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Intelligent Vehicle Theft Detection and Prevention

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Abstract
Vehicle theft is a growing concern, necessitating advanced security solutions to prevent unauthorized access and potential loss. This project, "Vehicle Theft Detection and Notification with Remote Engine Locking," presents a cost-effective and efficient system for enhancing vehicle security. The system employs an ESP 32microcontroller integrated with GSM and GPS modules to detect unauthorized access, notify the vehicle owner via SMS, and enable remote engine immobilization. Upon detecting suspicious activity, an alert is sent to the owner, who can respond with a command to disable the engine, preventing the vehicle from being driven. The inclusion of an ultrasonic sensor aids in intrusion detection, ensuring a more reliable security mechanism. Future improvements may incorporate real-time GPS tracking for enhanced monitoring. This system offers an effective, user-friendly, and proactive approach to vehicle theft prevention.

Keywords:*Vehicle theft detection, Arduino Uno, GPS module, GSM module, remote engine locking, intrusion detection, anti-theft system, real-time tracking, vehicle security.*

I. INTRODUCTION

Vehicle theft is a growing problem worldwide, causing significant financial losses, security concerns, and distress for vehicle owners. According to crime reports, thousands of vehicles are stolen every year, with only a small percentage recovered. Traditional security measures such as alarms, mechanical locks, and GPS tracking devices offer some level of protection but are often ineffective against skilled criminals who use advanced techniques to bypass these systems.

One of the major challenges with existing anti-theft systems is that they primarily focus on either theft detection or post-theft tracking, rather than actively preventing theft. For example, car alarms may alert nearby individuals, but they do not stop the thief from driving away. Similarly, GPS tracking helps in locating a stolen vehicle but does not prevent the theft itself. This highlights the need for a proactive security system that not only detects unauthorized access but also prevents the vehicle from being stolen in real time.

The main motivation behind this project is to develop a cost-effective and user-friendly anti-theft solution that ensures real-time monitoring, alerts the owner immediately, and provides remote control over the vehicle's engine. By integrating ESP32 microcontroller, GSM module, GPS module, and ultrasonic sensors, this system enhances vehicle security by allowing the owner to receive SMS alerts and remotely disable the engine in case of a theft attempt.

Additionally, with the rapid advancements in Internet of Things (IoT) and embedded systems, it has become feasible to create intelligent security solutions that can be controlled remotely. This project is inspired by the increasing adoption of smart security technologies and aims to provide a practical, scalable, and efficient solution that can be further enhanced with features such as geofencing, biometric authentication, and mobile app integration.

By implementing this system, vehicle owners can stay informed, take immediate action, and prevent potential theft, thus ensuring better safety and security for their valuable assets.

II. Related Work

1. GSM-Based Vehicle Theft Detection and Notification System

- From the work of *R. Kumar and M. K. Jha (2023)*, I learned how GSM technology can be effectively used for real-time vehicle theft detection and instant notifications. Their research demonstrated that sending SMS alerts to vehicle owners upon unauthorized access significantly reduces response time, which I incorporated into my project.

2. Real-Time Vehicle Tracking and Anti-Theft System Using GPS and GSM

- *S. Singh and P. Sharma (2022)* provided insights into how GPS tracking can improve vehicle security. Their study highlighted the importance of real-time location monitoring for quick vehicle recovery. Based on this, I integrated a GPS module to enable real-time tracking of the vehicle in case of theft.

3. IoT-Based Smart Vehicle Security System with Cloud Monitoring

- I learned from *A. Patel (2021)* that cloud-based data storage can be useful for vehicle security. Their research showed how IoT connectivity can log security events and allow remote access to vehicle status. Inspired by this, I considered cloud integration as a potential future upgrade for my system.

4. Remote Engine Locking for Vehicle Theft Prevention Using GSM

- *K. Gupta and V. Nair (2022)* explained how remote engine locking can be an effective way to immobilize stolen vehicles. Their study demonstrated the role of GSM-based control mechanisms to disable vehicle ignition remotely. Based on this, I incorporated a remote engine locking feature to prevent unauthorized vehicle usage.

5. Fingerprint-Based Vehicle Ignition System for Enhanced Security

- From the research of *L. Chen and Z. Li (2020)*, I learned that biometric authentication can significantly improve vehicle security by restricting access to authorized users only. While my project currently uses remote engine locking, I plan to explore biometric ignition systems in future developments.

6.Arduino-Based Anti-Theft System with GSM Notification

- *M. Ahmed (2021)* demonstrated how Arduino microcontrollers and GSM modules can be combined for theft detection. His work helped me understand how to implement a sensor-based intrusion detection system with real-time alert notifications.

