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# Performance Evaluation of Electric Vehicle Battery Monitoring System Using IOT

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**Abstract:** High-capacity lithium-ion batteries are commonly used in electric vehicles. In electric vehicles (E.V.s), a Battery Management System (BMS) is a crucial component for controlling and monitoring the health and performance of the battery pack. For the purpose of ensuring safe and effective battery operation, the Battery Management System (BMS) keeps an eye on temperature, voltage, current, and charge level. The battery pack's cell voltages are measured by the voltage sensors, which Arduino can read to detect whether any cells are overcharged or undercharged. The current sensors measure the charging and discharging currents. Based on the current flow over time, Arduino can calculate the state of charge while the temperature sensors monitor the temperature of the battery cells. By using this data, Arduino can implement thermal management to prevent overheating. Algorithms are used to calculate the SOC based on the voltage, current, and temperature readings, which Arduino can implement to keep track of the battery's energy level. Controllers and sensors are used in this suggested system to monitor and assess the performance of an electric vehicle's battery utilizing Internet of Things approaches. The system may identify deteriorating battery performance based on experimental findings and needs to notify the user to take the necessary steps. The framework screens and stores parameters that give a sign of the state of charge, voltage, current, temperature of battery, and charge limit in a continuous situation. The data gathered from all the related battery customers in the framework is examined in a beat transmission control convention/client datagram convention and put together a C server program running with respect to an individual PC to decide significant parameters.

**Index terms-** Arduino Uno, Ac/Dc, , Acid Gravity Sensor, Boost/Buck, Lm35, IoT, Temperature Sensor, Voltage Sensor.

## INTRODUCTION

When using a two-stage charging method, the pack of batteries gets charged at a constant current rate up to 80% of its total charge voltage.Next, for getting charged, a constant voltage is utilized. The battery until it achieves its full charge. Self-discharge is the term used to describe the tendency of rechargeable batteries to drain while they are not in use. Typically, the idle state self-discharge rate occurs between 2 and 4% of each month. Certain devices, like black start generators in power plants, have built-in battery monitoring systems that charge and check the battery constantly, even while the generator is not in use. An external solution may be utilized to check the battery's specifications, charge it if needed, and notify the users of irregularities for devices without such monitoring systems. The monitoring system not only oversees the battery but also facilitates a two-stage charging process involving constant current (CC) mode and constant voltage (CV) mode. It incorporates alerts for elevated battery temperature or depleted electrolyte levels, enables data logging, and allows users to remotely access data through the Internet when connected within their wireless network. The observing system consistently tracks battery metrics utilizing various sensors like voltage, charging current, and temperature. These readings are acquired through a voltage sensor, current sensor, temperature sensor, and an Arduino connection. The system incorporates an LCD to present all the collected battery data. This study analyses the usage of Internet of Things (IoT) to track operational effectiveness of batteries used in electric vehicles. Given the exclusive reliance of electric vehicles on batteries for power, the progressive decline in supplied Energy raises concerns about performance degradation, posing a significant challenge for battery manufacturers—the direct monitoring of the vehicle's battery performance. Our IoT-driven battery monitoring system comprises two primary elements: a monitoring device and a user interface. According to our empirical findings, the system effectively identifies deteriorating battery performance, and issues alerts to prompt necessary user intervention. This initiative revolves around the proposition and assessment of a continuous observation approach for lithium-ion batteries utilizing the Internet of Things. Our proposed framework consistently tracks and records keyfactors, like as the accusation status, voltage, current, and temperature of battery. Data gathered from all pertinent battery users within the system undergo analysis through a beat transmission control protocol/client datagram protocol-based C server program running on an individual PC to ascertain the pivotal parameters.

### *A. Objective*

- ➢ To evaluate the accuracy of the Electric Vehicle (E.V.) battery monitoring system through the use of IoT technology.

- To assess efficiency of the IoT-enabled monitoring method in providing real-time data for timely decision-making and preventive maintenance.
- To ensure the security and integrity of data collected by the E.V. battery monitoring system through IoT.

## LITERATURE REVIEW

Maitreya et al. (2021) introduce a decentralized pack management system as an innovative alternative. Unlike the traditional master-slave configuration, it eliminates the need for centralized hardware, enabling individual battery packs to communicate independently. The proposed decentralized approach removesthe maximum number of packs that may function concurrently, theoretically offering unprecedented scalability for large-scale energy storage systems catering to diverse sizes and applications. A decentralized pack management system has been suggested and examined, revealing a minimal overshoot of 0.0675 volts and a short settling time of 90 milliseconds in the obtained results.

X. Li et al. (2020)**,** the utilization of echelon-use batteries in a Battery Energy Storage System (BESS) for the power grid requires a distinct energy management strategy (EMS) compared to conventional batteries. Introduces a proposed EMS for a Hybrid Energy Storage System (HESS) that incorporates echelon-use batteries. The EMS, based on the State of Health (SOH) of echelon-use batteries, allocates power according to the SOH of each battery pack. This approach ensures optimal performance from echelon-use batteries by tailoring their contribution based on individual pack conditions.

