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Smart Alcohol Sensing System for Vehicle Safety

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Abstract: Road accidents caused by drunk driving are a major concern worldwide. The Smart Alcohol Detection System for Vehicle Safety is designed to prevent such accidents by detecting alcohol consumption of the driver and restricting vehicle operation. This system uses an MQ-3 alcohol sensor to measure the alcohol concentration in the driver's breath. The sensor is interfaced with a microcontroller, which continuously monitors the alcohol level and compares it with a predefined safe limit. If the detected alcohol level exceeds the threshold value, the system automatically disables the vehicle ignition system and prevents the engine from starting. Additionally, a buzzer alert and warning message can be generated to indicate the presence of alcohol. Advanced versions of the system can also integrate GSM and GPS modules to send alert messages along with the vehicle's location to authorized contacts. The proposed system is cost-effective, reliable, and easy to install in vehicles. It enhances road safety by minimizing accidents caused by drunk driving and promotes responsible driving behaviour. This project demonstrates the practical implementation of embedded systems and sensor-based safety mechanisms in the automotive field.
Keywords: Smart Alcohol Detection System, Vehicle Safety, Drunk Driving Prevention, Vehicle Ignition Control, Driver Monitoring, Accident Prevention.

I. INTRODUCTION

Road safety remains a critical global concern, as alcohol-impaired driving continues to be a leading cause of fatal traffic accidents worldwide J. Smith [1]. While legal regulations and law enforcement efforts serve as important deterrents [2], they are inherently reactive and often fail to intercept intoxicated drivers before they begin operating a vehicle [3]. To address this persistent gap in road safety, this project presents the Smart Alcohol Detection System [4], a proactive, embedded solution designed to restrict vehicle operation when a driver is under the influence [5]. By integrating advanced sensing technology directly into the vehicle's infrastructure, the system provides an automated and reliable barrier against impaired driving [6], shifting the focus from post-incident enforcement to real-time accident prevention.

The core of the system utilizes an MQ-3 Alcohol sensor interfaced with a microcontroller to continuously monitor the driver's breath alcohol concentration (Br AC) before the vehicle is started Omary Bakari Salehe [7]. When the detected alcohol level exceeds a predefined safety threshold, the system immediately triggers a relay to disable the ignition [8], physically preventing the engine from firing [9]. Furthermore, the system is equipped with a buzzer and a visual alert interface to warn the driver of the restriction [10], with advanced configurations capable of utilizing GPS and GSM modules to transmit location-based alerts to emergency contacts [11]. By promoting responsible driving behaviour through technological intervention R. Kuma [12], this paper demonstrates a cost-effective and scalable approach to minimizing alcohol-related fatalities and enhancing overall automotive safety.

The key contributions of this work are summarized as follows:

1) To design and develop a smart alcohol detection system for vehicle safety.
2) To detect the presence of alcohol in the driver's breath using an MQ-3 alcohol sensor.
3) To continuously monitor the alcohol concentration level before vehicle operation.
4) To prevent vehicle ignition when the detected alcohol level exceeds the predefined threshold.

The remainder of this paper is organized as follows: Section 2 describes the proposed system and overall methodology. Section 3 presents the hardware implementation. Section 4 explains the working principle of the system. Section 5 discusses the experimental results and analysis. Finally, Section 6 concludes the paper.

II. PROPOSED SYSTEM AND METHODOLOGY

The proposed Smart Alcohol Detection System for Vehicle Safety is designed to prevent accidents caused by drunk driving by automatically detecting the presence of alcohol in the driver's breath before and during vehicle operation. The block diagram of proposed system is presented in figure 1.

The system utilizes an MQ-3 alcohol sensor interfaced with a microcontroller to continuously monitor the alcohol concentration level. When the detected alcohol level exceeds a predefined threshold, the microcontroller immediately disables the vehicle ignition system, preventing the vehicle from starting. If alcohol is detected while the vehicle is in motion, an alert is generated and appropriate safety actions can be initiated. The system also incorporates a buzzer and LCD display to provide real-time warnings and status information to the driver. The compact design, low power consumption, and cost-effective implementation make it suitable for installation in personal vehicles, commercial transport systems, and public transportation. By integrating alcohol detection directly into the vehicle control system, the proposed solution offers a proactive approach to road safety and significantly reduces the risk of alcohol-related accidents.

