VEHICLE SPEED MONITORING USING GPS AND OLED, USE AT COMMANDS TO INTERFACE

EMBEDDED SYSTEM AND IOT

A Project Report

Submitted by

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ABSTRACT

The Vehicle Speed Monitoring System is an innovative project that leverages GPS technology and the ESP32 microcontroller to provide accurate real-time speed data of a vehicle. The system uses a GPS receiver to obtain the vehicle's location and speed, which is then processed by the ESP32 microcontroller. This data is displayed on a compact OLED screen, allowing users to monitor speed with high clarity and precision, even in varying light conditions. The OLED screen's small form factor and energy-efficient design make it ideal for integration into vehicles without taking up much space or adding significant weight. This system can serve various purposes, including vehicle safety monitoring, providing drivers with real-time speed feedback to prevent speeding, and supporting speed analysis for fleet management or data collection. Additionally, it serves as an excellent educational tool for students and enthusiasts learning about Internet of Things (IoT) and embedded systems, showcasing a practical application of GPS and microcontroller technology in a real-world setting. Its simple yet effective design makes it accessible for DIY projects, offering an affordable solution for anyone interested in exploring embedded system development. Furthermore, the system can be adapted for use in different types of vehicles, making it versatile and scalable for a wide range of applications.

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CHAPTER

INTRODUCTION

In recent years, advancements in embedded systems and IoT technology have paved the way for innovative solutions to address various challenges in transportation and road safety. Vehicle speed monitoring has become an essential tool for enhancing road safety, ensuring regulatory compliance, and reducing accident risks. Speed monitoring systems are increasingly vital in personal, commercial, and industrial applications, providing critical data to drivers and authorities alike. This project, Vehicle Speed Monitoring System. It is designed to measure and display real-time vehicle speed, combining *GPS* technology with the powerful ESP32 microcontroller and an OLED display for efficient data visualization.

The ESP32 microcontroller is an ideal choice for this project due to its high performance, low power consumption, and versatility, making it suitable for various IoT applications. Using AT commands, the ESP32 can efficiently interface with GPS modules to collect and process location data, which is then used to calculate the vehicle's speed. GPS technology offers precise measurements of speed and position, making it suitable for real-time monitoring systems. By periodically obtaining the vehicle's position from the GPS module, the system calculates the speed based on the change in position over time, providing accurate and up-to-date readings.

OLED technology is energy-efficient and ideal for compact embedded systems, where power consumption and display clarity are critical. The display presents the calculated speed clearly, allowing the driver or user to view the information without distraction. Furthermore, OLED displays enhance user experience with their sleek design and improved legibility compared to older display technologies.

The system's applications are broad, ranging from automotive safety and fleet management to educational projects in embedded systems. It can serve as a practical tool for drivers to monitor their speed in real-time, providing valuable data for maintaining speed limits and improving driving habits. Additionally, the project has educational significance, as it demonstrates practical applications of GPS interfacing, data processing, and display management in embedded systems.

This Vehicle Speed Monitoring System exemplifies a cost-effective and versatile solution for real-time speed tracking, serving as a foundation for further development and customization. It provides a functional prototype that can be expanded with additional features, such as data logging, Bluetooth or Wi-Fi connectivity, and integration with mobile applications. Through this project, we aim to highlight the capabilities of IoT and embedded technology in addressing real-world challenges in road safety and transportation.

METHODOLOGY

The methodology for developing the Vehicle Speed Monitoring System Using GPS and ESP32 with OLED Display consists of several key steps, including component selection, system design, programming, and testing. This structured approach ensures accurate speed calculation, efficient data processing, and reliable display of information.

1. COMPONENT SELECTION AND SETUP:

   - **ESP32 Microcontroller:** The ESP32 microcontroller is chosen for its built-in Wi-Fi and Bluetooth capabilities, as well as its compatibility with AT commands for interfacing with GPS. It provides a reliable platform for handling real-time data and executing precise speed calculations.
   - **GPS Module:** A GPS module, such as the NEO-6M, is used to acquire latitude, longitude, and time data. This data enables the calculation of vehicle speed based on changes in position over time.
   - **OLED Display:** An OLED display is used instead of an LCD due to its superior contrast, energy efficiency, and readability. The display shows speed information to the user clearly, even in varied lighting conditions.

