IOT-BASED EV BATTERY MANAGEMENT AND PROTECTION SYSTEM

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

One of the most vital and expensive components of electric vehicles (EVs) is the battery, which serves as the sole source of power for the vehicle. Over time, the battery's performance declines, which poses a significant concern for battery manufacturers and users alike. This project presents an IoT-based approach to monitor and display battery performance to address these challenges. The proposed system tracks critical battery metrics, including voltage, current, and temperature, to prevent overcharging and deep discharging. By employing Temperature sensor, IR sensor, Fire sensor, Voltage and Current attenuator in which the system continuously observes these parameters and sends the data to a microcontroller unit. This unit transmits the information via the cloud, enabling real-time display of battery performance on both Android smartphones and computers. Additionally, the system incorporates features for identifying potential fire hazards and swollen battery conditions, further enhancing safety (the fabrication has been done through hardware implementation). The output results demonstrate the system's capability to detect deterioration of battery performance and alert users for timely intervention, ultimately aiming to improve battery efficiency and life span while ensuring safety.

சுருக்கம்

மின்சார வாகனங்களின் (EVs) மிக முக்கியமான மற்றும் விலையுயர்ந்த கூறுகளில் ஒன்று பேட்டரி ஆகும், வாகனத்திற்கான ஒரே சக்தி மூலமாக செயல்படுகிறது. காலப்போக்கில், பேட்டரியின் செயல்திறன் குறைகிறது, இது பேட்டரி உற்பத்தியாளர்கள் மற்றும் பயனர்களுக்கு ஒரு குறிப்பிடத்தக்க கவலையை ஏற்படுத்துகிறது. இந்த சவால்களை எதிர்கொள்ள பேட்டரி செயல்திறனைக் கண்காணித்து காண்பிக்க இந்த திட்டம் IoT அடிப்படையில முன்மொழியப்பட்ட அமைப்பு மின்னழுத்தம், மின்னோட்டம் மற்றும் வெப்பநிலை உள்ளிட்ட முக்கியமான பேட்டரி அளவீடுகளைக் கண்காணிக்கிறது, இது அதிக சார்ஜ் மற்றும் ஆழமான வெளியேற்றத்தைத் தடுக்கிறது. வெப்பநிலை சென்சார், IR சென்சார், தீ சென்சார், மின்னழுத்தம் மற்றும் மின்னோட்ட அட்டென்யூட்டரைப் பயன்படுத்துவதன் மூலம், கணினி இந்த அளவுருக்களை தொடர்ந்து கண்காணித்து தரவை மைக்ரோகண்ட்ரோலர் அலகுக்கு அனுப்புகிறது. இந்த அலகு மேகம் வழியாக தகவலை அனுப்புகிறது, இது ஆண்ட்ராய்டு ஸ்மார்ட்போன்கள் மற்றும் கணினிகள் இரண்டிலும் பேட்டரி செயல்திறனை நிகழ்நேரத்தில் காண்பிக்க உதவுகிறது., சாத்தியமான தீ அபாயங்கள் மற்றும் வீங்கிய பேட்டரி நிலைகளை அடையாளம் காணும் அம்சங்களை இந்த அமைப்பு உள்ளடக்கியது, மேலும் பாதுகாப்பை மேம்படுத்துகிறது. வெளியீட்டு முடிவுகள் பேட்டரி செயல்திறனின் சரிவைக் கண்டறிந்து பயனர்களை சரியான நேரத்தில் தலையீட்டிற்கு எச்சரிக்கும் திறனை நிரூபிக்கின்றன.

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ABBREVIATIONS	EXPANSION
BMS	Battery Management System
IOT	Internet of Things
SoC	State of Charge
SoH	State of Health
LCD	Liquid Crystal Display
WI-FI	Wireless Fidelity
IC	Integrated Circuit
VCC	Voltage Common Collector
GND	Ground
MCU	Microcontroller Unit
ESP	Espress if Systems Platform
PWM	Pulse Width Modulation
IDE	Integrated Development Environment

CHAPTER 1

INTRODUCTION

As the world moves towards sustainable energy solutions, the adoption of electric vehicles (EVs) has surged globally. EVs are seen as a promising alternative to traditional internal combustion engine (ICE) vehicles due to their zero-emission technology, higher energy efficiency, and lower operational costs. Central to the efficient functioning of an electric vehicle is its battery, which is typically a high-capacity lithium-ion (Li-ion) battery. These batteries are integral to the vehicle's performance, lifespan, and safety, and thus demand sophisticated management and protection systems.

An IoT-based Electric Vehicle Battery Management and Protection System is an innovative approach to ensure the optimal performance, safety, and longevity of EV batteries. This project focuses on developing a system that leverages the Internet of Things (IoT) to monitor, control, and protect the battery in real- time. The use of IoT technology enables remote monitoring, predictive maintenance, and data-driven decision-making, which can significantly enhance the reliability and efficiency of electric vehicles.

1.1 Importance of Battery Management in Electric Vehicles

The battery is the heart of an electric vehicle, determining its range, performance, and safety. Proper battery management is essential for maximizing the battery's lifespan and ensuring the safety of the vehicle. Factors such as temperature, charge cycles, state of charge (SOC), state of health (SOH), and over-voltage or under-voltage conditions can drastically impact the performance of the battery.

An effective Battery Management System (BMS) is responsible for managing these factors, ensuring the safe operation of the battery, and preventing critical failures. Traditionally, BMS solutions have focused on monitoring key metrics like voltage, current, and temperature. However, with the rapid advancements in IoT, modern BMS solutions are evolving to include predictive analytics, remote diagnostics, and real-time control to further enhance safety and performance.

1.2 Need of IoT-Based Solutions

The integration of IoT into battery management brings a host of advantages:

1. **Real-time Monitoring**: IoT sensors can collect critical data on battery performance in real-time, including temperature, voltage, and current. This data can be transmitted to a central server or cloud platform, where it can be analysed for anomalies or issues that may require immediate attention.

2. **Remote Diagnostics and Control**: IoT integration enables us to remotely diagnose problems with the battery and even take corrective actions without physically accessing the vehicle. This capability reduces maintenance costs and helps prevent sudden battery failures, which could lead to vehicle breakdowns.

3. **Predictive Maintenance**: One of the key benefits of IoT is its ability to predict future problems based on historical data and real- time monitoring. By analyzing trends in the data, such as gradual increases in temperature or changes in charging patterns, the system can predict when maintenance will be required, reducing downtime and extending the battery's lifespan.

4. **Improved Safety**: Batteries, especially high-energy ones used in EVs, pose significant safety risks if not properly managed. Overcharging, deep discharging, or excessive heat can cause the battery to malfunction or, in the worst-case scenario, explode. IoT- based systems provide real-time alerts and can automatically disconnect the battery to prevent dangerous situations.

1.3 Challenges in Battery Management

While IoT-based battery management systems offer numerous benefits, they also come with challenges. Some of these challenges include:

- **Data Security and Privacy**: As IoT devices collect and transmit sensitive information about battery performance and vehicle usage, ensuring data security becomes a priority. Protecting the system from cyberattacks or data breaches is crucial to maintaining the integrity of the battery management system.
- **Scalability**: As the number of electric vehicles grows, the volume of data generated by IoT devices will increase significantly. The system must be scalable to handle large datasets and ensure that real-time monitoring and predictive analytics can be performed without delays.
- **Battery Degradation**: Over time, all batteries degrade, and managing this degradation efficiently is crucial for maintaining vehicle performance. IoT systems must be capable of tracking battery health over long periods and adapt their management strategies as the battery ages.

1.4 Objectives of the Project

The primary objectives of this IoT-based EV Battery Management and Protection System are as follows:

- **Enhanced Monitoring and Control**: To develop a system that continuously monitors battery parameters such as voltage, current, temperature, SOC, and SOH using IoT-based sensors, and ensures optimal performance.
- **Safety and Protection**: To implement protective mechanisms that can autonomously disconnect the battery from the vehicle in case of dangerous situations, such as overheating, overcharging, or short circuits.
- **Predictive Maintenance**: To create an analytics platform that predicts potential battery failures or degradation, enabling proactive maintenance and minimizing vehicle downtime.
- **Remote Access and Diagnostics**: To provide users and technicians with remote access to the battery management system for diagnostics, firmware updates, and control actions.
- **Cost-Effectiveness**: To ensure that the solution is cost-effective, scalable, and easy to integrate with different types of electric vehicles, ranging from two-wheelers to commercial fleets.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

1. Patel A., Shah R. presented their work in 2021 on IoT-Based Battery Management System for Electric Vehicles. The system enables real-time monitoring of battery performance and health using sensors and cloud based platforms. The authors discuss the integration of IoT sensors with the vehicle's battery, ensuring reliable monitoring and predicting battery failures to improve the overall safety of electric vehicles.

2. Chaturvedi S., Jha M. presented their work in 2020 titled IoT- Enabled Predictive Maintenance in Battery Management Systems for Electric Vehicles. The paper explores how IoT-enabled predictive maintenance can extend the life of electric vehicle batteries. The system uses advanced analytics and real-time data from battery sensors to predict potential failures and optimize charging cycles. The study demonstrates significant improvements in battery lifespan and energy efficiency, reducing the risk of sudden failure.

3. Kumar S., Verma A. in 2019 published a study titled Design and Development of IoT-Based Battery Monitoring System for EVs. This research focuses on the design of an IoT-based system to monitor the state of charge (SoC) and state of health (SoH) of electric vehicle batteries. The system provides real-time data about battery temperature, voltage, and current, allowing for more efficient management and early detection of issues that could lead to reduced battery performance or failure.

4. Gupta P., Singh N. proposed a study in 2021 titled IoT-Based Smart Battery Management System for Electric Vehicles. This study proposes a smart battery management system (BMS) that leverages IoT technologies for electric vehicles. By integrating cloud services with real-time monitoring, the system can track battery parameters such as charge cycles, degradation patterns, and environmental conditions to enhance performance and safety. The authors emphasize the use of machine learning for predictive battery analytics.

