

# IoT-Based Battery Monitoring System for Electric Vehicle

**B.Sarath chandra (Assistant professor), SK.Salma,N.Abhilash,U.V.Kishore**

Department of Electrical and Electronics Engineering

RVR&JC College of Engineering Chowdavaram,Guntur,Andhra Pradesh, India

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## Abstract

The **IoT-Based Battery Monitoring System for Electric Vehicles** is developed to ensure safe, efficient, and reliable battery operation through continuous real-time monitoring and intelligent control. The system integrates an Arduino microcontroller with voltage, current, and temperature sensors to measure key battery parameters and display them on an LCD module. A NodeMCU module enables IoT connectivity by transmitting real-time data to the ThingSpeak cloud platform for remote monitoring, visualization, and analysis. To enhance safety, the system incorporates automated protection mechanisms: when abnormal conditions such as low voltage, overcurrent, or excessive temperature are detected, relays disconnect the load, LEDs provide visual indication, and a buzzer generates an audible alert. Additionally, a GSM module sends instant notifications to a registered mobile number. A DC motor is used to simulate the electric vehicle drive load, while auxiliary mobile chargers demonstrate controlled charging operations. Powered by a 12V battery and regulated supply system, the prototype offers a compact, cost-effective, and scalable solution for smart battery health monitoring and protection in electric vehicles, improving operational safety and extending battery lifespan.

## Keywords:

1. Battery Monitoring
2. Internet of Things (IoT)
3. Electric Vehicle
4. Real-Time Data Acquisition
5. Remote Fault Detection

## 1 Introduction

The rapid growth of electric vehicles (EVs) has increased the need for effective battery monitoring systems. Batteries are the main power source in EVs, and their performance directly affects vehicle efficiency, safety, and lifespan. Monitoring important parameters such as voltage, current, and temperature is essential to prevent issues like overheating, overcharging, and deep discharge.

With the help of **Internet of Things (IoT)** technology, real-time monitoring and remote supervision of battery systems have become possible. IoT enables data collection and transmission to cloud platforms, allowing users to observe battery performance and detect faults at an early stage.

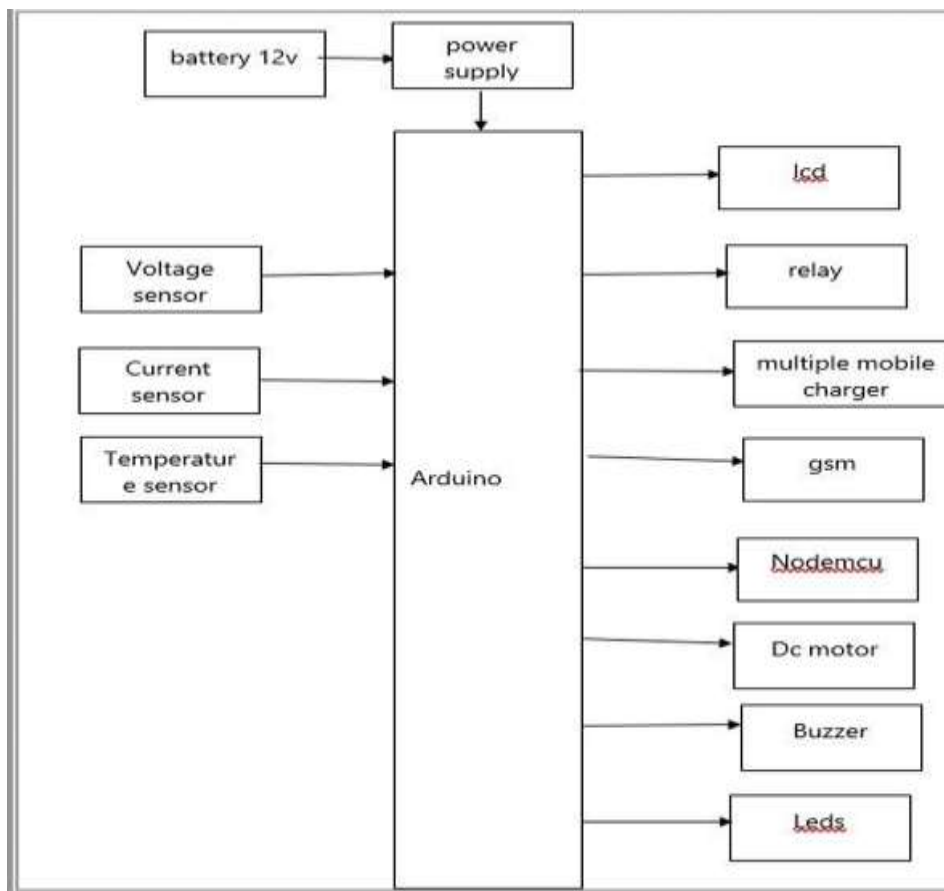
In this project, an **IoT-Based Battery Monitoring System** is developed using Arduino and NodeMCU. Sensors measure voltage, current, and temperature, and the data is displayed on an LCD and sent to the ThingSpeak cloud for