2. SYSTEM DESIGN AND HARDWARE INTEGRATION:

   - **GPS to ESP32 Interface:** The GPS module is connected to the ESP32 via serial communication, allowing the GPS to send continuous data streams. AT commands enable seamless integration of GPS data into the ESP32, which processes the data to calculate speed.
   - **ESP32 to OLED Interface:** The OLED display is interfaced with the ESP32 through I2C communication. This setup allows efficient data transfer between the microcontroller and display for quick updates of the vehicle’s speed.

3. DATA PROCESSING AND SPEED CALCULATION:

   - **Data Parsing:** The GPS module sends data in the NMEA format, which includes information about location, time, and satellites. The ESP32 parses the NMEA sentences to extract latitude, longitude, and timestamp values required for speed calculation.

- **Speed Calculation Algorithm:** Using the timestamped position data from the GPS module, the ESP32 calculates speed by measuring the change in position over time. The speed formula Speed=Δ distance/Δ time is implemented to provide real-time vehicle speed.
- **Data Filtering:** To ensure accuracy, the system applies filtering techniques to ignore noisy GPS data, especially at low speeds where GPS readings can be less reliable. This step helps maintain consistent and precise speed measurements.

4. DISPLAY MANAGEMENT:

- The OLED display receives data from the ESP32 in a readable format, showing real-time speed. To optimize display refresh, the ESP32 updates the OLED only when there is a significant change in speed, minimizing power consumption and enhancing readability.
- Additional visual cues, such as speed units (km/h or mph), are included on the OLED to ensure clarity for the user.

5. TESTING AND CALIBRATION**:**

- **Initial Testing:** The system is tested in a controlled environment to verify GPS data acquisition, communication, and speed calculations.
- **Field Testing:** Once the basic functionality is confirmed, the system is tested in a moving vehicle to validate speed accuracy and ensure reliable real-time display on the OLED.
- **Calibration:** Calibration is performed to adjust for any inaccuracies in GPS readings, especially in environments with weak GPS signals or high interference.

6. OPTIMIZATION AND FINAL ADJUSTMENTS:

- After testing, the system is optimized to enhance its efficiency and performance. This includes adjusting data filtering parameters, refining the display refresh rate, and minimizing power consumption by optimizing code execution.

Through this methodology, the Vehicle Speed Monitoring System provides accurate real-time speed monitoring, demonstrating a practical application of IoT and embedded systems in transportation safety.

RESULT AND DISCUSSION:

PROGRAM:

```
#include <Wire.h>
#include <Adafruit_SSD1306.h>
#include <TinyGPS++.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

// On ESP32: GPIO-21(SDA), GPIO-22(SCL)
#define OLED_RESET -1 // Reset pin # (or -1 if sharing Arduino reset pin)
#define SCREEN_ADDRESS 0x3C // See datasheet for Address
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

#define RXD2 16
#define TXD2 17
HardwareSerial neogps(1);

TinyGPSPlus gps;

void setup() {
  Serial.begin(115200);
  // Begin serial communication with Neo6m GPS
  neogps.begin(9600, SERIAL_8N1, RXD2, TXD2);

  // Initialize OLED display
  if(!display.begin(SSD1306_SWITCHCAPVCC, SCREEN_ADDRESS)) {
    Serial.println(F("SSD1306 allocation failed"));
    for(;;); // Don't proceed, loop forever
  }

  display.clearDisplay();
  display.display();
  delay(2000);
}
void loop() {
```