5. Reddy T., Kiran G. in 2020 introduced a study titled IoT and Machine Learning-Based Battery Management System for Electric Vehicles. The paper discusses a hybrid IoT and machine learning system designed to improve battery management in electric vehicles. By combining real-time sensor data and predictive models, the system can optimize charging schedules, detect faults early, and reduce the risk of overheating. The authors show how the system improves overall vehicle reliability.

6. Das S., Rajeev V. presented their research in 2021 under the title Enhanced Battery Life Prediction in Electric Vehicles Using IoT. The research highlights the role of IoT in predicting the remaining useful life (RUL) of electric vehicle batteries. The IoT-based system collects realtime battery data and uses predictive algorithms to forecast when the battery will require replacement. This approach leads to better energy management and extends battery life through optimized usage patterns.

7. Mehta R., Srinivasan A. in 2019 published a paper titled IoT-Based Safety Management System for EV Battery Protection. This paper introduces an IoT-based safety system designed to protect electric vehicle batteries from potential hazards like thermal runaway and short circuits. The system continuously monitors battery temperature, current, and voltage, triggering alarms or shutdowns in case of abnormal behavior.

   This work emphasizes safety and proactive protection using IoT.

8. Sharma A., Bhalla M. proposed their work in 2022 titled Battery Management in Electric Vehicles Using IoT and Blockchain Technologies. The study investigates the application of IoT and blockchain technologies for secure and transparent battery management in electric vehicles. IoT sensors collect battery data, while blockchain ensures data integrity and transparency. This system can enhance user confidence and improve battery life by preventing tampering and unauthorized access to data.

9. Fernandez J., Lopez M. presented their work in 2020 titled Wireless IoT Based Battery Management System for Electric Vehicles. The authors explore the feasibility of a wireless IoT-based battery management system that can monitor and communicate battery status to the cloud without physical connections. The system is designed to improve the ease of installation and reduce wiring complexity in electric vehicles, while still ensuring reliable battery data transmission for real-time analysis.

10. Nair K., Joshi P. in 2019 introduced a study titled IoT-Based Real-Time Battery Health Monitoring System for Electric Vehicles. This

paper presents a real-time battery health monitoring system using IoT technology. The system tracks various battery parameters, including temperature, current, and voltage, and provides users with actionable insights to maintain optimal battery health. The authors emphasize how the system can help prevent premature battery degradation and improve vehicle safety.

2.2 Research Gap

The existing systems for electric vehicle (EV) battery management predominantly rely on basic Battery Management Systems (BMS) that monitor only essential parameters such as voltage, current, and temperature. These systems lack real-time connectivity and often operate in isolation without cloud integration, limiting their ability to offer remote diagnostics or predictive maintenance.

Furthermore, users of current BMS setups are typically unaware of battery degradation or emerging safety issues until failure symptoms become critical. This reactive approach increases the risk of sudden breakdowns, reduces battery lifespan, and may compromise user safety due to undetected conditions like overheating or internal short circuits.

Another critical limitation is the absence of intuitive data visualization tools. Without clear and accessible performance insights, users and maintenance personnel are unable to make informed decisions regarding battery health and maintenance schedules.

Additionally, the existing systems do not incorporate proactive safety features such as automatic disconnection in hazardous situations, nor do they support user alerts through modern platforms like smartphones or cloud dashboards.

These limitations reveal a clear research gap in developing a smart, connected, and user-friendly IoT-based BMS that provides:

- Real-time monitoring and remote access via mobile or web interfaces,
- Early detection of faults and predictive analytics,
- Automated safety responses such as disconnection during abnormal conditions, and
- Enhanced user awareness through data visualization and alert systems.

Addressing these gaps would significantly improve the efficiency, safety, and usability of EV battery management systems.

CHAPTER 3

METHODOLOGY

3.1 PROPOSED SYSTEM

- The proposed system introduces an IoT-based approach to enhance battery monitoring for EVs, addressing the limitations of existing systems. This solution employs advanced sensors to continuously track critical battery parameters, including voltage, current, and temperature. The data is transmitted to a microcontroller, which sends the information to the cloud, enabling real-time monitoring on Android smartphones and computers.
- The system provides a user-friendly interface that displays battery performance metrics and alerts users to potential issues such as overcharging, deep discharging, fire hazards, and swollen battery conditions. By leveraging IoT technology, the proposed system allows for continuous remote monitoring and early detection of battery deterioration, enhancing safety and extending battery life.
- Test results validate the system’s effectiveness in providing timely interventions, ensuring optimal battery efficiency and user safety.

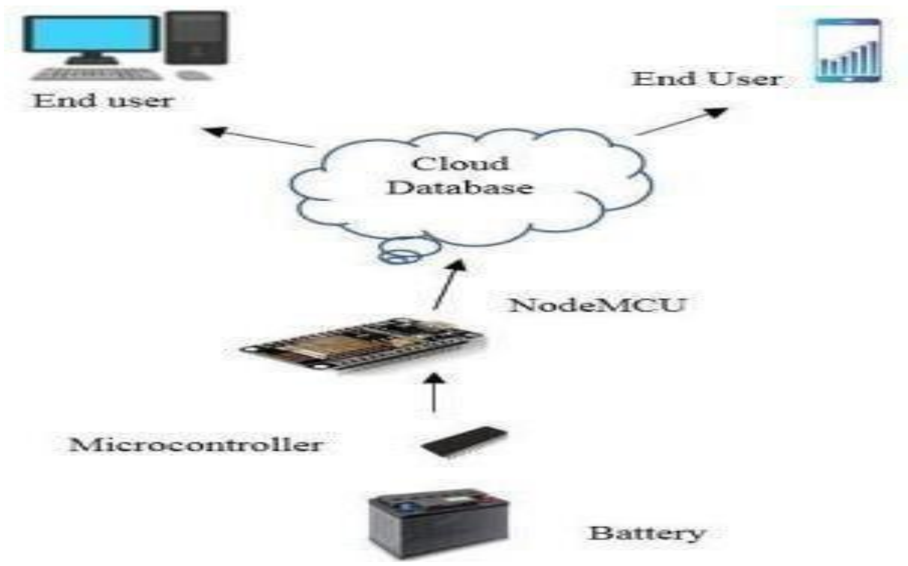

Figure 3.1 Proposed Architecture

This figure 3.1 shows the basic architecture of the proposed system for EV battery monitoring.

BLOCK DIAGRAM

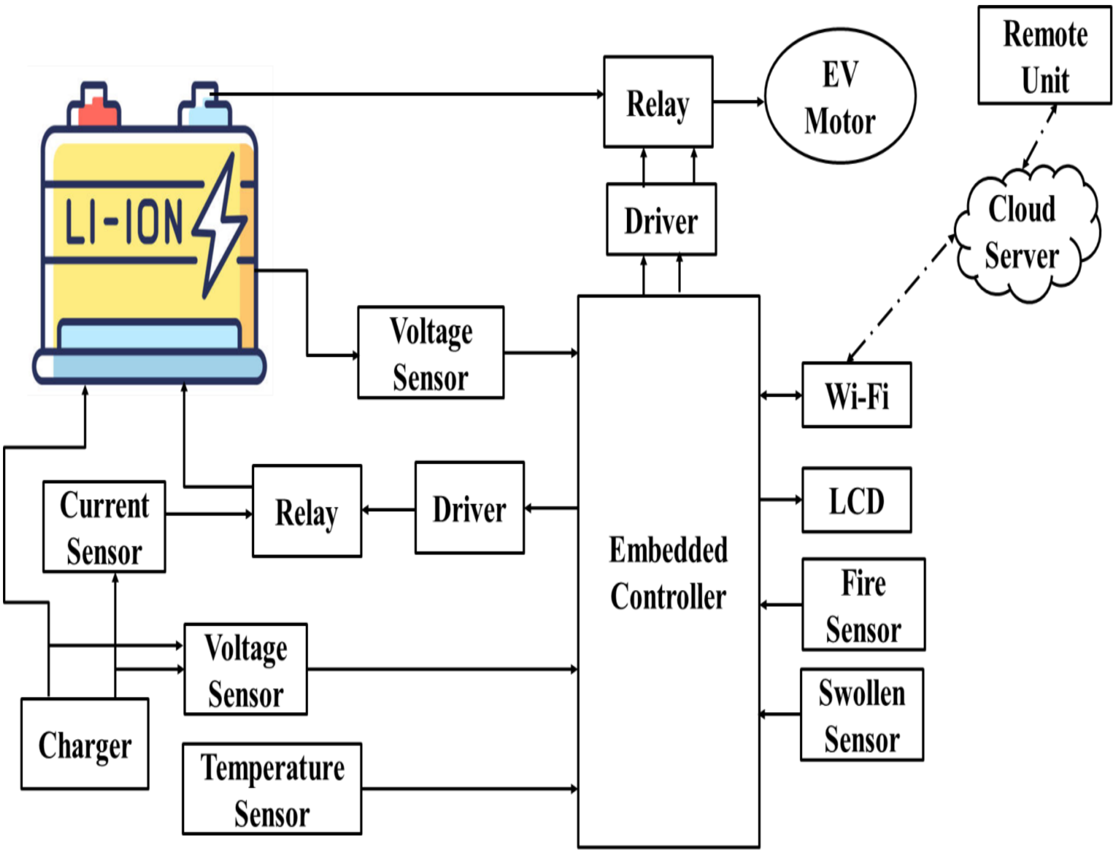

Figure 3.2 Proposed Block Diagram

The figure 3.2 shows the components of the proposed system

3.2 COMPONENTS OF BLOCK DIAGRAM

Power Supply

- Power supply gives supply to all components. It is used to convert AC voltage into DC voltage.

Voltage Sensor

- The DC voltage sensor working on voltage divider principle works reduce the battery voltage input for embedded controller. It converts voltages from high to low.

Current Sensor

- A battery current to measurement device designed series load resistor based current measurement unit.

Temperature Sensor

- DS18b20 is a one wire sensor, linear temperature sensor whose output voltage varies linearly with change in temperature.

