E-ISSN: 3107-5843
International Journal of Advanced Engineering and Management System
Volume 02, Issue 02, April-June 2026, pp. 19-26

IoT-Based Solar Powered Battery Management System for an Electric Vehicle

Dr.P.Jeyaprakash [1], Associate Professor, Department of Electrical and Electronics Engineerong,Vivekanandha College of Engineering for Women, Tiruchengode, jeyaprakash4806@gmail.com

Jeshikaa Harini K.J[2], Department of Electrical and Electronics Engineerong,Vivekanandha College of Engineering for Women, Tiruchengode, kjjeshikaaharini@gmail.com

Methunashree D[3], Department of Electrical and Electronics Engineerong,Vivekanandha College of Engineering for Women, Tiruchengode, manasadevarasu@gmail.com

Sivanathi M[4], Department of Electrical and Electronics Engineerong,Vivekanandha College of Engineering for Women, Tiruchengode, manasadevarasu@gmail.com

Preethi M[5], Department of Electrical and Electronics Engineerong,Vivekanandha College of Engineering for Women, Tiruchengode, sivanathisivanathi951@gmail.com

Abstract:

The rapid growth of electric vehicles (EVs) has increased the demand for efficient, safe, and intelligent battery management solutions. This paper presents the design and implementation of a solar-powered battery management system (BMS) for electric vehicles integrated with Internet of Things (IoT) technology and a Global Positioning System (GPS) module for location-based services. The proposed system utilizes renewable solar energy to supplement conventional charging methods, thereby reducing dependency on grid power and supporting sustainable transportation. The BMS continuously monitors critical battery parameters such as voltage, current, temperature, and state of charge (SOC) to ensure safe and optimal operating conditions. An IoT-enabled communication module transmits real-time battery data to a cloud platform, allowing remote monitoring, data logging, and early fault detection. Intelligent control and protection mechanisms are incorporated to prevent overcharging, deep discharge, and thermal stress, which significantly enhance battery safety and lifespan. In addition, the integrated GPS module provides real-time vehicle location tracking and enables the identification of nearby EV charging or fuel stations. By analyzing the vehicle's remaining battery capacity and location data, the system can alert the driver and recommend the nearest available charging stations, thereby improving route planning and reducing range anxiety. The system also enables efficient energy management by optimizing charging based on available solar energy, battery conditions, and geographic location. The proposed solar-powered IoT-based BMS with GPS-enabled station identification offers a reliable, eco-friendly, and scalable solution for next-generation electric vehicles and smart mobility applications.

Key Words: Solar-Powered Battery Management System, Electric Vehicles, Internet of Things (IoT), GPS system, Real-Time Battery Monitoring, State of Charge Estimation, Renewable Energy Integration, Smart Energy Management, Battery Safety and Lifespan

1. Introduction

The rapid advancement of electric vehicle

(EV) technology has emerged as a key solution to reduce greenhouse gas emissions, fossil fuel dependency, and environmental pollution caused by conventional internal combustion engine - based transportation systems.Governments and industries worldwide are promoting electric mobility as part of sustainable development initiatives. However, the widespread adoption of EVs is strongly dependent on the performance, safety, and reliability of their battery systems, which represent the most critical and costly component of electric vehicles. A Battery Management System (BMS) plays a vital role in ensuring safe operation and efficient utilization of battery packs by continuously monitoring parameters such as voltage, current, temperature, and state of charge (SOC). Conventional EV charging systems primarily depend on grid-based electricity and often lack intelligent monitoring, adaptive control, and remote accessibility. These limitations can result in battery degradation, thermal issues, reduced lifespan, and increased maintenance costs. Moreover, increased reliance on grid power contributes to higher energy demand and indirect carbon emissions, particularly in regions where electricity generation is still dominated by non-renewable sources.

The integration of renewable energy sources, especially solar photovoltaic (PV) systems, with EV battery management offers a promising approach to enhance energy sustainability and reduce grid dependency. Solar-powered charging systems utilize clean and abundant energy while supporting decentralized energy generation. However, effective coordination between solar energy input and battery charging requires intelligent control and monitoring to maintain battery safety and charging efficiency under varying environmental conditions.

