CHAPTER 1:

INTRODUCTION

1.1 Project Title

"Integrated Data Acquisition System for Vehicle Monitoring"

1.2 Background

With the rapid development of the automotive industry, vehicles are increasingly dependent on embedded electronic systems for safety, efficiency, and driver comfort. Monitoring critical parameters such as engine/cabin temperature, battery voltage, and ambient lighting conditions has become essential for ensuring vehicle health and enhancing performance. Traditional monitoring systems in low-cost vehicles are limited in scope and lack integrated real-time data logging capabilities. To overcome these limitations, a Data Acquisition System (DAS) can be developed using microcontrollers to collect, process, and display sensor data in real time.

1.3 Overview

The project "Integrated Data Acquisition System for Vehicle Monitoring" focuses on developing a real-time monitoring system for vehicles using the ARM7-based LPC2129 microcontroller. The system integrates multiple sensors to measure critical parameters such as temperature, voltage levels, and light intensity within the vehicle environment. It also uses a Real-Time Clock (RTC) for accurate timestamping of acquired data.

The architecture employs ADC channels for sensor data conversion, SPI for external ADC communication, I2C for RTC interfacing, and UART for transmitting data to a PC or central unit. The processed information is simultaneously displayed on an LCD module for local monitoring and logged for further analysis.

By combining efficient hardware and software modules, this system provides a reliable platform for vehicle health monitoring, supporting applications such as battery voltage tracking, cabin environment sensing, and driver assistance.

1.4 Problem Statement

Data Acquisition (DAS) is the process of collecting and measuring real-world physical or electrical signals. (such as Temperature, pressure, voltage, speed or light) and converting them into digital data that can be analyzed monitored or stored by a computer or microcontroller.

1.5 Objectives

- The primary objective of this project is to develop a Data Acquisition System (DAS) using the LPC2129 microcontroller for real-time monitoring and data logging.
- Acquiring real-time data from temperature, voltage, and light intensity sensors.
- Implementing I2C, SPI, UART, and ADC for seamless sensor interfacing.
- Displaying acquired data on an LCD screen and transmitting it to a PC via UART.
- Using an RTC module to associate each data point with a time stamp.

1.6 Scope of the Project

This project is applicable in vehicle health monitoring systems, where drivers can be alerted about changes in battery voltage, temperature, or light conditions. It can be extended to industrial vehicles, electric vehicles, and even integrated with IoT platforms for remote monitoring. The modular design allows future enhancements such as wireless communication, cloud integration, and AI-based predictive analysis

1.7 Applications

- Monitoring of vehicle cabin and engine temperature.
- Real-time battery voltage tracking in electric and conventional vehicles.
- Ambient light detection for automatic headlight control.
- Logging of sensor data for vehicle performance analysis and predictive maintenance.
- Integration into IoT-based vehicle monitoring systems.

CHAPTER 2:

LITERATURE REVIEW

2.1 Introduction

A Literature Review provides an overview of previous research, systems, and technologies related to the project. It helps in understanding existing solutions, their limitations, and how the proposed system improves upon them. In the context of vehicle monitoring systems, several methods have been developed using microcontrollers, sensors, and data acquisition techniques. However, gaps remain in terms of integration, cost-effectiveness, and real-time logging.

2.2 Data Acquisition Systems (DAS)

Data Acquisition Systems are widely used in industries, healthcare, and automotive applications for collecting and processing real-time data. Traditional DAS involved standalone instruments, but with the advancement of embedded systems and microcontrollers, compact and affordable DAS can now be designed. Microcontrollers provide built-in ADC, I2C, SPI, and UART interfaces that make integration of multiple sensors easier and efficient.

2.3 Existing Vehicle Monitoring Systems

- High-end vehicles use advanced Electronic Control Units (ECUs) that monitor multiple parameters like fuel efficiency, tire pressure, and battery health. However, these systems are expensive and not scalable for low-cost vehicles.
- Low-cost vehicles usually include only basic displays such as a fuel gauge, speedometer, or battery indicator, which provide limited monitoring and no data logging.
- Some research prototypes use Arduino, PIC, or ARM-based microcontrollers to build custom monitoring systems. While these demonstrate feasibility, many lack timestamped data logging and modularity for future expansion.