Fire Sensor (Photodiode Type):

- A photodiode-based fire sensor detects flames or fire by sensing the infrared light emitted by fire. It uses a photodiode that responds to specific wavelengths associated with fire, making it useful for flame detection in various safety and monitoring applications.

Swollen Sensor (IR Sensor):

- A swollen battery can indicate a buildup of gas due to overheating or a chemical reaction, posing a safety risk. If a battery shows swelling, it's essential to stop using the device and handle the battery carefully to avoid leaks or explosions. A swollen battery in an infrared (IR) sensor can compromise its performance and safety. It's crucial to replace the battery immediately to prevent damage and ensure the sensor operates correctly.

ATmega 328

- ATMEGA 328 microcontroller, which acts as a processor for the Arduino board. Nearly it consists of 28 pins. From these 28 pins, the inputs can be controlled by transmitting and receiving the inputs to the external device.

Relay & driver IC:

- Relay Driver is used for driving the relay. ULN2003A IC is used as driver. Relays are switching devices. Switching devices are the heart of industrial electronic systems.

LCD:

- A 2x16 LCD is used for displaying the message. We are going to use 16x2 alphanumeric Liquid Crystal Display (LCD) which means it can display Alphabets along with numbers on 2 lines each are containing 16 characters.

Wi-Fi:

- The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network.

Internet of Things (IOT):

- The Internet of Things (IoT) is a system the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data. That is provided with unique identifiers and the ability to transfer data over a network without requiring human to-human or human-to-computer interaction.

3.3 CIRCUIT DIAGRAM

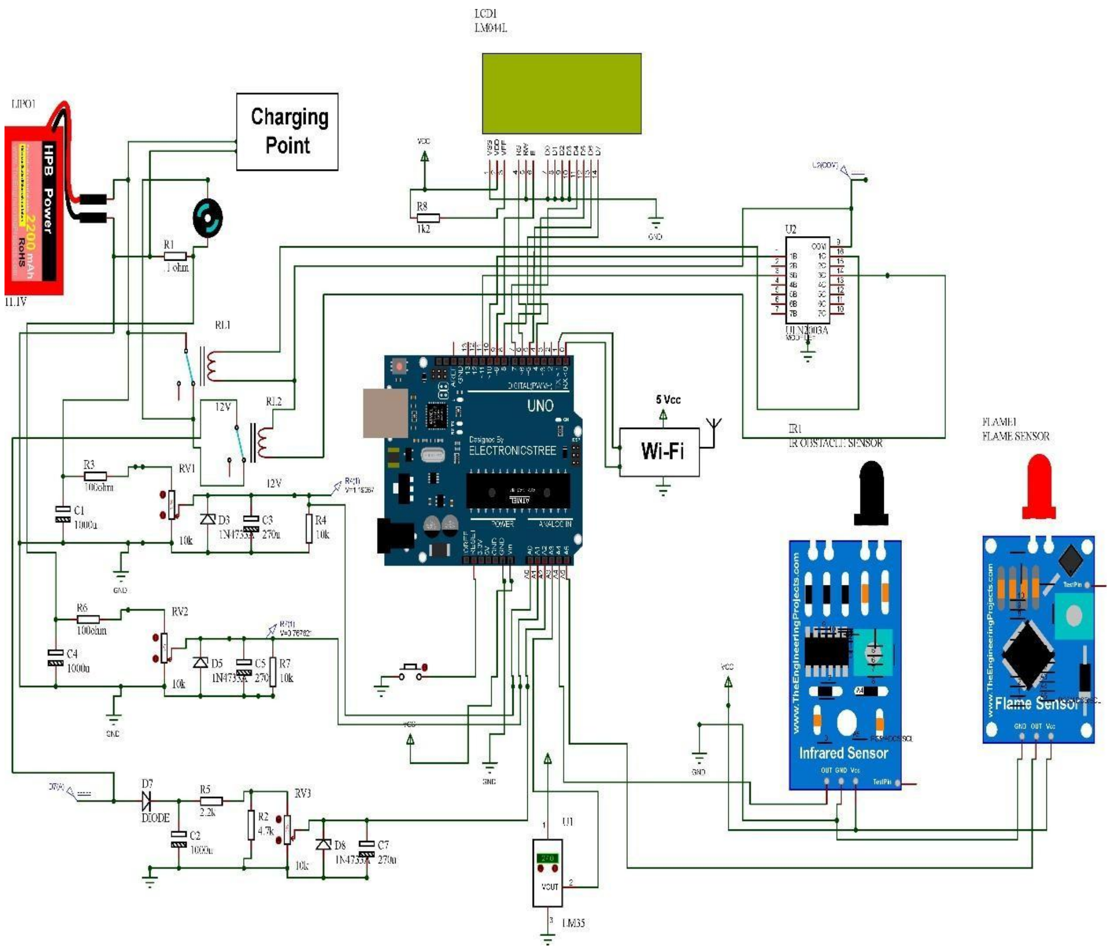

Figure 3.3 Proposed Circuit Diagram

The Figure3.3 shows the connections of different components

3.2 CIRCUIT DIAGRAM EXPLANATION:

ATmega 328 Analog/Digital pins connect to the sensors (e.g., current sensor, temperature sensor). Communicates with the ESP8266 Wi-Fi module via UART. Drives the LCD through appropriate digital pins.The sensor is connected to the battery's positive terminal and to the ATmega 328's analog input pin. The voltage sensor is connected to the battery's terminals and to an analog input pin on the ATmega 328.The temperature sensor is placed in close proximity to the battery and connected to one of the analog input pins of the ATmega 328.Connected to the ATmega 328 via UART (TX, RX) for data transmission and reception. Powers the ATmega 328, sensors, and LCD via a power distribution circuit. Connected to the voltage and current sensors for monitoring. Directly connected to the battery and provides power to the various components. The control pins of the relay are connected to the driver circuit. The relay switch connects to high-power components, such as the battery or motor. The base (B) of the transistor is connected to a GPIO pin on the ATmega 328 through a current-limiting resistor..The collector (C) is connected to one end of the relay coil. The emitter (E) is grounded. Connected to the digital I/O pins of the ATmega 328 for data input and control. Connected to a digital input pin of the ATmega 328, with the system programmed to take safety measures when triggered.Connected to a digital input pin on the ATmega 328 for monitoring battery swelling.

CHAPTER 4

HARDWARE DESCRIPTION

4.1 ARDUINO

Arduino is an open-source computer hardware and software company, project and user community that designs and manufactures microcontroller based kits for building digital devices and interactive objects that can sense and control objects in the physical world.

The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets of digital and analogI/Opins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, includingUSBon some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides anintegrated development environment(IDE) based on theProcessingproject, which includes support for the CandC++programming languages.

The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simplerobots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or asdo-it-your self kits. The hardware design specifications are openly available, allowing the Arduino boards to be manufactured by any one.Ada fruit Industries estimated in mid-2011 that over 300,000 official Arduino had been commercially produced, and in 2013 that 700,000 official boards were in users' hands.

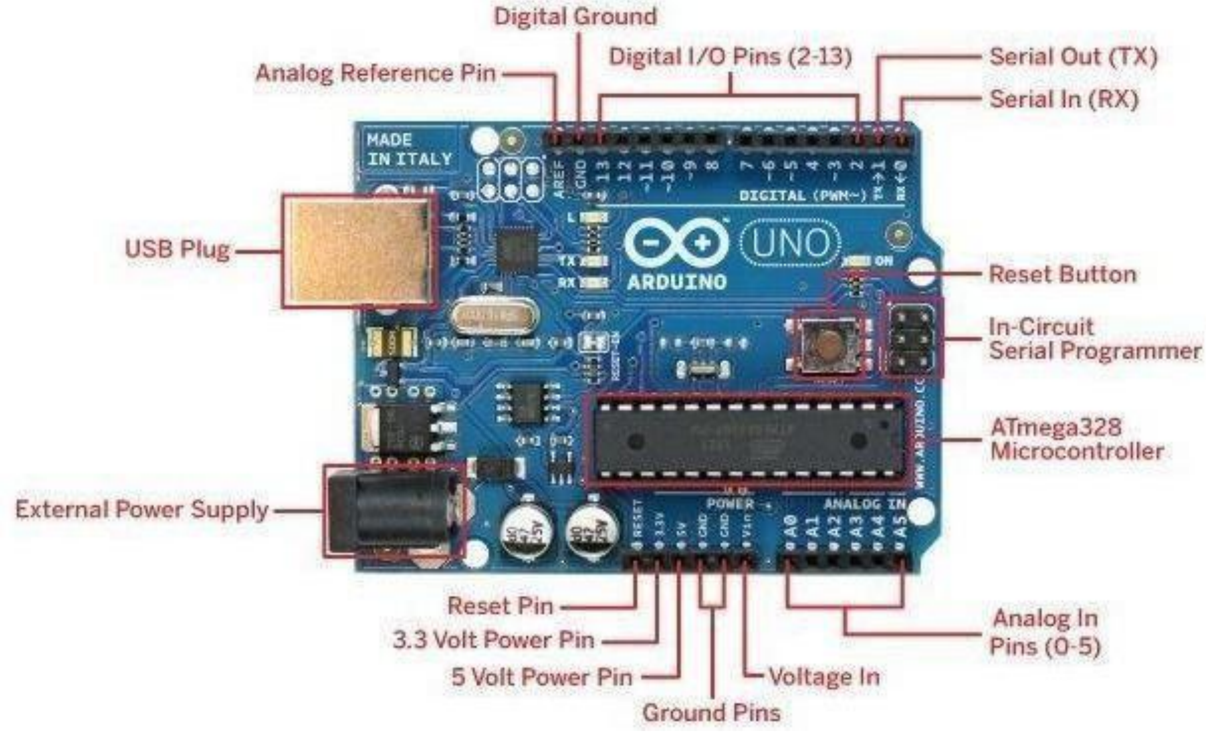

Figure 4.1 Arduino Uno

The figure 4.1 shows the image of the Arduino board with ATmega 328P used in this system.

