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MAKERERE UNIVERSITY

ALCOHOL DETECTION AND INTERNET OF THINGS (IOT) ALERT SYSTEM

(PRACTICAL COURSEWORK)

(CSC-2118)

GROUP 3 (DAY - CLASS)

NO	NAME	STUDENT NUMBER	REG. NO
1	ATURINZIRE HARGREAVE	2400722603	24/U/22603/PS
2	AKANKUNDA RITA	2400703072	24/U/03072/PS
3	NDAGIRE NAIRAH	2400710032	24/U/10032/PS
4	MUTEBI STUART	2400725953	24/U/25953/PS
5	NANTALE CECILIA	2400724555	24/U/24555/PS

Assessor/Mentor: Dr. Marry Nsabagwa

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1. Introduction and Project Overview

1.1 Problem and Solution

The core problem this project addresses is the danger posed by impaired driving. Current breathalyzer methods are **reactive**, used only after an incident or stop. We built a **proactive, continuous monitoring system** for enclosed spaces, such as a vehicle cabin.

The **Alcohol Detection and IoT Alert System** uses a sensor to continuously check for alcohol vapor. If the level exceeds a safe limit, it triggers an immediate, three-part response:

1. **Local Alerts:** A **Buzzer** sounds and an **LED** lights up.

2. **Remote SMS Alert:** A text message is instantly sent to a designated phone number using **GSM**.
3. **Data Logging:** The sensor data and status are uploaded to the **ThingSpeak IoT platform** using **GPRS** for remote monitoring and historical tracking.

1.2 Executive Summary

The system is built around the **TTGO T-Call ESP32 board**, which integrates a powerful **ESP32 microcontroller** (for processing) and a **SIM800L GSM/GPRS modem** (for communication). The firmware manages parallel tasks: reading the **MQ-3 analog sensor**, controlling the digital alerts, and handling network communication. A key software feature is the **debounce state machine**, which requires multiple consistent "Drunk" readings before triggering an alarm, preventing false alerts caused by sensor noise. The project successfully demonstrates the integration of sensing, local control, and cellular-based remote communication.

1.3 Project Objectives and Significance

The primary goals were to implement a system that could **accurately detect** alcohol vapor after establishing a **clean air baseline**, and reliably use the SIM800L modem to send both **SMS alerts** (for instant notification) and **IoT data uploads** (for continuous logging).

The system is significant because it provides a **preventative** tool that immediately alerts both the driver and a remote party, thereby enhancing safety and offering an **immutable record** of exposure events via the ThingSpeak cloud.

2. Methodology and System Design

2.1 System Architecture

The system architecture features the TTGO T-Call board at the center. It receives **Analog Input** from the MQ-3 sensor and sends **Digital Outputs** to the LED and Buzzer. Its internal SIM800L module connects to the cellular network to provide both instant SMS and periodic GPRS data upload to the cloud.

2.2 Sensor Calibration and State Logic

Calibration Routine

To ensure accuracy, the system first runs a **Calibration Routine** in clean air. It reads the MQ-3 sensor $\mathbf{20}$ times and calculates the average, which becomes the **baseline**. The alarm **threshold** is set by adding a fixed safety margin (e.g., $\mathbf{100}$) to this baseline.

$$\mathbf{threshold = baseline + 100}$$

Debounced State Machine

The system operates in two modes: SAFE and DRUNK. To avoid false alarms, it uses **debouncing**:

- **Transition to DRUNK:** The sensor must read above the threshold for $\mathbf{2}$ consecutive checks (DEBOUNCE_COUNT) before the alarm is triggered.
- **Transition to SAFE:** The sensor must read below the threshold for $\mathbf{2}$ consecutive checks before the alarm is cleared.

2.3 Operation Summary

1. **Initialization:** The system powers up, connects to the network, calculates the **baseline**, and sends a **startup SMS**.
2. **Sensing:** The sensor is read every $\mathbf{3}$ seconds (READING_INTERVAL).
3. **Alerting:** If the reading exceeds the threshold for two consecutive checks, the system:
   - Flashes the **LED** and sounds the **Buzzer**.
   - Sends an urgent **SMS Alert** via GSM.
4. **Logging:** Every $\mathbf{15}$ seconds (THINGSPEAK_INTERVAL), the current sensor reading and status (1 for DRUNK, 0 for SAFE) are uploaded to **ThingSpeak** via GPRS.

