Faridpur Engineering College

Department of Electrical & Electronic Engineering (EEE)

Course Title : **Electrical & Electronic Workshop Practice**
Course Code : **EEE-2108**
Session : **2022-23**
Batch : **10**
Project name : **Vehicle Safety & Accident Alert System**

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Date of Submission: **11.11.2025**

Project Title: **Vehicle Safety & Accident Alert System**

(*A microcontroller-based system using ESP32-WROOM, RFID authentication, GPS, GSM, and sensor monitoring to detect accidents and provide immediate alerts.*)

Introduction

Road traffic accidents and vehicle misuse remain major issues worldwide. Rapid response to vehicular accidents or unauthorized vehicle use can save lives and reduce damage. This project implements a multi-sensor embedded system that combines driver authentication, real-time location tracking, obstacle/proximity detection, and emergency alerting. The system uses a central microcontroller module (ESP32-WROOM), an RFID module (RC522 RFID Module) to identify the driver, a GPS module (NEO-6M GPS Module) to obtain the vehicle's coordinates, a GSM/GPRS module (SIM800L Module) for sending SMS or calls, an OLED display to show system status, and an IR sensor for proximity / impact detection. The device is powered by a 3.7 V Li-ion cell and appropriate power supply regulation. By combining these elements, the system provides not only tracking, but proactive safety and alerting akin to an "eCall" implementation in vehicles. [Wikipedia+2Zenodo+2]

Objectives

- To implement reliable driver authentication using RFID such that only authorized drivers can enable the vehicle.
- To continuously acquire GPS coordinates and track the vehicle's location in real time.
- To detect accident or emergency events via sensor inputs (IR sensor for obstacle or proximity, optionally shock/tilt detection) and trigger alerts automatically.
- To send an SMS (and optionally a voice call) with the current GPS coordinates to a predefined number immediately upon alert detection.
- To display clear system status (driver authenticated, GPS fix, alert condition) on an OLED display for on-vehicle feedback.
- To design a safe, compact, energy-efficient embedded system suited for vehicle installation (power management, battery protection, robust module supply).
- To discuss the system's effectiveness, limitations, and possible enhancements for future work.

Components Used (Hardware & Software)

Hardware

Component	Purpose
ESP32-WROOM module	Core **microcontroller** with Wi-Fi/BT, handles logic, communication and sensor interfacing.
RC522 RFID module	Driver identification/authentication using an **RFID card**.
U-blox NEO-6M GPS module	Provides latitude/longitude/time data via NMEA sentences.
SIM800L GSM/GPRS module	Enables SMS and call functionality for alerting.
OLED display (0.96" I^2C/SPI)	Visual feedback of system status (RFID accepted, GPS fix, alert triggered).
MP6050 Sensor module	Detect Shock and over rotation.
TCRT5000 IR sensor module	Measure & detect overspeed.
Li-ion 3.7 V battery	Power supply for mobile installation.
MP2315 Buck Converter	Ensure stable power rails for ESP32 and other modules.
TT Gear motor & wheel	For showing demo wheel rotation.
Others necessary basic components	For complete the system circuit.

Software

Software	Purpose
EasyEDA Pro	For Design and simulate complete Circuit Schematic & PCB Board.
Arduino IDE	The integrated development environment used for code development, compilation, and microcontroller programming.
ChatGPT, DeepSeek, GitHub Copilot	For developing brainstorming ideas & code assistance.

