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EV Dashboard Monitoring System

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Abstract: *The rapid growth of electric vehicles (EVs) over the past decade has been driven by the global transition toward cleaner and more sustainable transportation systems, highlighting the importance of advanced human–machine interface technologies such as dashboard panels. The dashboard panel serves as a critical component in EV operation, providing drivers with real-time information necessary for safe and efficient vehicle control while also displaying the status of key subsystems, including battery performance, power consumption, and system diagnostics. Important parameters presented through the dashboard include speed, energy usage, battery state indicators, and warning signals, which collectively enhance driver awareness and decision-making. With the automotive industry progressing toward higher levels of electrification and digitalization, there is an increasing demand for intelligent and adaptive dashboard solutions that can cater to diverse user preferences and evolving system requirements. In recent years, dashboard technologies have significantly advanced, incorporating digital displays, customizable interfaces, and integrated smart features that improve usability and aesthetics. However, conventional dashboard systems still face several limitations, such as lack of flexibility, difficulty in reconfiguration, limited scalability, and challenges in integrating new functionalities over time. These constraints create a need for innovative design approaches that not only improve existing systems but also enable dynamic adaptability throughout the vehicle's lifecycle. Several studies have explored various aspects of automotive dashboard systems, focusing on user interface design, display technologies, and system integration. Nevertheless, much of the existing work remains descriptive and does not systematically address opportunities for innovation in flexible dashboard design. Therefore, this paper aims to analyze current dashboard panel technologies, identify their limitations, and propose a reconfigurable and aesthetically appealing dashboard design tailored for electric vehicles. This research specifically seeks to: (1) review existing dashboard systems and their limitations, (2) evaluate the need for flexibility and customization in modern EV interfaces, and (3) propose a design framework for next-generation adaptable dashboard panels.*

Keywords: Electric Vehicles (EVs), Dashboard Panel, Flexible Interface Design, Human–Machine Interface (HMI), Reconfigurable Systems, Digital Dashboard, Vehicle Subsystems Monitoring, User Customization, Automotive Electronics, Smart Display Systems

I. INTRODUCTION

A key aspect of any vehicle architecture is the user interface. The means by which the vehicles operational information is being displayed to the user (driver) is an imperative aspect. Information's such as current speed and the autonomy of the vehicle are regular feedbacks the driver needs when driving. The current operational status of subsystems and accumulated travel distance play an important role when carrying out maintenance to the vehicle. When these sets of data are obtained a dashboard is can be design accordingly using dedicated gauges and indicators.

Most dashboards are defined at design time and cannot be altered through its lifetime. This contradicts the current trend towards reconfigurable vehicles that not only support customization at delivery time but also during the lifetime of the

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system. For example when the driver replaces an existing sub-system or the user decides to alter the subsystems specifications during the lifetime of the vehicle. A dashboard that can manage such level of flexibility will be able to meet the users' requirements. Such flexibility can be achieved using the current mainframe of technologies like high resolution screen, sensors and controllers to name a few. Further advancements in technology has enabled the customization of the dashboard by the driver during the lifetime of the vehicle. It has not only made the dashboard flexible it has also brought economic benefits since the same hardware can be used among many different car models. In this paper a flexible dashboard panel system is proposed using soft gauges implemented on a high resolution screen. The dashboard will not only be reconfigurable but also be designed to accommodate changes in the vehicle sub-systems providing different aesthetic options.

II. LITERATURE SURVEY

1. Author(s), "Title of paper," Journal/Conference, Year. The dashboard panel is a fundamental component in any vehicle, as it provides the driver with essential real-time information regarding vehicle operation. In Electric Vehicles (EVs), the role of the dashboard becomes significantly more critical due to the complexity of electrical subsystems and the need for continuous monitoring of parameters such as speed, temperature, mileage, and battery State of Charge (SOC). According to [1], modern dashboard panels function as integrated systems that display both conventional vehicle data and advanced diagnostics, including safety parameters such as Anti-lock Braking System (ABS) and Traction Control System (TCS)

2. Author(s), "Title of paper," Journal/Conference, Year. The advancement of Graphical User Interface (GUI) technologies has transformed human-machine interaction in the automotive industry. Over the past decade, leading manufacturers such as Toyota, Nissan, and Mitsubishi Motors have incorporated EVs into their product portfolios, including models like the Toyota Prius, Nissan Leaf, and Mitsubishi i-MiEV. These vehicles utilize advanced GUI-based dashboards to present complex system data in an intuitive manner, improving driver awareness and decision-making [2].