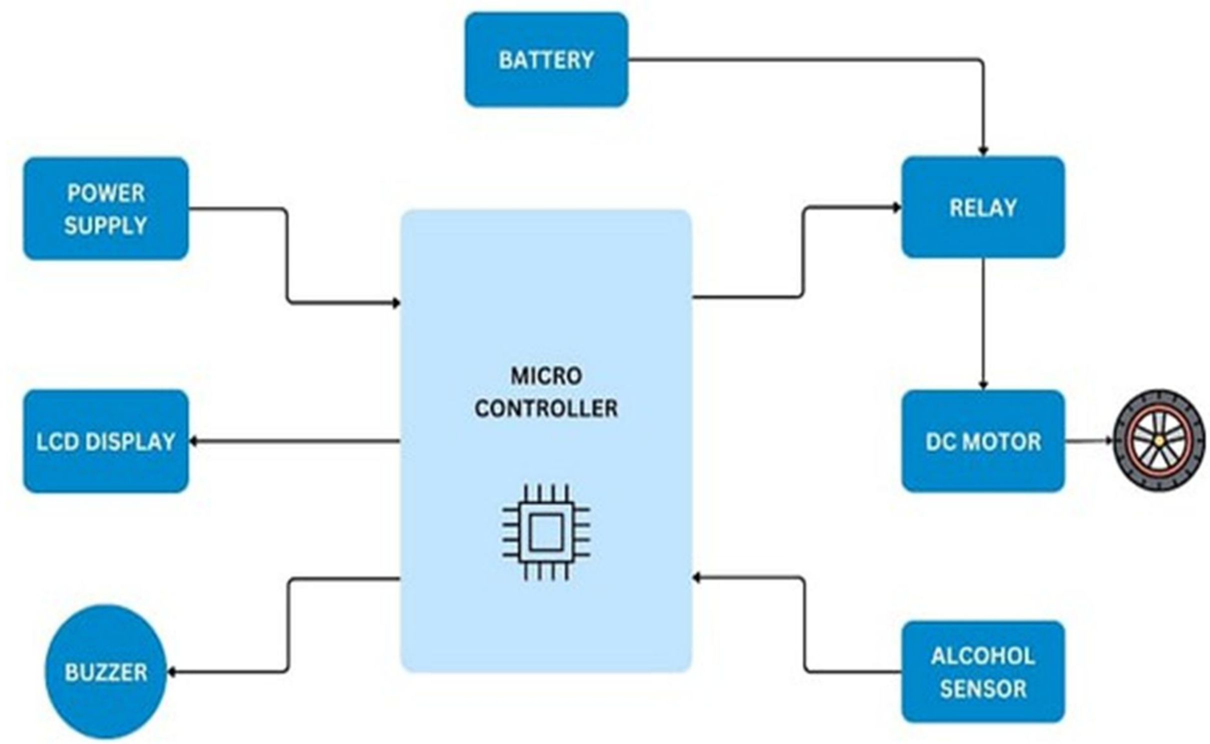

Fig.1 Block Diagram of Proposed System

A. System Working Description

The system block diagram shown in Fig.1 represents the hardware architecture of the Smart Alcohol Detection System for Vehicle Safety. The architecture illustrates the interaction between the microcontroller and various peripheral devices, including the alcohol sensor, relay, buzzer, LCD display, power supply, battery, and DC motor. The system is designed to monitor the driver's alcohol level and prevent vehicle operation if intoxication is detected.

The power supply unit provides the required operating voltage to the microcontroller and other low-power electronic components. A battery is used as the primary energy source for the DC motor, which represents the vehicle's engine or ignition system. The battery power is controlled through a relay that acts as an electronic switching device. This arrangement ensures reliable operation of both the control circuitry and the vehicle ignition mechanism.

At the core of the system is the microcontroller, which functions as the central processing unit. It continuously receives input data from the alcohol sensor, processes the information according to the programmed logic, and generates appropriate control signals for the output devices. The microcontroller is responsible for making decisions based on the detected alcohol concentration and controlling the overall operation of the system.