2.4 Role of Microcontrollers in Vehicle Monitoring

Microcontrollers such as **LPC2129 (ARM7TDMI-S)** play a crucial role in embedded DAS due to their multiple interfaces:

- **On-chip ADC**: Reads analog signals from temperature and voltage sensors.
- **I2C**: Enables communication with RTC modules for time stamping.

- **SPI**: Interfaces with external ADCs for additional sensors like LDR.
- **UART**: Provides serial communication with PC for data logging.

Compared to other controllers, LPC2129 provides high-speed processing, multiple communication protocols, and low power consumption, making it suitable for real-time vehicle monitoring.

2.5 Review of Sensor Technologies

- **MCP9700 Temperature Sensor:** Provides accurate temperature measurement with linear voltage output proportional to °C.
- **Potentiometer:** Used for variable voltage simulation, ideal for monitoring vehicle battery levels.
- **LDR (Light Dependent Resistor):** Detects ambient lighting conditions, useful for automatic headlight control.
- **RTC (DS1307):** Provides continuous time and date information, enabling timestamped logging of vehicle data.

2.6 Summary

The literature survey highlights the need for a modular, scalable, and low-cost DAS specifically designed for vehicle monitoring. By integrating LPC2129, sensors, RTC, and communication interfaces, the proposed system addresses the shortcomings of existing methods by ensuring real-time acquisition, display, and logging of multiple parameters.

CHAPTER 3:

METHODOLOGY

3.1 Introduction

The proposed Integrated Data Acquisition System for Vehicle Monitoring is designed using a modular hardware-software approach. The system is built around the ARM7-based LPC2129 microcontroller, which acts as the central processing unit. Various sensors such as the MCP9700 temperature sensor, potentiometer (for voltage measurement), and LDR (for ambient light detection) are interfaced with the microcontroller through onboard ADC channels and an external ADC (MCP3204 via SPI). A Real-Time Clock (DS1307) is connected using the I2C protocol to provide accurate time stamping for all acquired data.

The processed sensor values, along with the timestamp, are displayed on a 16×2 LCD for real-time vehicle monitoring and simultaneously transmitted to a PC terminal through UART communication for data logging and further analysis. This integrated approach ensures accurate, reliable, and real-time monitoring of critical vehicle parameters.