3. Author(s), "Battery technologies in EVs," Journal, Year. An EV typically consists of several key components, including electric motors, battery packs, converters, and battery management systems (BMS). Recent research has explored alternative energy storage solutions such as fuel cells and supercapacitors, as well as hybrid energy systems [3]–[5]. Dual-source EV architectures have been shown to achieve higher efficiency compared to single-source systems [6]. As a result, conventional dashboard systems are inadequate for managing such complexity, leading to the development of Flexible Dashboard Panels.

4. Author(s), "Fuel cell systems for EV," Journal, Year. Flexible dashboard systems are capable of monitoring multiple subsystems while allowing driver interaction for system optimization. According to [7], these dashboards not only display vehicle parameters but also enable drivers to control energy usage and improve system performance. Additionally, they provide real-time fault detection and enhance vehicle safety by alerting drivers to abnormal conditions.

5. Author(s), "Supercapacitors in EV applications," Journal, Year. Microcontrollers play a vital role in the implementation of EV dashboard systems, particularly in the development of Electronic Control Units (ECUs). The choice of microcontroller depends on the subsystem requirements. For instance, the PIC18F2680 is used in [1] to create a scalable and homogeneous network across subsystems. Similarly, platforms such as the Arduino Uno and specialized controllers have been used to monitor parameters including motor speed, current, battery voltage, and temperature [9]. In addition, the 8051 microcontroller has been utilized in vehicle security systems integrated with communication modules [10].

6. Author(s), "Dual-source EV efficiency analysis," Journal, Year. Efficient communication between EV subsystems is achieved using the Controller Area Network. CAN is a serial communication protocol designed for real-time data exchange between ECUs. It employs short data frames, non-destructive arbitration, and flexible communication mechanisms, making it highly reliable for automotive applications [11]. The implementation of CAN networks

enhances system reliability, safety, and maintainability while enabling efficient data sharing across multiple subsystems.

III. METHODOLOGY

The proposed Electric Vehicle (EV) dashboard system is designed to acquire, process, and display real-time vehicle parameters using a centralized processing unit. The system architecture, as illustrated in the block diagram, consists of multiple sensors interfaced with a processing unit, which then outputs data to a display module.

A. System Overview

The system is centered around the Raspberry Pi, which acts as the main processing unit. It receives input signals from various sensors, processes the data, and displays the results on a TFT screen. The entire system is powered by a regulated power supply to ensure stable operation.

B. Sensor Data Acquisition

Multiple sensors are used to monitor different parameters of the EV:

- Temperature Sensor (LM35): Measures the temperature of critical components such as the battery or motor. The LM35 provides an analog voltage output proportional to temperature.
- Voltage Sensor Module: Monitors the battery voltage to determine the state of the power system and prevent over-voltage or under-voltage conditions.
- Current Sensor (ACS712): Measures the current flowing through the system, enabling power consumption analysis and fault detection.
- RPM Sensor (Groove Coupler Module): Measures the rotational speed of the motor, which is essential for determining vehicle speed and performance.

These sensors continuously collect real-time data and send it to the processing unit.

C. Data Processing Unit

The Raspberry Pi processes the incoming sensor data. Since some sensors provide analog outputs, an Analog-to-Digital Converter (ADC) may be used to convert signals into digital form compatible with the Raspberry Pi.

The processing unit performs the following functions:

- Data acquisition from sensors
- Signal conditioning and filtering
- Conversion of raw data into meaningful parameters (e.g., temperature in °C, speed in RPM)
- Threshold analysis for fault detection

D. Display and Graphical User Interface

The processed data is displayed on a TFT screen connected to the Raspberry Pi. A Graphical User Interface (GUI) is developed to present the information in an intuitive and user-friendly manner.

The dashboard displays:

- Temperature readings
- Battery voltage levels
- Current consumption
- Motor speed (RPM)
- Warning alerts for abnormal conditions

The GUI ensures real-time updates and clear visualization, enabling the driver to monitor the EV status efficiently.

E. Power Supply Unit

A regulated power supply is used to provide stable voltage to all components in the system. It ensures proper functioning of sensors, the Raspberry Pi, and the display module. Voltage regulation is critical to prevent system failures and ensure accurate sensor readings.