The alcohol sensor serves as the primary sensing element of the system. It continuously monitors the surrounding air for the presence of ethanol vapours in the driver's breath. The sensor converts the detected alcohol concentration into an electrical signal and sends it to the microcontroller. The microcontroller then compares the received signal with a predefined threshold value to determine whether the alcohol level is within the safe limit.

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The system includes several output devices to provide warnings and control actions. The LCD display provides real-time information regarding the system status, such as system readiness, alcohol detection, and vehicle access conditions. The buzzer functions as an audible alert mechanism and is activated whenever alcohol levels exceed the permissible limit. This warning notifies both the driver and nearby individuals about the unsafe condition.

The relay is the most important safety component in the system. It acts as an electrically controlled switch between the battery and the DC motor. When the alcohol level is below the threshold value, the microcontroller energizes the relay, allowing current to flow from the battery to the motor, thereby enabling normal vehicle operation. However, when alcohol is detected above the specified limit, the microcontroller deactivates the relay, interrupting the power supply to the motor and preventing the vehicle from starting.

The DC motor is used to represent the vehicle's ignition or engine system in the prototype model. Its operation demonstrates the functionality of the vehicle control mechanism. The motor runs only when the driver is sober and the system determines that it is safe to operate the vehicle.

Overall, the Smart Alcohol Detection System continuously monitors the driver's alcohol level and takes immediate action whenever intoxication is detected. The microcontroller processes data from the alcohol sensor, activates warning devices such as the buzzer and LCD display, and simultaneously disables the vehicle ignition through the relay. This integrated approach enhances road safety by preventing alcohol-impaired driving and reducing the likelihood of accidents.

III. HARDWARE IMPLEMENTATION

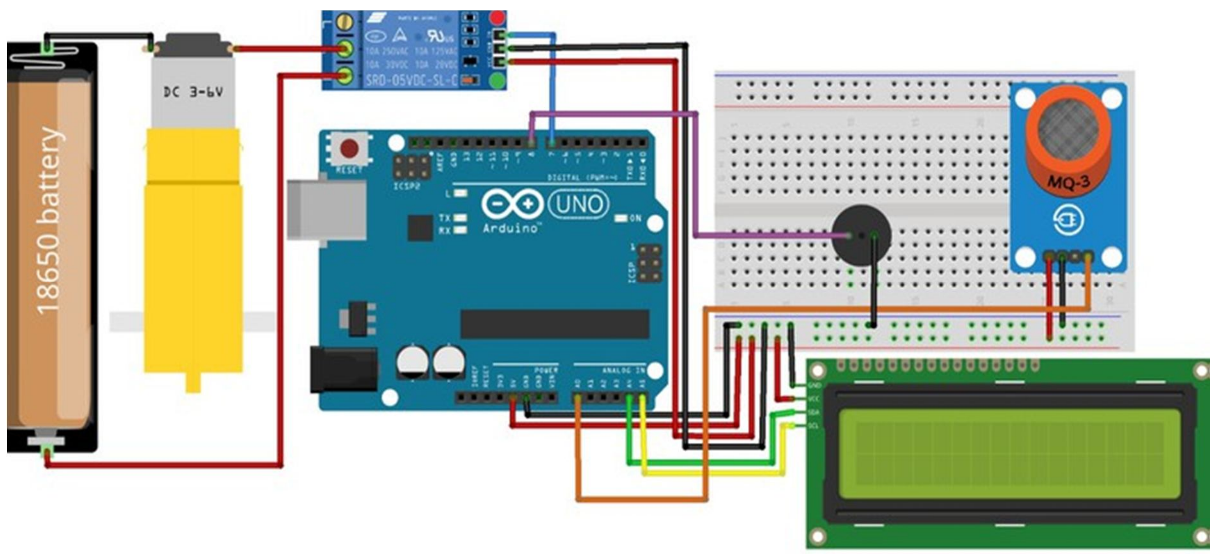

Fig.2 Hardware Setup of the Proposed System

Figure 2 shows the Hardware Setup of the Proposed System. The hardware setup of the Smart Alcohol Detection System is designed to provide a reliable and efficient mechanism for preventing vehicle operation under the influence of alcohol. The entire system is built around the Arduino UNO microcontroller, which serves as the central control unit responsible for coordinating all sensing, processing, and control operations. The major hardware components used in the system include the MQ-3 alcohol sensor, Arduino UNO, relay module, DC motor, 16×2 LCD display with I2C interface, buzzer, LED indicator, 18650 battery, and regulated power supply unit. Each component performs a specific function that contributes to the overall operation of the system.

