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BATTERY MANAGEMENT SYSTEM TOWARDS AN INTEGRATED ELECTRICAL VEHICLE

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ABSTRACT:

Any electric vehicle's (EV) battery storage is the most important part as it holds the energy required for the vehicle to run. To maximise battery life and ensure safe operation, an efficient battery management system is thus necessary. Since battery management systems (BMS) are an essential part of any electric vehicle, there is now a lot of research being done to make them better. It is crucial to keep an eye on, adjust, and maximise the performance of the battery modules in an electric car. Another is the capacity to control the process by which the system's components are separated in the event of anomalous circumstances. The "battery management system (BMS)" is all that this management system is. In order to ensure the battery operates safely, BMS monitors the parameters, determines SOC, and provides necessary services.

I. INTRODUCTION OF PROJECT

Because we lead contemporary lives in the twenty-first century, we use more energy in our everyday lives. Everybody has a personal electronic gadget these days, whether it be a phone, laptop, tablet, or smart watch. A battery was needed as a backup power source for all of these gadgets. A battery's electricity has to be handled carefully and securely. A battery power management system, also known as a management system, is required as energy consumption demands rise and battery power rises along with them. A battery management system is an electrical device that controls and monitors a battery's protection against overloading, overheating, and overcharging. For the electrical energy storage system and energy storage devices to operate safely, BMS must be carried out quite precisely. Many systems are under real-time operation management by BMS.

The BMS monitoring system provides features for overvoltage, overcurrent, overheating, optimising battery performance, adhering to a schedule, anticipating failure, and preventing system failure. In order to increase BMS efficiency, the battery management system also gathers system data and performs calculations and analysis. 2. NEED FOR BMS Lithium ion batteries account for 90% of all batteries used in everyday life. Any time a battery malfunctions, the lithium ion battery runs the risk of exploding from overheating or overcurrent. This ought should be detrimental to humanity. In order to increase the lifespan of a cell or battery and to monitor current conditions like charging, discharging, overcharging, etc., we are required to take precautions against this accident. For this reason, a battery management system (BMS) is necessary. In a battery bank, there are server cells that are connected in parallel or series, but each cell has unique characteristics for charging and discharging. It is possible that some seam cells are connected in series, but their charging characteristics may differ [2]. It is necessary to control each and every cell in a battery in order to control its total power or voltage. A BMS is necessary for all lithium-ion (Li-ion) batteries.

This is because all Li-ion batteries have a failure point if they are overcharged, fully depleted, or used outside of their acceptable operating temperature range. Since each kind of Li-ion cell has a unique safe operating area, the BMS must be programmed to display the usual safe operating area for a C/lithium iron phosphate cell. Li-ion batteries need to be long-lasting and safe. State of function as represented by the discharge, state of charge (SOC), and condition of health (capacity) prompt attention to safety and battery management system maintenance. It can be a high temperature, a calibration issue, or an imbalanced cell. End of life is indicated when the capacity drops below the user-set goal level.

II. LITERATURE SURVEY

A brief summary of the body of research on energy management and smart home systems is given in this section. In one of the research projects described, an Internet of Things (IoT)-based automated temperature and humidity monitoring and control system was built using a Raspberry Pi. Pi receives the measured humidity and temperature data, which are then sent online. [1]. Temperature and light intensity sensors are employed in an Internet of things-based energy management system, and an Arduino microcontroller receives the information. The Arduino microcontroller is configured to control the appliance's power consumption as needed. In addition to controlling appliance use, the Raspberry Pi3 uses data from Hall Sensors that are wirelessly communicated over a Wi-Fi module to compute each appliance's total power consumption on a regular basis and display the findings as a graph. Every appliance, regardless of climate, has its graphical data on power use vs time sent to a cloud server [2]. This research has examined the detection of hydrogen gas emitted by batteries using an Internet of Things-based battery management system. Monitoring the health of the battery is also aided by the basic battery parameters. Cloud and IoT connection will help the Battery Management System since it will simplify data analysis. Additionally, this BMS has a GPS tracker [3], which enables tracking of vehicles and prompt help. [4] is an example of a comprehensive battery management system that monitors vital signs continually and adjusts the active cells in a battery pack as necessary. A microprocessor (MSP430) integrated within the BMS system is used for unit control and monitoring. We have found that the BMS is an electrical device that may be used in everyday life. As a result, the system's power factor, power quality, and efficacy may all increase.