Input and Output

Each of the 14 digital pins on the Arduino Uno can be used as an input or output, using pin Mode (), digital Write (), and digital Read () functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 k Ohms.

In addition, some pins have specialized functions:

Serial: pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.

SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. Additionally, some pins have specialized functionality:

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

AREF: Reference voltage for the analog inputs.Used with analog Reference ().

Reset: Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

ATMEGA 328

Figure 4.2 ATMEGA Microcontroller

The figure 4.2 shows the image of the ATmega328 MCU.

ATMEGA 328 microcontroller, which acts as a processor for the arduino board. Nearly it consists of 28 pins. From these 28 pins, the inputs can be controlled by transmitting and receiving the inputs to the external device. It also consists of pulse width modulation (PWM). These PWM are used to transmit the entire signal in a pulse modulation. Input power supply such as Vcc and Gnd are used. These IC mainly consists of analog and digital inputs. These analog and digital inputs are used for the process of certain applications.

DESCRIPTION OF INPUT:

ANALOG INPUT:

Arduino atmega-328 microcontroller board consist of 6 analog inputs pins. These analog inputs can be named from A0 to A5. From these 6 analog inputs pins, we can do the process by using analog inputs. Analog inputs can be used in the operating range of 0 to 5V. Analog signal is considered as the continuous time signal, from which these analog signal can be used for certain applications. These are also called as non-discrete time signal. Inputs such as voltage, current etc.., are either analog signal or digital signal only by analysing the time signal properties. Various applications of Arduino microcontroller can use only an analog input instead of digital inputs. For these applications, analog input ports or pins can be used.

DIGITAL INPUT:

Digital inputs can be defined as the non-continuous time signal with discrete input pulses. It can be represented as 0's and 1's. These digital inputs can be either on state or in off state. Arduino atmega328 microcontroller also consists of 12 digital input pins. It can be stated as D0 to D11. Nearly 12 inputs can be used for digital input/output applications. The working of the digital input ports is where the discrete input pulses can be triggered and supplied to the ports. These ports receive the input and therefore the port can be used for both input and output process. These digital pins can access only the digital inputs.

ATMEGA-328 IC:

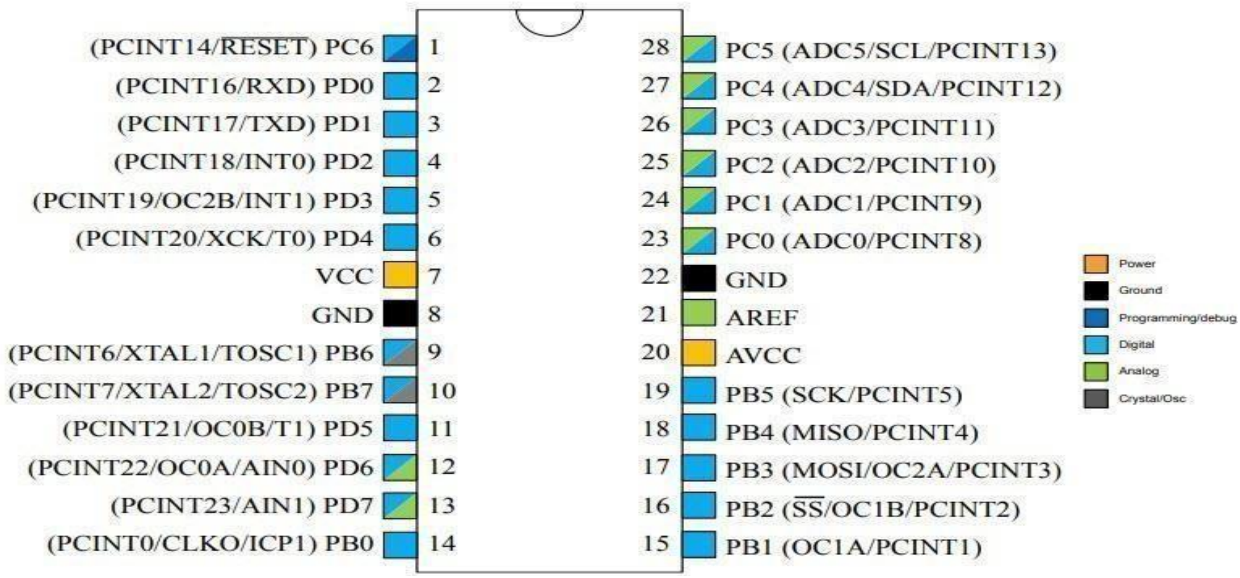

Figure 4.3 ATMEGA Microcontroller IC Diagram

The figure 4.3 represent the chip diagram of ATmega328 MCU.

This ATMEGA-328 integrated chip consists of 28 pins. It consists of 6 analog inputs that are shown in the pin diagram. Analog inputs can be represented as PC0 to PC5. These analog input pins possess the continuous time signal which acts as an analog input for the system. Further it also consists of 12 digital inputs. It can be represented as PD1 to PD11 which act as a digital input port based on pulse width modulation (PWM). These

PWM, which transmits the signal in the form of discredited form. Both analog and digital input ports can be used for various applications for the input power supply, VCC and GND pins are used. Pins PB6 and PB7, which acts as a crystal to generate a clock signal. By using this crystal, we can generate the clock signals and by these clock signals, we can use this clock signals for input sources. PC6 pin are the one where it can be used for the reset option. Resetting the program can be done by using this PC6 pin.

Table 4.1 gives a description for each of the pins ATmega, along with their function.

TABLE 4.1 Pins of ATmega328

Pin Number	**Description**	**Function**
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin
5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	Vcc	Positive Voltage (Power)
8	GND	Ground

9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input
24	PC1	Analog Input

25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

Features:

High Performance, Low Power Design

- 8-Bit Microcontroller Atmel® AVR® advanced RISC architecture
  ○131 Instructions most of which are executed in a single clock cycle ○Up to 20 MIPS throughput at 20 MHz ○32 x 8 working registers

  ○2 cycle multipliers

- Memory Includes ○32KB of of programmable FLASH ○1KB of EEPROM ○2KB SRAM
  - 10,000 Write and Erase Cycles for Flash and 100,000 for EEPROM
  - Data retention for 20 years at 85°C and 100 years at 25°C ○Optional boot loader with lock bits
    - ✦ In System Programming (ISP) by via boot loader
    - ✦ True Read-While-Write operation

    ○Programming lock available for software security

- Features Include ○2 x 8-bit Timers/Counters each with independent prescaler and compare modes

- A single 16-bit Timer/Counter with an independent prescaler, compare and capture modes
- Real time counter with independent oscillator ○10 bit, 6 channel analog to digital Converter ○6 pulse width modulation channels ○Internal temperature sensor ○Serial USART (Programmable)
- Master/Slave SPI Serial Interface – (Philips I2C compatible) ○Programmable watchdog timer with independent internal oscillator ○Internal analog comparator ○Interrupt and wake up on pin change

• Additional Features ○Internal calibrated oscillator

- Power on reset and programmable brown out detection ○External and internal interrupts
- 6 sleep modes including idle, ADC noise reduction, power save, power down, standby, and extended standby

• I/O and Package ○23 programmable I/O lines ○28 pin PDIP package

• Operating voltage:

○1.8 – 5.5V

• Operating temperature range:

○-40°C to 85°C.

4.2 BATTERY PACK :

Figure4.4 Battery Pack

The figure 4.4 shows Lithium-ion Battery pack in which three cells are connected in series

A 3S Li-ion battery is a rechargeable battery pack made by connecting three lithium-ion cells in series. The term "3S" stands for "3 cells in series," which means the voltages of the individual cells add up while the capacity remains the same as that of one cell. Each Li-ion cell typically has a nominal voltage of 3.7 volts, so a 3S battery has a total nominal voltage of 11.1 volts. When fully charged, each cell reaches 4.2 volts, making the total fully charged voltage 12.6 volts. The battery is usually protected by a Battery Management System (BMS) that prevents overcharging, over-discharging, and ensures all cells are balanced.

A real-time battery arrangement for an electric scooter involves a structured combination of lithium-ion battery cells, a Battery Management System (BMS), sensors, and a monitoring system. Typically, lithium-ion cells (such as 18650 or 21700) are connected in a series-parallel configuration to meet the required voltage and capacity. For example, a 48V battery pack might use a 13S4P configuration—13 cells in series to achieve 48V and 4 cells in parallel for increased capacity. The BMS plays a critical role by continuously monitoring each cell's voltage, the total current, and the temperature of the pack to ensure safety and efficiency.

It prevents overcharging, deep discharging, and overheating, and disconnects the battery in hazardous situations.

Key Specifications

1. Nominal Voltage:

Each Li-ion cell typically has a nominal voltage of 3.7V. So,

a 3S pack = 3.7V × 3 = 11.1V nominal.

2. Full Charge Voltage:

Each cell charges up to 4.2V, so the pack reaches 12.6V (4.2V × 3) when fully charged.

3. Cut-off Voltage:

The minimum safe discharge voltage is around 3.0V per cell, making the total cut-off voltage 9.0V (3.0V × 3).

4. Capacity:

If each cell has a capacity of, say, 2200 mAh, then the total pack capacity is still 2200 mAh, not multiplied, since they're in series.