remote monitoring. Safety features such as relays, LEDs, buzzers, and GSM alerts are included to protect the battery during abnormal conditions.

### Proposed model:

The proposed IoT-Based Battery Monitoring System for Electric Vehicles enhances conventional methods by integrating embedded control with IoT connectivity for real-time monitoring and intelligent protection. The system utilizes an Arduino to continuously measure voltage, current, and temperature parameters, displaying them locally on an LCD while transmitting live data to the ThingSpeak cloud platform through NodeMCU. Automated protection mechanisms are implemented using relays to control charging and load conditions when abnormal parameters are detected. Visual (LED) and audible (buzzer) alerts are activated during faults, and instant notifications are sent to users via a GSM module. The system also simulates EV load using a DC motor and manages auxiliary charging operations. By combining real-time data acquisition, remote monitoring, automated control, and alert systems, the proposed model provides a smart, reliable, and scalable battery management solution for electric vehicles.

### 2. Block diagram:



**Software components:**

Arduino ide

Embedded c

**Hardware components:**

Arduino

Lcd

Voltage sensor

current sensor

temperature sensor

relay-3

multiple mobile charger

Dc motor

Leds-2

Buzzer

nodemcu

Gsm

power supply

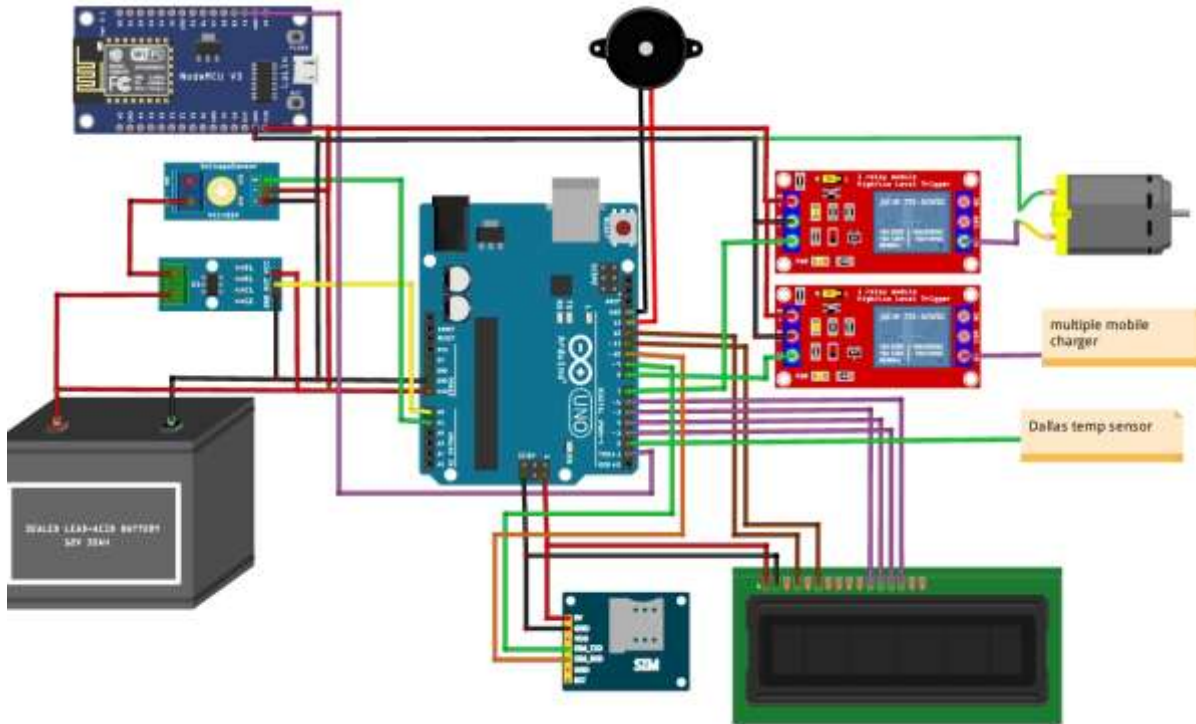
battery 12v

slide switch

female power jack

12v Adapater 2amp

### 3 . Hardware Circuit Diagram



#### 1. Power supply and sensing stage

- The system employs a **12 V, 35 Ah sealed lead-acid battery** as the primary energy source, representing the traction battery of an electric vehicle prototype.