The MQ-3 alcohol sensor is the primary sensing element used for detecting alcohol vapours present in the driver's breath. It is connected to the analogue input pin A0 of the Arduino UNO and continuously monitors the surrounding air. The sensor is highly sensitive to ethanol and generates an analogue output voltage proportional to the concentration of alcohol detected. The Arduino reads this analogue signal and processes it to determine whether the detected alcohol level is within the permissible range. The sensor is positioned in such a way that it can effectively sample the driver's breath before vehicle ignition.

A relay module is employed as an electrically operated switch to control the operation of the DC motor, which represents the vehicle's ignition or engine system.

The relay is connected to one of the Arduino's digital output pins and acts as an interface between the low-power control circuit and the high-power load. Under normal conditions, when no alcohol is detected, the relay remains energized, allowing current from the battery to reach the motor. However, when alcohol is detected above the threshold level, the relay is deactivated, interrupting the power supply and preventing the motor from operating. This mechanism forms the core safety feature of the proposed system.

The system also includes a 16×2 LCD display integrated through an I2C communication module. The display provides real-time information regarding system status, sensor readings, and warning messages. By utilizing I2C communication, only two signal lines are required for data transfer, significantly reducing wiring complexity and conserving Arduino input/output pins. In addition to the display, a buzzer and LED indicator are connected to digital output pins of the Arduino. These components provide immediate audio and visual alerts whenever alcohol is detected, ensuring that the driver is informed about the unsafe condition. The entire system is powered using a regulated power supply, while an 18650 rechargeable battery provides sufficient energy to drive the DC motor. The combination of these hardware components creates a compact, cost-effective, and highly reliable vehicle safety system.

IV. WORKING PRINCIPLE

The working principle of the Smart Alcohol Detection System is based on continuous monitoring of alcohol concentration in the driver's breath and controlling vehicle operation according to the detected level. When the system is powered on, the Arduino UNO initializes all connected peripherals, including the alcohol sensor, LCD display, relay module, buzzer, and LED indicator. The MQ-3 sensor requires a short warm-up period to stabilize its sensing element and provide accurate measurements. Once stabilized, the sensor begins continuously sampling the surrounding air and generating an analogue voltage corresponding to the detected alcohol concentration.

The analogue output from the MQ-3 sensor is fed into the Arduino's analogue input pin, where it is converted into a digital value using the built-in Analog-to-Digital Converter (ADC). The microcontroller continuously compares the obtained sensor value with a predefined threshold level stored in the program. This threshold represents the maximum permissible alcohol concentration allowed for safe vehicle operation.

If the detected value remains below the threshold, the system considers the driver to be sober and allows normal vehicle operation. In this condition, the relay remains activated, enabling power flow from the battery to the DC motor. The LCD display indicates a safe status message, confirming that the vehicle is ready for operation.

When the alcohol concentration exceeds the predefined threshold, the system immediately identifies the presence of alcohol in the driver's breath. The Arduino then executes a series of safety actions designed to prevent vehicle operation. First, the relay is deactivated, cutting off the electrical connection between the battery and the DC motor. This effectively prevents the motor from running and simulates the locking of the vehicle's ignition system.

Simultaneously, the buzzer is activated to generate an audible warning signal, while the LED glows to provide a visual indication of the detected alcohol condition. The LCD display updates its message to inform the user that alcohol has been detected and that vehicle operation is restricted.

The system continues monitoring the alcohol level in real time even after detection. This continuous monitoring ensures reliable operation and prevents accidental vehicle usage by an intoxicated driver. The integration of sensing, processing, alert generation, and engine control mechanisms creates a proactive safety solution that can significantly reduce alcohol-related road accidents. By automatically preventing vehicle ignition when unsafe alcohol levels are detected, the proposed system enhances road safety and promotes responsible driving behavior.

V. RESULTS AND DISCUSSIONS

This chapter presents the experimental results obtained from the developed smart alcohol detection system with autonomous vehicle ignition interlocking and telemetric alert monitoring. The prototype system was tested under distinct operating conditions—including clean ambient air baselines and varying simulated breath alcohol concentration (Br AC) levels—to evaluate sensor responsiveness, relay switching accuracy, and localized visual-auditory alert performance. The obtained real-time analytical readings were displayed locally on the embedded 16X2 character Liquid Crystal Display (LCD) interface and successfully verified against the hardware's fail-safe execution routines.