Y. Xu et al. (2019) To enable real-time monitoring of the operational status of rental battery packs utilized in electric bicycles during both charging and discharging processes, A method for managing lithium batteries has been crafted specifically for electric bicycles. This system is equipped to seamlessly track real-time metrics suchasLocation, energy storage, voltage, current, and temperature of the battery pack. Subsequently, this information is promptly transmitted to aReal-time cloud management platform. Two temperature detection channels operate under distinct temperature conditions, ensuring accuracy with a maximum error of 0.5°C, thereby meeting the specified requirement of <2°C.

Mohd Helmy Abd Wahab et al. (2018) the benefits of using the Internet of Things (IoT) to monitor electric vehicle battery performance are clear. As electric vehicles depend solely on the Energy provided by their batteries, any gradual reduction in energy supply leads to a decline in performance, posing a notable challenge for battery manufacturers. This research introduces the utilization of IoT methods to supervise vehicle performance directly. Two crucial components make up the recommended Internet of Things-based battery monitoring system: i) a monitoring device and ii) a user interface. The system demonstrates through testing findings its capacity to identify decreasing battery performance and instantly notify the user, requesting timely interventions.

Sarrafan. K et al. (2017)**,** the algorithm proactively notifies drivers when charging is deemed necessary based on their chosen route. By utilizing GPS data, it identifies the nearest charging location and accurately estimates the state of charge (SoC) at the destination. Throughout the charging process, the algorithm computes the ideal duration for charging, ensuring the battery is charged enough to reach its destination. The user-friendly GUI shows real-time range and not only presents a precise estimate of the distance left to reach the goal but also delivers continuous updates on the current State of Charge (SoC).

Urooj. S et al. (2021), Electric vehicles now integrate internet connectivity through an online monitoring system known as Things Speak. This system ensures the continuous day-by-day monitoring of all vehicles. This approach's efficacy was evaluated using visual analysis, and the performance outcomes validate the improvement of the suggested method when incorporating IoT-based technology in electric vehicles. Furthermore, implementation cost decreases, and electric vehicle capacity shows an approximate 74.3% increase through continuous monitoring with sensors.

Qureshi et al. (2021) A charging scheduling and intelligent energy management system (IEM-CSS)for electric vehicles (E.V.s) and charging station management has been developed. This innovative system offers efficient energy management services through the integration of the optimization of charging decisions, which is achieved by communication between charging stations and battery control devices. By empowering drivers to make informed choices regarding charging, the system enables seamless communication between drivers and charging stations. Moreover, to protect all data and stop illegal access, the suggested system has a strong security mechanism.

Lokhande J. S et al. (2020)**,** the field of battery optimization involves the creation of electrical circuit design and methods to enhance the efficiency of battery utilization. Monitoring crucial operational parameters such as internal and ambient temperature, current, and voltage is essential for ensuring the optimal performance of batteries during charging and discharging. A Battery Management System (BMS) serves as a mechanism to oversee these parameters and control the charging and discharging processes. Explores various intriguing approaches and systems employed in battery management.

Kosuru V. S. R et al. (2023) Battery Management Systems (BMSs), which are in charge of managing for electric automobiles to be secure, the electronic components in every single cell or rechargeable battery pack are essential. By enhances battery management system safety and reliability by presenting an improved method for identifying and categorizing fake battery data using Incipient Bat-

Optimized Deep Residual Networks (IB-DRN). The IB-DRN system performs exceptionally well when compared to current techniques, showing excellent accuracy (98%), precision (90%), recall (97%), and F1 score (94%). On the other hand, its performance in mean square error (55%) and root mean square error (50%) could be better.

Vasanthkumar. P et al. (2022) The Deep Learning-enhanced Battery Management System (DL-BMS), known as the Innovative Wild Horse Optimizer (IWHODL-BMS), is specifically crafted for Hybrid Electric Vehicles (HEVs) operating within the Internet of Things (IoT) framework. This groundbreaking system seamlessly incorporates an attention-based bidirectional long short-term memory (ABiGRU) approach strategically tailored to estimate the state of charge (SOC) accurately in HEVs. To enhance the precision of SOC estimation using the ABiGRU technique, the IWHO algorithm is integrated as a hyperparameter optimizer. This synergistic combination not only refines SOC estimation accuracy but also streamlines the representation of input data within the IWHODL-BMS. The result is a sophisticated yet simplified model that significantly advances the performance of battery management in IoT-based Hybrid Electric Vehicles.

Wei Liu et al. (2022) The focal points in electric vehicle (E.V.) applications revolve around concerns related to energy density, rapid charging, and safety. A novel outlook on E.V. batteries is gaining prominence, especially in the context of Vehicle-to-Vehicle (V2V) and Vehicle-to-Grid (V2G) operations within the wireless E.V. power network. This thorough exploration explores diverse strategies for health diagnostics, status estimate, and battery modelling. Based on data state predictions in practice demonstrates a promising potential to attain an accuracy rate surpassing 90.0%, leveraging a dataset that encompasses the first 100 cycles.