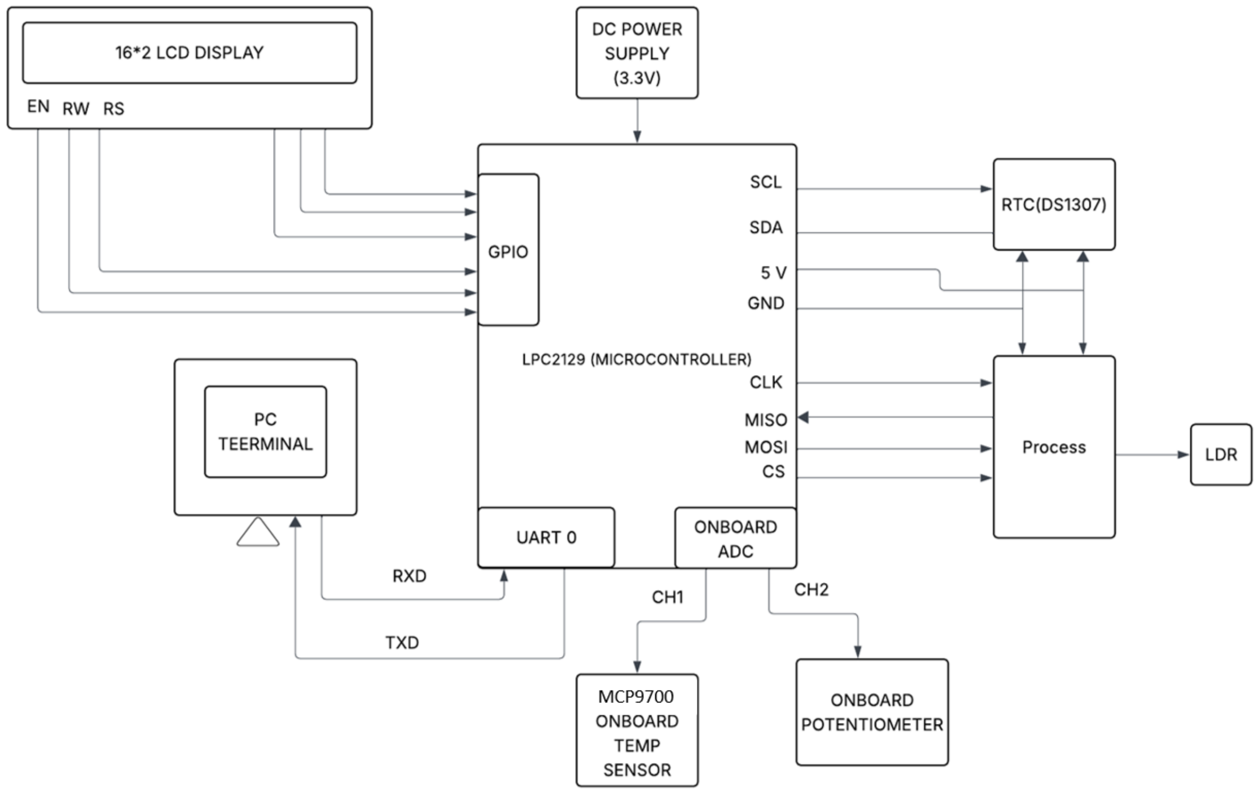


Figure 3.1 Block Diagram of Integrated Data Acquisition System for Vehicle Monitoring

3.2 Block Diagram Explanation

The system is built around the LPC2129 microcontroller, which acts as the central processing unit. Sensors such as the MCP9700 temperature sensor, potentiometer (for voltage measurement), and LDR (for ambient light detection) provide analog input signals. The MCP9700 and potentiometer are connected to the on-chip ADC channels, while the LDR is connected via an external ADC MCP3204 interfaced using SPI protocol.

A Real-Time Clock (DS1307) communicates with the microcontroller over the I2C bus to provide accurate timestamps. The processed data, along with time information, is displayed on a 16×2 LCD for real-time monitoring. Simultaneously, the same data is transmitted to a PC terminal via UART communication for logging and analysis.

3.3 Hardware Methodology

1. **Power Supply:** A regulated 3.3V supply powers the LPC2129 and its peripherals.
2. **Sensor Interfacing:**
   - MCP9700 → ADC Channel 1 for temperature measurement.
   - Potentiometer → ADC Channel 2 for voltage measurement (battery simulation).
   - LDR → MCP3204 external ADC via SPI.
3. **RTC Interfacing:** DS1307 connected to LPC2129 via I2C (SDA, SCL).
4. **Display:** 16×2 LCD interfaced with GPIO for real-time data display.
5. **Communication:** UART0 used to send sensor readings and timestamps to a PC terminal.

3.5 Software Methodology

The software is structured in modules to ensure modularity and scalability. The development steps include:

1. **Initialization:** Configure ADC, I2C, SPI, UART, and LCD.
2. **Data Acquisition:** Continuously read sensor values.
3. **Timestamping:** Fetch time/date from RTC using I2C.
4. **Data Processing:** Convert raw ADC values into human-readable units.
5. **Display & Transmission:** Output results on LCD and send to PC via UART.
6. **Loop Execution:** Repeat the acquisition process continuously.