A. LCD Based System Monitoring

Fig.3 Showing alcohol detection system ready on lcd screen

The image displays a standard 16X2 alphanumeric Liquid Crystal Display (LCD) module functioning as the primary user interface for the project. The alcohol detection system ready on lcd screen presented in figure 3. The screen features a blue background backlight with white characters, which provides clear visibility under various lighting conditions inside a vehicle cabin. The text on the screen is divided across two lines, presenting the user with real-time status updates regarding the system's operational state.

The message reading **"Alcohol Detect"** on the top line and **"System Ready"** on the bottom line indicates that the microcontroller has successfully booted up and initialized all connected hardware peripherals. At this stage, the system has completed its internal power-on self-tests and the MQ-3 sensor has undergone its initial heating phase to stabilize its internal chemistry. The system is now actively waiting to receive and process a breath sample from the driver.

While this specific message is displayed, the system remains in a monitoring loop, keeping the vehicle's ignition relay in a neutral state. This visual confirmation is crucial for the operator, as it signals that the device is fully functional, free of errors, and prepared to evaluate the driver's sobriety before allowing vehicle operation.

B. Normal Condition Readout and Safe Threshold Verification

Fig.4 Showing no alcohol on lcd screen

The figure 4 illustrates the real-time operational readout of the system under normal, safe environmental conditions. The LCD module displays two critical pieces of data processed by the microcontroller's firmware logic. The top row provides a numerical value corresponding to the sensor's current atmospheric measurement, while the bottom row provides a clear text-based status update for the operator.

The first line reads **"Sensor: 54"**, which represents the raw digital value obtained by the microcontroller's Analog-to-Digital Converter (ADC) from the MQ-3 gas sensor's output voltage. In clean air, the sensor produces a low base voltage, resulting in a low integer count (in this case, 54). This numerical readout proves that the system continuously quantifies the air quality inside the cabin rather than just relying on basic binary high or low logic.

Because this value falls well below the pre-programmed safety threshold, the system triggers its "safe path" response. The second line clearly states **"No Alcohol"**, giving visual verification that the driver is sober and fit to operate the vehicle. In this state, the microcontroller commands the relay module to remain energized (closed circuit), allowing power to flow seamlessly to the DC motor assembly so the vehicle can be safely started and driven.

C. Violation Threshold Detection and System Interlock Activation

The figure 5 captures the system's behavioural response when exposed to an environment containing alcohol vapor. The LCD interface switches its display parameters to reflect a critical safety violation, demonstrating the real-time decision-making capability of the embedded firmware when the calibrated safety parameters are breached.

The top line displays **"Sensor: 416"**, showing a sharp numerical increase compared to the clean-air baseline reading. This elevated integer count indicates that the MQ-3 sensor's internal tin dioxide () semiconductor layer has interacted with ethanol molecules, resulting in an increased electrical conductivity. The microcontroller converts this surge in analog output voltage into a high digital value via its internal ADC, confirming a significant concentration of alcohol vapor.

Fig.5 Showing alcohol found on lcd screen

Because the value (416) sharply exceeds the pre-programmed safety threshold, the system executes its fail-safe emergency routine. The bottom line displays the critical alert **"Alcohol FOUND"**. Simultaneously, the microcontroller cuts the signal to the relay module, causing the electronic switch to snap open and isolate the vehicle's ignition power lines. This action instantly deactivates the DC motor to simulate a complete vehicle lock and turns on the buzzer to generate a continuous acoustic alarm.

D. Temperature Monitoring

The developed temperature monitoring system was tested under different environmental conditions to evaluate its performance and reliability. Figure 6 represents the temperature variations. The temperature sensor continuously measured the ambient temperature and transmitted the readings to the microcontroller for processing. The measured values were displayed on the LCD screen in real time, allowing users to observe temperature variations instantly. The system responded effectively to changes in temperature and maintained stable operation throughout the testing period.