F. System Operation

The overall operation of the system follows these steps:

1. Sensors continuously measure physical parameters.
2. Data is transmitted to the Raspberry Pi.
3. The Raspberry Pi processes and analyzes the data.
4. Processed information is displayed on the TFT screen in real time.
5. Alerts are generated if any parameter exceeds predefined thresholds.

G. System Advantages

• Real-time monitoring of EV parameters
• Centralized processing for efficient data handling
• Improved safety through early fault detection
• User-friendly visualization via GUI

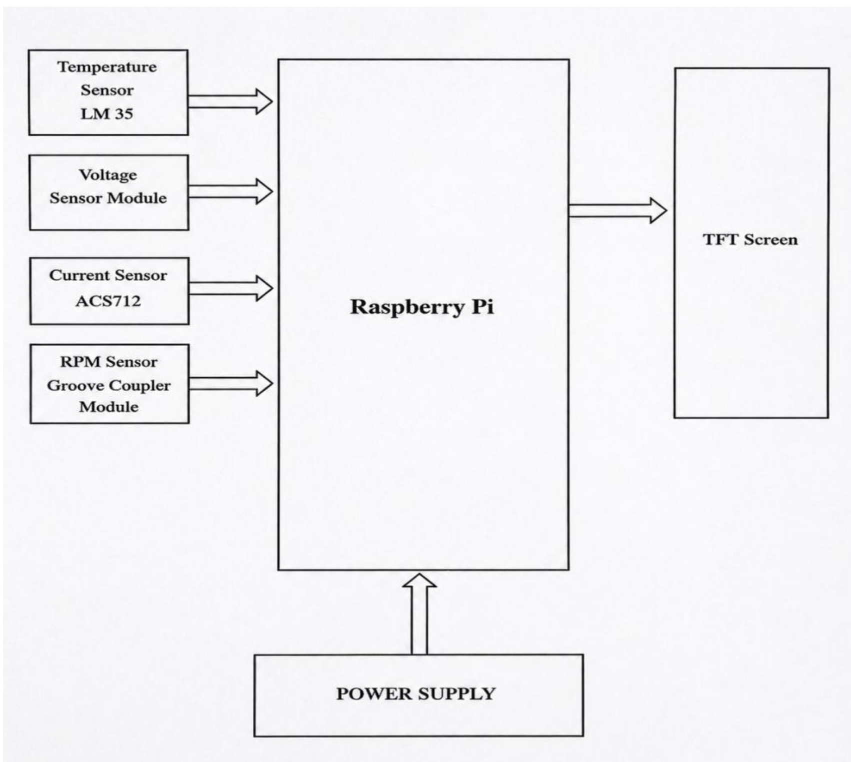

Fig. 1. Block diagram of the Ev Dashboard Monitoring System

Description:

Figure 1 shows the Raspberry Pi-based Electric Vehicle (EV) dashboard system, which is designed to monitor and display important vehicle parameters in real time for safe and efficient operation. The system consists of multiple sensors interfaced with the Raspberry Pi, which acts as the central processing unit.TheLM35 temperature sensor is used

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to measure the temperature of critical components, while the voltage sensor module continuously monitors the battery voltage. The ACS712 current sensor measures the current flowing through the system, and the RPM sensor (groove coupler module) detects the rotational speed of the motor.All these sensors generate analog signals, which are processed by the Raspberry Pi (using suitable interfacing/ADC where required). The Raspberry Pi collects and analyzes the data to provide meaningful information such as temperature, voltage, current, and motor speed.The processed information is displayed on a TFT screen, which acts as the user interface, providing real-time feedback to the driver. This helps in monitoring the overall performance and condition of the electric vehicle.The system is powered by a regulated power supply, ensuring stable operation of the Raspberry Pi and all connected modules.Overall, this EV dashboard system improves vehicle monitoring, enhances safety, and provides an efficient way to visualize key operational parameters in real time.

a) Block Diagram

Description:

This block diagram represents a Raspberry Pi-based electric vehicle dashboard system designed to monitor and display important vehicle parameters in real time.The system consists of multiple sensors connected to the Raspberry Pi. The LM35 temperature sensor measures the temperature of the vehicle components. The voltage sensor module monitors the battery voltage, while the ACS712 current sensor measures the current flowing through the system. The RPM sensor (groove coupler module) is used to detect the rotational speed of the motor.All these sensors provide input signals to the Raspberry Pi, which acts as the main processing unit. The Raspberry Pi collects, processes, and converts the sensor data into meaningful information.The processed data is then displayed on a TFT screen, providing real-time feedback such as temperature, voltage, current, and motor speed to the user.A regulated power supply is used to provide the required power to the Raspberry Pi and connected components.This system helps in efficient monitoring of electric vehicle performance and ensures safe and reliable operation.

