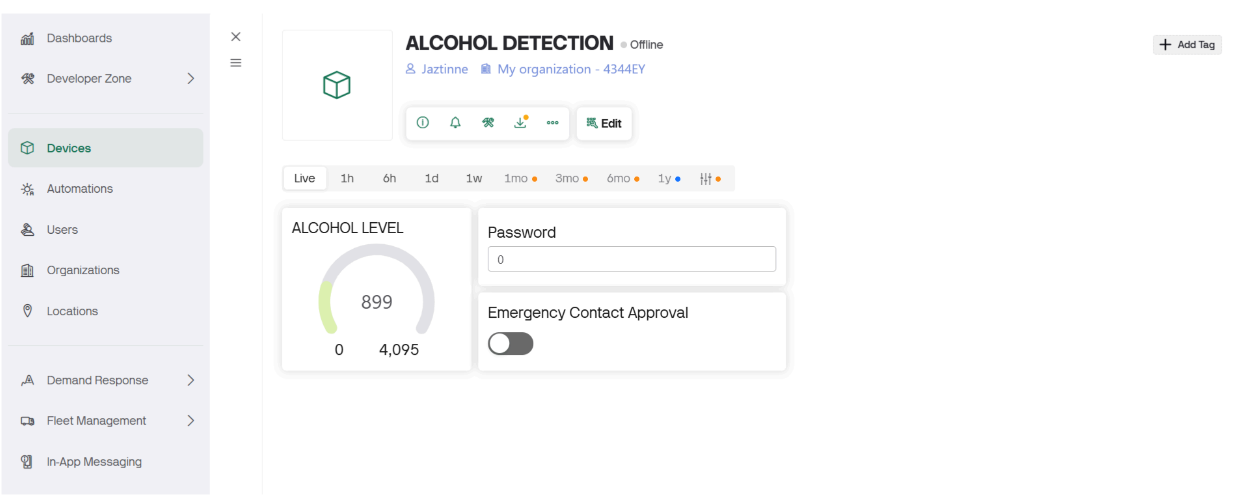
Blynk supports sending notifications, such as push messages or emails, when alcohol levels exceed safety limits. This feature can be extended to alert emergency contacts or vehicle owners. Additionally, Blynk can be programmed to send control signals back to the ESP32 microcontroller to immobilize the vehicle remotely or reset the system after authentication.

Incorporating Blynk IoT into the alcohol detection and vehicle control system enhances both functionality and usability. It transforms the prototype into a connected smart safety solution, providing real-time visualization, remote alerts, and interactive control that traditional systems cannot offer alone. This implementation of the alcohol level gauge as part of a Blynk template dashboard demonstrates an effective and intuitive way to monitor driver sobriety, contributing significantly to accident prevention efforts.



Creating a custom dashboard in Blynk is straightforward. In the project, we designed a dashboard with a gauge widget labeled “Alcohol Level”, which displays the sensor’s real-time readings. The gauge reflects the exact alcohol level detected by the prototype, ensuring accurate and immediate feedback on the driver’s intoxication status.

Blynk dashboard’s alcohol level gauge is linked to a virtual pin on the ESP32. The microcontroller reads the analog sensor value from the MQ-3 sensor, processes it, and updates the Blynk gauge in real time. This seamless data synchronization ensures that the displayed alcohol level on the dashboard matches exactly what the hardware senses.



Building on the current alcohol detection and vehicle immobilization system, our further development aims to improve security and user control by integrating additional Blynk IoT features to support double authentication mechanisms.

1. **Password Input via Text Widget for Driver Authentication**
   To enhance system security and ensure that only sober drivers operate the vehicle, we will implement a text input widget on the Blynk dashboard, enabling the driver to enter a predefined password. The password will be a carefully chosen combination of uppercase

and lowercase letters (e.g. DrIVeR noT DrUnK*)*, making it complex enough to prevent accidental or unauthorized bypass.

- The ESP32 will validate the entered password before enabling vehicle operation.
- If the password is incorrect or not entered, the system will continue to immobilize the vehicle.
- This step helps verify the driver's cognitive ability to input the password correctly, serving as an indirect sobriety check.

2. **Emergency Contact Approval with Switch Widget**
   Following successful password verification, a second layer of emergency contact approval will be required before the vehicle can be started. The emergency contact will have access to the Blynk dashboard and will use a switch widget to either:
   - Turn ON to approve and allow vehicle operation.
   - Turn OFF to deny and keep the vehicle immobilized.

This two-step authentication process adds a crucial fail-safe mechanism to prevent drunk driving by ensuring that an authorized individual confirms the driver's fitness to operate the vehicle. By requiring both the driver's password input and the emergency contact's approval, the system empowers emergency contacts to intervene remotely when necessary, thereby enhancing overall safety and accountability.

Appendix

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