[5] The accuracy and functionality of the sensors, CPU, and communications are explained. Next, the battery hardware testbed was used to test a SOC estimation method called Co-estimate, which was developed in MATLAB. By contrasting the testbed's findings with those of the MATLAB simulation, it is shown that the constructed battery hardware testbed is capable of carrying out CoEstimation efficiently.

[6] It also shows how the Co-Estimation approach may be implemented using the suggested hardware design as a practical solution in EV applications. An IoT- and PLC-based energy management solution for VPP in the unified power market is provided by this study. It is anticipated that solar generation and university enrolment will rise for the DA market. By controlling the supply and loads of VPP, the system leverages PLC and IoT-based

automation to provide optimal energy management. Control signals are sent to the relay switches by the PLC and Raspberry Pi to regulate the utilised source and loads. PLCs are programmed using the NodRed programming tool.

III. DESIGN OF HARDWARE

This chapter provides a quick explanation of the hardware. It goes into great depth about each module's circuit diagram.

ARDUINO UNO

A microcontroller board based on the ATmega328 is called the Arduino Uno (datasheet). It has a 16 MHz ceramic resonator, 6 analogue inputs, 14 digital input/output pins (six of which may be used as PWM outputs), a USB port, a power connector, an ICSP header, and a reset button. It comes with everything required to support the microcontroller; all you need to do is power it with a battery or an AC-to-DC converter or connect it to a computer via a USB connection to get going.The FTDI USB-to-serial driver chip is not used by the Uno, setting it apart from all previous boards. As an alternative, it has the Atmega16U2 (or Atmega8U2 up to version R2) configured as a serial-to-USB converter. The 8U2 HWB line on the Uno board is pulled to ground by a resistor, which facilitates DFU mode entry. The Arduino board now includes the following updates:

• 1.0 pin out: two further new pins, the IOREF, are positioned next to the RESET pin, the SDA and SCL pins that were introduced, and they enable the shields to adjust to the voltage supplied by the board. Shields will eventually work with both the Arduino Due, which runs on 3.3V, and the boards that utilise the AVR, which runs on 5V. The second pin is unconnected and set aside for future uses.

• A more robust RESET circuit.

• The 8U2 is replaced with an ATMega 16U2.

"Uno" is an Italian word for one, and it was chosen to commemorate the impending introduction of Arduino 1.0. Going future, the Arduino reference versions will be the Uno and version 1.0. The Uno is the most recent in a line of USB Arduino boards and the platform's standard model; see the index of Arduino boards for a comparison with earlier iterations.

Fig: ARDUINO UNO

POWER SUPPLY:

The purpose of the power supplies is to convert the high voltage AC mains energy into a low voltage supply that is appropriate for use in electronic circuits and other devices. One may disassemble a power supply into a number of blocks, each of which carries out a specific task. "Regulated D.C. Power Supply" refers to a d.c. power supply that keeps the output voltage constant regardless of differences in the a.c. main or the load.

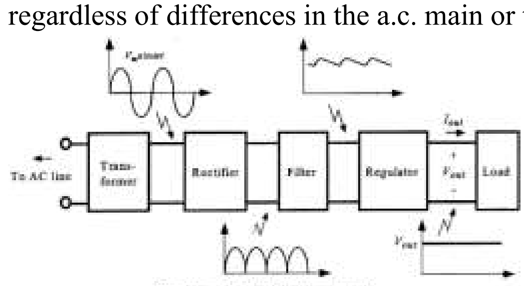

Fig: Block Diagram of Power Supply

LCD DISPLAY

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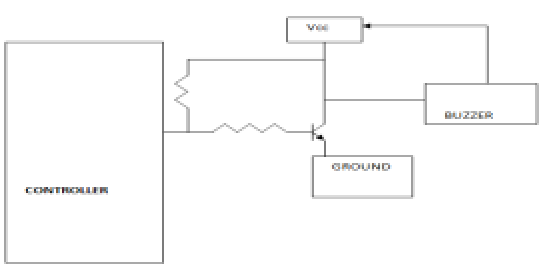
The model shown here is the one that is most often utilised in practice due to its cheap cost and enormous potential. Its HD44780 microcontroller (Hitachi) platform allows it to display messages in two lines of sixteen characters each. All of the alphabets, Greek letters, punctuation, mathematical symbols, etc., are shown. Furthermore, it is possible to show custom symbols created by the user. Some important features are the automatic changing of the message on the display (shift left and right), the presence of the pointer, the lighting, etc.