- A **voltage sensor module (VCC < 25 V)** is interfaced with the battery to scale down and condition the terminal voltage for safe acquisition by the Arduino Uno analog input.
- A **Dallas digital temperature sensor (DS18B20)** is thermally coupled to the battery surface to enable precise monitoring of battery temperature for thermal protection.

#### 2. Control and processing units

- An **Arduino Uno** microcontroller board serves as the central processing unit, periodically sampling the voltage and temperature signals and executing the battery health monitoring algorithm.
- A **NodeMCU V3 (ESP8266-based Wi-Fi module)** is integrated with the Arduino via serial communication to provide **IoT connectivity**, enabling real-time uploading of battery parameters to a cloud platform.

#### 3. Actuation and load/charger management

- Two **5 V single-channel relay modules (JQC-3F-T73-DC5V)** are driven by digital outputs of the Arduino to control higher power AC/DC circuits while maintaining electrical isolation.
- One relay is configured to control a **multiple mobile charger block**, emulating the battery charging interface, whereas the second relay governs the **load path**, which can include a DC motor or equivalent resistive load.

- The relay contacts (COM, NC/NO) are utilized to automatically disconnect the charger or load whenever the controller detects undervoltage, overtemperature, or abnormal operating conditions.

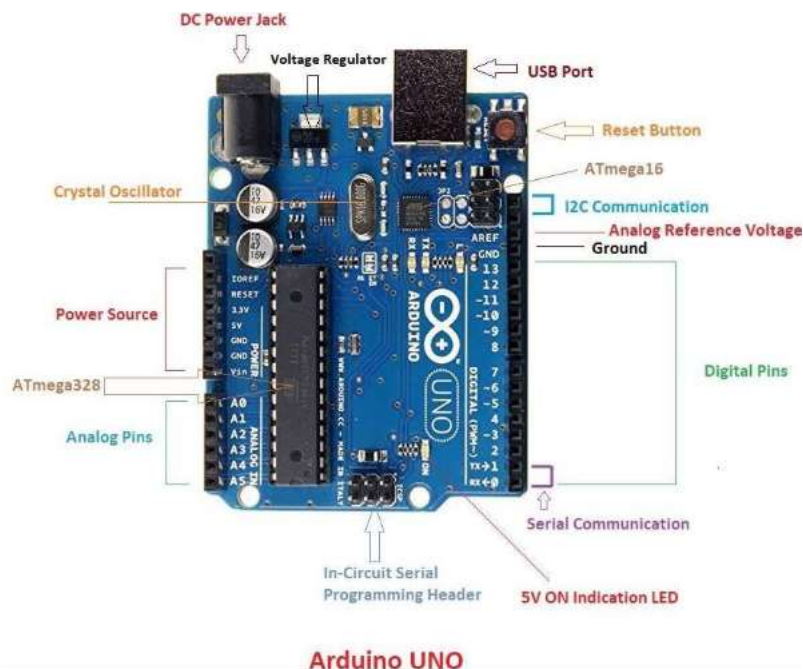
#### 4. Communication and alert mechanisms