b) Circuit Diagram and Design Considerations

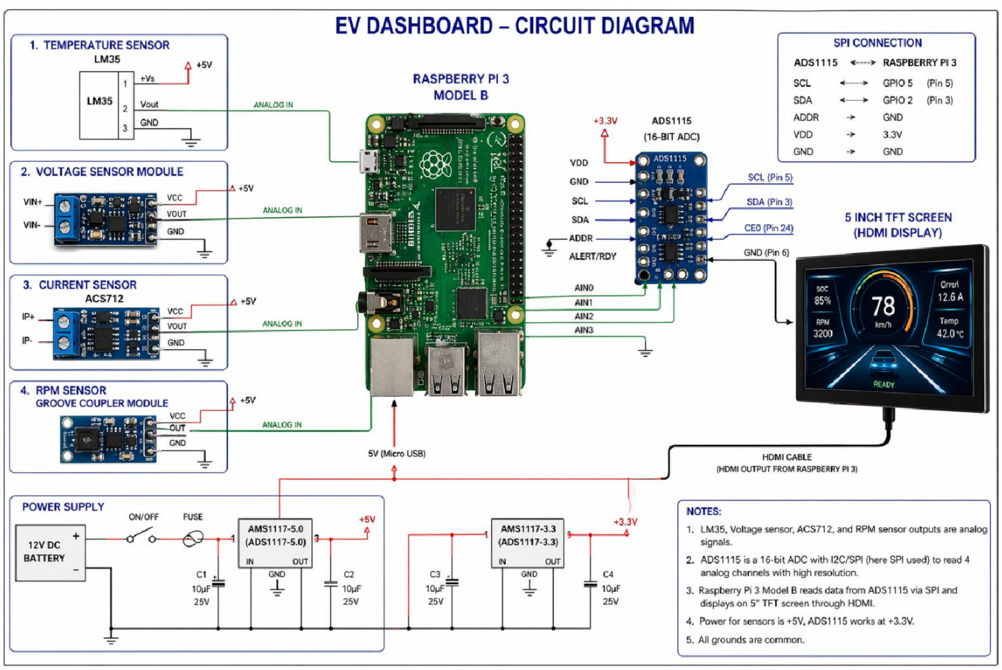

Fig. 2. Circuit Diagram and Design Considerations

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Description:

The circuit diagram represents a Raspberry Pi-based Electric Vehicle (EV) dashboard system designed to monitor key vehicle parameters such as temperature, voltage, current, and motor speedin real time.The system uses multiple sensors for data acquisition. The LM35 temperature sensor measures temperature and provides an analog output proportional to it. The voltage sensor module is used to monitor the battery voltage, while the ACS712 current sensor measures the current flowing through the system. The RPM sensor (groove coupler module) detects the rotational speed of the motor.Since the Raspberry Pi does not have built-in analog input pins, an external ADS1115 (16-bit ADC) is used to convert analog signals from all sensors into digital data. These sensor outputs are connected to the analog input channels (AIN0–AIN3) of the ADS1115. The ADC communicates with the Raspberry Pi 3 Model B using I2C communication protocol through SDA and SCL pins.The Raspberry Pi processes the received digital data and displays the parameters on a 5-inch TFT screen using HDMI interface, providing a real-time graphical dashboard to the user.The power supply section consists of a 12V DC battery, which is stepped down to regulated 5V and 3.3V using voltage regulators (AMS1117-5.0 and AMS1117-3.3). The 5V supply powers the sensors and Raspberry Pi, while the 3.3V supply is used for the ADS1115 ADC. Capacitors are used for filtering and ensuring stable voltage output. All components share a common ground to maintain proper circuit operation.Overall, this system enables accurate monitoring, efficient data processing, and real-time visualization of essential EV parameters, thereby improving vehicle safety and performance.

c) Mathematical Calculations:

• The LM35 temperature sensor gives output voltage and temperature is calculated as T=30°C.