Working Procedure

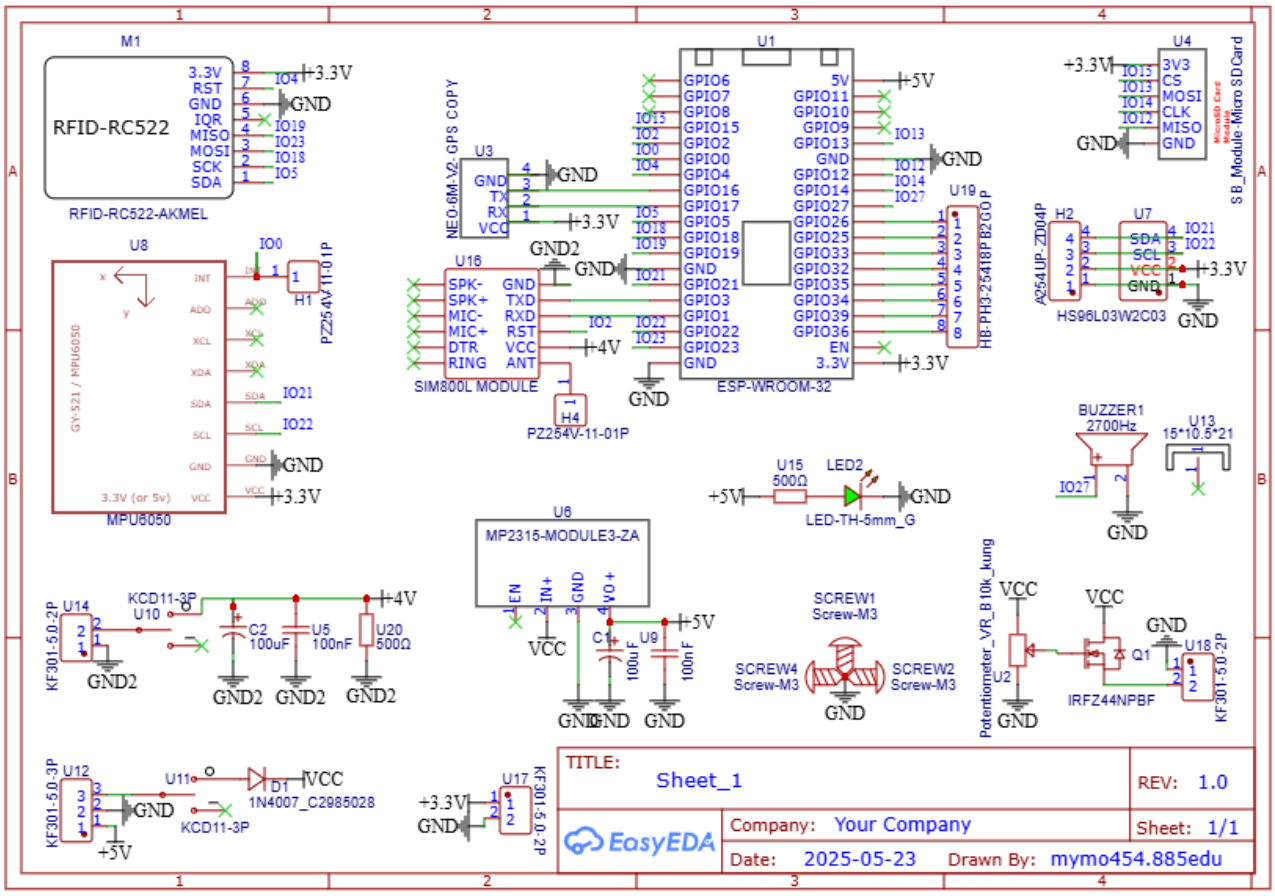

Fig-1.1: **Schematic** Diagram Design

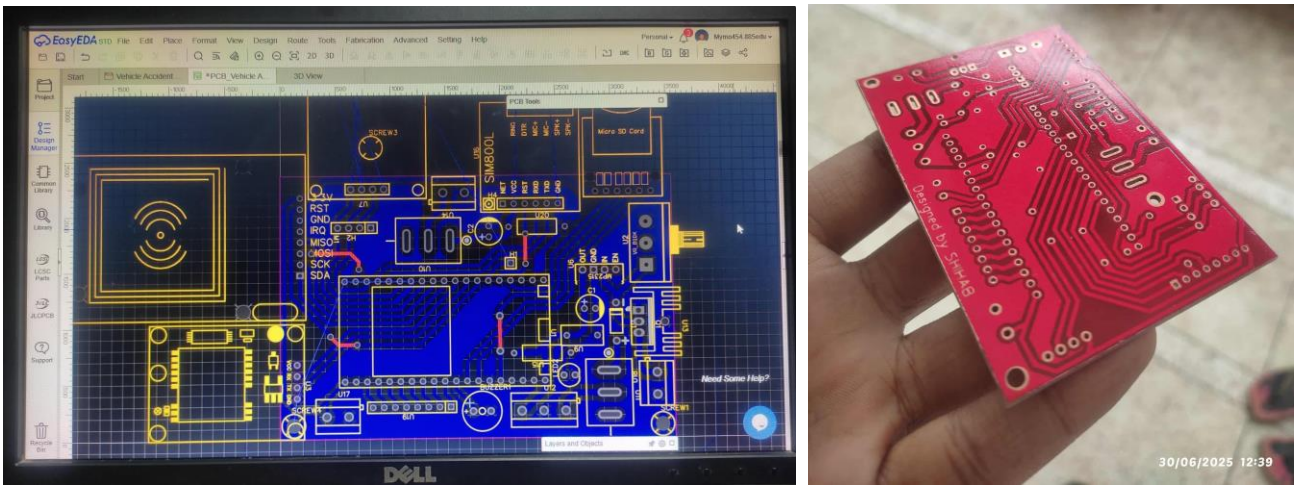

Fig-1.2: **PCB** Design & Fabrication

Working Flowchart

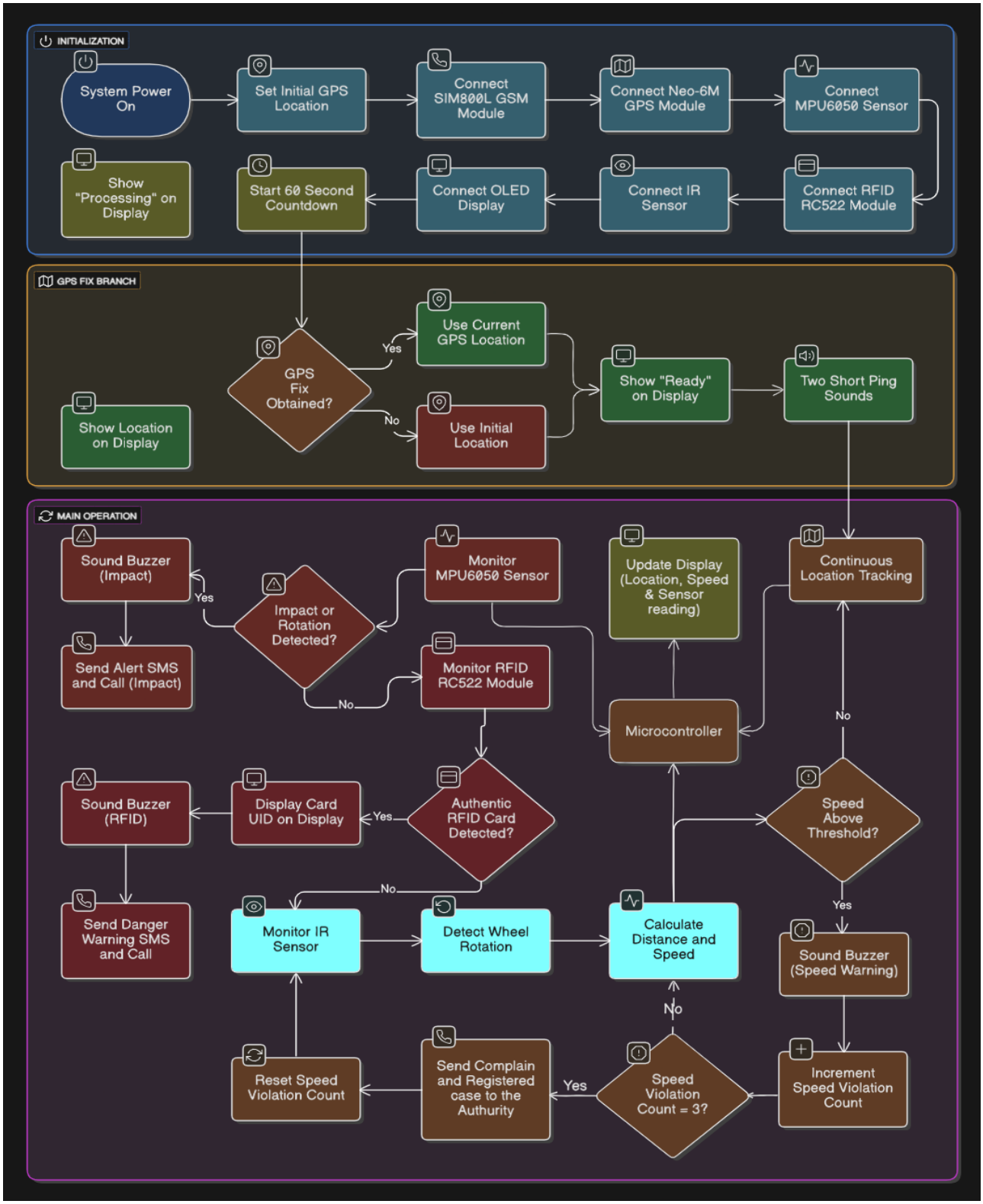

Fig-1.3: **Working Flowchart**

Result and Discussion

Results:

- The system successfully authenticates drivers using RFID and prevents unauthorized use.
- GPS module obtains fix within acceptable time (e.g., under 60 s in open sky) and reports coordinates accurately.
- On sensor trigger (IR proximity / obstacle or simulated accident), the system sends an SMS with the text:
  `ALERT: Vehicle accident detected. Driver ID: [ID]. Location: https://maps.google.com/?q=LAT,LON. Time: YYYY-MM-DD HH:MM.`
- OLED displays status: “Driver: [Name]”, “GPS: locked”, “Monitoring”, “Alert Sent”.
- Power system sustains ESP32 + SIM800L operation; the SIM800L peaks (~2 A) were handled with a dedicated regulator and capacitor bank.

