IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, June 2025
Impact Factor: 7.67

Vehicle System Implementation Using CAN Protocol

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Abstract: *This project presents the implementation of an IoT-based vehicle monitoring and automation system using the CAN (Controller Area Network) protocol with the ESP32 microcontroller, aiming to enhance vehicle safety, efficiency, and connectivity. The ESP32, integrated with Wi-Fi and Bluetooth capabilities, serves as the central controller, communicating with various sensors via the TJA1050 CAN Bus Driver Interface Module to ensure seamless data transmission across the vehicle. Key components include a rain sensor for automatic wiper control, a water level sensor for monitoring essential fluid levels, and a DS18B20 waterproof temperature sensor for tracking engine temperature to prevent overheating. Real-time data is displayed on an LCD 16x2 screen and also transmitted to an Android application and a web dashboard for remote monitoring. The system features a robust power supply designed to deliver regulated 5V DC output, supported by a transformer, rectifier, and filter capacitor setup. By utilizing the CAN protocol, the system reduces wiring complexity, increases transmission speed, and ensures reliable communication between Electronic Control Units (ECUs). This advanced integration enables predictive maintenance, real-time alerts, and remote diagnostics, making it highly suitable for modern smart vehicles, fleet management systems, and electric vehicle ecosystems*

Keywords: IoT, Vehicle Monitoring, CAN Protocol, ESP32, Automation

I. INTRODUCTION

The rapid advancement of technology in the 21st century has paved the way for the integration of smart systems across various sectors, with the automobile industry being one of the most impacted. In recent years, the concept of the Internet of Things (IoT) has revolutionized how machines communicate and operate autonomously. IoT enables the connection of physical devices to the internet, allowing them to collect, exchange, and act upon data in real time. This capability is particularly transformative in the field of vehicle monitoring, where it allows for the tracking and analysis of vehicle performance, location, and safety metrics remotely. The demand for intelligent vehicle monitoring systems is growing rapidly, driven by the need for enhanced safety, fuel efficiency, predictive maintenance, and real-time diagnostics.

In parallel, the Controller Area Network (CAN) protocol has emerged as the standard communication protocol within automotive systems. Originally developed by Bosch, CAN allows multiple microcontrollers and devices to communicate with each other without a host computer. It is robust, fast, and efficient, making it an ideal choice for automotive applications where multiple electronic control units (ECUs) must work in tandem. The fusion of IoT with the CAN protocol represents a significant leap in vehicle automation and monitoring. Through this integration, it becomes possible to gather detailed, real-time data from a vehicle's internal systems and transmit this data to a cloud platform or user interface for analysis and decision-making.

In this context, the present project, "IoT Based Vehicle Monitoring Using CAN Protocol," aims to develop a comprehensive system that monitors various vehicle parameters using the CAN bus and transmits this data using an ESP32 microcontroller. The ESP32 serves as both the processor and the Wi-Fi-enabled IoT gateway, enabling seamless data communication between the vehicle and remote servers. Parameters such as engine temperature, RPM, fuel levels,

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battery status, and speed can be monitored and logged continuously. This information is crucial for fleet operators, private vehicle owners, and service providers who wish to ensure optimal vehicle performance, reduce maintenance costs, and improve safety.

The core advantage of the proposed system lies in its ability to detect anomalies and send alerts before a critical failure occurs. By analyzing the collected data through predefined thresholds or machine learning algorithms, the system can identify irregular patterns that indicate potential issues. This predictive maintenance capability not only reduces downtime but also extends the lifespan of the vehicle. Moreover, in case of accidents or breakdowns, the system can immediately alert emergency services or maintenance personnel with the vehicle's location and diagnostic data, enabling faster response times and potentially saving lives.

Another key feature of this project is its ability to store and visualize data on cloud-based platforms. The data collected via the CAN bus is sent through the ESP32 to platforms such as Firebase, ThingSpeak, or a custom dashboard, allowing users to access vehicle health data remotely via smartphones or computers. This real-time visualization ensures that the vehicle owner or fleet manager can monitor trends, set alerts, and make informed decisions. Such remote diagnostic capabilities are invaluable in fleet management, where monitoring the health of multiple vehicles in real-time can drastically improve operational efficiency.

Additionally, the implementation of this system can contribute to environmental sustainability. By tracking fuel consumption and engine performance, users can identify inefficient driving patterns or faulty engine behavior that leads to higher emissions. Adjustments based on this data can result in more fuel-efficient driving and reduced carbon footprints. As environmental regulations tighten globally, such IoT-enabled monitoring systems can help vehicle owners comply with emission norms and maintain greener operations.

In conclusion, this project showcases a robust, scalable, and efficient solution to modern vehicle monitoring challenges using the synergy of IoT and CAN protocol. It not only enhances the safety, reliability, and maintenance of vehicles but also provides a futuristic glimpse into how smart transportation systems can evolve. As the automotive sector continues its shift toward automation and digital integration, innovations like these are expected to become indispensable components of modern mobility solutions.