Mohammadi. F et al. (2021) significant technological challenges arise from the complexities of the real-time monitoring and control of Energy Storage Systems (ESSs) serving Electric Vehicles (EVs) in intelligent urban environments. This research includes the use of Internet of Things (IoT) technology, which is critical to overcoming these obstacles and improving Battery Management Systems (BMS) effectiveness. Establishing Autonomous Wireless Sensor Networks (WSNs) is the cornerstone of smart city infrastructure, enabling advanced E.V. features like autonomous parking. Furthermore, by utilizing cloud computing services and data-driven approaches, E.V.'s state-of-charge (SoC) may be determined by utilizing IoT sensors.

Chitra et al. (2020) Isolated power converters play an essential role in electric vehicles (E.V.s) and D.C. microgrids. Among these converters, CLLC converters surpass DAB converters in comprehensive bidirectional E.V. charge systems. Notably, the primary switch of the isolated three-port D.C.–D.C. bidirectional converter exhibits lower voltage stress and di/dt values compared to its equivalent hard-switched counterpart. Demonstrating superior performance with a peak efficiency of 94.5%, this converter excels. Undercharging conditions, the LLC converter achieves an efficiency of 98.39%, while in discharged conditions, it maintains an efficiency of 97.80%. Additionally, a GaN converter achieves an impressive 98.8% efficiency at 50% of the full load.

Q. Yu et al. (2021) a strategy utilizing model-based techniques is proposed for diagnosing sensor faults, coupled with a fault-tolerant control approach applicable to both voltage and current sensors. The methodology relies on Recursive Least-Square (RLS) and Unscented Kalman Filter (UKF) algorithms. In this approach, fault diagnosis is facilitated through open-circuit voltage and capacity residual generators, generating multiple residuals. A selection process tailored to the distinct State of Charge (SOC) intervals associated with each residual is implemented to assess the presence of a sensor fault. The comprehensive derivation of fault values for voltage and current sensors is grounded in the analysis of open-circuit voltage and capacity residuals, respectively.

Gaoet al. (2021) Using offline data, the validated model has been shown to be very accurate in forecasting terminal voltage over a range of temperatures and state-of-charges. The terminal voltage prediction's root-mean-square (RMS) error is restricted to 28 mV when the temperature falls below -10 °C. In order to assess the model's efficacy in real-time, it is then discretized and incorporated into the intended algorithm framework inside the Battery Management System (BMS) of an electric vehicle (E.V.). It is shown that the RMS error for the online voltage estimate is less than 15.8 mV at −13 °C, which is a realistic city driving circumstance. This attests to the established electrochemical model's suitability for a variety of electric vehicle applications.

Kamil Okay et al. (2022) A customized Battery Management System (BMS), 400-watt photovoltaic (P.V.) modules, a 353-watt lithium-ion battery (LIB) block made of 18650 type cells, a 300-watt electronic D.C. load that can be programmed to simulate different load profiles and reduce actual home energy consumption by one-fifth, a 300-watt power supply to draw Energy from the grid, and 24 volt light bulbs to sell excess Energy back to the grid are all part of the conceptualized prototype system.

Justin Raj et al. (2020)**,** the battery management system guards against overcharging and over-discharging situations by employing fuzzy logic. A solar photovoltaic (P.V.) battery system underwent experimental testing whereby it was subjected to sudden variations in irradiation conditions. Following the acquisition, the data was carefully measured and examined. A simulation model for the BMS approach reveals an exceptional overall efficiency of 95.1%, supporting the proven efficacybased on a fuzzy logic battery management scheme.

Y.-C. Wanget al. (2020) the recommended convolutional residual blocks provide a twofold advantage, concurrently enhancing precise State of Charge (SOC) regression. To gauge the efficacy of the suggested network model, experiments were carried out using data from a Panasonic NCR18650PF lithium-ion battery exposed to nine distinct driving schedules at five different temperatures. The average mean absolute error and average root-mean-square error, respectively, were shown to be 1.260% and 0.998%, respectively. Significantly, the computational cost for a singular SOC estimation amounted to 2.24 × 106 floating-point operations. These findings underscore the efficacy and proficiency of the system.

Zhang et al. (2018) An LSTM network has been deployed to enhance the accuracy of State of Charge (SOC) prediction amid challenges such as temperature fluctuations, diverse working conditions, and battery life deterioration. The SOC estimation algorithm displays notable resilience against both the degradation of battery life and fluctuating working conditions. Under QCT settings, the highest estimate error is constantly kept below 2.5%, and the average estimation error per cycle stays below 1.6% even in the presence of battery deterioration. Furthermore, the SOC estimate technique shows resilience to temperature variations. Across a range of temperatures (0℃, 25℃, 45℃), the maximum estimation error consistently stays below 2%, underscoring its reliability across diverse thermal environments.

D. H. Castillo-Martínezet al. (2022) A communication system has been integrated to enhance the interaction between a Li-ion battery and an Ingecon® Sun Storage 1Play inverter, with a focus on control and monitoring capabilities. The prototype, built using an Arduino® microcontroller and incorporating a graphical user interface (GUI) created in LabVIEW®, has undergone experimental trials. These tests have effectively validated the feasibility of employing automotive sector Li-ion battery packs (B.P.s) alongside an inverter, obviating the necessity for pre-existing disassembly and reconstruction procedures.