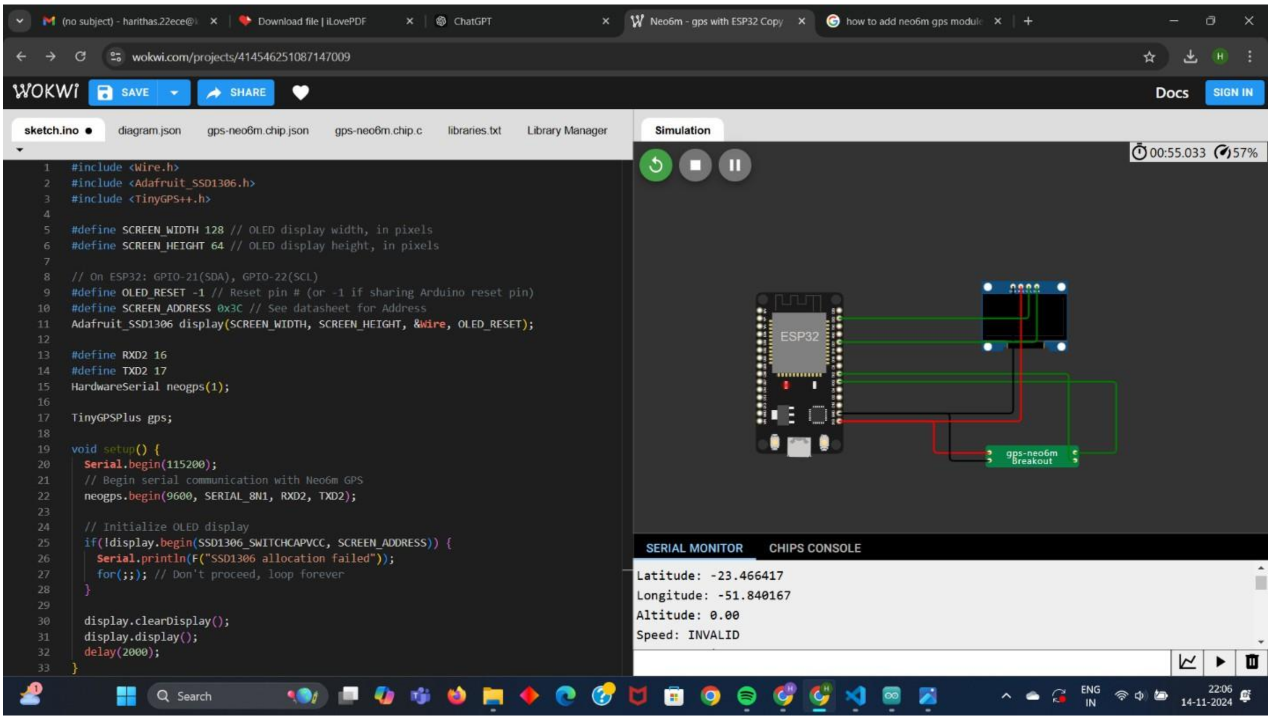
```
boolean newData = false;

 // Collect GPS data for 1 second
 for (unsigned long start = millis(); millis() - start < 1000;) {
   while (neogps.available()) {
     if (gps.encode(neogps.read())) {
       newData = true;
     }
   }
 }

 // If new data is received, display it; otherwise, display default values
 if (newData) {
   newData = false;
   Serial.println(gps.satellites.value());
   print_speed();
 } else {
   // Show default values if no new data
   display.clearDisplay();
   display.setTextColor(SSD1306_WHITE);
   display.setTextSize(1);

   display.setCursor(25, 5);
   display.print("Lat: ?");

   display.setCursor(25, 20);
   display.print("Lng: ?");

   display.setCursor(25, 35);
   display.print("Speed: 0 km/h");

   display.setCursor(0, 50);
   display.print("SAT: ?");

   display.setCursor(70, 50);
   display.print("ALT: ?");
```

```
display.display();
  }
}

void print_speed() {
  display.clearDisplay();
  display.setTextColor(SSD1306_WHITE);

  if (gps.location.isValid()) {
    display.setTextSize(1);

    display.setCursor(25, 5);
    display.print("Lat: ");
    display.setCursor(50, 5);
    display.print(gps.location.lat(), 6);

    display.setCursor(25, 20);
    display.print("Lng: ");
    display.setCursor(50, 20);
    display.print(gps.location.lng(), 6);

    display.setCursor(25, 35);
    display.print("Speed: ");
    display.setCursor(65, 35);
    display.print(gps.speed.kmph());
    display.print(" km/h");

    display.setTextSize(1);
    display.setCursor(0, 50);
    display.print("SAT:");
    display.setCursor(25, 50);
    display.print(gps.satellites.value());

    display.setCursor(70, 50);
    display.print("ALT:");
    display.setCursor(95, 50);
```