Fig: LCD

BUZZER

Relays, buzzer circuits, and other circuits cannot be driven by the current available on digital systems and microcontroller pins. The microcontroller pin can provide a maximum of 1-2 milliamps of current, even though these circuits need around 10 milliamps to work. Because of this, a driver—such as a power transistor—is positioned between the buzzer circuit and microcontroller.



LED:

A light source made of semiconductors with two leads is called an LED. When turned on, this p-n junction diode generates light.[5] Within the device, electrons may recombine with electron holes when a proper voltage is given to the leads, releasing energy in the form of photons.

This phenomenon is known as electroluminescence, and the energy band gap of the semiconductor controls the colour of the light, which corresponds to the photon's energy. Since LEDs are usually tiny—less than 1 mm2—the radiation pattern may be modified by integrated optical components.

Early LEDs were often utilised to replace tiny incandescent bulbs as indication lighting for electrical equipment. They were quickly bundled into seven-segment displays for use as numeric readouts, and digital clocks became popular with them. Modern advancements have led to the creation of LEDs that are appropriate for task and ambient lighting. New displays and sensors have been made possible by LEDs, and enhanced communications technology has benefited from their rapid switching rates.Compared to incandescent light sources, LEDs are smaller, quicker switching, more physically resilient, need less energy, and have a longer lifespan. Applications for light-emitting diodes are many and include traffic signals, advertising, traffic lights, camera flashes, lit wallpaper, aircraft illumination, and car headlights. Additionally, they are much more energy-efficient, and their disposal may pose less environmental risks.

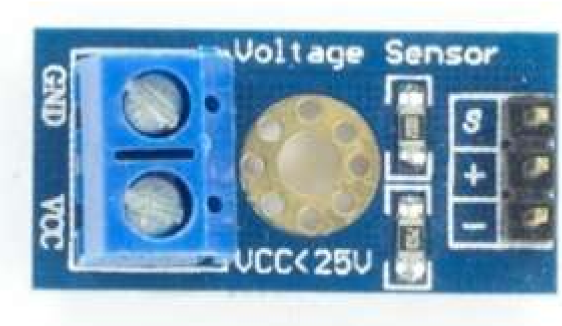
BATTERY

Lithium-ion, or Li-ion, batteries are a kind of rechargeable battery that stores energy by the reversible reduction of lithium ions. It is the most common form of battery used in electric cars and portable consumer gadgets. In addition, it finds extensive use in military and aerospace applications as well as grid-scale energy storage. Li-ion batteries feature high energy densities, minimal self-discharge, and negligible memory effect as compared to other rechargeable battery technologies (however a minor memory effect claimed in LFP cells has been attributed to badly produced cells).[9]

There are differences in the chemistry, performance, cost, and safety of different kinds of lithium-ion batteries. Intercalation compounds are the active ingredients found in the majority of commercial Li-ion cells. Graphite is often used as the anode, or negative electrode, while silicon-carbon is now being utilised more and more. It is possible to produce cells with an emphasis on power density or energy density.[10] The most common battery types used in handheld devices are lithium polymer batteries (which employ polymer gel as the electrolyte), graphite anode, and lithium cobalt oxide ($LiCoO2$) cathode material. These materials provide a high energy density when combined.[11][12] Materials with longer half-lives and higher rate capabilities include lithium iron phosphate ($LiFePO4$), lithium manganese oxide (LiMn 2O4 spinel, or $Li2MnO3$-based lithium rich layered materials, LMR-NMC), and lithium nickel manganese cobalt oxide (LiNiMnCoO 2 or NMC). When paired with renewable energy, NMC and its derivatives are one of the primary technologies for lowering greenhouse gas emissions from transportation. They are also frequently utilised in electrification of transportation.[13][14] In the 1970s, M. Stanley Whittingham developed the first rechargeable lithium-ion battery using a titanium disulphide cathode and a lithium-aluminum anode. Despite its limitations in terms of safety, the battery was never put into production. Whittingham also discovered the notion of intercalation electrodes.[15] John Goodenough used lithium cobalt oxide as a cathode in 1980 to build on this work.[16] Akira Yoshino created the first prototype of the current Li-ion battery in 1985. Using a carbonaceous anode instead of lithium metal, the battery was eventually commercialised in 1991 by a team headed by Yoshio Nishi at Sony and Asahi Kasei.

