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On Board Integrated Charger and Battery Management System for E-Vehicle

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Abstract: *The transportation industry is experiencing a switch towards electrification. Availability of electric vehicle (EV) charging infrastructure is very critical for broader acceptance of EVs. The increasing use of OBCs, due to their cost-effectiveness and ease of installation, necessitates addressing key challenges. These include achieving high efficiency and power density to overcome space limitations and reduce charging times. Additionally, the growing interest in bidirectional power flow, allowing EVs to supply power back to the grid, highlights the importance of innovative OBC solutions. This review article provides a thorough analysis of the current advancements, challenges, and prospects in EV on-board charger technology. It aims to offer a comprehensive review of OBC architectures, components, technologies, and emerging trends, guiding future research and development. Addressing these challenges is essential to enhance the efficiency, reliability, and integration of OBCs within the broader EV ecosystem..*

Keywords: On-Board Integrated Charger, Battery Management System, E-Vehicle Battery, Embedded System

I. INTRODUCTION

Automotive market analysis shows that the market share of electric vehicles (EVs) will be about 30% by 2030 [1]. Battery technology has a great effect on the expansion of EVs. The cost, weight, charging time and lifetime of the EV battery constitute vital challenges for commercialization. In addition to numerous electrochemistry and material challenges, the performance of battery modules is affected by module design/packaging as well as electrical charging and discharging characteristics [2, 3]. There is significant correlation between charging time, lifetime of the battery and the characteristics of the employed battery charger [4]. EV battery chargers can be broadly classified into off board and on-board configurations with unidirectional or bidirectional power flow capability [5]. Unidirectional charging reduces hardware requirements and simplifies interconnection with the grid. Whereas, bidirectional charging permits battery power injection back to the grid. Off-board chargers are installed in dedicated charging stations which are designed to offer higher power transfer capabilities, albeit, at a high infrastructure cost. Numerous off-board charger topologies and control techniques have been introduced in the available literature [5]. On the other hand, vehicle on-board charging systems can be directly connected to single-phase or three-phase mains, which offload infrastructure cost. However, power transfer capability is typically limited due to several constraints/trade-offs such as cost, volume, and weight of the vehicle [6]. Various topologies and control schemes of on-board chargers have been presented in [7].

The global transition towards a sustainable and carbon-neutral future highlights the critical role of electric vehicles (EVs) in mitigating climate change and reducing greenhouse gas emissions [1]. Policy initiatives such as the European Green Deal, which aims for net-zero carbon emissions by 2050 [2,3], and India's commitment at the 26th climate change conference to achieving net-zero emissions by 2070 highlight the urgency of this transition [4]. This shift is driven by environmental regulations, advancements in battery technology, and innovative propulsion systems, leading to an increasing preference for EVs over traditional internal combustion engine (ICE) vehicles. This statement is supported by the reports in [5,6], according to which 14% of all car sales in 2022 were electric vehicles, almost 9% more than sales in 2021.

We can broadly classify EVs as into the following categories: Battery electric vehicles (BEVs) consist of a battery powered electric motor. For charging purpose, BEVs need to be plugged into a wall outlet. Plug-in Hybrid Electric

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Vehicles (PHEVs) consist of an electric motor and an ICE powered by a battery and some fuel respectively. PHEVs are either charged from an outlet or make use of regenerative braking. Hybrid Electric Vehicles (HEVs) make use of an ICE along with one or more electric motors. The ICE and regenerative braking are used for charging purposes. Fuel Cell Electric Vehicles (FCEVs) use fuel cell technology to produce the electricity. They employ a propulsion system which convertshydrogen energy into electrical power. The primary subject of this study is battery electric vehicles (BEVs).

1.1 Problem statement

Battery management system needs to be enhanced in order to provide a better performance.

The behaviour of the battery fuel is greatly affected by temperature and the battery aging. A true battery management needs to consider these effects by measuring current, voltage, and temperatures with a function of time.

Battery monitoring system is also part of BMS that is required in order to monitor operational system, performance and battery life such as charge and discharge process.

Provide battery safety and longevity, a must-have for Li-ion.

Reveal state-of-function in the form of state-of-charge and state-of-health (capacity)

The BMS also needs to provides protection when charging and discharging; it disconnects the battery if set limits are exceeded or if a failure occurs.