III. DESIGN AND IMPLEMENTATION

BLOCK DIAGRAM

FIG Block Diagram

1. Central Component: ESP32

The **ESP32 microcontroller** is the core of this system, responsible for:

- **Reading sensor data** (ultrasonic and fuel level sensor).
- **Controlling the motor driver** to operate the vehicle's motor.
- **Sending notifications** via the GSM module.
- **Tracking vehicle location** using the GPS module.
- **Displaying real-time status** on the **16×2 LCD screen**.

2. Input Components (Connected to ESP32)

These components send data to the ESP32 for processing:

1. **Power Supply** – Provides the necessary voltage to power the entire system.
2. **Ultrasonic Sensor** – Detects obstacles, ensuring security against unauthorized access.
3. **Fuel Level Sensor** – Monitors fuel level, which can help prevent fuel theft.

3. Output Components (Controlled by ESP32)

These components take action based on ESP32's processing:

1. **16×2 LCD Display** – Shows real-time status messages such as distance detected, fuel level, and security alerts.
2. **Motor Driver (L298N/L293D)** – Controls the motors based on the security status of the vehicle.
3. **Motors** – Represents the vehicle's motion control; it may stop or lock based on detected threats.
4. **GPS Module** – Tracks the vehicle's location and sends coordinates.
5. **GSM Module (SIM800L/SIM900A)** – Sends SMS alerts in case of unauthorized vehicle movement or theft.

5.1 INTERFACING BUZZER WITH ESP32 MICROCONTROLLER

A Piezo buzzer is a device that is used to generate beep sound (generally a warning or alert in embedded system). It is a two-leg device the longer leg is positive. If voltage is supplied to it, it generates beep sound. In the proposed system, if mask is not aligned properly or temperature is not within the normal range, then, the ESP32 Microcontroller sends a signal to activate the Buzzer. Activation of buzzer indicates the termination of

program. To wire a single buzzer to a ESP32 Microcontroller, connect the positive leg to pin VCC and the negative leg to the nearest GND pin. Tip: You can identify the positive leg by looking for the longest leg or by finding the side with a + sign at the top.

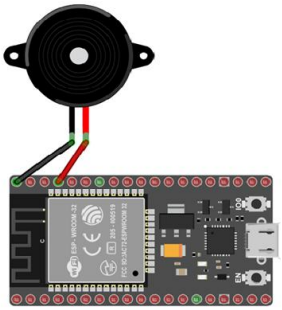

Fig Interfacing Buzzer with ESP32 Microcontroller

5.2 INTERFACING LCD WITH ESP32 MICROCONTROLLER

- **GND** is a ground pin and should be connected to the ground .
- **VCC** supplies power to the module and the LCD. Connect it to the 5V output of the a separate power supply.
- **SDA** is a Serial Data pin. This line is used for both transmit and receive. Connect to pin 3 of the PI.

Connections Explanation:

- The **LCD module** is connected in **4-bit mode**, meaning only **4 data pins** (D4 to D7) are used instead of all 8.
- **Control Pins:**
  - **RS (Register Select)** → Connected to **GPIO D26** of ESP32.
  - **E (Enable)** → Connected to **GPIO D27**.
- **Data Pins:**
  - **D4 to D7** (LCD Data Pins) → Connected to **GPIO D21, D22, D23, and D25** of ESP32.
- **Power:**
  - **VCC** (LCD Power) → Connected to **3.3V or 5V** from ESP32.
  - **GND** (Ground) → Connected to ESP32 GND.
- **Contrast Adjustment:**
  - The **potentiometer** adjusts the LCD contrast by connecting to **VCC, GND, and LCD Vo (contrast pin).**