- A **GSM module** is connected to the Arduino through UART pins (TXD/RXD) to transmit **SMS-based notifications** to a registered mobile number under fault events, ensuring remote user awareness independent of Wi-Fi availability.
- The combined use of **Wi-Fi (NodeMCU)** and **GSM** provides dual communication channels for enhanced reliability of data reporting and alerting.

#### 5. Human-machine interface and protection

- **LED indicators** are incorporated to provide visual feedback on system states such as charging, load status, and fault activation, facilitating quick local diagnostics.
- An **audio buzzer** is used as an audible alarm to signal critical conditions (e.g., excessive temperature or unsafe voltage levels), prompting immediate user intervention.
- Overall, the circuit realizes a **low-cost embedded protection layer** that integrates sensing, decision-making, and actuation to enhance battery safety and operational reliability in an EV context

#### Arduino:



- This board comes with all the features required to run the controller and can be directly connected to the computer through USB cable that is used to transfer the code to the controller using IDE (Integrated Development Environment) software, mainly developed to program Arduino. IDE is equally compatible with Windows, MAC or Linux Systems, however, Windows is preferable to use. Programming languages like C and C++ are used in IDE.

- Apart from USB, battery or AC to DC adopter can also be used to power the board.
- Arduino Uno boards are quite similar to other boards in Arduino family in terms of use and functionality, however, Uno boards don't come with FTDI USB to Serial driver chip.
- There are many versions of Uno boards available, however, Arduino Nano V3 and Arduino Uno are the most official versions that come with Atmega328 8-bit AVR Atmel microcontroller where RAM memory is 32KB.
- When nature and functionality of the task go complex, Mirco SD card can be added in the boards to make them store more information.

### Features of Arduino

- Arduino Uno comes with USB interface i.e. USB port is added on the board to develop serial communication with the computer.
- [Atmega328](#) microcontroller is placed on the board that comes with a number of features like timers, counters, interrupts, PWM, CPU, I/O pins and based on a 16MHz clock that helps in producing more frequency and number of instructions per cycle.

### Communication and Programming:

Arduino Uno comes with an ability of interfacing with other other Arduino boards, microcontrollers and computer. The Atmega328 placed on the board provides serial communication using pins like Rx and Tx.

The Atmega16U2 incorporated on the board provides a pathway for serial communication using USB com drivers. Serial monitor is provided on the IDE software which is used to send or receive text data from the board. If LEDs placed on the Rx and Tx pins will flash, they indicate the transmission of data.

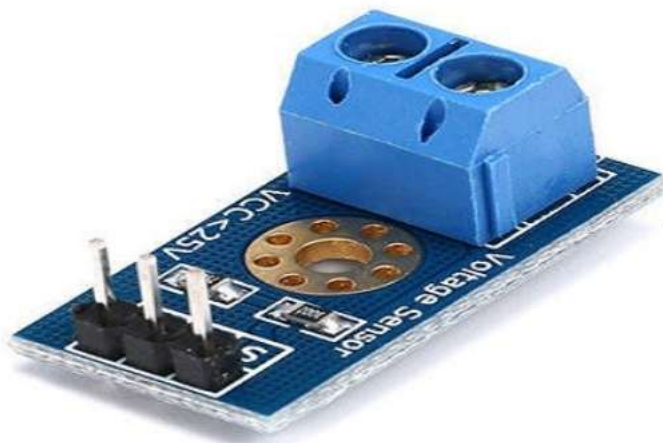
Arduino Uno is programmed using Arduino Software which a cross-platform application called IDE is written in Java. The AVR microcontroller Atmega328 laid out on the base comes with built-in boot loader that sets you free from using a separate burner to upload the program on the board.