The prototype demonstrated accurate sensing capabilities with minimal delay in data acquisition and display. The integration of the sensor, microcontroller, and display module ensured continuous monitoring of environmental conditions. Experimental observations confirmed that the system could be effectively deployed in industrial, domestic, and safety-critical applications requiring real-time temperature supervision.

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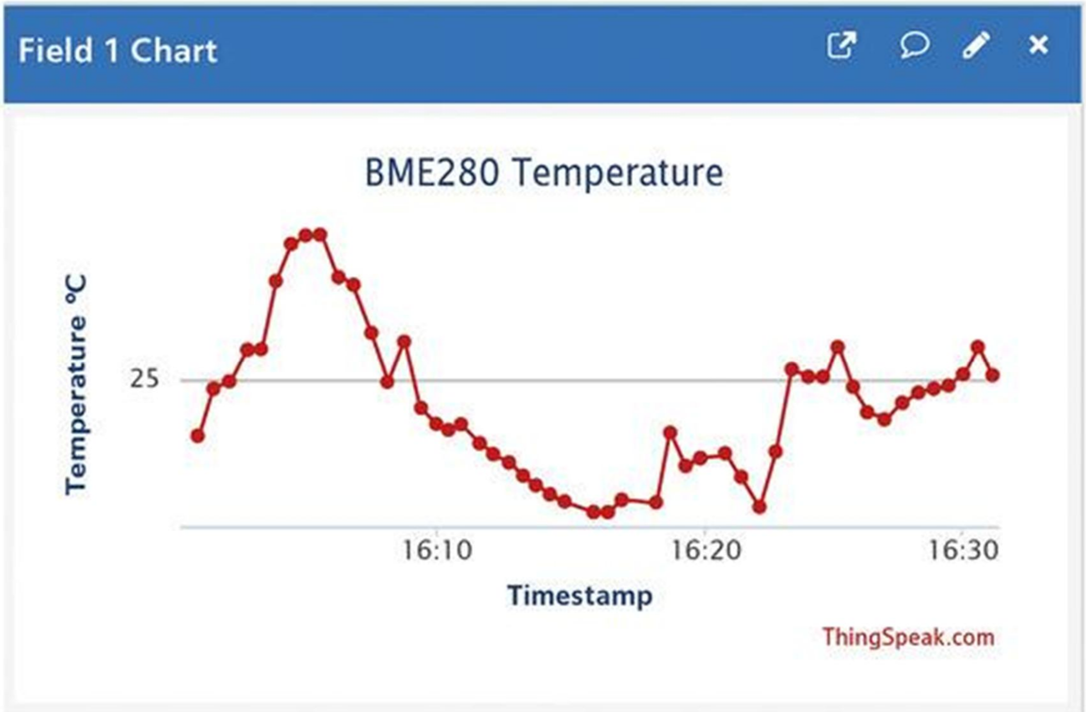

Fig.6 Showing temperature vs Timestamp Graph

When the measured temperature exceeded the predefined threshold value, the system successfully activated the warning mechanism. The buzzer generated an audible alert, and a warning message was displayed on the LCD screen to notify users of the abnormal condition. This rapid response ensures timely intervention and helps prevent equipment damage or safety hazards.

The alert generation process occurred immediately after the threshold temperature was crossed, demonstrating the effectiveness of the programmed control logic. The results validate the system's capability to function as an early-warning temperature monitoring solution for industrial and environmental safety applications.

The collected temperature data were analyzed to observe trends and variations over time. The graphical representation shows a gradual increase and decreases in temperature corresponding to environmental changes. The monitoring system successfully captured these variations and recorded them without data loss.

The trend analysis demonstrates the capability of the system to provide continuous monitoring and historical temperature records. Such information can be utilized for predictive maintenance, environmental assessment, and intelligent decision-making in industrial automation systems. Overall, the experimental results confirm that the proposed temperature monitoring system is accurate, reliable, and suitable for real-time safety monitoring applications.

VI. CONCLUSION

The Smart Alcohol Detection System for Vehicle Safety demonstrates an embedded system implementation integrating an MQ-3 gas sensor, microcontroller (Arduino UNO), and peripheral modules for real-time alcohol monitoring. The system acquires analogue sensor data, processes it using ADC, and compares it with a predefined threshold to determine the driver’s sobriety level. Based on this decision logic, control signals are generated to actuate outputs such as a relay (engine control), buzzer (audio alert), and I2C-based LCD (visual feedback).