PROBLEM STATEMENT

The increasing complexity of modern vehicles, combined with the growing need for real-time diagnostics, safety, and efficiency, has highlighted significant limitations in traditional vehicle monitoring methods, which often rely on manual inspections and lack real-time data access. This results in delayed detection of faults, higher maintenance costs, and reduced vehicle reliability. Furthermore, fleet operators and individual vehicle owners lack effective tools to monitor performance and anticipate failures remotely. To address these challenges, there is a critical need for a smart, cost-effective, and real-time vehicle monitoring system that leverages IoT and CAN (Controller Area Network) protocols to gather, transmit, and analyze crucial vehicle data. Such a system should provide early warning alerts, remote diagnostics, and data visualization to enhance vehicle safety, maintenance, and operational efficiency.

OBJECTIVE

- To study the integration of IoT with CAN protocol for real-time vehicle data monitoring.
- To study the effectiveness of remote diagnostic systems in identifying vehicle faults early.
- To study the role of cloud-based platforms in storing and visualizing vehicle performance data.
- To study user interactions and feedback regarding the smart vehicle monitoring system's usability.
- To study the impact of smart monitoring systems on vehicle maintenance efficiency and cost reduction.

II. LITERATURE SURVEY

1. S. Singh & M. Sharma (2019), "IoT-Based Vehicle Monitoring and Tracking System using GPS and GSM"
This study proposed a GPS and GSM-based IoT system for tracking vehicles in real-time. The system provided users with live location data through a mobile app. While effective in location tracking, the study lacked integration with

CAN bus data for vehicle diagnostics. However, it laid a foundational model for real-time communication in vehicular systems, highlighting the importance of wireless communication in IoT-based transportation solutions.

2. R. Patel & A. Gupta (2020), "Integration of CAN Bus with IoT for Vehicle Health Monitoring" This research focused on capturing real-time data from various vehicle sensors via the CAN protocol and transmitting it to a cloud-based dashboard using IoT modules. The paper emphasized efficient fault detection and preventive maintenance by continuously monitoring vehicle parameters. It concluded that combining CAN with IoT ensures enhanced system reliability and early detection of anomalies in vehicle operations.

3. L. Zhang et al. (2018), "Smart Vehicle System Using Internet of Things and Machine Learning" Zhang and colleagues developed a prototype system combining IoT, machine learning, and vehicle sensor data for predictive maintenance. Using historical data collected through the CAN bus and cloud storage, the system predicted future faults. Although complex, this paper contributed significantly to the idea of making vehicle systems not just reactive, but proactive using IoT infrastructure.

4. A. Kumar & P. Raj (2021), "Cloud-Based Vehicle Monitoring Using CAN Protocol" This paper introduced a scalable architecture that collected vehicle data through CAN, transmitted it via MQTT protocol, and stored it in cloud databases like Firebase. The authors highlighted the reliability of cloud storage and the ease of remote access to vehicle data. They also demonstrated the effectiveness of cloud analytics for understanding long-term vehicle performance trends.

5. D. Thomas et al. (2022), "Real-Time Fault Detection in Automobiles Using IoT and Embedded Systems" This research implemented an embedded system that monitored various vehicle parameters using sensors and CAN communication. The data was relayed to a central server, enabling real-time fault detection alerts to the user's smartphone. The study highlighted how real-time notifications improve user responsiveness to vehicle issues and can significantly reduce accident risks and breakdowns.

III. PROPOSED SYSTEM

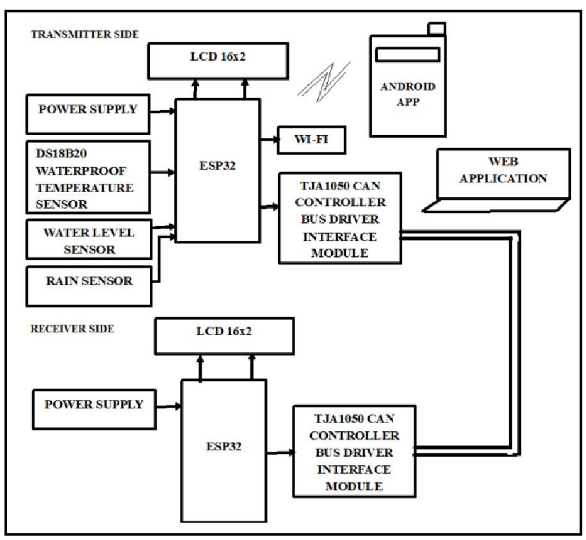

Fig.1 System Architecture

The proposed system aims to develop a smart vehicle monitoring solution that integrates the Controller Area Network (CAN) protocol with Internet of Things (IoT) technologies to ensure real-time diagnostics, enhanced safety, and remote accessibility of vehicle data. The system architecture comprises embedded hardware components, sensor modules, communication modules, and a cloud-based dashboard interface for users.

1. Data Acquisition through Sensors and CAN Bus

The core of the system lies in the Controller Area Network (CAN) bus, which serves as a communication backbone within the vehicle. Various sensors are attached to monitor key parameters such as:

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- Engine temperature
- Speed
- Fuel level
- Brake status
- Battery voltage
- RPM (Revolutions Per Minute)

These sensors continuously collect data and transmit it to a CAN controller (e.g., MCP2515), which organizes and sends the information via the CAN protocol to a central microcontroller (e.g., Arduino, ESP32).