To further enhance the system functionality, the integration of a Global Positioning System (GPS) module enables real-time location tracking of electric vehicles. GPS technology allows users to monitor the vehicle's position, track routes, and locate nearby charging stations through connected applications. This feature improves vehicle security, supports navigation, and provides useful data for fleet management and energy usage optimization.

The combined implementation of solar-powered charging, advanced battery management, and GPS- based tracking creates a smarter, more efficient, and sustainable EV ecosystem.

2. Literature Review

Extensive research has been conducted on battery management systems (BMS) to enhance the safety, efficiency, and lifespan of electric vehicle batteries. Conventional BMS designs mainly focus on monitoring basic parameters such as voltage, current, and temperature, along with protection mechanisms against overcharging and deep discharge. These systems are typically designed for grid-based charging environments and employ fixed control strategies, which limit their ability to adapt to varying operating conditions and provide intelligent energy management.With the advancement of Internet of Things (IoT) technology, several researchers have proposed IoT-enabled battery monitoring systems that allow real- time data acquisition, remote access, and cloud-based visualization of battery parameters. Such systems improve fault detection and maintenance efficiency by enabling continuous monitoring. However, most existing IoT-based solutions function primarily as monitoring platforms and do not actively participate in charging control or integrate renewable energy sources, thereby limiting their overall effectiveness in sustainable electric vehicle applications.

Recent studies have explored the use of renewable energy, particularly solar photovoltaic (PV) systems, for electric vehicle charging to reduce dependency on grid power and carbon emissions. Solar-assisted charging systems demonstrate improved energy sustainability but often lack integrated battery management and intelligent monitoring capabilities. The limited coordination between solar energy utilization, battery protection, and real- time IoT monitoring highlights a research gap. In addition, modern intelligent transportation systems are increasingly integrating Global Positioning System (GPS) technology to enable real-time vehicle tracking and navigation support. GPS-based systems allow users to monitor the location of electric vehicles and identify nearby fuel or charging stations through location-based services. These systems enhance vehicle security, improve route planning, and assist drivers in locating the nearest charging infrastructure, especially in unfamiliar areas. However, many existing GPS-based tracking solutions operate independently and are not integrated with battery management and energy monitoring systems. Therefore, there is a need for a unified system that integrates solar-powered charging, IoT-based battery monitoring, and GPS-enabled vehicle tracking with charging or fuel station detection. Such an integrated approach can ensure safe battery operation, efficient renewable energy utilization, real-time monitoring, and intelligent navigation support for electric vehicle users.

3. Methodology

1. Solar Energy Generation – Solar photovoltaic (PV) panels are used as the primary renewable energy source to generate electrical power for charging the electric vehicle battery.

2. Charge Controller Regulation – The output from the solar panels is regulated using a charge controller to maintain stable voltage and current levels for safe battery charging.

3. Battery Charging Management – The charge controller manages the charging process and protects the battery from overcharging and deep discharge.

4. Sensor Integration – Sensors are installed to measure important battery parameters such as voltage, current, temperature, and state of charge (SOC).

5. Data Processing using Microcontroller – A microcontroller collects and processes the sensor data to monitor battery performance in real time.

6. Protection Mechanism – The system implements threshold-based protection to prevent abnormal conditions such as overvoltage, overcurrent, overheating, and unsafe SOC levels.

7. IoT Communication Module – An IoT module transmits battery data to a cloud platform for real-time monitoring and remote access.

8. Cloud Monitoring Platform – The collected data is stored and visualized through a web or

E-ISSN: 3107-5843
International Journal of Advanced Engineering and Management System
Volume 02, Issue 02, April-June 2026, pp. 19-26

mobile application for system diagnostics and performance tracking.

9. GPS Tracking Integration – A GPS module is integrated to track the real-time location of the electric vehicle and provide location-based services.

10. Nearest Fuel/Charging Station Detection – Using GPS location data, the system identifies and displays nearby fuel or EV charging stations, helping drivers locate the nearest available energy source during low battery conditions.