The design ensures low power consumption, high reliability, and rapid response, making it suitable for automotive safety applications. The use of I2C communication minimizes hardware complexity and optimizes GPIO utilization. Furthermore, the system architecture is scalable and can be extended with GSM/GPS modules for remote monitoring and alert transmission.

A. Disclosure Statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

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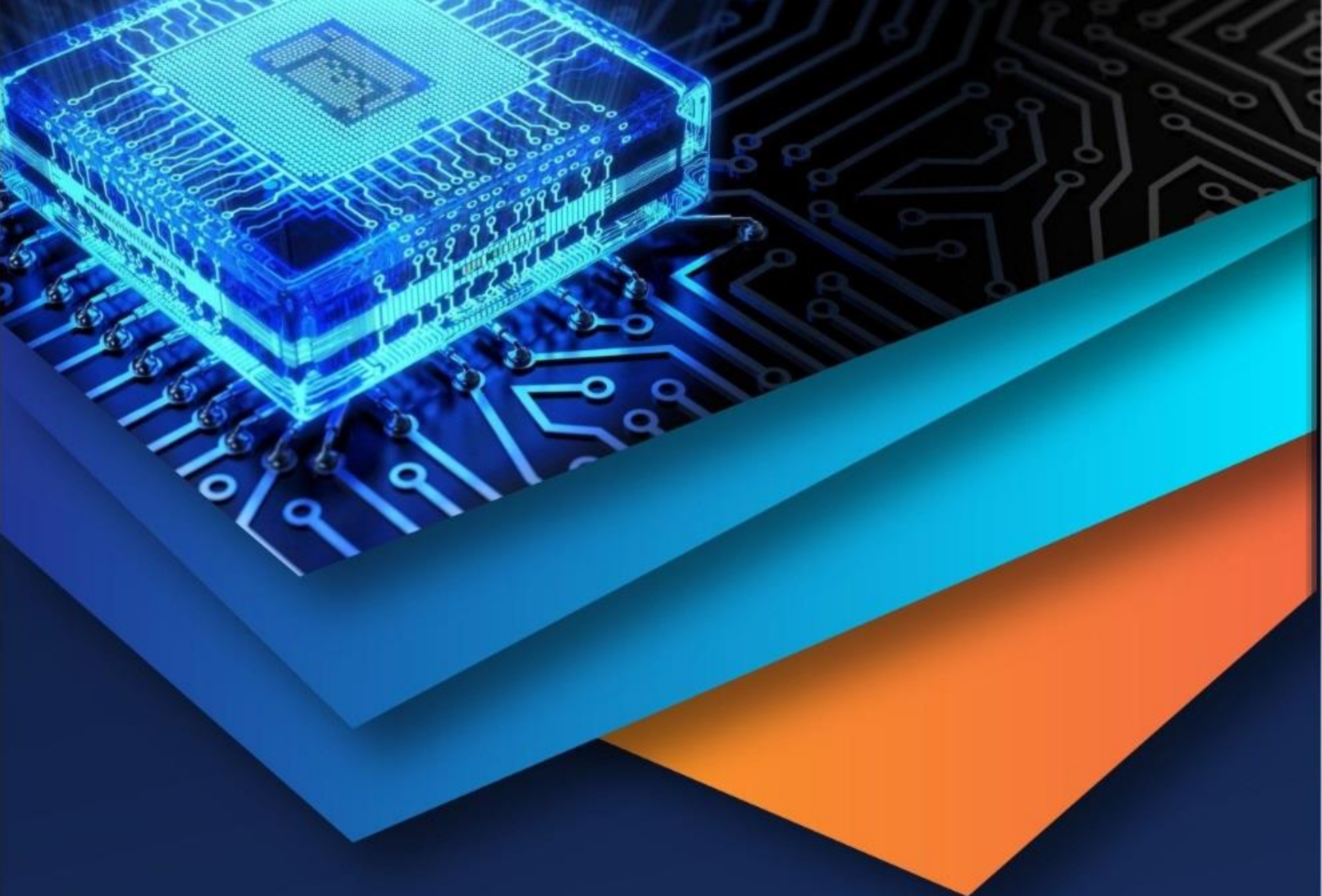

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