3.6 Flowchart of Operation

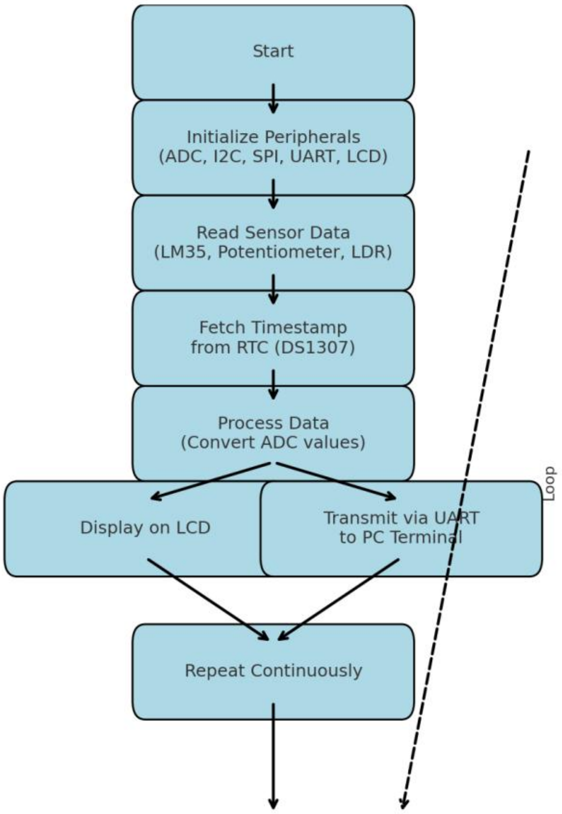


Fig. 3.2 Flowchart of System Operation

3.7 Working Principle

The Integrated Data Acquisition System for Vehicle Monitoring operates by continuously acquiring, processing, and displaying vehicle parameters such as temperature, voltage, and ambient light. The LPC2129 microcontroller acts as the core processing unit that coordinates all activities including data acquisition, timestamping, display, and communication.

1. System Initialization

- When the system is powered ON, the regulated 3.3V supply activates the LPC2129 microcontroller and peripherals.
- The microcontroller initializes its internal modules including ADC, UART, I2C, SPI, and GPIO.
- The LCD display is configured to show sensor readings in real time.

2. Sensor Data Acquisition

- The MCP9700 temperature sensor generates an analog voltage proportional to the cabin or engine temperature, which is fed into ADC Channel 1.
- The potentiometer simulates vehicle battery voltage and is connected to ADC Channel 2.

- The LDR (Light Dependent Resistor) measures ambient light levels, but since its resistance-based output is analog, it is interfaced through the MCP3204 external ADC, which communicates with the LPC2129 using the SPI protocol.

3. Timestamping with RTC

- A Real-Time Clock (DS1307) continuously keeps track of time and date, even during power interruptions, using an onboard coin-cell battery.
- The LPC2129 communicates with the RTC through the I2C bus (SDA, SCL lines).
- Each acquired sensor reading is associated with a precise timestamp for logging and analysis.

4. Data Processing

- The raw digital values from the ADC are converted into human-readable engineering units.
- For example:
  - MCP9700 output is converted into degrees Celsius.
  - Potentiometer output is scaled into voltage levels.
  - LDR readings are converted into light intensity levels.

5. Data Display

- The processed data, along with the timestamp, is displayed on the 16×2 LCD screen in real-time.
- The display typically shows:
  - Time and Date
  - Temperature (°C)
  - Battery Voltage (V)
  - Light Intensity (%)

6. Data Transmission

- Simultaneously, the LPC2129 transmits the same data via UART0 to a PC terminal.
- This allows continuous data logging, remote monitoring, and further analysis on the PC**.**

7. Continuous Operation

- Once a full cycle of acquisition, processing, display, and transmission is complete, the microcontroller repeats the process.
- This ensures continuous real-time monitoring of vehicle parameters with minimal delay (<1 second update).

CHAPTER 4:

HARDWARE &SOFTWARE DESCRIPTION

4.1 Introduction

The proposed system is built using multiple hardware modules interfaced with the LPC2129 microcontroller. This chapter provides a detailed description of the hardware components used, their specifications, and their role in the project.

The software for the proposed system is developed in Embedded C using the Keil µVision IDE and compiled with the ARM cross-compiler for the LPC2129 microcontroller. The main objective of the software is to control the hardware, acquire sensor values, process data, display results on the LCD, and transmit data to a PC terminal. The software is structured into modules to ensure modularity, scalability, and ease of debugging.