**Voltage Sensor:**

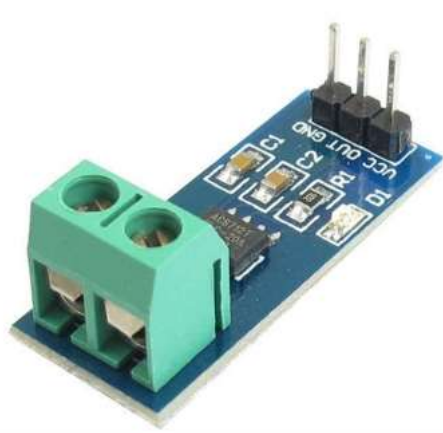
This sensor is used to monitor, calculate and determine the voltage supply. This sensor can determine the AC or DC voltage level. The input of this sensor can be the voltage whereas the output is the switches, analog voltage signal, a current signal, an audible signal, etc. Some sensors provide sine waveforms or pulse waveforms like output & others can generate outputs like [AM \(Amplitude Modulation\)](#), [PWM \(Pulse Width Modulation\)](#) or [FM \(Frequency Modulation\)](#). The measurement of these sensors can depend on the voltage divider.

<b>Input Voltage (V)</b>	0 to 25
<b>Voltage Detection Range (V)</b>	0.02445 to 25
<b>Analog Voltage Resolution (V)</b>	0.00489
<b>Length (mm)</b>	28
<b>Width (mm)</b>	14
<b>Height (mm)</b>	13
<b>Weight (gm)</b>	4



This sensor includes input and output. The input side mainly includes two pins namely positive and negative pins. The two pins of the device can be connected to the positive & negative pins of the sensor. The device positive & negative pins can be connected to the positive & negative pins of the sensor. The output of this sensor mainly includes supply voltage (Vcc), ground (GND), analog o/p data

### ACS712 Current Sensor:



Current Sensor detects the current in a wire or conductor and generates a signal proportional to the detected current either in the form of analog voltage or digital output.

[Current Sensing](#) is done in two ways – Direct sensing and Indirect Sensing. In Direct sensing, to detect current, Ohm's law is used to measure the voltage drop occurred in a wire when current flows through it.

A current-carrying conductor also gives rise to a magnetic field in its surrounding. In Indirect Sensing, the current is measured by calculating this magnetic field by applying either [Faraday's law](#) or Ampere law. Here either a [Transformer](#) or [Hall effect sensor](#) or fiberoptic current sensor are used to sense the magnetic field.

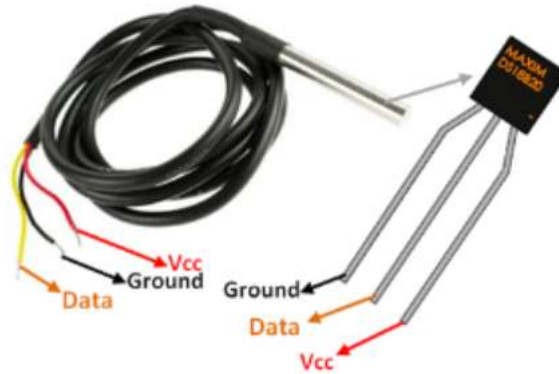
ACS712 Current Sensor uses Indirect Sensing method to calculate the current. To sense current a linear, low-offset Hall sensor circuit is used in this IC. This sensor is located at the surface of the IC on a copper conduction path. When current flows through this copper conduction path it generates a magnetic field which is sensed by the Hall effect sensor. A voltage proportional to the sensed magnetic field is generated by the Hall sensor, which is used to measure current.

The proximity of the magnetic signal to the Hall sensor decides the accuracy of the device. Nearer the magnetic signal higher the accuracy. ACS712 Current Sensor is available as a small, surface mount SOIC8 package. In this IC current flows from Pin-1 and Pin-2 to Pin-3 and Pin-4. This forms the conduction path where the current is sensed. Implementation of this IC is very easy.