VOLTAGE SENSOR:

Based on the resistance points pressure theory, this module may lower the red terminal's input voltage by five times its initial value.Since the maximum analogue input voltage for an Arduino board is 5 V, the input voltage for this module should not exceed 5 V x 5 = 25 V (or, if the system is 3.3 V, not exceed 3.3 V x 5 = 16.5 V).The input voltage of this module should be more than 0.00489 V x 5 = 0.02445 V since the Arduino AVR chip has 10 bit AD, which means that the simulation resolution of this module is 0.00489 V (5 V / 1023).



IV. BLOCK DIAGRAM AND HARDWARE DISCRIPTION

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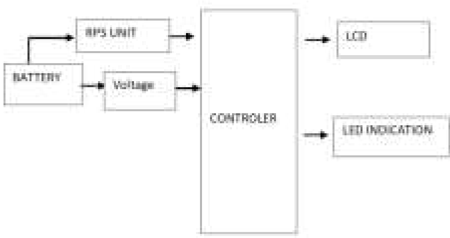
4.1. BLOCK DIAGRAM:



WORKING

For electric vehicles (EVs), a Battery Management System (BMS) is essential to guaranteeing the battery pack's safe and effective functioning. The system operates by monitoring, safeguarding, and controlling the battery pack via the use of voltage sensors and an Arduino microcontroller, guaranteeing maximum life and performance.

This is a thorough description of how this system operates:

1. Components of the BMS

- **Arduino Microcontroller**: The central control unit that processes data from the voltage sensors and other components.
- **Voltage Sensors**: These are used to measure the voltage of individual cells or the entire battery pack to monitor charge and discharge levels.
- **Current Sensor (Optional)**: Measures the flow of current in and out of the battery pack to ensure it is operating within safe limits.
- **Temperature Sensors (Optional)**: Monitors the temperature of the battery pack to prevent overheating.
- **Relays and Switches**: Used for connecting or disconnecting the battery from the vehicle's powertrain based on conditions like overvoltage, undervoltage, or overcurrent.
- **Display (LCD or LED)**: Provides real-time feedback on the battery status, such as voltage levels, state of charge (SOC), or any fault conditions.
- **IoT Module (Optional)**: Provides remote monitoring and data logging capabilities for the BMS system.

2. Main Functions of the BMS

1. **Voltage Monitoring**:
   - The system constantly measures the voltage of individual cells or groups of cells within the battery pack using voltage sensors.
   - If the voltage is too high (overcharge) or too low (over-discharge), the Arduino triggers protective actions to prevent damage to the battery.
2. **Current Monitoring (Optional)**:
   - A current sensor can be used to monitor the flow of electricity in and out of the battery pack. This ensures that the current is within the safe operational range of the battery.
3. **Temperature Monitoring (Optional)**:
   - Battery temperature is monitored to prevent overheating, which can lead to thermal runaway (dangerous overheating that can result in fire or explosion).
   - The Arduino triggers cooling mechanisms or disconnects the battery if temperatures exceed safe limits.
4. **State of Charge (SOC) Estimation**:
   - By monitoring the voltage and current data, the BMS estimates the battery's state of charge (SOC), which is a measure of how much energy remains in the battery.

- This helps prevent overcharging or deep discharge, both of which can reduce battery life.

5. **Fault Detection and Alerts**:
   - The BMS identifies issues such as overvoltage, undervoltage, overcurrent, short circuits, or high temperature.
   - Upon detecting a fault, the Arduino will trigger an alarm, disconnect the battery, and display the issue on an LCD or send it via an IoT module for remote alerts.
6. **Cell Balancing (Optional)**:
   - If the battery pack consists of multiple cells, the BMS ensures that all cells are equally charged to avoid imbalance. This is crucial for battery longevity and performance.
   - Balancing can be done passively (resistive balancing) or actively (redistributing energy between cells).

V. CONCLUSION

The BMS is an electrical gadget that we may use on a regular basis, as we have discovered. This may raise the system's power factor, power quality, and efficiency. Because BMS raises the system's battery bank's output voltage, it may also be utilised for protection and monitoring.

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