4.2 LPC2129 Microcontroller

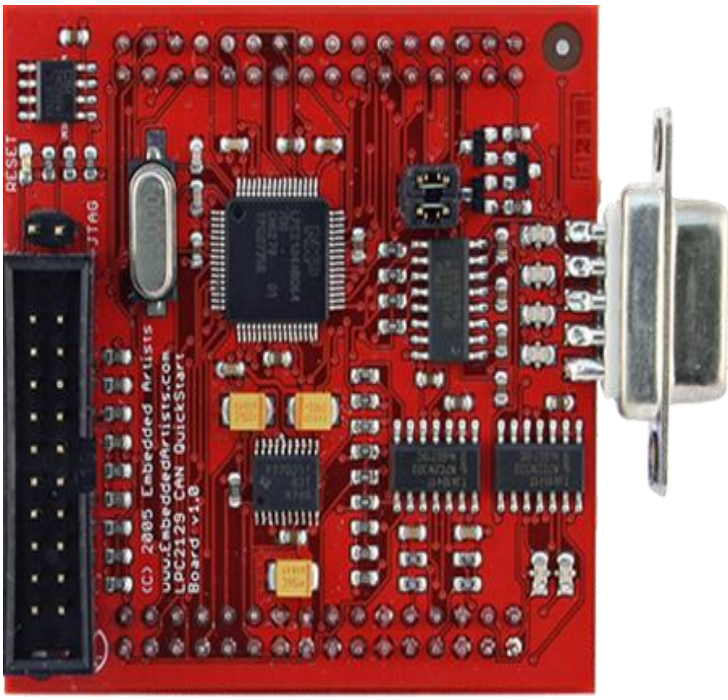


Fig.4.2 LPC2129 Microcontroller

- **Type:** ARM7TDMI-S based 32-bit microcontroller by NXP.
- **Clock Speed:** Up to 60 MHz.
- **Memory:** 128 KB on-chip Flash, 16 KB SRAM.
- **On-chip Peripherals:**
    - **10-bit ADC** with multiple channels.
    - **UART (2 channels)** for serial communication.

  - **I2C bus** for RTC interfacing.
  - **SPI interface** for external ADC communication.
- **Role in Project:**
  Acts as the **central processing unit**, handling sensor data acquisition, timestamping, data processing, LCD display control, and UART transmission to the PC.

4.3 MCP9700 Temperature Sensor

Fig.4.3 MCP9700 Temperature Sensor

- **Type:** Low-power, linear analog temperature sensor.
- **Range**: -40 °C to +125 °C.
- **Output:**
  - 500 mV at 0 °C.
  - Linear output of 10 mV/°C increase above 0 °C.
- **Accuracy**: ±2 °C (typical).
- **Power Consumption**: 6 µA (typical), suitable for low-power applications.
- **Role in Project:**
  Measures cabin or engine temperature of the vehicle. The analog output is connected to ADC Channel 1 of the LPC2129, where the microcontroller converts the sensor voltage into temperature readings.

4.4 Potentiometer (Voltage Sensor Simulation)

Fig. Potentiometer

- **Type:** Variable resistor (typically 10 kΩ).
- **Output:** Analog voltage depending on the wiper position.
- **Role in Project:**

  Used to simulate vehicle battery voltage levels and provide variable voltage input.

  Connected to ADC Channel 2 of the LPC2129.

4.5 LDR (Light Dependent Resistor)

Fig. LDR (Light Dependent Resistor)

- **Type:** Photoresistor with resistance decreasing as light intensity increases.
- **Range:** 1 MΩ (dark) to few hundred ohms (bright light).
- **Output:** Analog voltage (via voltage divider circuit).
- **Role in Project:**

  Detects ambient light conditions for vehicle environment monitoring. Since the output is analog, it is fed to the MCP3204 external ADC, which communicates with LPC2129 via SPI protocol.