4.3 TEMPERATURE SENSOR - DS18B20:

Figure 4.5 Temperature Sensor

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with non volatile user programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply. Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

Pin Configurations

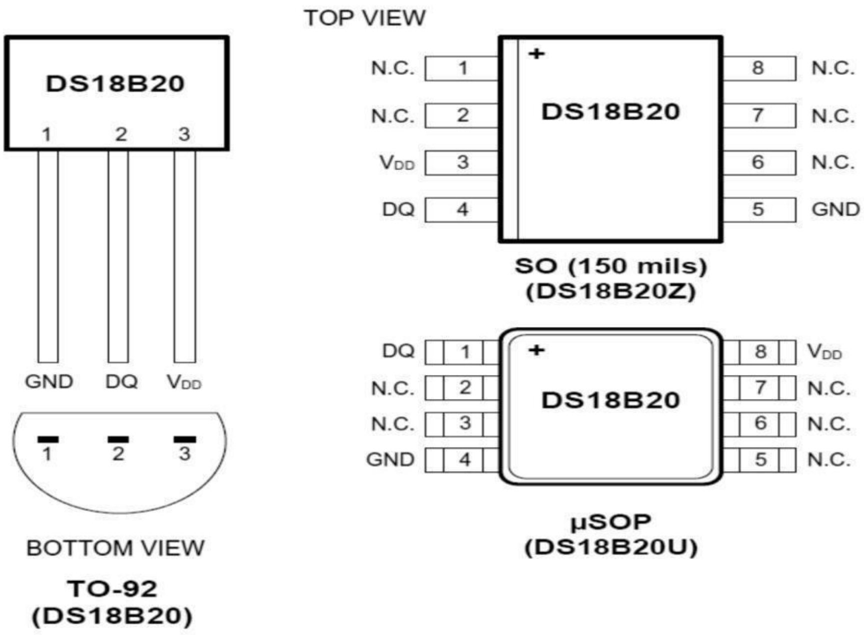

Figure 4.6 DS18B20 Pin Diagram

The figure 4.6 represnts pin diagram of temperature sensor DS18B20.

- GND - Ground
- DQ - Data In/Out
- VDD – Power Supply Voltage

Features of DS18B20

- Unique 1-Wire interface requires only one port pin for communication
- Multidrop capability simplifies distributed temperature sensing applications
- ±0.5°C accuracy from -10°C to +85°C
- Power supply range is 3.0V to 5.5V
- Zero standby power required
- Measures temperatures from -55°C to+125°C. Fahrenheit equivalent is 67°F to+257°F

- Thermometer resolution is programmable from 9 to 12 bits
- Converts 12-bit temperature to digital word in 750 ms (max.)
- User-definable, nonvolatile temperature alarm settings
- Applications include thermostatic controls, industrial systems, consumer products,thermometers, or any thermally sensitive system

Operation—Measuring Temperature

The core functionality of the DS18B20 is its direct-to digital temperature sensor. The resolution of the temperature sensor is user-configurable to 9, 10, 11, or 12 bits, corresponding to increments of 0.5°C, 0.25°C, 0.125°C, and 0.0625°C, respectively. The default resolution at power-up is 12-bit. The DS18B20 powers up in a low power idle state. To initiate a temperature measurement and A-to-D conversion, the master must issue a Convert T [44h] command. Following the conversion, the resulting thermal data is stored in the 2-byte temperature register in the scratchpad memory and the DS18B20 returns to its idle state. If the DS18B20 is powered by an external supply, the master can issue "read time slots" (see the 1-Wire Bus System section) after the Convert T command and the DS18B20 will respond by transmitting 0 while the temperature conversion is in progress and 1 when the conversion is done. If the DS18B20 is powered with parasite power, this notification technique cannot be used since the bus must be pulled high by a strong pull-up during the entire temperature conversion. The DS18B20 output temperature data is calibrated in degrees Celsius; for Fahrenheit applications, a lookup table or conversion routine must be used. The temperature data is stored as a 16-bit sign-extended two's complement number in the temperature register .The sign bits (S) indicate if the temperature is positive or negative, for positive numbers S = 0 and for negative numbers S = 1. If the DS18B20 is configured for 12-bit resolution, all bits in the temperature register will contain valid data. For 11-bit resolution, bit 0 is undefined. For 10-bit resolution, bits 1 and 0 are undefined, and for 9-bit resolution bits 2, 1, and 0 are undefined.

1-Wire Bus System

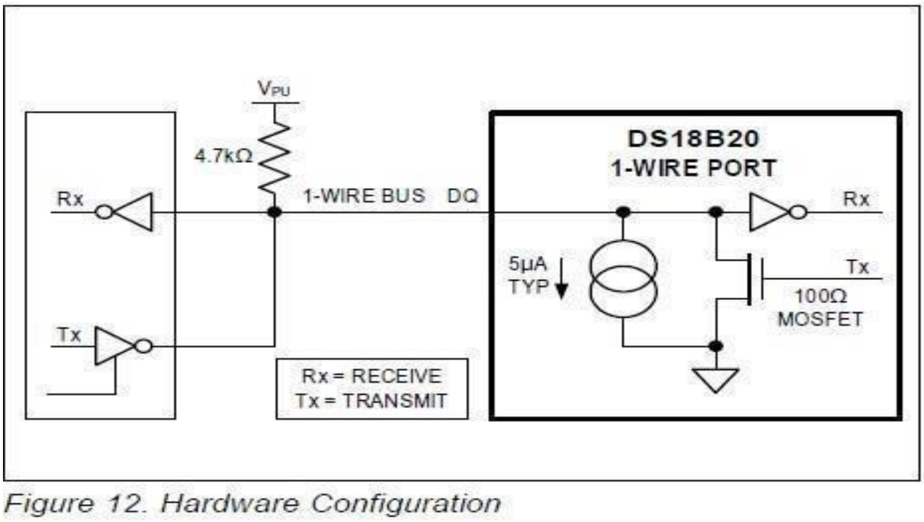

Figure 4.7 1 wire bus system

The figure 4.7 shows the hardware configuration of 1 wire bus system.

The 1-Wire bus system uses a single bus master to control one or more slave devices. The DS18B20 is always a slave. When there is only one slave on the bus, the system is referred to as a "single-drop" system; the system is "multidrop" if there are multiple slaves on the bus. All data and commands are transmitted least significant bit first over the 1-Wire bus.

4.4 FIRE SENSOR

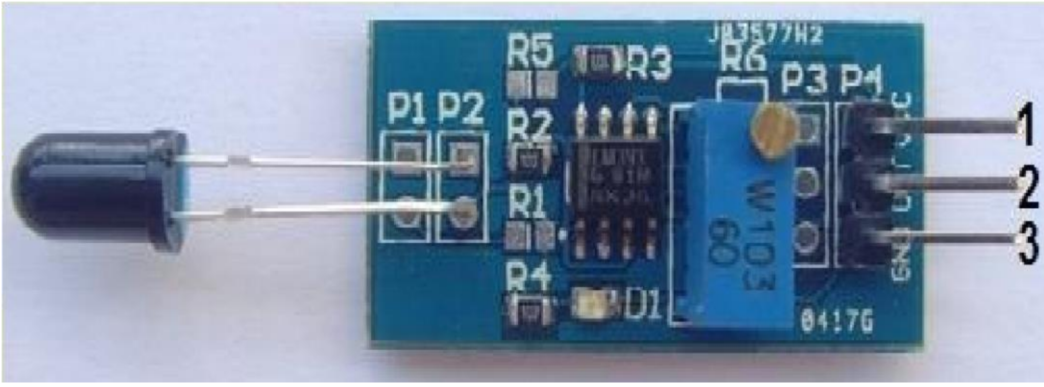

Figure 4.8 Fire Sensor

Flame sensor is the most sensitive to ordinary light that is why its reaction is generally used as flame alarm purposes. This module can detect flame or wavelength in 760 nm to 1100 nm range of light source. Small plate output interface can and single-chip can be directly connected to the microcomputer IO port. The sensor and flame should keep a certain distance to avoid high temperature damage to the sensor. The shortest test distance is 80 cm, if the flame is bigger, test it with farther distance. The detection angle is 60 degrees so the flame spectrum is especially sensitive. The detection angle is 60 degrees so the flame spectrum is especially sensitive.

Schematic Diagram:

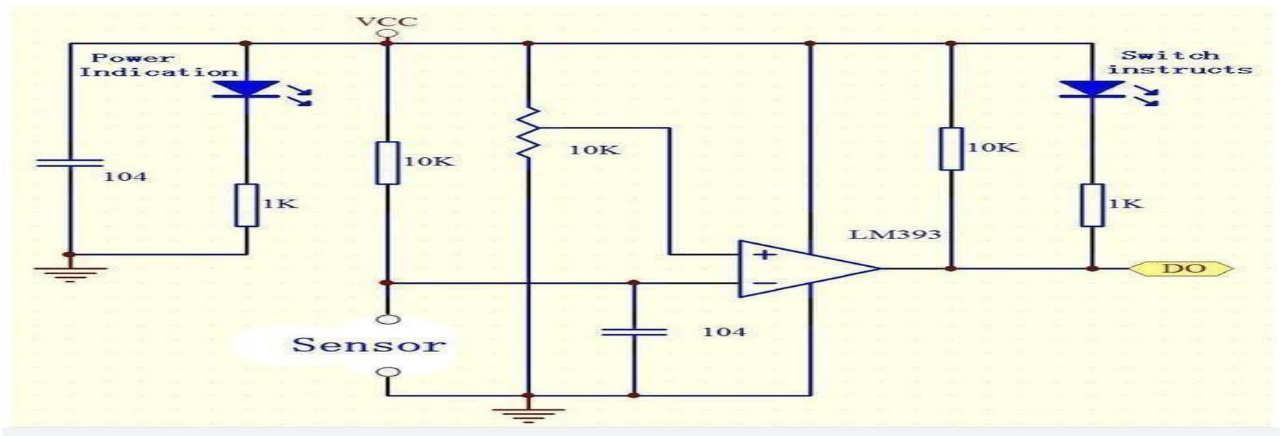

Figure 4.9 Schematic Diagram

The figure 4.9 shows the schematic diagram of fire sensor.

Pin Configuration:

1. VCC - Voltage supply ranges from 3.3v to 5v
2. GND - This is a ground pin
3. OUT - This is analog(AOUT) or digital(DOUT) output pns

Specifications:

- On-board LM393 voltage comparator chip and infrared sensing probe.
- Support 5V/3.3V voltage input.
- On-board signal output indication, output effective signal is high level, and the same time the indicator light up, output signal can directly connect with microcontroller IO.
- Signal detection sensitivity can be adjusted.
- Reserved a line voltage compare circuit (P3 is leaded out).
- PCB size: 30(mm) x15(mm).