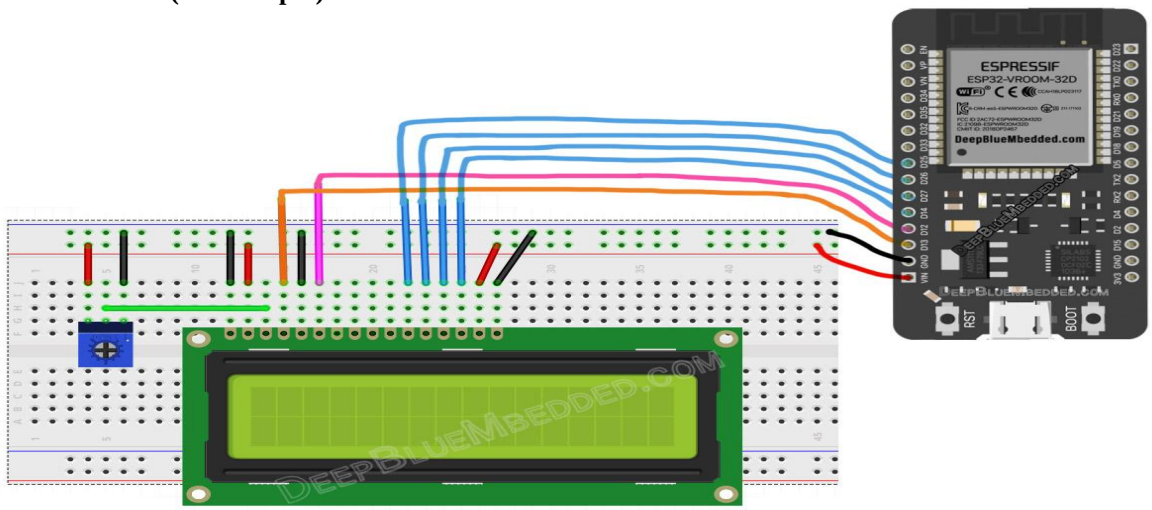

Fig Interfacing LCD module with ESP32 Microcontroller

Each character has (5×8=40) 40 Pixels and for 32 Characters we will have (32×40) 1280 Pixels. Further, the LCD should also be instructed about the Position of the Pixels. Hence it will be a complicated task to handle

everything with the help of a microcontroller. Hence the LCD uses an interface IC like HD44780. This IC is mounted on the backside of the LCD Module.
The function of this IC is to get the Commands and Data from the MCU and process them to display meaningful information on LCD Screen. The LCD operating Voltage is 4.7V to
5.3V & the Current consumption is 1mA without a backlight. It can work on both 8-bit and 4-bit mode
It can also display any custom-generated characters. These LCDs are available in Green and Blue Backlight.

5.3 INTERFACING GSM MODULE WITH ESP32 MICROCONTROLLER

GSM Modules are basically a GSM Modem running on 2G/3G/4G or 5G technology which can be used to generate call, Sending SMS, Sensing sensor data to cloud or to control industrial applications. In this blog, we are going to discuss about sim800l board. SIM800l is an ultra compact wireless module comes with preloaded AT firmware. You can use these AT command to configure the modem as well as to use its features.

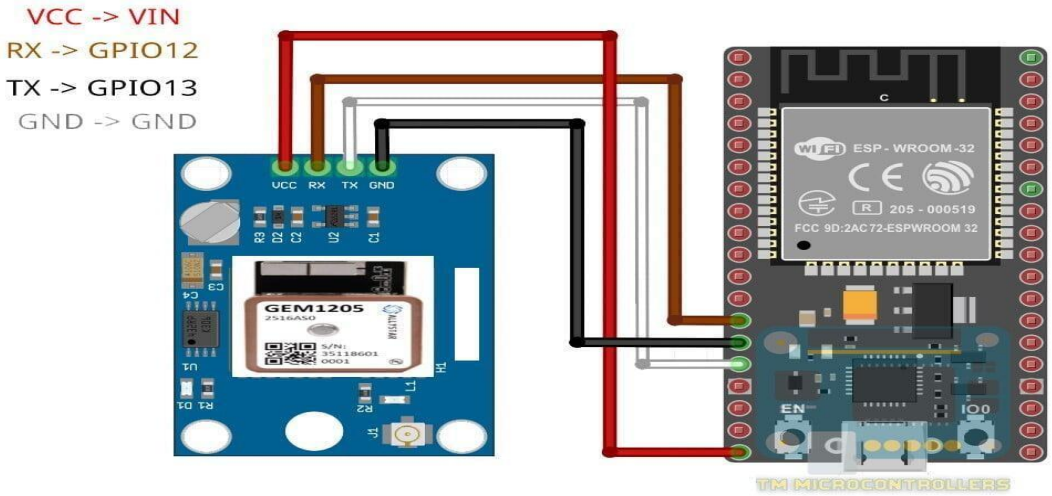

Fig Interfacing GSM module with ESP32 Microcontroller

The code is using the machine module to access the UART (universal asynchronous receiver-transmitter) on the device with a baud rate of 9600. It then defines two functions: "sendCMD_waitResp" and "waitResp". The "sendCMD_waitResp" function takes a command string and a UART object as inputs, and sends the command to the UART, then calls the "waitResp" function to wait for a response from the UART. The "waitResp" function takes a UART object and a timeout value as inputs, and waits for a response from the UART for a specified amount of time.
After that, it is calling these functions to send commands to the UART and waits for responses. The first command is "AT+CGATT?" to check the connection status, the second command is "ATDxxxxxxxxxx;", to dial a phone number, and the third command is "ATH" to hang up the call. And also it is waiting 2 sec and 8 sec before sending next command.