ACS712 can be used in applications requiring electrical isolation as the terminals of the conduction path are electrically isolated from the IC leads. Thus, this IC doesn't require any other isolation techniques. This IC requires a supply voltage of 5V. Its output voltage is proportional to AC or DC current. ACS712 has a nearly zero [magnetic hysteresis](#).

Where Pin-1 to Pin-4 forms the conduction path, Pin-5 is the signal ground pin. Pin-6 is the FILTER pin that is used by an external capacitor to set the bandwidth. Pin-7 is the analog output pin. Pin-8 is the power supply pin

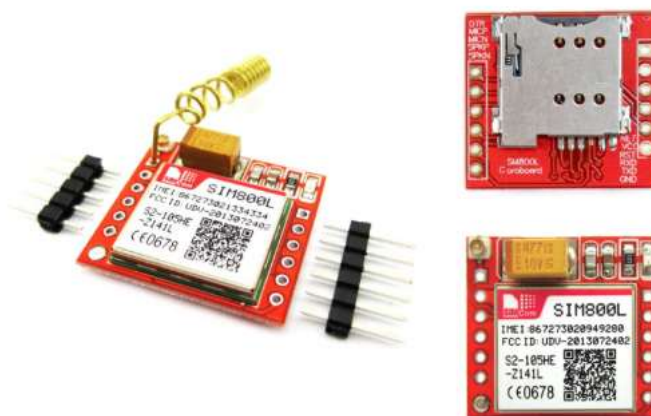
### DS18B20 Temperature Sensor



The working principle of this DS18B20 temperature sensor is like a temperature sensor. The resolution of this sensor ranges from 9-bits to 12-bits. But the default resolution which is used to power-up is 12-bit. This sensor gets power within a low-power inactive condition. The temperature measurement, as well as [the conversion of A-to-D](#), can be done with a convert-T command. The resulting temperature information can be stored within the 2-byte register in the sensor, and after that, this sensor returns to its inactive state.

If the sensor is power-driven by an exterior power supply, then the master can provide read time slots next to the Convert T command. The sensor will react by supplying 0 though the temperature change is in the improvement and reacts by supplying 1 though the temperature change is done.