Le Gall et al. (2021) the inherent performance of an IEEE STD 802.15.4-2015 TSCH IoT network embedded within an electric vehicle (E.V.) battery pack. Our assessment included a detailed examination of individual radio channel performance and the interference dynamics with Wi-Fi devices operating in the 2.4GHz band. In response to the observed challenges, two potential solutions aimed at establishing an efficient network topology and TSCH schedule capable of satisfying the stringent Quality of Service (QoS) requirements. The first approach relies on Linear Programming (L.P.) to generate a high-quality topology, albeit at the expense of processing time, particularly in scenarios where all links exhibit high quality with Packet Delivery Ratio (PDR) close to 1.

Figueiredo et al. (2021) The PMS system uses a hybrid wireless network structure that consists of a local hub/gateway. This hub/gateway connects to various Bluetooth Low Energy (BLE) and Wi-Fi sensor/actuator devices. These wireless devices use the Message Queuing Telemetry Transport (MQTT) protocol to exchange information within the smart home. To ensure that the overall current consumption stays within predefined limits, a configurable algorithm is used for the dynamic observing and managing both the EV, and batteries charger in addition to other domestic electrical devices. It helps prevent the home circuit breaker from being triggered.

Zhonghao Rao et al. (2011)**,** the cells were discharged at a rate of 35 amperes, approximately five times the discharge rate (5 C). Formulations for 3-D modules were carried out for both individual cells and battery packs. The findings suggest that the inherent thermal resistance within the cell results in an unavoidable temperature variance. Consequently, this variance influences the thermal conductivity and reduces the melting point of the phase change material (PCM). The most effective heat dissipation occurs with a PCM featuring a melting point below 45 °C, aiming to keep the overall unit temperature difference below 50 °C before PCM melting, thereby minimizing the difference significantly. Additionally, it is essential to attain an appropriate ratio of thermal conductivity between the PCM (kPCM) and the cell (kc) for an optimally designed battery thermal energy management system.

F. Feng et al. (2015) proposed an online identification method for Open Circuit Voltage (OCV) that incorporates aspectsof hysteresis, polarization, and concentrations, defining it as the OCV Parametric Identification (OCVPI) approach. Taking temperature into account, we establish a new map for the relationship between OCV and State of Charge (SOC) using OCVPI at different temperatures. To validate our method, we conduct experiments based on consecutive loading profiles. The results affirm the effectiveness and adaptability of our approach for batteries operating in diverse ambient temperatures.

Zhang et al. (2023)**,** under constant laboratory current conditions, the maximum SOC estimation errors for B.P., PSO-BP, and LSTM neural network models were found to be 4.57%, 2.65% and 1.84%, respectively. This underscores the superior precision of the LSTM model developed in this study for SOC estimation.The PSO-LSTM model demonstrated a maximum estimation error of merely 1.5%, enhancing overall accuracy by 1% compared to the LSTM model. For DST and US06 conditions, the PSO-LSTM model exhibited maximum estimation errors of 1.92% and 2.1%, respectively, representing a 1% to 2% improvement over LSTM. These findings underscore the superior accuracy and generalization capabilities of the PSO-LSTM model across the entire estimation process.

J. Sarda et al. (2023) Improving estimation accuracy can be achieved by developing integrated algorithms for State of Health (SOH) and State of Charge (SOC) estimation. For swift state estimation, it is particularly advisable to explore approaches based on both EIS models and data-driven methods in a complementary manner. The creation of estimation techniques is essential for enabling the effective use of batteries across various applications, such as electric vehicle battery packs and charging systems. In order to improve the precision and effectiveness of estimation using data-driven methods, it is essential to explore efficient estimation techniques and perform feature selection based on sample data. There is a hope that data-driven methodologies based on big data platforms will be developed, facilitating their practical implementation in real-world applications.

Gaojian Ren et al. (2021) SOC estimation is defined, and various estimation methods are examined encompassing. The methods that have been used are the discharge experiment, neural network algorithm, internal resistance, open circuit voltage, ampere-hour, linear model, and Kalman filter. This work provides an educated scientific choice for determining the state of charge (SOC) in nickel-hydrogen batteries by contrasting and evaluating different approaches.

S. R.G. et al. (2022) state that the most recent advancements in electric vehicle technology incorporate IoT monitoring and life cycle management. Despite the presence of an advanced (BMS) Battery Management System in contemporary E.V.s, the risk of battery damage persists due to various factors such as overcharging and exposure to extreme temperatures. Proactive measures are crucial, analogous to the "reserve" feature in traditional petrol cars. Introduces a battery monitoring system utilizing IoT and the MQTT protocol, providing real-time information on battery levels. Additionally, the system displays navigation to the nearest available charging station, enhancing overall battery care and vehicle efficiency.

V. G. G. et al. (2023)**,** the setup comprises a data connection module utilizing Internet of Things protocols coupled with a solid-state circuit controlled by a microcontroller and intended for use with sensors. The battery monitoring and management system includes a liquid cooling system to increase safety. This system employs a coolant tube positioned among battery cells to mitigate overheating risks.This advanced system is seamlessly integrated into electric vehicles, allowing users to optimize battery usage and detect potential issues before any failures occur. By constantly monitoring key parameters, such as lifecycle, safety, and mileage, the system provides valuable insights. In case of abnormalities, the system promptly sends relevant information to the user's mobile phone through IoT, ensuring timely awareness and proactive maintenance.