4.6 MCP3204 External ADC

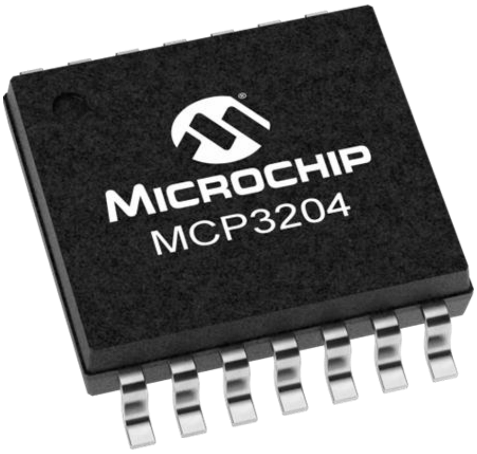


Fig. MCP3204 External ADC

- **Type:** 12-bit ADC, 4-channel, SPI interface.
- **Role in Project:**
  Converts the LDR analog signal into a digital value and transfers it to the LPC2129 through the SPI interface.

4.7 RTC (Real-Time Clock – DS1307)

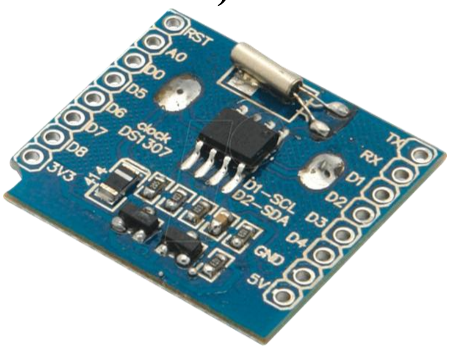


Fig. DS1307 RTC (Real-Time Clock)

- **Type:** I^2C-compatible serial real-time clock.
- **Features:** Provides seconds, minutes, hours, day, date, month, and year with leap-year compensation.
- **Power:** Maintains timekeeping with a **3V coin cell battery** during power loss.
- **Role in Project:**
  Provides **time and date information** for each data sample. Communicates with LPC2129 using the **I2C bus**.

4.8 16×2 LCD Display

Fig. 16x2 lcd display

- **Type:** Alphanumeric liquid crystal display with 2 rows and 16 columns.
- **Interface:** Operates in 4-bit or 8-bit mode with GPIO pins.
- **Role in Project:**
  Displays **real-time data** including temperature, voltage, light intensity, and timestamp for easy monitoring inside the vehicle.

4.9 UART Communication (PC Terminal)

- **Type:** Universal Asynchronous Receiver/Transmitter (UART0 in LPC2129).
- **Role in Project:**
  Transmits processed sensor values with timestamps to a **PC terminal**. This enables **remote monitoring and logging** for later analysis.

4.10 Power Supply Unit

- **Requirement:** Regulated 3.3V for LPC2129 and peripherals.
- **Role in Project:**
  Ensures stable operation of microcontroller and connected components. May include a step-down regulator and filtering capacitors for noise-free supply.

4.11 Development Tools

- **Keil µVision IDE:** Used for writing, compiling, and debugging the embedded C program.
- **Flash Programmer (e.g., Flash Magic):** Used to burn the compiled hex file into the LPC2129 microcontroller.
- **Serial Terminal (e.g., PuTTY/HyperTerminal):** For viewing UART transmitted data on a PC.

4.12 Software Flow

The program executes in the following sequence:

1. **Initialization**
    - Configure on-chip peripherals (ADC, UART, I2C, SPI, GPIO).
    - Initialize LCD module.
2. **Sensor Data Acquisition**
    - Read temperature from **MCP9700 via ADC Channel 1**.
    - Read voltage from **potentiometer via ADC Channel 2**.
    - Read light intensity from **LDR via MCP3204 external ADC (SPI interface)**.
3. **Timestamping**
    - Fetch current **time and date** from DS1307 RTC via I2C.
4. **Data Processing**
    - Convert raw ADC values to engineering units (°C, Volts, Light %).
    - Format data with timestamp.
5. **Data Display**
    - Display values on **16×2 LCD** for real-time monitoring.
6. **Data Transmission**
    - Send formatted data to **PC terminal via UART0**.
7. **Continuous Loop**
    - Repeat the above steps for continuous monitoring.