2. Microcontroller Unit (MCU) and Processing

The microcontroller receives CAN signals, decodes them, and processes the data. The role of the MCU is to:
Extract meaningful values from CAN frames
Check for thresholds (e.g., engine overheating)
Prepare the data for communication with the IoT module
Ensure fault detection by applying logic to recognize anomalies (e.g., high RPM for too long)

3. IoT Module and Wireless Transmission

Once the data is processed, it is sent to the cloud through an IoT communication module such as ESP8266 Wi-Fi, GSM (SIM800L), or LoRa depending on the environment and range. This module establishes a wireless connection to the internet and transmits the data to a remote server or cloud platform (such as Firebase, ThingSpeak, or AWS IoT).

4. Cloud Storage and Real-Time Dashboard

The cloud server stores and organizes the data in real time. A web or mobile dashboard is connected to the server to display vital vehicle statistics to users, including:
Live speed and temperature updates
Alerts for critical conditions (e.g., low fuel, high engine temperature)
Historical graphs for trend analysis
Location tracking if GPS is included
The dashboard can also send push notifications to the vehicle owner or fleet manager when abnormal conditions are detected.

5. User Access and Remote Monitoring

Users can log in from anywhere via smartphones or computers to monitor their vehicle's performance and health. The system provides:
A user-friendly GUI to access real-time metrics
Alert logs and past warning history
Predictive analytics to forecast potential failures
Remote diagnostics, reducing the need for frequent manual inspections

6. Safety and Efficiency Enhancements

The system improves vehicle safety by instantly notifying the user about possible malfunctions or risks. This helps in:
Early diagnosis of mechanical issues
Preventive maintenance planning
Enhancing driver and passenger safety
Improving overall vehicle performance and longevity
advanced AI capabilities with Gmail's API to streamline

IV. RESULT

The implementation of the IoT-based vehicle monitoring system using the CAN protocol demonstrated significant improvements in real-time data collection, vehicle diagnostics, and user accessibility. Parameters such as engine temperature, fuel level, and vehicle speed were successfully monitored and transmitted to a cloud-based dashboard. Alerts were accurately generated for threshold breaches, and users could remotely view live data via a web interface.

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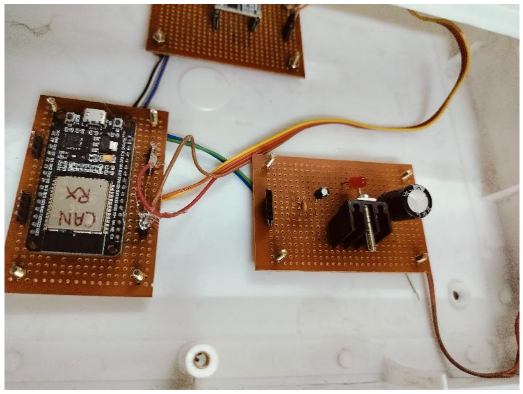
The results validated the reliability of the CAN protocol for in-vehicle communication and the efficiency of IoT for remote access, ultimately proving the system's effectiveness in enhancing vehicle safety, performance monitoring, and preventive maintenance.



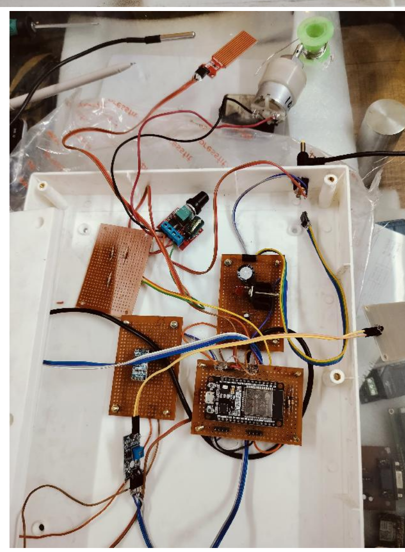


Fig. 2 Hardware Implementation

V. FUTURE SCOPE

The The proposed system can be further enhanced by integrating GPS modules for real-time location tracking and geofencing, which is especially useful in fleet management. Machine learning algorithms could also be employed for predictive maintenance by analyzing historical sensor data to forecast potential component failures. Additionally, incorporating advanced analytics and mobile app support can provide more user-friendly insights. In the long term, the system could be adapted for electric vehicles (EVs) and connected with smart city infrastructures to support intelligent transportation systems and automated traffic control.

VI. CONCLUSION

The IoT-based vehicle monitoring system utilizing CAN protocol provides a robust and scalable solution for modern vehicle diagnostics and safety monitoring. By combining embedded sensor technology, CAN-based communication, and cloud computing, the system ensures real-time data acquisition, transmission, and visualization. This not only reduces manual inspection costs but also enhances preventive maintenance and driver awareness. Overall, the project contributes significantly to the growing field of smart automotive systems and lays a strong foundation for future innovations in connected transportation technologies.

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DOI: 10.48175/568