• The voltage sensor uses a voltage divider and actual voltage is

Vin=Vout×(R1+R2)/R2V_{in} = V_{out} \times (R_1 + R_2)/R_2Vin=Vout×(R1+R2)/R2; for Vout=2VV_{out}=2VVout=2V, Vin=10VV_{in}=10VVin=10V.

• The ACS712 current sensor calculates current using

I=(Vout−2.5)/0.185I = (V_{out} - 2.5)/0.185I=(Vout−2.5)/0.185; for Vout=2.87VV_{out}=2.87VVout=2.87V, I=2AI = 2AI=2A.

• The RPM is calculated using pulse count

RPM=(N×60)/tRPM = (N × 60)/tRPM=(N×60)/t; for N=50N=50N=50, RPM=3000RPM = 3000RPM=3000.

• The ADS1115 ADC converts analog to digital using

Vin=(Digital Value/65535)×VrefV_{in} = (Digital\ Value/65535) × V_{ref}Vin=(Digital Value/65535)×Vref; for 32768, Vin≈2.048VV_{in} ≈ 2.048VVin≈2.048V.

• The electrical power is calculated as

P=V×IP = V × IP=V×I; for V=10VV=10VV=10V, I=2AI=2AI=2A, P=20WP = 20WP=20W.

d) System Specifications :

The system has the following performance specifications:

- Communication Range: 15-20 m (Line of Sight)
- Latency: ±1 second
- Temperature Accuracy: ±2°C
- Humidity Accuracy: ±5% RH
- Power Supply: 12V with approximately 2200 mA current consumption

e) Hardware Requirements :

•Raspberry Pi (Model 4):

Acts as the main controller. It reads sensor data, processes it, and controls all operations.

•Current Sensor (ACS712):

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Measures the current flowing in the system.
•Temperature Sensor (LM35):
Measures temperature and gives output in °C.
•Voltage Sensor (25V Module):
Measures voltage safely using a voltage divider.
• LCD Display:
Displays values like voltage, current, and temperature.

f) Software Requirements :
•Thonny IDE:
Used for writing and executing Python Programs.
•Raspberry Pi:
Used as the main controller of the EV Dashboard Monitoring System.
•LCD Library:
Used to interface and display data on the LCD.

IV. RESULTS AND DISCUSSION :

The EV Dashboard Monitoring System was successfully developed and tested for real-time monitoring of electric vehicle parameters. The dashboard accurately displayed vehicle speed, battery percentage, voltage, charging status, temperature, distance, and average speed through a graphical user interface. During testing, the system showed smooth and responsive performance with proper data visualization on the display. Bluetooth communication between the microcontroller and mobile application worked efficiently for wireless monitoring. The developed system improves driver awareness, provides better monitoring of EV performance, and offers an effective and user-friendly digital dashboard solution for electric vehicles.

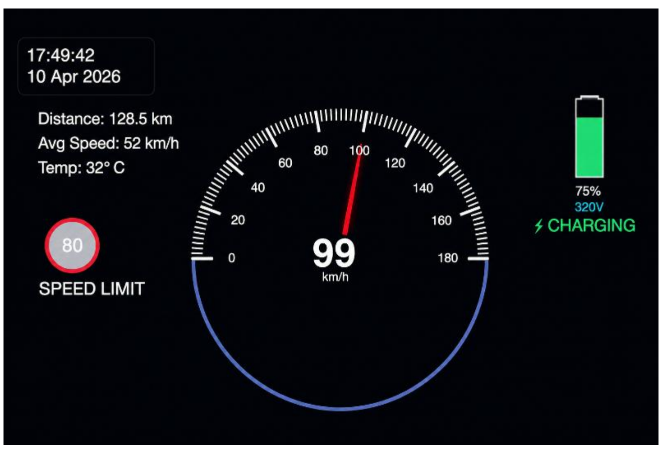

Fig. 3. Login Interface for the Ev Dashboard Monitoring System

Description:

Figure 3a futuristic digital dashboard of an electric vehicle designed with a modern and user-friendly interface. The dashboard provides complete real-time information related to vehicle performance, driving conditions, and battery status. The entire display uses a dark black background with bright white, blue, red, and green color combinations, making the information clearly visible and visually attractive.At the center of the dashboard, a large circular digital speedometer is displayed. The speedometer indicates the current speed of the vehicle as 99 km/h. The meter is calibrated from 0 to 180 km/h, and a red needle points towards the current speed reading. The speed value is also shown numerically at the center for better readability. Around the lower portion of the speedometer, a blue semicircular arc enhances the modern appearance of the dashboard.On the left side of the display, important trip and environmental information is provided. The upper box shows the current time as 17:49:42 and the date as 10 April 2026. Below this, the dashboard displays the total distance traveled, which is 128.5 km. The average speed during the trip is recorded as 52 km/h, while the outside temperature is shown as 32°C. These details help the driver monitor journey performance and surrounding conditions.Below the trip information, a circular traffic speed limit sign is displayed. It indicates the permitted road speed limit as 80 km/h. Since the current vehicle speed is 99 km/h, the dashboard suggests that the vehicle is moving above the allowed speed limit. This feature helps improve road safety and assists the driver in maintaining proper speed regulations.On the right side of the dashboard, a battery monitoring system is shown. The battery charge level is displayed graphically and numerically as 75%. The battery icon is filled with green color, indicating sufficient battery power. Below the battery indicator, the charging voltage is shown as 320V, along with a green lightning symbol and the word “CHARGING.” This confirms that the electric vehicle is currently connected to a charging system.The dashboard design reflects advanced automotive technology used in modern electric vehicles. It combines speed monitoring, trip management, environmental data, battery management, and safety alerts into a single integrated display system. Such digital dashboards improve driving efficiency, enhance safety, and provide a better user experience through accurate and real-time information.

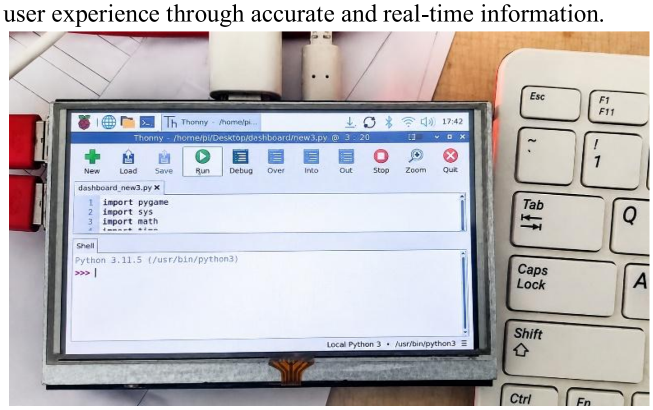

Fig. 4. Interfacing raspberry pi to TFT screen for the Monitoring System

Description:

The figure shows the interfacing of a Raspberry Pi with a TFT touchscreen display. The TFT screen is connected to the Raspberry Pi system along with USB cables and a compact keyboard for programming and control purposes.

The display is running the Thonny Python IDE, which is commonly used for Python programming on Raspberry Pi. A Python file named dashboard_new3.py is open on the screen, indicating that the system is being used for graphical dashboard or embedded application development. The code includes Python libraries such as pygame, sys, and math, which are useful for creating display interfaces and performing calculations.

The TFT touchscreen provides a compact and portable visual interface for the Raspberry Pi. Such interfacing is widely used in embedded systems, IoT projects, smart dashboards, automation systems, and real-time monitoring applications. The setup demonstrates how Raspberry Pi can be connected with a TFT display to create interactive graphical applications using Python programming.

V. CONCLUSION AND FUTURE SCOPE

The designed Electric Vehicle (EV) dashboard system successfully demonstrates an efficient and reliable method for real-time monitoring and visualization of important vehicle parameters such as temperature, voltage, current, and motor speed. By integrating multiple sensors with the ADS1115 module and processing data using the Raspberry Pi 3 Model B, the system achieves accurate and high-resolution data acquisition while overcoming analog input limitations. The implementation of a graphical dashboard on a 5-inch TFT display provides a clear and user-friendly interface with real-time updates and basic fault detection features, improving vehicle safety and operational awareness. The regulated power supply further enhances system stability and reliability, making the proposed dashboard a cost-effective and scalable solution for modern EV applications. In future, the system can be improved by integrating Controller Area Network (CAN) communication for better interaction between Electronic Control Units (ECUs), along with wireless technologies such as Wi-Fi and Bluetooth for remote monitoring and cloud-based data logging. Additional features like GPS-based tracking, advanced graphical interfaces, touchscreen controls, machine learning-based fault prediction, and industrial-grade sensors can further enhance the performance, intelligence, and durability of the dashboard system, enabling it to evolve into a fully functional smart dashboard for next-generation electric vehicles.

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