4.5 IR SENSOR

Infrared radiation is the portion of electromagnetic spectrum having wavelengths longer than visible light wavelengths, but smaller than microwaves, i.e., the region roughly from 0.75µm to 1000 µm is the infrared region. Infrared waves are invisible to human eyes. The wavelength region of 0.75µm to 3 µm is called near infrared, the region from 3 µm to 6 µm is called mid infrared and the region higher than 6 µm is called far infrared.

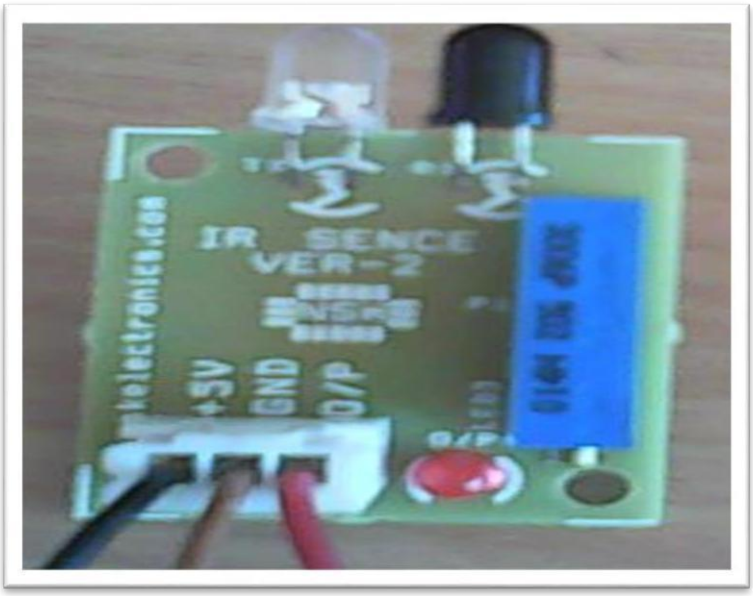

Figure 4.10 IR Sensor

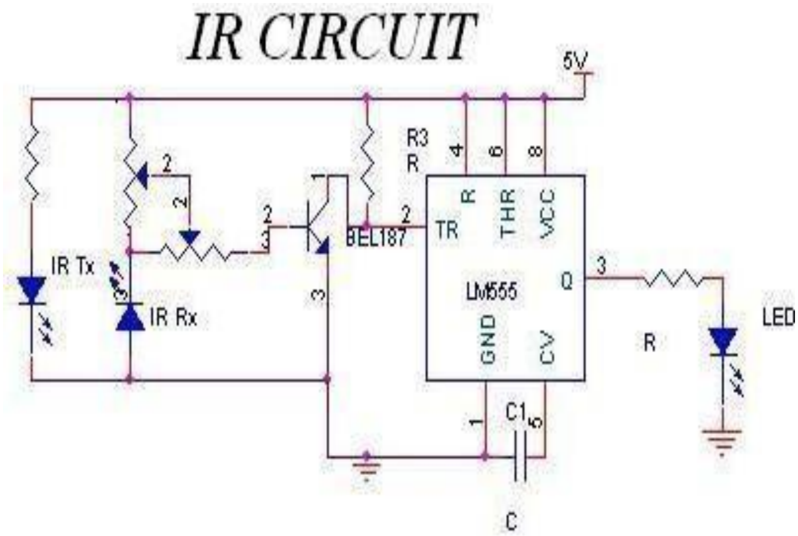

Figure 4.11 IR Sensor Circuit

The figure 4.11 shows the circuit representation of IR sensor.

IR sensors are used to produce IR waves. IR sensors consist of IR Transmitter and IR receiver. IR transmitter is the one type of LED which emits infrared rays generally called IR transmitter. One important point is that both IR transmitter and receiver it placed in the straight line to each other.

Specifications:

- Operating Voltage: 3.0V – 5.0V
- Detection range: 2cm – 30cm (Adjustable using potentiometer)
- Current Consumption: at 3.3V : ~23 mA, at 5.0V: ~43 mA
- Active output level: Outputs Low logic level when obstacle is detected
- On board Obstacle Detection LED indicator

4.6 IC DRIVER :

Driver is used for drive the relay. ULN2003A IC is used as driver. This IC has some special features

- Seven Darlington's per package
- output current 500ma per driver (600ma peak)
- output voltage 50v
- integrated suppression diodes for inductive loads
- outputs can be paralleled for higher current

DESCRIPTION

The ULN2001A, ULN2002A, ULN2003 and ULN2004Aare high voltage, high current Darlington arrays each containing seven open collector dar-lington pairs with common emitters. Each channel rated at 500mAand can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout. The four versions interface to all common logic families.

Table 4.2 gives different types of IC ULN2000 families.

TABLE 4.2 IC Driver types

ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors; LED displays filament lamps, thermal print-head sand high power buffers ULN2001A/2002A/2003Aand 2004A is sup-plied in 16 pin plastic DIP packages with a copper lead frame to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

Pin Diagram – ULN 2003

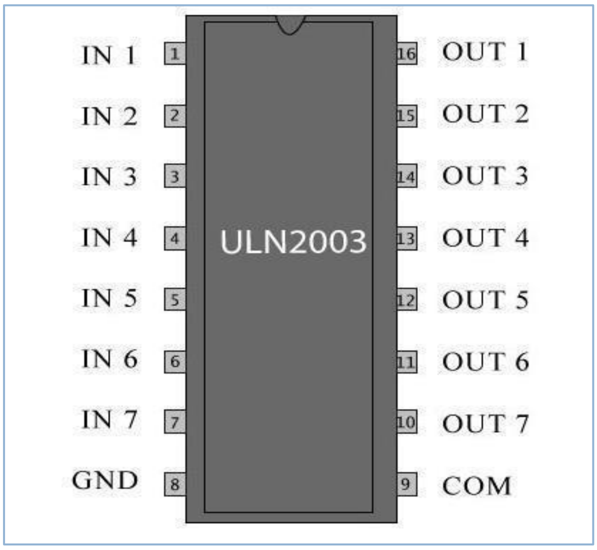

Figure 4.12 Pin Diagram ULN 2003

The figure 4.12 shows the pins of IC(ULN 2003) driver.

The ULN2003A is a high voltage, high current, Darlington Arrays each containing seven open collection Darlington pairs with common emitters.

Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite to outputs to simplify layout. It is a 5V TTL, CMOS. This versatile device is useful for driving a wide range of loads including solenoids, relays, DC motors, LED displays, and high-power buffers. Outputs can be paralleled for higher current.

The output of MC is applied to the input of relay driver transistor at its phase terminals. When the input base voltage is reduced so that the relay is deenergized, the collector current falls to zero abruptly. This sudden switching off the relay current induces a very high back emf in the relay coils, which may be high enough to puncture the collector-emitter junction at the transistor and damage it. A large capacitor connected in parallel with the relay coil absorbs this transient and protects the transistor. However large capacitor connected in parallel with the relay coil absorbs this transient, protects the transistor and sluggish the relay operations.

In an alternative method, a diode is connected in parallel with relay coil instead of the capacitor. During normal operation, the diode is reversed biased and has no effects on circuit performance, but, when the high back emf is induced, it has the proper polarity for the diode to conduct. The diode there after conducts heavily and absorbs all the transient voltage. The use of a diode is parallel with the relay coil is highly recommended.

4.7 RELAY

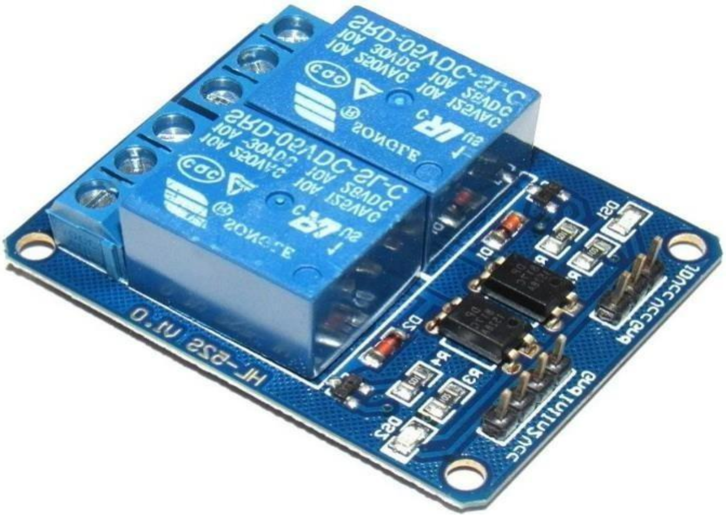

Figure 4.13 Relay Diagram

Relay Pin Diagram

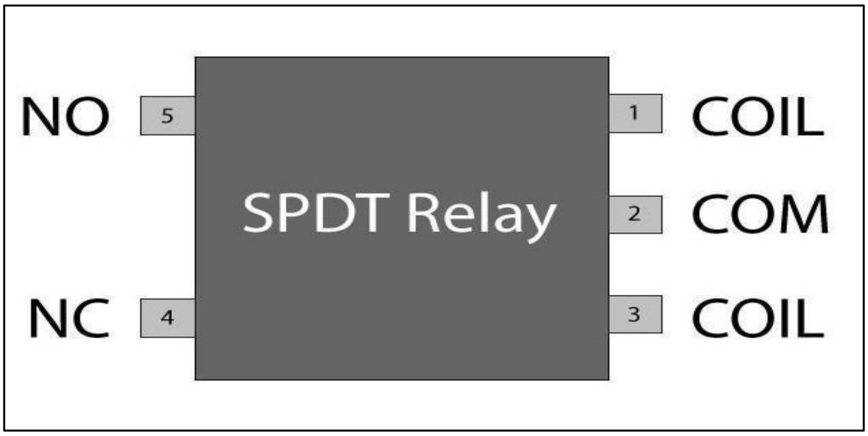

Figure 4.14 Pin Diagram

The figure 4.14 shows the pins of relay driver.