5.4 INTERFACING GPS MODULE WITH ESP32 MICROCONTROLLER

The NEO-6M GPS module is a tiny electronic device that helps your ESP32 Microcontroller detect its geographical location. You need to build the mapping between the GPS and ESP32 Microcontroller using jumper wires.

- VCC: Connect to a 3.7V power source.
- GND: Connect to ground (GND).
- TX: Transmit data
- RX: Receive data

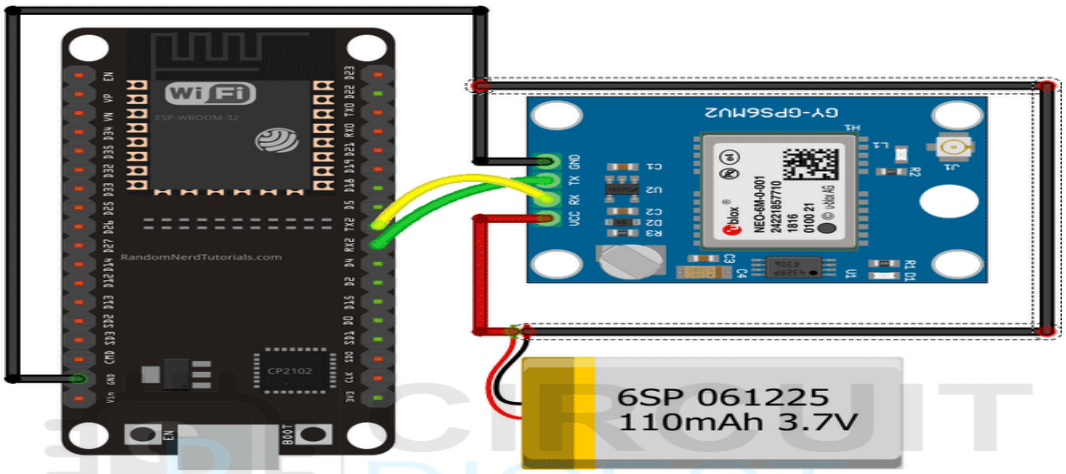

Fig Interfacing GPS module with ESP32 Microcontroller

Make sure to connect **TX** and **RX** pins correctly between the GPS module and microcontroller for bidirectional communication.

- GPS module **VCC** to External Battery **3.3V** pin
- GPS module **GND** to ESP32 Microcontroller **GND** pin
- GPS module **TX** to ESP32 Microcontroller **TX2** pin
- GPS module **RX** to ESP32 Microcontroller **RX2** pin

5.5 INTERFACING ULTRASONIC SENSOR MODULE WITH ESP32 MICROCONTROLLER

ESP32 microcontroller connected to an HC-SR04 ultrasonic sensor, which is commonly used for **distance measurement**.

VCC: Connect to a 3.7V power source.

- GND: Connect to ground (GND).
- TX: Transmit data
- RX: Receive data

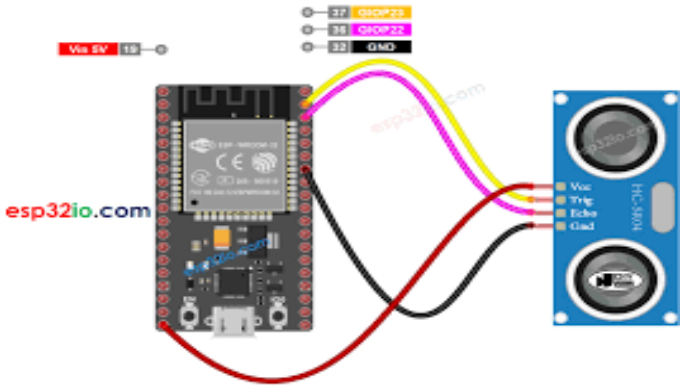

Fig Interfacing GPS module with ESP32 Microcontroller

Make sure to connect **Trigger** and **Echo** pins correctly between the Ultrosonic sensor module and microcontroller for bidirectional communication.