### GSM:



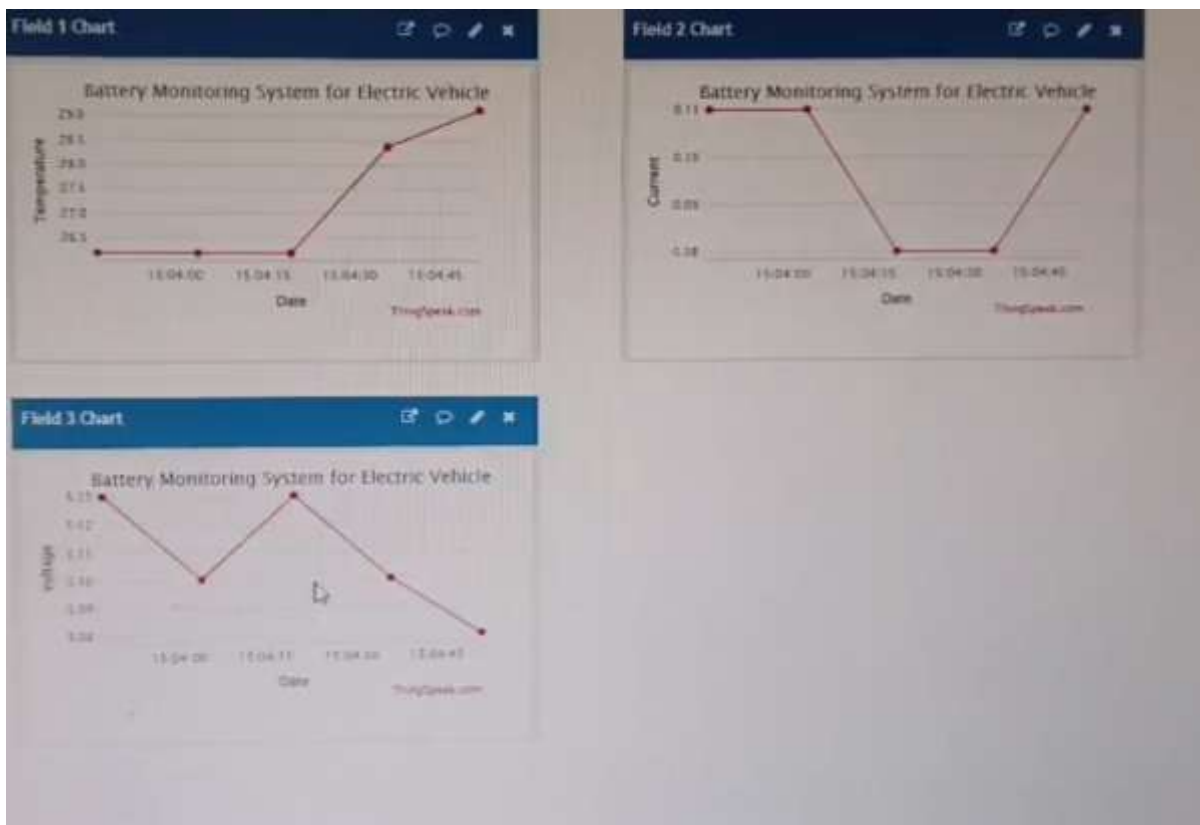
It requires a **SIM (Subscriber Identity Module)** card just like mobile phones to activate communication with the network. Also they have **IMEI (International Mobile Equipment Identity)** number similar to mobile phones for their identification. A GSM/GPRS MODEM can perform the following operations:

1. Receive, send or delete SMS messages in a SIM.
2. Read, add, search phonebook entries of the SIM.
3. Make, Receive, or reject a voice call.

The MODEM needs **AT commands**, for interacting with processor or controller, which are communicated through serial communication. These commands are sent by the controller/processor. The MODEM sends back a result after it receives a command. Different AT commands supported by the MODEM can be sent by the processor/controller/computer to interact with the **GSM and GPRS cellular network**.

### GSM Architecture

#### IoT Dashboard Monitoring:



#### Conclusion:

The IoT-Based Battery Monitoring System for Electric Vehicles provides an effective solution for monitoring and protecting battery performance. The system continuously measures important parameters such as voltage, current, and temperature using sensors connected to an Arduino microcontroller. Real-time data is displayed on an LCD and transmitted to the ThingSpeak cloud platform through NodeMCU for remote monitoring.

The integration of safety features such as relays, LEDs, buzzer alerts, and GSM notifications helps detect abnormal conditions and take immediate protective actions. This prevents battery damage caused by overcurrent, overheating, or low voltage conditions.

Overall, the proposed system improves battery safety, reliability, and lifespan while offering a low-cost and scalable solution for smart battery monitoring in electric vehicles. The use of IoT technology enables efficient data monitoring, analysis, and remote accessibility, making it suitable for modern EV applications.

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### 3 seconds

- Sensor readings were accurate and stable
  - Renewable energy integration improved system sustainability
  - Buzzer alerts effectively indicated abnormal voltage conditions
  - Integration of renewable energy sources
  - Remote monitoring through IoT platforms
  - Early detection of abnormal conditions
  - Low-cost and easy implementation
  - Renewable energy monitoring
  - Industrial energy management
  - Smart campus energy systems
  - Smart building automation
- IoT-based Smart Microgrid Monitoring System** designed to monitor electrical and environmental parameters in microgrid environments. The system integrates embedded sensors, renewable energy sources, and cloud-based communication technologies to provide real-time monitoring capabilities. **machine learning algorithms for energy prediction and advanced cybersecurity techniques for IoT-based power systems.** If you want, I can also **generate a downloadable IEEE-format Word document (with figures, captions, and two-column layout)** so you can **submit directly to a conference or journal.**