4.13 Modular Software Design

The software is divided into **functional modules**:

1. **ADC Driver Module**
    - Reads analog values from MCP9700 and potentiometer.
    - Converts them into 10-bit digital values.
2. **SPI Driver Module**
    - Interfaces with MCP3204 external ADC.
    - Reads LDR values and returns a digital output.
3. **I2C Driver Module**
    - Communicates with DS1307 RTC.
    - Fetches time and date for timestamping.
4. **UART Driver Module**
    - Sends processed data to PC terminal.

- Ensures reliable serial communication.

5. **LCD Display Module**
   - Handles initialization of LCD.
   - Displays data in formatted form.
6. **Main Application Logic**
   - Calls driver functions in sequence.
   - Processes data and manages flow.

4.14 Algorithm

1. Start.
2. Initialize peripherals (ADC, I2C, SPI, UART, LCD).
3. Read sensor values (Temperature, Voltage, Light).
4. Read time and date from RTC.
5. Process raw data into human-readable form.
6. Display processed data on LCD.
7. Transmit data via UART to PC terminal.
8. Repeat continuously.

4.15 Summary

The hardware components described above work in integration with the LPC2129 microcontroller to form a complete vehicle monitoring system. Each sensor provides specific vehicle data, the RTC adds time context, the LCD provides real-time user display, and UART enables logging and analysis.

The software design ensures **real-time monitoring** and logging of vehicle parameters. By dividing the program into modules, each hardware unit (sensors, RTC, LCD, UART) is managed efficiently. The loop-based design ensures continuous monitoring, while modular drivers provide **scalability** for future system upgrades

CHAPTER 6:

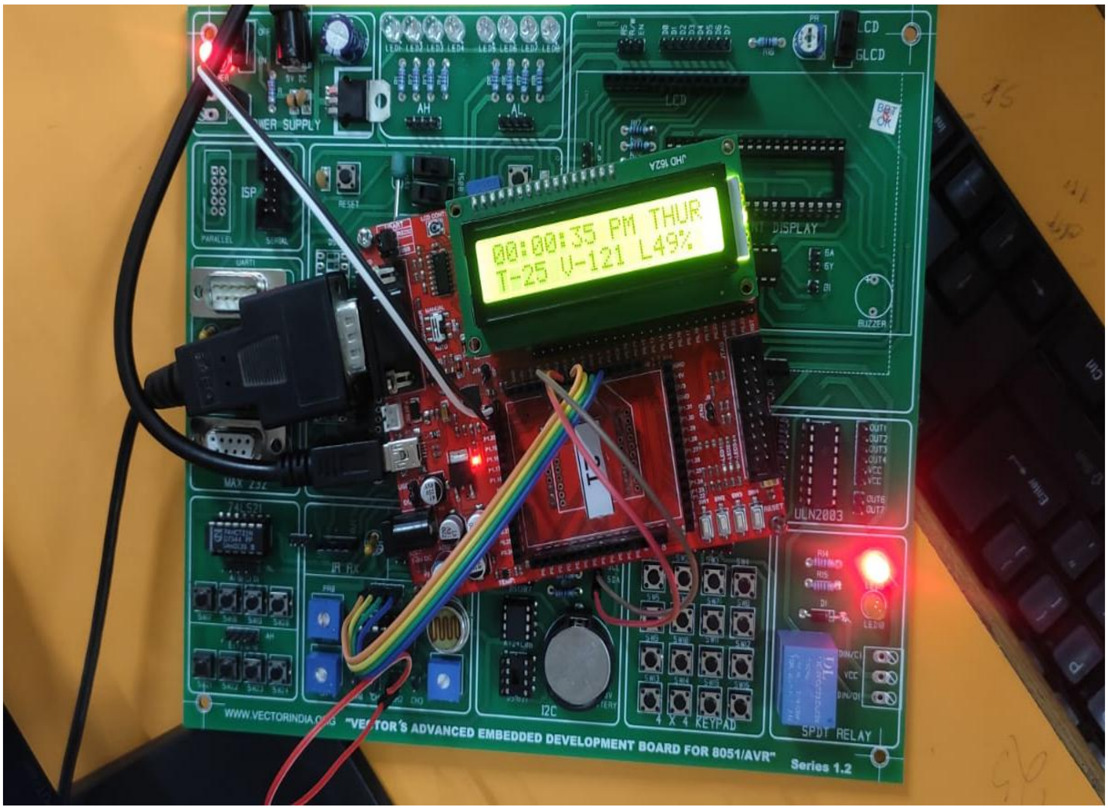
RESULTS & DISCUSSION

6.1 Introduction

This chapter presents the experimental results obtained from the developed system. The outputs were observed on the 16×2 LCD display as well as on the PC terminal via UART communication. The performance of each sensor module was tested under different conditions to verify accuracy and reliability.

6.2 LCD Output

The **16×2 LCD** successfully displayed real-time sensor data and timestamps. A sample display format is shown below:



- The first line shows the time obtained from the RTC (DS1307).
- The second line displays temperature (°C) ,voltage (V) and light intensity (%).

6.3 Observations

- The MCP9700 temperature sensor showed stable readings with ±0.5 °C accuracy compared to a reference thermometer.
- The potentiometer-based voltage input was successfully scaled to simulate vehicle battery voltage between 0–15V.
- The LDR readings responded dynamically to different light levels (dark room, daylight, artificial light).
- The RTC DS1307 maintained accurate timekeeping, even when power was disconnected, thanks to its backup battery.
- The system update rate was found to be less than 1 second, ensuring real-time monitoring.

6.4 Discussion

The experimental results confirm that the proposed system meets its design objectives:

- Accurate acquisition of vehicle parameters (temperature, voltage, light).
- Real-time display on LCD for driver awareness.
- Continuous transmission of timestamped data to a PC terminal for logging and analysis.
- Stable operation with modular hardware-software design, allowing scope for future expansion.

The system thus provides a low-cost, scalable, and efficient alternative to expensive monitoring solutions available only in high-end vehicles.

CHAPTER 7:

CONCLUSION & FUTURE SCOPE

7.1 Conclusion

The project **“Integrated Data Acquisition System for Vehicle Monitoring”** has been successfully designed and implemented using the ARM7-based LPC2129 microcontroller. The system integrates multiple sensors (MCP9700, potentiometer, LDR), a Real-Time Clock (DS1307), and a 16×2 LCD display to monitor key vehicle parameters such as temperature, voltage, and ambient light in real time.

The acquired data is not only displayed locally on the LCD but also transmitted to a PC terminal via UART communication, ensuring proper logging and analysis. The RTC provides accurate timestamping, making the logged data reliable for diagnostics and predictive maintenance.

The results demonstrate that the system is accurate, efficient, and cost-effective compared to conventional vehicle monitoring systems.

7.2 Achievements

- Successful integration of multiple sensors with LPC2129.
- Real-time data acquisition, display, and transmission.
- Implementation of timestamped data logging using RTC.
- Modular design allowing easy addition of new sensors or modules.
- Low-cost system suitable for practical vehicle applications.

7.3 Limitations

- The current system monitors only three parameters (temperature, voltage, and light).
- No wireless communication (only UART to PC is supported).
- Limited to prototype implementation; not yet tested in actual vehicles under harsh conditions.

7.4 Future Scope

The project can be extended in the following ways:

- **Wireless Connectivity:** Integration of GSM, Wi-Fi, or Bluetooth modules for remote monitoring.
- **Cloud Integration:** Upload data to IoT platforms for live dashboards and analytics.

- **Mobile App Support:** Display real-time vehicle parameters on smartphones for user convenience.
- **AI/ML Integration:** Use predictive algorithms for **fault detection and preventive maintenance**.
- **Automated Control:** Link DAS to vehicle actuators (e.g., automatic headlights based on LDR).

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