Kavitha K et al. (2023) A voltage sensor, current sensor, and Arduino microcontroller form the electrical system's fundamental components. The temperature of the battery is continually monitored by a temperature sensor included in this device. A cooling system comes on to stop overheating if the temperature rises over a certain threshold. Beyond these monitoring and cooling functions, the system integrates a GSM module. This module facilitates the sending of text messages to the vehicle owner's phone in situations where the battery voltage is low, or the temperature is excessively high. This feature empowers the owner to address issues and prevent potential battery damage promptly. Leveraging an Arduino microcontroller adds programming flexibility and customization possibilities. The inclusion of a GSM module not only allows real-time notifications but also enables remote monitoring capabilities.

Sankarananth. S et al. (2022) the proposed converter combines various renewable energy sources and a DC-DC converter. If the primary energy source is unavailable, any excess power can be stored in battery storage devices and used to meet peak power demands. The converter has three ports: two for input and one for output. The first port connects to the photovoltaic system, while the second is to the battery storage system. The study focuses on a split-type secondary port for hybrid energy systems using energy storage and solar energy sources. These sources alternate through a bi-directional switching topology. The proposed work aims to improve the voltage boost ratio, output power, and efficiency. The Resilient Back Propagation and Adaptive Neuro-Fuzzy Interference (ANFIS) approaches regulate Maximum PowerPoint Tracking and optimize power extraction from the photovoltaic system. The hybrid energy system uses an isolated converter topology to separate the input from the load. The Adaptive Neuro-Fuzzy Controller, implemented through the Back Propagation Method, achieves a favourable voltage transfer ratio and net efficiency results.

Sankarananth. S et al. (2022) to enhance a higher-level voltage DC-DC converter, integrating innovative methods based on Continuous Inductor (CI) and Switched Capacitor Converter (SCC). The CI and SC are pivotal in efficiently charging and discharging energy, resulting in an elevated overall gain. A clamp circuitry was introduced to mitigate stress on switching voltage levels and minimize inductance leakage. The inherent issue of reversed retrieval in the diode was successfully addressed by incorporating a Coupled Inductor (CI). The novel topology not only aims to amplify voltage but also strives to enhance overall efficiency. A comprehensive analysis of the steady-state performance, along with operational procedures for the advanced DC-DC converter, is elucidated in this study. In the proposed model, the input voltage is set at 24V, yielding an output voltage (Vo) of 410V, and a maximum power (Pmax) of 150W was applied to achieve a peak efficiency (ηmaximum) of 96.4%.

### A. *Problem Statement*

- GSM relies on mobile networks for communication, and in certain areas or situations with poor network coverage, there may be delays in data transmission or even complete loss of connectivity.
- LSTMs are known for their relatively higher computational requirements compared to simpler models, which can be a limiting factor in real-time applications, especially when dealing with the continuous and high-frequency data generated by IoT sensors in an E.V. battery monitoring system.
- The IB-DRN, being a deep learning model, may require significant computational resources for training and inference. This complexity can lead to longer processing times and higher energy consumption, which might be a concern in resource-

constrained environments or for applications where real-time responsiveness is critical.

## PROPOSED METHODOLOGY

The Arduino Uno serves as the main microcontroller for the system. It interfaces with various sensors and modules to collect data from the electric vehicle's battery. It transforms the power source's Alternating Current (A.C.) into Direct Current (D.C.), which is appropriate for electronic components. The buck/boost Stabilizes the voltage level to ensure a consistent and appropriate power supply to the components connected to the system. The acid gravity sensor measures the specific gravity of the battery electrolyte, indicatingthe condition and level of battery charge. Changes in specific gravity can help identify battery deterioration or charging issues. Monitors the temperature of the battery. Temperature is a critical factor affecting battery performance, and monitoring it helps prevent overheating and enhances battery life. Enables communication between the battery monitoring system and the IoT (Think Speak) platform. Sends real-time data, including battery status, temperature, and voltage, to a central server for remote monitoring and analysis. Measures the voltage across the battery terminals.

Voltage is a key parameter for determining a battery's state of charge, and abnormal voltage levels can indicate potential issues. The Arduino Uno is programmed using C program language, specifically the Arduino IDE. The code includes algorithms to read sensor data, process information, and communicate with the IoT module. Moreover, the electric vehicle battery status is monitored by utilizing the respective sensor for each parameter. The status of the battery and its performance level are notified in Think Speak IoT. The performance evaluation of this system would involve testing it under various conditions, such as different temperatures, charging/discharging rates, and voltage levels. The collected informationis analyzed to assess the accuracy of the monitoring system in reflecting the actual state of the electric vehicle battery. Additionally, the efficiency and reliability of the IoT communication would be evaluated for real-time monitoring and remote management.