Discussion:

- The combination of GPS + GSM is well-supported in vehicle tracking/safety literature. For example, a GPS/GSM based anti-theft tracker using ESP32 was shown to operate effectively for real-time monitoring and low-cost deployment. [ResearchGate+1]
- The main challenge encountered was the power supply stability for the SIM800L; during transmission bursts the voltage dropped unless a sufficient decoupling capacitor (100 µF+ ceramic)
- GPS fix time can be improved by ensuring clear sky view and possibly using a backup antenna or assisted GPS.
- False triggers from the IR sensor were minimal in test conditions, but for actual accidents a more robust sensor (accelerometer/gyroscope) could enhance detection accuracy.
- Battery life is acceptable for short trips; long-term deployment would require battery capacity planning, sleep modes for microcontroller during idle, and possibly integration with vehicle power supply.
- The system depends on cellular network coverage for GSM; in areas of poor signal the alerting may be delayed or fail — a limitation common in many GSM-based vehicular systems. [Circuit Digest+1]

Summary: The prototype meets the defined objectives, demonstrating driver authentication, location tracking, and automatic accident/alert detection. The flexibility of the system allows future refinements and scaling for real-vehicle deployment.

Applications

- Vehicle fleet management: Ensuring authorized driver use, monitoring route and location, detecting incidents.
- Private vehicle safety: For personal cars or bikes, enabling emergency alerts after accidents.
- School transport buses: Authenticate driver, track bus location, alert on collisions or unauthorized usage.
- Rental/lease vehicles: Ensure only authorized users drive, track vehicle, detect misuse or accident events.
- Insurance usage-based models: Provide data for incident events and location, support rapid rescue response.