Relays are switching devices. Switching devices are the heart of industrial electronic systems. When a relay is energized or activated, contacts are made or broken. They are used to control ac or dc power. They are used to control the sequence of events in the operation of a system such as an electronic heater, counter, welding circuits, and X-ray equipment, measuring systems, alarm systems and telephony. Electromagnetic relays are forms of electromagnets in which the coil current produces a magnetic effect. It pulls or pushes flat soft iron armatures or strips carrying relay contacts. Several relay contact can be operated to get several possible ON/OFF combinations.

OPERATION OF ELECTROMAGNETIC RELAY

Relays are usually dc operated. When dc is passed to the coil, the core gets magnetized. The iron armature towards the core contacts 1 and 2 open and contacts 2 and 3 close. When coil current is stopped, the attraction is not there and hence the spring tension brings 1 and 2 to closed position, opening the other set 2 and 3.

When the relay is not activated (ie.) in the reenergized state, NC contacts are closed and NO connections are opened. When the relay is activated (ie.)in the energized state, NC contacts broken and NO contacts are made. When the relay is de energized the original states of the contacts are returned. The Above relays are single contact relays. This means that the relays have one common point, one NO contact and one NC contact.

Double contact relays are also present. These relays have a set of common points, a set of NO contacts and set of NC contacts. In single contact relay, only one relay independent load or a series of different loads can be connected.

In double contact relay, two independent loads can be connected at two different contacts and these two different and these two loads can be operated as desired.

4.8 DC Motor :

Figure 4.15 DC motor

The figure 4.15 shows the image of 12v DC motor with 1000rpm.

A 12V DC gear motor is a compact and efficient electric motor that operates on 12 volts of direct current and features an integrated gearbox to reduce speed and increase torque. This makes it ideal for applications requiring precise and powerful motion control, such as robotics, automation systems, and small machinery. In the context of a project prototype for an electric scooter (EV) the 12V DC gear motor is used as the primary drive mechanism by convert electrical energy to mechanical motion which is powered by a 12V battery. This setup enables basic demonstration of motion, torque transfer, and energy consumption. The gear motor not only drives the wheel but also provides sufficient torque due to its built-in gearbox, making it suitable for low-speed, high-torque applications such as this prototype. This configuration allows us to monitor how the battery discharges under load, which is useful for testing battery capacity and health under various scenario.

4.9 LCD – Liquid Crystal Display

Figure 4.16 LCD – Liquid Crystal Display

Liquid Crystal Displays (LCDs) have materials, which combine the properties of both liquid and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polarizer are pasted outside the two glass panels. This polarizer would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarizer and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarizer, which would result in activating / highlighting the desired characters.

The LCDs are lightweight with only a few millimeters thickness. Since the LCD's consume power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD does don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range. Changing the display size of the layout size is relatively simple which makes the LCD's more customers friendly. The LCD's used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

LCD display used in of our project to show title message and information message. Our project connect to a microcontroller unit data line connected to a 4,5,6,7 and control lines connected to 8 and 9.

Features:

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is build by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters

4.10 POWER SUPPLY (9V & 12V adapter) :

Power supply gives supply to all components. It is used to convert AC voltage into DC voltage. Transformer used to convert 230V into 12V AC.12V AC is given to diode. Diode range is 1N4007, which is used to convert AC voltage into DC voltage. AC capacitor used to charge AC components and discharge on ground. LM 7805 regulator is used to maintain voltage as constant. Then signal will be given to next capacitor, which is used to filter unwanted AC component.

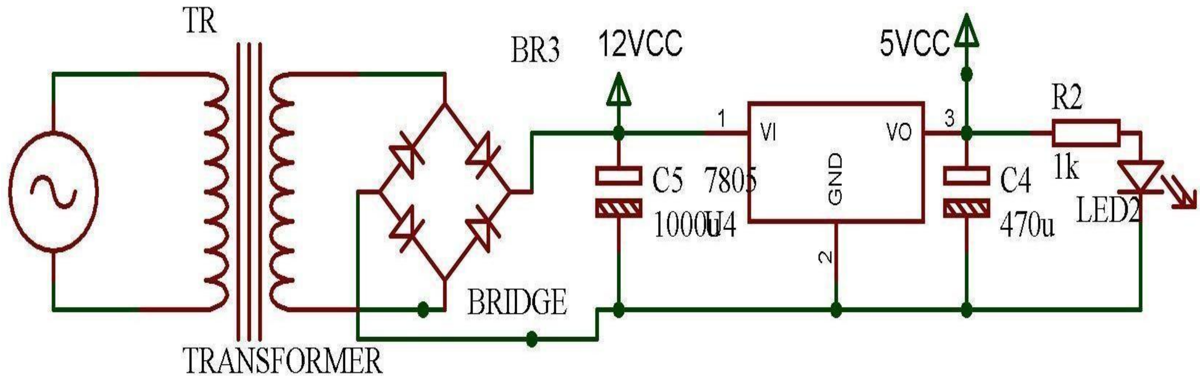

Figure 4.17 Single Power Supply

The figure 4.17 shows the circuit diagram of power supply.

4.8 WI-FI MODULE (ESP8266)

The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that’s just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

Figure 4.18 WIFI Module

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

The **ESP8266** is a low-costWi-Fimicrochip with fullTCP/IPstackandmicrocontrollercapability produced by Shanghai-based Chinese manufacturer, Espressif Systems.

The chip first came to the attention of westernmakersin August 2014 with the **ESP-01** module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections usingHayes-style commands.

However, at the time there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation.

The **ESP8285** is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.

Wi-Fi Protocols

- 802.11 b/g/n support
- 2 x Wi-Fi interface, supports infrastructure BSS Station mode / P2P mode / SoftAP mode support
- Hardware accelerators for CCMP (CBC-MAC, counter mode), TKIP (MIC,

RC4), WAPI (SMS4), WEP (RC4), CRC

- 802.11n support (2.4 GHz)
- Configurable packet traffic arbitration (PTA) with dedicated slave processor based design provides flexible and exact timing Bluetooth co- existence support for a widerange of Bluetooth Chip vendor.

CHAPTER 5

SOFTWARE DESCRIPTION

5.1 ARDUINO IDE SOFTWARE

The Arduino Integrated Development Environment (IDE) is used to write, compile, and upload code to the Arduino Uno. It provides a simple, user-friendly interface with support for a wide range of programming functions.

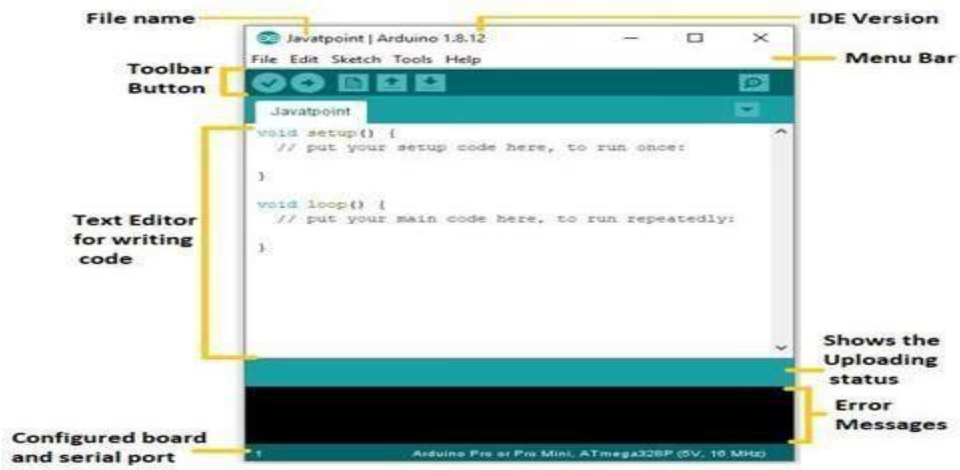

Figure 5.1 Arduino IDE

This figure 5.1 shows the interface of Arduino IDE.

Table 5.1 give the list of toolbars present in the Arduino IDE.

	Verify/compile	Checks the code for errors
	New	Creates a new blank Sketch
	Open	Shows a list of Sketches in your sketchbook
	Save	Saves the current Sketch
	Upload	Uploads the current Sketch to Arduino
	Serial Monitor	Displays serial data being sent from Arduino

TABLE 5.1 Toolbar List

5.2 Installation and setup of the Arduino software

. a) The board that you want to connect, has to be selected on the arduino software.

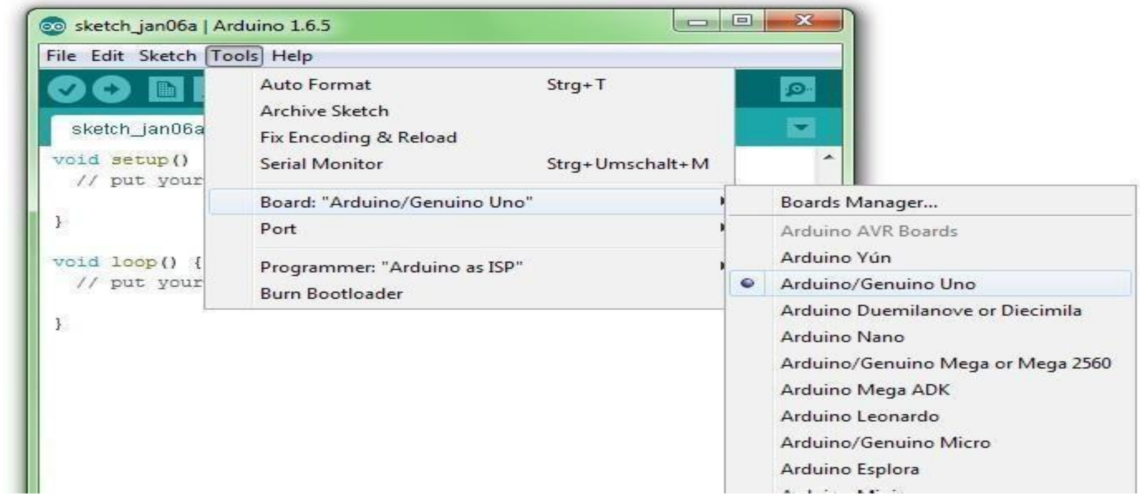

Figure 5.2 Installation and setup of the Arduino software

b) You have to choose the right “Serial-Port”, to let the Computer know to which port the board has been connected. That is only possible if the USB driver has been installed correctly. It can be checked this way:

At the moment the Arduino isn’t connected to the PC. If you now choose “Port”, under the field “Tool”, you will already see one or more ports here (COM1/ COM2/ COM3…).