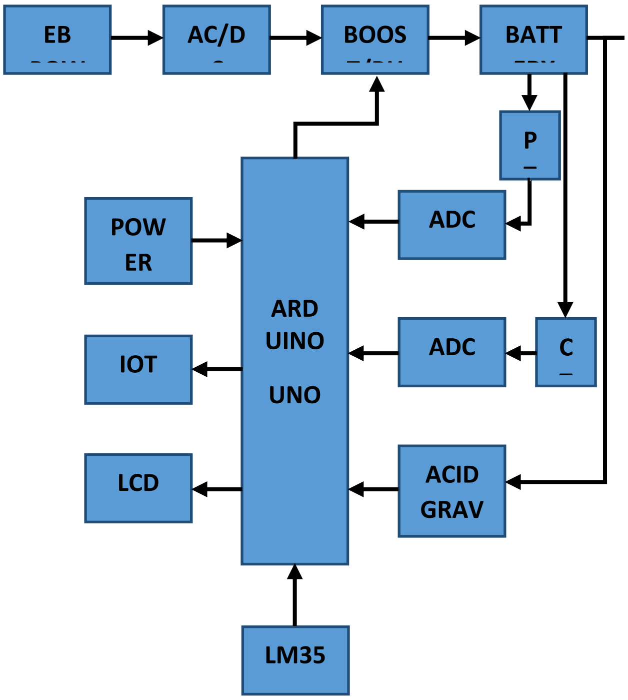

FIGURE 1 SUGGESTED SYSTEM'S BLOCK DIAGRAM

### *3.1 Power Supply*

A power supply plays a vital role in converting electrical energy from one form to another, commonly converting alternating current (A.C.) to direct current (D.C.). Transformers play a key role in electrical systems by enabling the efficient transmission of power over long distances. They allow for voltage multiplication or division in A.C. circuits, reducing power losses in transmission lines. Step-up transformers elevate voltage to facilitate transmission, whereas step-down transformers reduce voltage to ensure safer operation and promote cost-effective equipment usage. Rectifiers, such as half-wave and diode bridge rectifiers, are essential in converting A.C. to D.C. by allowing only one direction of current flow. The rectification process is crucial in power supplies, contributing to the efficiency of power transfer. Diode bridge rectifiers, for instance, utilize four diodes in series pairs to ensure a continuous D.C. output during both halves of the A.C. cycle.

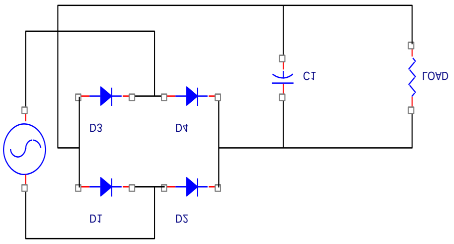

FIGURE 2 FULL BRIDGE RECTIFIER CIRCUIT

### *3.2 Boost Converter*

The boost converter, categorized as a switching mode power supply (SMPS), is specifically designed to elevate the difference between the input and output D.C. voltages. This is achieved through the utilization of a minimum of two switching semiconductors, namely a diode and a transistor, along with an energy storage element. In its operational phase, the inductor works against alterations in current, leading the converter through two discernible states: when the switch is closed, or the On-state, augmenting inductor current, and the Off-state, where the switch is open.

In the Off-state, the inductor current traverses through the diode and capacitor, transferring stored energies to the load. The SG3525 is a control circuit with a pulse width modulation that is utilized in power supply switching. Notable features of the SG3525 include its function as a voltage control PWM controller, which controls the duty cycle of PWM by comparing feedback voltage to a reference value. Widely applied in inverter applications, the SG3525 boasts two principal PWM outputs during inversion. The circuit includes a +5.1 reference with ±1% modification, an error amplifier with input common-mode voltage range, a sync input for external system clock synchronization, and a shutdown pin for controlling output stages and soft-start circuitry, including under-voltage lockout for protection.

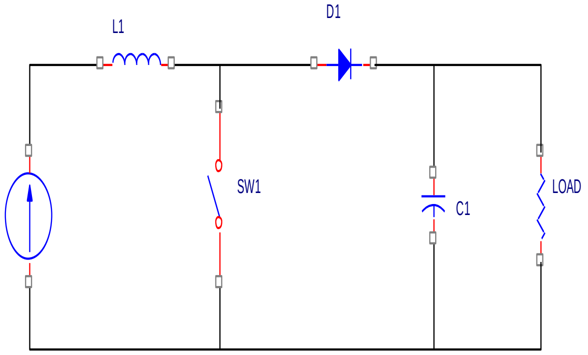

FIGURE 3 CIRCUIT DIAGRAM OF BOOST CONVERTER

### 3.3 LCD Display

The most common character-based LCDs on the market, such as the 1 Line, 2 Line, and 4 Line versions, are usually built using Hitachi's HD44780 controller or alternative controllers that work with the HD44580. Understanding the specifications and technical information of the HD44780 controller is crucial for effectively interfacing these LCDs with various microcontrollers. Character-based LCDs commonly employ 8-bit or 4-bit interfaces. Exploring the nuances of interfacing these LCDs with different microcontrollers, along with programming considerations, is essential. This encompasses the intricacies of working with both single-controller (14-pin) and dual-controller (16-pin) LCDs, where the latter supports more than 80 characters.