Future Enhancement

- Integrate a MEMS accelerometer/gyroscope (e.g., MPU6050) for more accurate accident detection (tilt, impact, rollover) rather than just IR sensor.
- Add a voice-call functionality with pre-recorded message when alert triggers.
- Use a data-link/cloud backend (MQTT, HTTP API) to log vehicle telemetry, accident events, driver usage analytics.
- Incorporate a real-time map-dashboard for remote monitoring of vehicle location and status.
- Add vehicle bus (CAN/OBD) integration to read vehicle speed, engine status, fuel level, etc.
- Implement backup communication via LoRa or NB-IoT for areas with weak GSM coverage.
- Design a robust enclosure for automotive environment: vibration proof, temperature resilient, IP rating.
- Optimize power consumption: deep-sleep modes when vehicle idle, solar/battery backup for prolonged outage.

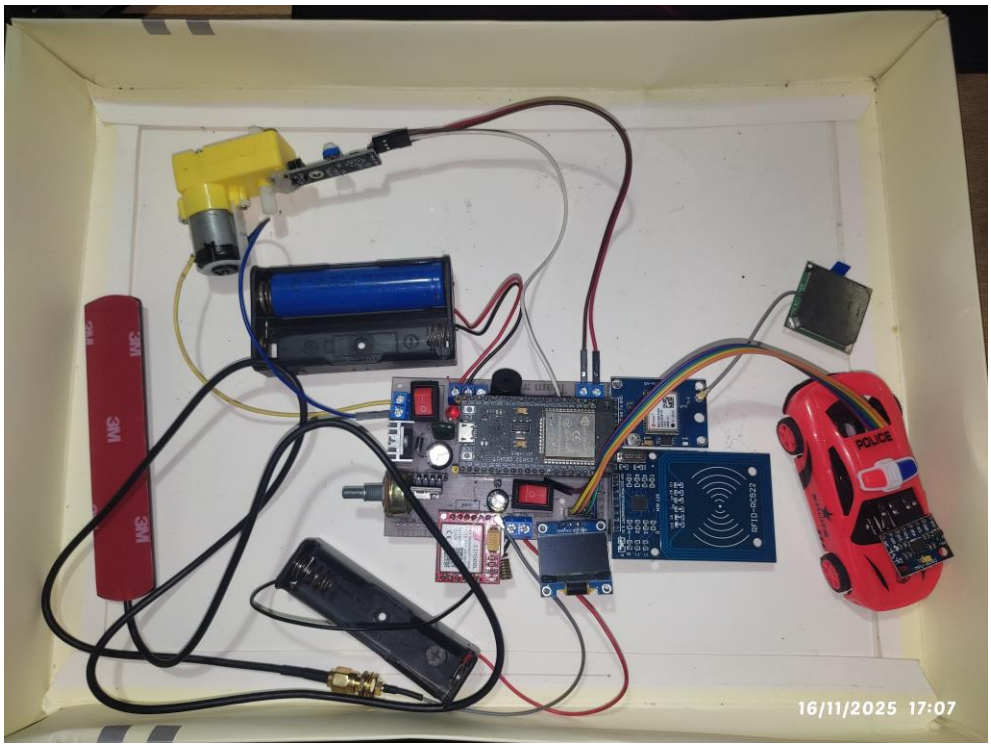

Fig-1.4: After total assembly

Conclusion

This project demonstrates a functional and extensible vehicle safety and alert system built using off-the-shelf modules and the ESP32 microcontroller platform. It delivers critical features: driver authentication, real-time location tracking, automatic emergency alerting, and on-vehicle status feedback. The system addresses real-world safety needs and can be scaled or enhanced for commercial deployment. While limitations exist (e.g., dependence on GSM coverage, sensor accuracy, and power management), the design provides a solid foundation for further development and practical application.

References & Documentation Link

- "Design and Implementation of Vehicle Tracking System Using ESP32, GPS and GSM" – IJIRT. [IJIRT]
- Additional documentation link (slides): https://gamma.app/docs/Vehicle-Safety-Alert-System-m5b44pyl2ejz0mo?mode=doc
- Further reading: Wikipedia article on "Automatic vehicle location" for contextual technology. [Wikipedia]
- Details Code: https://drive.google.com/file/d/1SNbfWR3iZPpbtuZwTnBXC7pHhPJMxq-Q/view?usp=drive_link