Figure 5.3 Installation and setup

In this figure 5.3 it is shown that the initial installation setup for Arduino IDE.

5.3 Installation of the USB driver

How it should be:

1. You connect the board to the computer.

2. The Computer recognizes the board and suggests to install a driver automatically.

Programming

First, a short explanation for possible error reports that can appear while working with the Arduino software. The two most common ones are:

3. The board is not installed right, or the wrong board is selected. After uploading the sketch, there will appear an error report underneath the sketch. It looks like the one in the picture on the right. The note "not in sync" shows up in the error report.

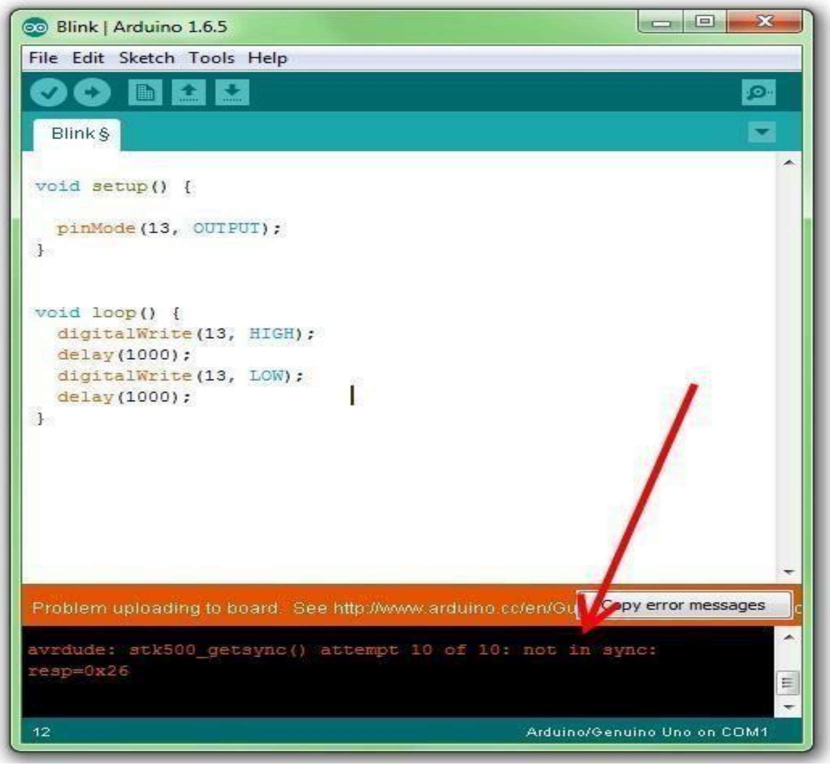

Figure 5.4 Installation of the USB Driver

The figure 5.4 shows the installation of USB Driver in Arduino IDE.

2.) There is a mistake in the sketch.

For example, a word is misspelled, or a bracket is missing. In the example on the left the last semicolon in the sketch is missing. In this Case the error report often starts with “excepted.”. This means that the program is still expecting something that is missing.

Figure 5.5 Error Message

This figure 5.5 shows the basic syntax error in Arduino uno code.

5.4 Basic structure of a sketch:

A sketch can be divided in three parts.

1. Name variable

In the first part elements of the program are named. This part is not necessary.

2. Setup (necessary for the program)

The setup will be performed only once. Here you are telling the program of

- ➢ Pin (slot for cables) should be an input and what should be an output on the boards.
- ➢ Defined as Output: The pin should put out a voltage. For example: With this pin a LED is meant to light up.
- ➢ Defined as an Input: The board should read out a voltage. For example: A switch isactuated. The board recognized this, because it gets a voltage on the Input pin.

3. Loop (necessary for the program)

This loop part will be continuously repeated by the board. It assimilates the sketch from beginning to end and starts again from the beginning and so on.

5.2 Cloud Platform :

The cloud setup is implemented to remotely monitor and manage the EV battery parameters through the internet. The ESP8266 Wi-Fi module is used to connect the IoT system to the internet. Sensor data such as battery voltage, temperature, and charge/discharge status is collected and transmitted to the cloud server hosted on Hostinger.A custom web dashboard is designed on Hostinger to display real-time data, allowing users to monitor battery health and performance remotely. This cloud-based system enhances accessibility, ensures timely alerts, and supports data logging for future analysis and protection strategies.

Key components of the cloud setup include:

1. Data Acquisition and Transmission:

- ESP8266 reads sensor values.
- Data is formatted in HTTP GET/POST requests.
- Transmitted to a PHP-based API endpoint hosted on Hostinger.

2. Web Hosting (Hostinger):

- Used to host a lightweight web application.
- Backend developed using PHP and MySQL to receive, store, and manage incoming data.
- Frontend dashboard built using HTML, CSS, and JavaScript to visualize live data.

3. Database Integration:

- MySQL database stores historical data for analysis.
- Enables plotting trends over time (e.g., voltage vs. time, temperature trends).

4. Remote Monitoring:

- Real-time access to data through any web browser.
- Set alerts or notifications for threshold breaches (e.g., overtemperature, undervoltage).

5. Scalability and Security:

- The setup is scalable for integration with more sensors or vehicles.
- Basic security measures include password protection, data validation, and secured communication protocols in future.

This cloud-based architecture not only ensures continuous battery health monitoring but also supports predictive maintenance, alert generation, and efficient energy management in EV systems.

CHAPTER 6

EXPERIMENTAL RESULT

Figure 6.1: Normal condition

The figure 6.1 shows initial setup of the system when the power turned on

Where battery voltage is normal 11.4v.

Figure 6.2: Low Voltage Detected

The figure 6.2 shows the low voltage warning message because the voltage is lower than the cut-off voltage 9V.

Figure 6.3: High Current Detected

The figure 6.3 shows that the Battery current (BC) is above 80mA when the load is applied which affects the battery life.

Figure 6.4: Bulging Detected

The figure 6.4 shows the warning message because there is deformation in the surface of the battery.

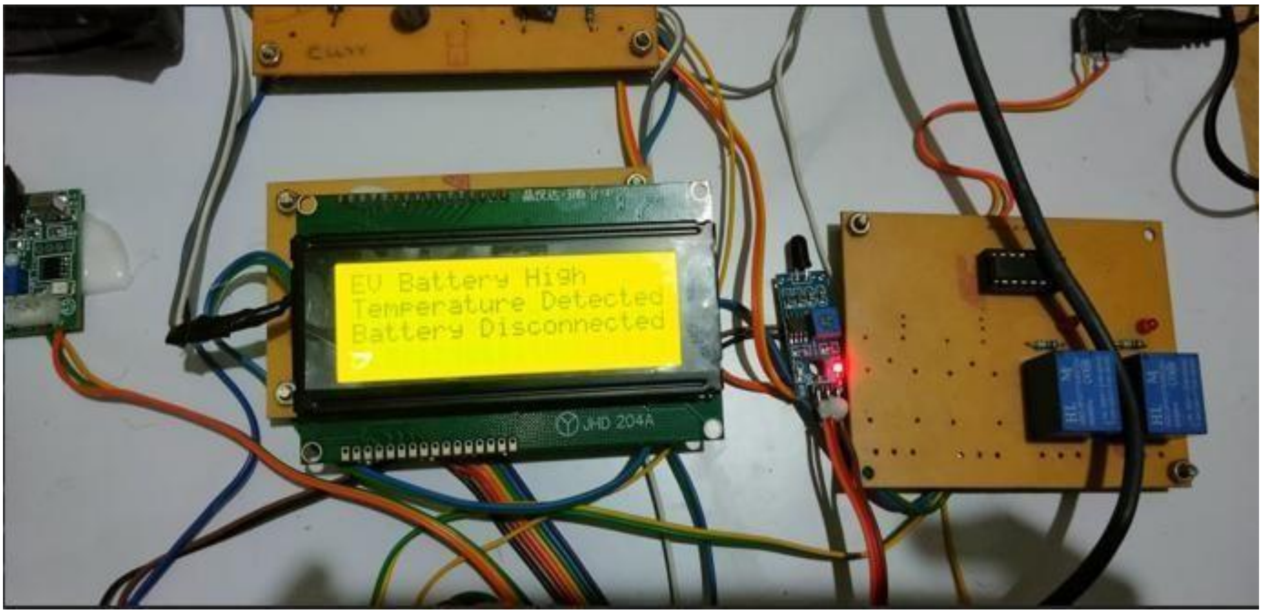

Figure 6.5: High temperature Detected

The figure 6.5 shows the warning message that the temperature is above the threshold value of 40 degree Celsius.

Figure 6.6: IoT Web Platform

The figure 6.6 shows the Web Dashboard of the battery status which hosted on cloud server, which displays all the data of battery like voltage, current, fire and temperature.

CHAPTER 7

CONCLUSION

The IoT-based Electric Vehicle Battery Management and Protection System, the project successfully implemented through hardware fabrication for enhanced battery monitoring and safety. The use of IoT allows for remote monitoring, predictive maintenance, and early detection of faults, contributing to extended battery life and reduced operational risks. Furthermore, the system ensures better protection against battery failures and overheating, thus enhancing the overall safety and efficiency of electric vehicles. This project paves the way for more advanced, reliable, and connected battery management solutions in the future of electric mobility.

Future Work

- Integration of machine learning for predictive analysis of battery health and fault detection.
- Implementation of wireless communication technologies like 5G or LoRaWAN for extended range and faster data transmission.
- Development of a dedicated mobile application for real-time battery status monitoring and alerts.
- Enhancement of data security using encryption techniques or blockchain for tamper-proof logging.
- Expansion of system compatibility to support various battery chemistries and configurations

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