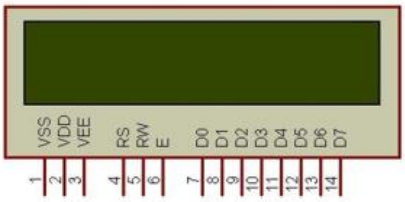

FIGURE 4 PIN DIAGRAM OF LCD DISPLAY

Additionally, special programming techniques can be applied to enhance the functionality and appearance of applications using these seemingly simple LCDs. LCDs supporting more than 80 characters typically utilize dual HD44780 controllers. Understanding the configuration and pin descriptions, including the presence of two extra pins in both single-controller and dual-controller LCDs for back-light LED connections, is crucial. This knowledge is vital for effectively integrating and utilizing these LCDs in electronic applications, providing valuable insights into their optimal functionality.

### 3.4 Arduino Uno

The Arduino Uno is equipped with the ATmega328P microcontroller, which comes with 32 K.B. flash memory to store programs, 2KB SRAM, and 1KB EEPROM. The ATmega328P operates at 16 MHz on the Arduino Uno. The board features 14 digital input/output pins, out of which six support PWM output, 6 analog inputs, a USB port for programming and power, a power jack, an ICSP header, and a reset button. Arduino Uno is programmed using Arduino Software (IDE), which is a cross-platform, open-source application written in C Language. It simplifies the process of writing and uploading code to the board. Connect sensors to measure voltage, current, temperature, and SoC of E.V. batteries. Use suitable sensor modules or sensors that can provide accurate and reliable data.

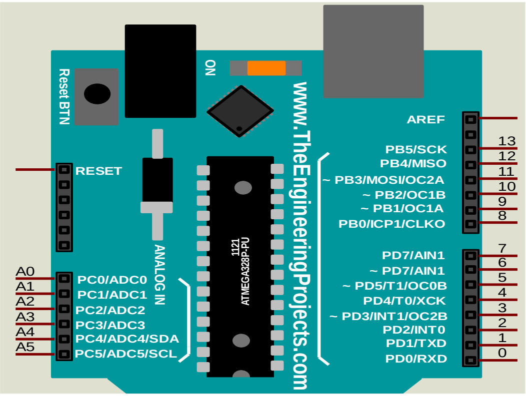

FIGURE 5 PIN CONFIGURATION OF ARDUINO UNO MICROCONTROLLER

### 3.5 Voltage Sensor

To measure high values of current and voltage economically, instrument transformers provide a solution by utilizing the transformation property of current and voltage. These transformers have known turn ratios and step-down current or voltage, enabling measurement with standard instruments like ammeters or voltmeters. There are two primary categories of instrument transformers utilized in electrical systems: Current Transformers (C.T.s) and Potential Transformers (P.T.s). Current transformers, commonly referred to as C.T.s, serve the purpose of being placed in conjunction with the electrical line in order to reduce the current levels' easy measurement by ammeters.

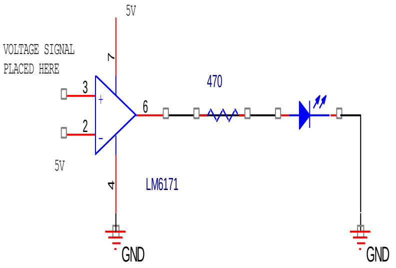

FIGURE 6 CIRCUIT DIAGRAM OF VOLTAGE SENSOR

The primary-to-secondary current ratio, such as 100:5 Amps, indicates that a 100 Amp primary current corresponds to a 5 Amp secondary current. Safety precautions are crucial; an open secondary circuit of a C.T. can lead to dangerous conditions, including insulation failure and potentially fatal shocks when manipulating the C.T. while the primary is energized. Excessive core flux in a current transformer can lead to hysteresis and eddy current losses, resulting in overheating. Overheating causes the oil in the C.T. to boil and vaporize, pressurizing the C.T. housing and potentially leading to a dangerous blast. The consequences extend to fire, smoke, and tripping of nearby power lines due to earth faults, emphasizing the critical importance of proper design and handling of current transformers.

### *3.6 Relay Driver*

A relay driver circuit serves the crucial function of operating a relay as a switch in a circuit, facilitating the opening or closing of the relay according to the circuit's needs. Different relay driver setups are required for D.C. and A.C. relays due to their distinct operating characteristics. The inclusion of a zener diode in D.C. relay driver circuits is essential to eliminate voltage spikes generated by the inductive nature of relay coils during abrupt changes in current flow.

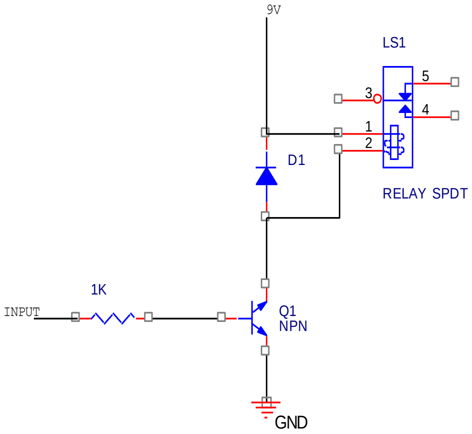

**FIGURE 7 CIRCUIT DIAGRAM OF RELAY**

The presence of a zener diode in parallel with the relay helps suppress transients caused by relay operations, safeguarding both the relay's switch contacts and other components in the circuit. Care must be taken to select a diode with a current rating above the normal operating current of the relay to ensure uninterrupted normal operation. The generic relay driver circuit is designed to be driven by an arbitrary control voltage, supporting both A.C. and D.C. input.