3. Hardware and Software Components

3.1 Hardware Components

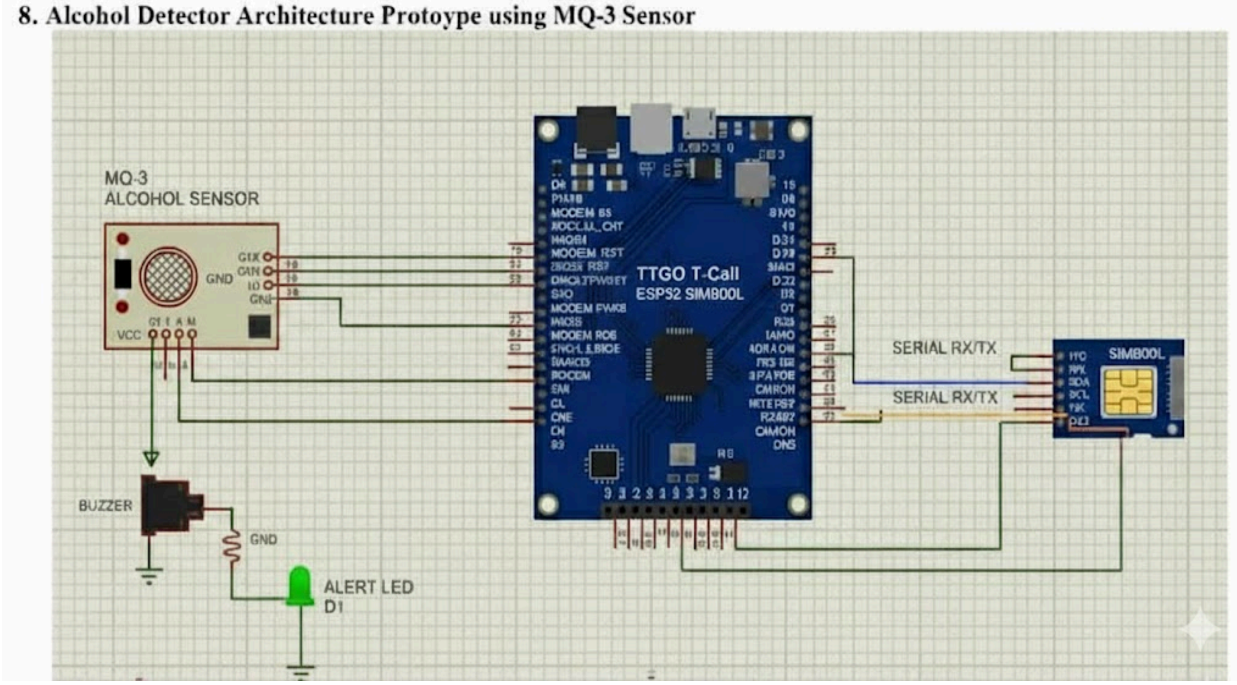
The system integrates four key components:

Component	Function	Interface Pin
TTGO T-Call (ESP32 + SIM800L)	Microcontroller (MCU) and Cellular Communication	N/A
MQ-3 Alcohol Sensor	Detects ethanol vapor and provides Analog Input.	**GPIO 34**
Active Buzzer	Provides audible alarm (Digital Output).	**GPIO 13**
Alert LED	Provides visual status (Digital Output).	**GPIO 12**

The **TTGO T-Call** is crucial as it combines the powerful **ESP32** for processing and the **SIM800L** modem for remote communication (SMS and IoT data) in a single unit.

3.2 Software and Protocols

The firmware is written in C++ using the Arduino framework, simplifying communication through the **TinyGsm library**.

- **GSM (SMS):** Used for fast, reliable, critical alerts. The system uses the cellular network to send an immediate text message when the DRUNK state is entered.
- **GPRS (ThingSpeak):** Used for continuous data logging. GPRS provides the internet connection necessary to send time-stamped sensor data and status to the ThingSpeak cloud channel every $\mathbf{15}$ seconds. This enables remote parties to view the system's history and real-time activity.
- 

8. Alcohol Detector Architecture Protoype using MQ-3 Sensor

4. Testing, Limitations, and Conclusion

4.1 Functional Test Plan

The system's reliability is confirmed through testing against specific acceptance criteria.

Test Case	Procedure	Acceptance Criteria
1. Startup Check	Power on and wait for modem registration.	A startup SMS is successfully received.
2. Drunk State Trigger	Expose sensor to alcohol vapor until reading is stable and high.	LED ON, Buzzer 3 times, and an SMS ALERT is received.
3. Debounce Check	Briefly expose sensor for less than 6 seconds (1 reading).	The system remains SAFE (no alarm or SMS) despite the temporary spike.
4. IoT Data Logging	Monitor the ThingSpeak channel during testing.	Data is uploaded

consistently every $\mathbf{15}$ seconds, correctly showing high level and status 1 during the alarm. |

4.2 Limitations and Future Work

Current Limitations:

1. **Non-Selectivity:** The MQ-3 sensor can react to other gases (like cleaning solvents), potentially causing **false alarms**.
2. **Environmental Drift:** The sensor's readings are affected by changes in temperature and humidity, which are not currently compensated for.
3. **Static Threshold:** The alarm threshold is a fixed analog number, not a scientifically accurate **PPM (Parts Per Million)** or BAC value.

Future Improvements:

1. **Environmental Compensation:** Add a temperature sensor (e.g., DHT22) to mathematically correct the MQ-3 readings, improving accuracy.
2. **GPS Tracking:** Implement the GPS functionality of the board to include the device's **location** in the SMS alerts, making remote intervention more effective.
3. **Power Optimization:** Utilize the ESP32's **deep sleep modes** to drastically reduce power consumption for battery-powered applications.

4.3 Conclusion

The **Alcohol Detection and IoT Alert System** successfully integrates alcohol sensing, local alerting, and cellular communication into a highly functional prototype. It meets all core objectives by providing a reliable, debounced, real-time safety system that utilizes both instant GSM alerts and continuous GPRS data logging. This project demonstrates proficiency in building complex embedded systems for public safety applications.

Appendix A - Key Firmware Configuration

This section lists the primary configuration constants defined in the firmware that govern the system's operational parameters:

- **READING_INTERVAL (**$\mathbf{3000 ms}$**):** This is the time delay between sensor checks in the main loop, meaning the sensor is read every 3 seconds.
- **THINGSPEAK_INTERVAL (**$\mathbf{15000 ms}$**):** This is the frequency of data upload to the ThingSpeak cloud (every 15 seconds).
- **DEBOUNCE_COUNT (**$\mathbf{2}$**):** This specifies the number of consecutive high readings required for the alarm to activate or deactivate, ensuring reliability.
- **THRESHOLD_OFFSET (**$\mathbf{100}$**):** This is the fixed safety margin added to the clean air baseline to set the alarm trigger point.
- **MQ3_PIN (**$\mathbf{34}$**):** This specifies the Analog Input pin used for connecting the MQ-3 alcohol sensor.