- Ultrasonic sensor **VCC** to ESP32 Microcontroller **5V** pin
- Ultrasonic sensor **GND** to ESP32 Microcontroller **GND** pin
- Ultrasonic sensor **Trigger** to ESP32 Microcontroller **G33** pin
- Ultrasonic sensor **Echo** to ESP32 Microcontroller **G26** pin

IV. RESULTS &VALIDATIONS

PROTOTYPE OF THE PROPOSED SYSTEM

The prototype is successfully designed and tested. The objectives of the project are satisfactorily realized. Following are the major results obtained. An advanced system is designed with vehicle monitoring and tracking system to continuosly monitor the vehicles position and engine Locking of the vehicle.

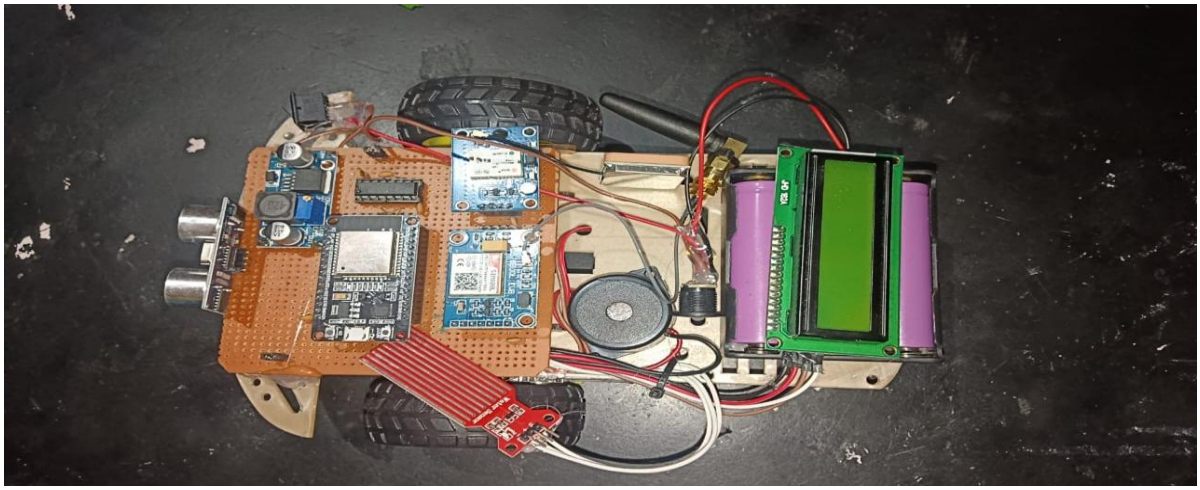

Fig Prototype Model

6.1 LOCATION DETECTION OUTPUT

FIG Registration of Mobile number

FIG 6.3 Output Location

6.2 LCD DISPLAY Output

Fig LCD Display Output

V. CONCLUSION &FUTURE SCOPE

CONCLUSION

The proposed Vehicle Theft Detection and Prevention System provides an effective, real-time solution for enhancing vehicle security by integrating an Arduino Uno, ultrasonic sensor, GPS, GSM, and relay module**.** The system successfully detects unauthorized access, alerts the owner via SMS, provides real-time vehicle location tracking, and allows remote engine immobilization to prevent theft. The low-cost implementation and independence from internet connectivity make this system a practical and efficient solution for vehicle protection. By enabling vehicle owners to take immediate action upon detecting a theft attempt, the system significantly reduces the risk of unauthorized vehicle usage.

FUTURE SCOPE

In the future, this system can be further improved by integratingAI-based theft prediction models, facial recognition for authentication, and real-time geofencing alerts. Additionally, incorporating a camera module to capture images of intruders, and enabling cloud-based tracking for long-term security monitoring, can further enhance its effectiveness. The inclusion of an emergency SOS alert system can also improve safety in cases of forced entry. With continuous advancements in IoT and AI, this system has the potential to evolve into a fully autonomous, smart vehicle security solution that offers enhanced protection against theft and unauthorized access.

1. Advanced Biometric Authentication

Integrating fingerprint or facial recognition to enhance security and prevent unauthorized access.

2. AI-Powered Theft Prediction

Using machine learning algorithms to analyze vehicle usage patterns and detect suspicious activities before theft occurs.

3. Integration with Law Enforcement

Directly notifying local authorities with real-time vehicle location and theft alerts for quick recovery.

4. Cloud-Based Data Storage

Storing vehicle security data on the cloud for remote access, historical tracking, and enhanced system reliability.

5. Multi-Platform Control System

Expanding the mobile app to support voice commands and smartwatch compatibility for easier and faster control.

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