1.2 Motivation –

Electric vehicles (EV) are playing a key role because of its zero-emission of harmful gases and use of efficient energy. Electric vehicles are equipped by a large number of battery cells which require a effective battery management system (BMS) while they are providing necessary power. The battery installed in a electric vehicle should not only provide long lasting energy but also provide high power. Lead-acid, Lithium-ion, -metal hydride are the most commonly used traction batteries, of all these traction batteries lithium-ion is most commonly used because of its advantages and its performance. The battery capacity range for a electric vehicle is about 30 to 100 KWH or more. Battery management system (BMS) makes decisions based on the battery charging and discharging rates, state of charge estimation, state of health estimation, cell voltage, temperature, current etc.

II. LITERATURE SURVEY

Atzoriet; al (2017) proposes Understanding the Internet of Things: Definition, potentials, and societal role of a fast-evolving paradigm. Ad Hoc Netw. 2017, 56, 122– 140.The Internet of Things (IoT) has been inscription in this review paper. Internet of Things is a keyword to cover various challenges related to internet and the web to the real physical world. We know that, today internet has already taken an important part of everyday life and it has also dramatically changed the lives of human being. The most important factor of this invention is, integration or combination of several technologies with the communication system solutions. The most applicable factors of IoT are the identification and tracking various factors for smart objects. The universal sensing networks is enabled by Wireless Sensing Networks (WSN) and these technologies cuts across many areas of modern day living. The escalation of these devices in a communicating and actuating network will create the Internet of Things (IoT). Here the sensors and actuators combine easily with the environment around us and the information is shared across various platforms in order to develop a common operating picture (COP). Internet of Things predicts the future that, the advance digital world and the physical world will get linked by means of proper information and wireless communication system technologies. In this survey paper they have mentioned the visions, concepts, technologies, various challenges, some innovation directions, and various applications of Internet of Things (IoT).

C. Wu et; al (2015) proposes Research on overcharge and over discharge effect on Lithium-ion batteries", Proc. IEEE Veh. Power Propul.Conf., pp. 1-6, 2015. The purpose of this study is to diagnose and analyses the overcharge and over discharge fault of lithium-ion battery. Through the dynamic simulation model, the phenomenon of overcharge and over discharge fault for automotive lithium-ion battery (LIB) was discussed, and the fault diagnosis effect was summarized. The results of this study show that the fault diagnosis analysis of LIB can achieve good results.

It is of certainLópez-Benítezet; al (2017) proposes Prototype for Multidisciplinary Research in the context of the Internet of Things. J. Netw. Comput. Appl. 2017, 78, 146–161. This work proposes a novel mathematical approach to accurately model data traffic for the Internet of Things (IoT). Most of the conventional results on statistical data traffic models for IoT are based on the underlying assumption that the data generation follows standard Poisson or Exponential distribution which lacks experimental validation. However, in some of the use case applications a single statistical distribution is not adequate to provide the best fit for the inter-arrival time of the data packets generation. Based on the real data collected for over 10 weeks using their customized experimental IoT prototype for smart home application, in this paper they have established this very fact, citing barometric air pressure as an example.

This paper presents a remote online monitoring system for the operation of lead acid battery group in telecommunication base stations. Combining the General Packet Radio Service (GPRS) communications and Internet connections, the system realizes data transmission between remote acquisition modules and data services center. The collected data of battery parameters in the center are analyzed and processed, and then it can be monitored by using any standard browser distributed worldwide if access permission is given. Both battery users and battery manufactures can use the system for the battery power management, maintenance and troubleshooting. module [10].

III. METHOD OF DISEASE DETECTION

This block diagram represents a hybrid power management system likely designed for an electric vehicle or a similar application where both mains power and solar power can be used to charge a battery bank. Let's break down the working of this system based on the diagram:

1. Power Input and Conversion:

Mains 230V AC: This is the standard household AC power supply.

Step Down Transformer: Reduces the 230V AC to a lower AC voltage suitable for charging the battery.

Bridge Rectifier (AC to DC): Converts the AC voltage from the transformer to a DC voltage.

Solar Panel: Generates DC power from sunlight.

DC to DC Converter: Optimizes the voltage from the solar panel to efficiently charge the battery. This could be a MPPT (Maximum Power Point Tracking) converter to maximize solar energy harvesting.