### *3.7 IoT Think to Speak*

Thing Speak functions as an open-source web service and API dedicated to theInternet of Things (IoT). It facilitates the identification and communication of objects or basic devices over the Internet. In order to function, the Thing Speak API must constantly receive incoming data, time-stamp it, and provide output for both computers and human users (via visual graphs). It is particularly advantageous for more modest hardware undertakings that demand Internet access, eliminating the need for a dedicated transmission server. The report explores practical applications of Thing Speak, demonstrating its utility with the Arduino microcontroller for hardware projects.

Additionally, it demonstrates the use of the C programming language to communicate with graphical user interfaces in operating systems, emphasizing Things Peak's versatility across different platforms. Things Peak's ability to timestamp and present data visually makes it user-friendly for both developers and end-users. Thing Speak stands out as a cost-effective solution for smaller IoT projects, providing connectivity over the Internet without the need for a dedicated transmission server. The report suggests that, unlike some other IoT services that require payment for certain functionalities, Thing Speak remains open source, making it accessible and adaptable for various applications. The conclusion underscores things Peak's practicality in scenarios where a committed transmission server may not be feasible or necessary.

## 4. RESULT AND DISCUSSION

Figure 8 illustrates the Think Speak IoT output showcasing the voltage of an electric vehicle battery.

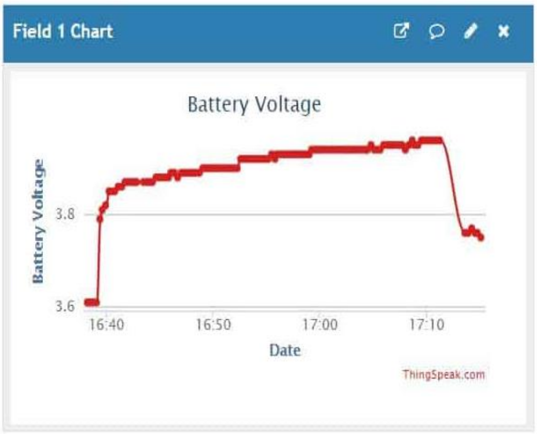

**FIGURE 8 BATTERY VOLTAGE IN THINK SPEAK**

Figure 9 illustrates the Think Speak IoT output showcasing the percentage of an electric vehicle battery.

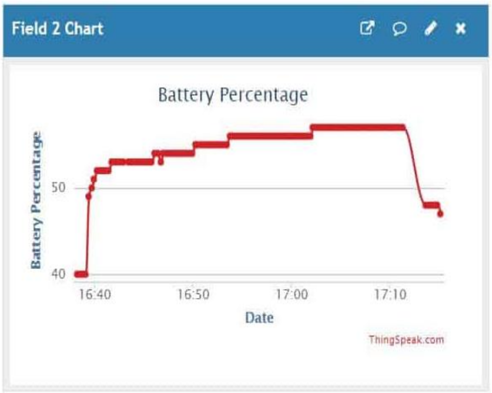

**FIGURE 9 BATTERY PERCENTAGE IN THINK SPEAK**

Figure 10 illustrates the Think Speak IoT output showcasing the temperature of an electric vehicle battery.

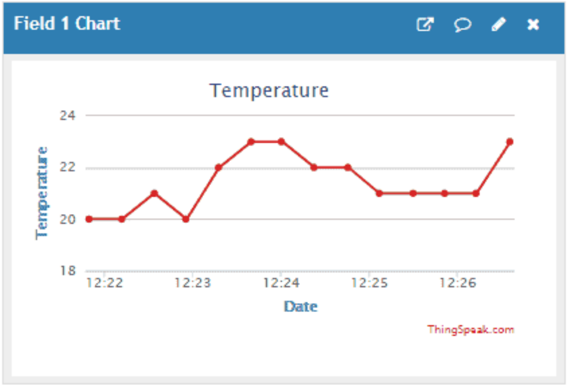

**FIGURE 10 BATTERY PERCENTAGE IN THINK SPEAK**

## 5. CONCLUSION

The battery monitoring mechanism for charging and monitoring batteries system utilizes an Arduino microcontroller board as its central controller to measure battery voltage, charging current, and temperature. This system can transmit collected data to the Internet, enabling remote monitoring of the battery's condition. A sophisticated charging system ensures the safe charging of lead-acid batteries and issues an alarm for significant changes in temperature and electrolyte levels. Through slight modifications, this monitoring and charging device can handle multiple batteries simultaneously. Enhancements in system performance and functionality can be achieved by implementing a superior charging algorithm and upgrading sensing elements.

While locally available generic chargers are cost-effective, they lack the data logging and monitoring capabilities found in the proposed system. In contrast to expensive industrial-grade generators with comprehensive monitoring features, the recommended structure is specifically for charging and observing lead-acid batteries in backup generators. It is not intended to replace an Arduino controller. However, considering its cost, monitoring capabilities, and functions for remote control, when utilized with backup power sources, it offers a strong substitute for common external lead-acid battery chargers. An Integrated IoT module ensures that all battery statuses are transmitted for comprehensive monitoring.

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