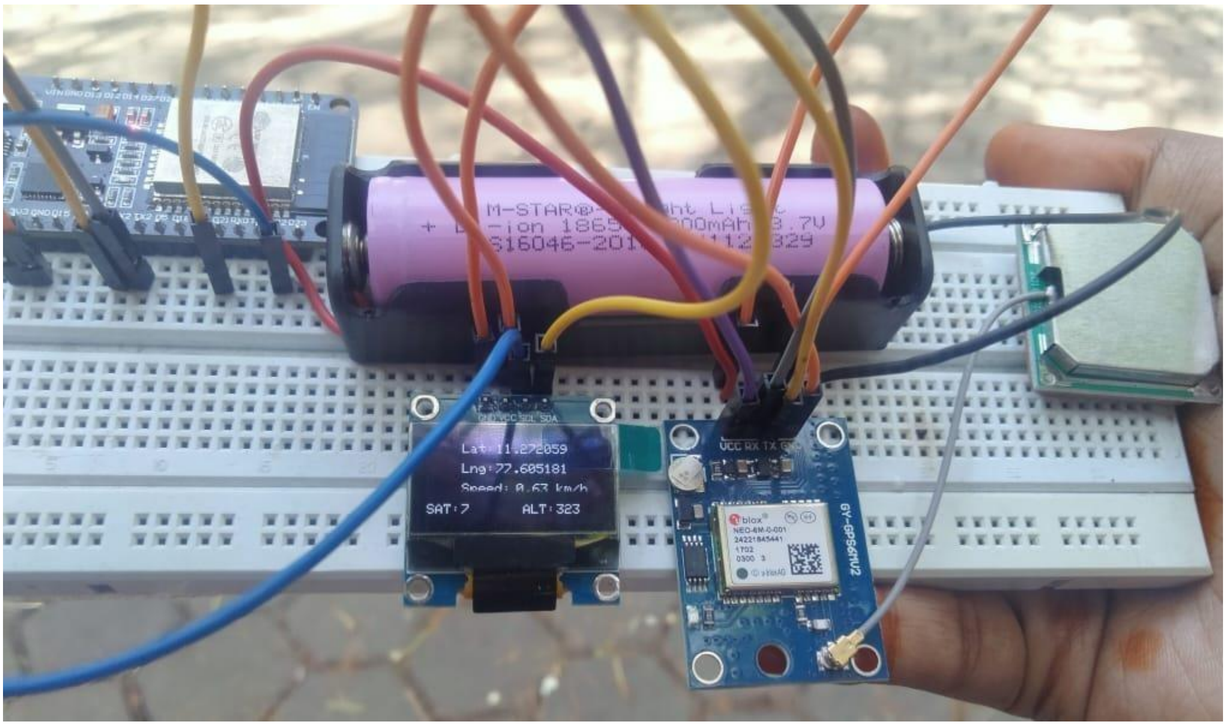
```
display.print(gps.altitude.meters(), 0);
  } else {
    // Display default values if GPS data is invalid
    display.setCursor(25, 5);
    display.print("Lat: ?");

    display.setCursor(25, 20);
    display.print("Lng: ?");

    display.setCursor(25, 35);
    display.print("Speed: 0 km/h");

    display.setCursor(0, 50);
    display.print("SAT: ?");

    display.setCursor(70, 50);
    display.print("ALT: ?");
  }

  display.display();
}
```

SIMULATION AND DISCUSSION

1. SIMULATION OUTPUT:



2. HARDWARE OUTPUT:



CONCLUSION

The Vehicle Speed Monitoring System Using GPS and ESP32 with OLED Display successfully demonstrates a practical and efficient approach to real-time vehicle speed tracking. By integrating GPS technology with the ESP32 microcontroller, the system can accurately calculate and display speed based on precise positional data. The choice of an OLED display enhances the user experience by providing high-contrast, easily readable information, even in challenging lighting conditions. This project showcases how embedded systems and IoT technology can be leveraged to create low-cost, effective solutions for vehicle safety and monitoring.

The system's design and implementation highlight the robustness and versatility of the ESP32 and the value of GPS for accurate speed monitoring. By employing data filtering techniques and calibration steps, the project achieves a reliable level of accuracy, proving its potential for various applications, including driver safety, fleet management, and educational purposes. This prototype also serves as a foundation for future enhancements, such as incorporating data logging, mobile connectivity, and integration with other vehicle telemetry systems.

Overall, this project illustrates the capabilities of embedded systems to address real-world challenges in transportation. The Vehicle Speed Monitoring System can contribute to improving road safety and offers a valuable educational experience in embedded systems and IoT applications.