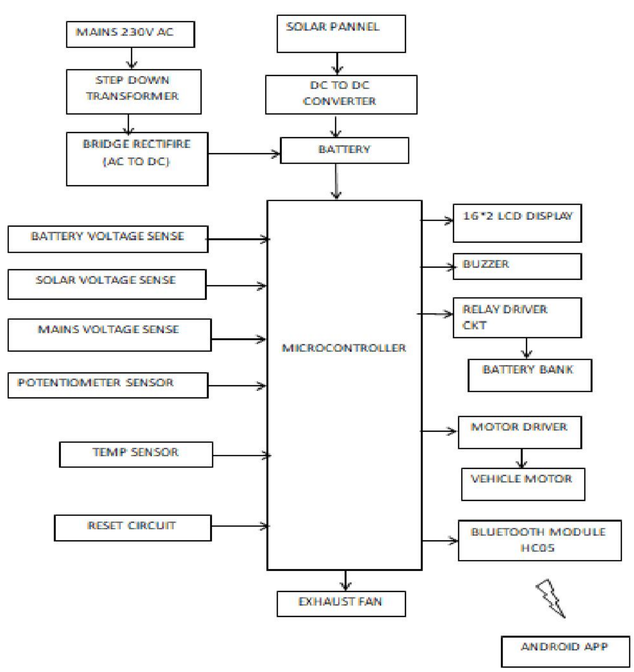

Fig. 1. Block Diagram

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2. Battery Charging and Management:

Battery: The core energy storage unit.

Microcontroller: The brain of the system, responsible for controlling and monitoring all aspects.

Battery Voltage Sense: Measures the battery's voltage to determine its state of charge (SOC).

Solar Voltage Sense: Measures the solar panel's voltage to monitor its output.

Mains Voltage Sense: Monitors the mains voltage to ensure it's within acceptable limits.

Relay Driver Circuit: Controls the connection between the battery and the charging sources (mains or solar). It likely switches between mains charging, solar charging, and potentially disconnecting the battery when fully charged or under fault conditions.

3. System Monitoring and Control:

16*2 LCD Display: Shows real-time information about the system, such as battery voltage, charging status, temperature, etc.

Buzzer: Provides audible alerts for events like low battery, over-voltage, or other faults.

Potentiometer Sensor: Allows the user to adjust settings or parameters of the system.

Temp Sensor: Monitors the system's temperature to prevent overheating.

Reset Circuit: Allows for manual reset of the microcontroller in case of errors.

Exhaust Fan: Provides cooling for the system components, especially during charging or high power operation.

4. Load and Communication:

Motor Driver: Controls the speed and direction of the Vehicle Motor, which is the primary load.

Battery Bank: Likely refers to the same battery mentioned earlier, but emphasized here as the power source for the vehicle motor.

Bluetooth Module HC05: Enables wireless communication with an Android App.

Android App: Likely provides a user interface for monitoring and controlling the system remotely. This could include displaying battery status, controlling charging modes, setting parameters, and receiving alerts.

Working Principle:

Power Source Selection: The microcontroller intelligently selects the power source for charging the battery. It might prioritize solar charging when available and switch to mains charging when solar power is insufficient or unavailable.

Charging Control: The microcontroller controls the charging process using the relay driver circuit, ensuring the battery is charged safely and efficiently. It monitors the battery voltage and current to prevent overcharging or undercharging.

Load Management: The microcontroller manages the power delivered to the vehicle motor through the motor driver, based on user input or pre-defined control strategies.

System Monitoring: The microcontroller continuously monitors various parameters like battery voltage, solar voltage, mains voltage, and temperature. It displays this information on the LCD and sends data to the Android app via Bluetooth.

Fault Detection and Protection: The microcontroller detects faults like over-voltage, under-voltage, over-temperature, etc., and takes appropriate actions, such as disconnecting the charging source, triggering an alarm (buzzer), and displaying error messages.

User Interface: The system provides user interaction through the potentiometer (for setting parameters) and the Android app (for remote monitoring and control).

Overall, this system provides a comprehensive solution for managing power in a hybrid energy system. It efficiently utilizes both mains and solar power to charge a battery bank, controls the power delivered to the load (vehicle motor), and provides real-time monitoring and control through an LCD display and an Android app.

PIC18f4520Microcontroller

PIC18f4520 is a 40 PIN Micro-controller from Microchip with 13 channel 10 bit Analog to Digital Converter.

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Special PIC18f4520 Micro controller Features
Power- Up to 10 MIPS Performance at 3V
C compiler optimized RISC architecture
8x8 Single Cycle Hardware Multiply System
Internal oscillator support-31 kHz to 8MHz with 4xPLL
Fail-Safe Clock Monitor- allows safe shutdown if clock fails
Watchdog Timer with separate RC oscillator
Wide operating Voltage range; 2.0V to 5.5V
nanoWatt Power Managed Modes

Fig. 3. PIC18F4520

HC05 Bluetooth module

The **HC-05 Bluetooth module** is a popular and inexpensive wireless communication module widely used in hobbyist electronics, embedded systems, and DIY projects. It allows devices like microcontrollers (Arduino, Raspberry Pi, etc.) to communicate wirelessly with other Bluetooth-enabled devices, such as smartphones, tablets, laptops, and other microcontrollers

Key Features:

Bluetooth 2.0: It uses the older Bluetooth 2.0 standard, which is sufficient for many simple data transfer applications.

Serial Communication (UART): It communicates with microcontrollers using the UART (Universal Asynchronous Receiver/Transmitter) protocol, making it relatively easy to interface with.

AT Command Set: It's configured and controlled using a set of AT commands, which are text-based commands sent over the serial interface.

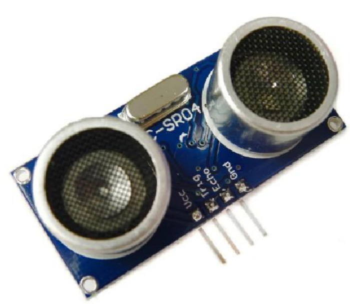

Fig. 4 HC05 Bluetooth Module

Voltage Sensor

A voltage divider is a simple circuit that turns a large voltage into a smaller one. Using just two series resistors and an input voltage, we can create an output voltage that is a fraction of the input. In this project, a voltage divider is used as a voltage sensor by making a voltage reference from a relatively big voltage source. The relatively large voltage biases the active electronic components, amplifier circuits, and so on.

A voltage divider is often used with a potentiometer, an electronic device that is used to design a voltage divider that could have a controlled output voltage. The voltage divider circuit principle consists of a serial circuit made of one or multiple components and connected to an input voltage source.

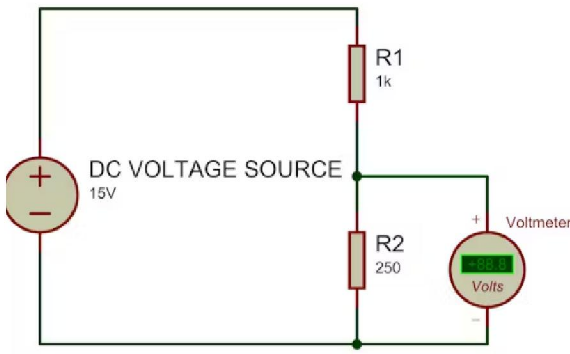

Fig. 5.Voltage Sensor

LCD Display

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

Fig. 6.LCD Display

IV. CONCLUSION

To provide EV users with highly effective, affordable, and dependable charging options, research in the field of power converters and charging strategies is required. This also supports the widespread use of EVs. Modern charging infrastructure and intelligent control techniques are also fundamental aspects of achieving effective adoption of EVs. n this way we are developing the model for battery management system in electric vehicle by controlling key parameters like voltage, temperature. It is an important that the BMS should be well maintained with battery credibility & security. This paper mainly focusses on the study of battery management system and enhance the power performances of electric vehicles. Besides, the goal of reducing the greenhouse gas can greatly be achieved by using battery management system.

The fully electrically operated vehicles will come in future because of depleting fossil fuels and will definitely create an impact in everyone's life. At this time the battery management system will be major phenomena that every electric vehicle manufacturing company will be looking for. It is clear that an electric vehicle totally depends on the source of energy from a battery.. The system is capable to detect degraded battery performance and sends notification messages to the user for further action

V. FUTURE SCOPE

Improved battery management algorithms: With the advent of artificial intelligence and machine learning technologies, there is a lot of scope for developing better algorithms to manage the life of electric vehicle batteries. These algorithms can predict battery aging, optimize charging cycles, and improve energy efficiency.

- Advanced energy storage technologies: There is a growing need for energy storage technologies that can provide higher energy density and longer cycle life for electric vehicle batteries. Research is underway to develop solid-state 65 batteries, which are expected to offer higher energy density and faster charging times.
- Battery recycling: Proper recycling of electric vehicle batteries is crucial to prevent environmental damage. Several research projects are focused on developing more efficient and sustainable battery recycling methods.
- Enhanced thermal management systems: Thermal management is a critical issue for electric vehicle batteries as overheating can damage them. Advanced thermal management systems that can provide better cooling and heating for batteries can improve their performance and prolong their lifespan.
- Integration with smart grid technologies: As electric vehicle adoption increases, it becomes important to integrate EVs with smart grid technologies. Battery management systems can be used to monitor the energy consumption of EVs and optimize their charging cycles to minimize the impact on the grid.
- Improved safety features: Electric vehicles need to be equipped with advanced safety features to prevent battery fires and other accidents. Battery management systems can be enhanced to provide better monitoring of battery temperature, voltage, and current, to detect any potential hazards early and prevent accidents from occurring.

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