4. Existing System

The existing system for electric vehicle battery management mainly focuses on monitoring basic battery parameters such as voltage, current, temperature, and state of charge (SOC). These systems generally depend on grid-based electricity for charging electric vehicle batteries. Basic protection mechanisms are implemented to prevent overcharging, deep discharge, and overheating of the battery. Fixed control strategies are used to regulate the charging and discharging process. Sensors are integrated to measure battery parameters and send the collected data to a controller for monitoring. In some systems, Internet of Things (IoT) technology is used to enable real-time monitoring of battery data and allow remote access through web or mobile applications. Additionally, solar photovoltaic systems are used in certain applications to generate renewable energy for EV charging. Global Positioning System (GPS) technology is also used in vehicles for location tracking and navigation purposes. These systems mainly operate to monitor battery performance and track vehicle location.

5. Proposed System

The proposed system presents an integrated solution for efficient electric vehicle battery management using solar energy, IoT technology, and GPS-based tracking. In this system, solar photovoltaic (PV) panels are used as the primary source of energy to charge the electric vehicle battery, reducing dependence on conventional grid electricity and promoting the use of renewable energy. A charge controller is used to regulate the power generated from the solar panels and ensure safe and stable charging of the battery. Various sensors are incorporated to continuously monitor important battery parameters such as voltage, current, temperature, and state of charge (SOC). These parameters are processed by a microcontroller that implements protection mechanisms to prevent abnormal conditions like overvoltage, overcurrent, overheating, and deep discharge. The system also integrates an Internet of Things (IoT) communication module that enables real-time transmission of battery data to a cloud-based platform. This allows users to monitor battery status, charging conditions, and system performance remotely through a web or mobile interface. In addition, a GPS module is incorporated to track the real-time location of the electric vehicle. Using the GPS data, the system helps users identify and locate the nearest fuel or EV charging stations when the battery level is low. By combining solar-powered charging, intelligent battery monitoring, IoT-based remote access, and GPS tracking, the proposed system improves energy efficiency, battery safety, and user convenience in electric vehicle applications.

6. Block Diagram

E-ISSN: 3107-5843
International Journal of Advanced Engineering and Management System
Volume 02, Issue 02, April-June 2026, pp. 19-26

Solar Power Generation – Solar PV panels generate electrical energy for charging the EV battery. Charge Regulation – A charge controller regulates voltage and current for safe battery charging .Battery Parameter Monitoring – Sensors measure voltage, current, temperature, and state of charge (SOC). Data Processing – A microcontroller processes the sensor data and manages battery protection.IoT Communication – An IoT module transmits battery data to the cloud.Remote Monitoring – Users can monitor battery status through a mobile or web application.GPS Tracking – A GPS module provides real-time location of the electric vehicle. Station Detection – The system helps locate nearby fuel or EV charging stations.

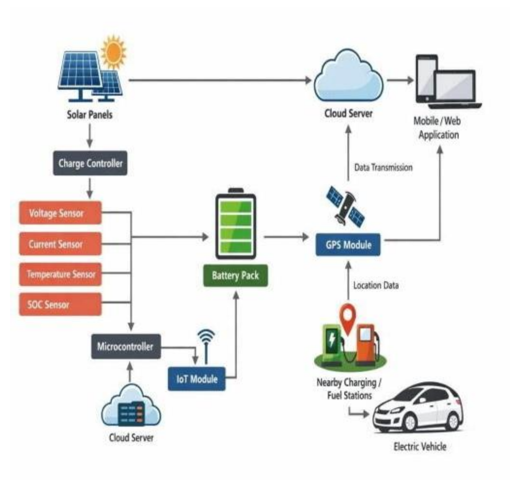

Figure 1: IG-1 IoT based solar powered smart battery management for electric vehicle

7. System Design

The system design consists of a power supply unit, sensing and control circuitry, and communication modules that work together to manage and monitor the electric vehicle battery system. A step- down transformer converts the 230 V AC input supply to a lower AC voltage. This voltage is then rectified and filtered using diodes and capacitors to obtain a stable DC power supply for the electronic components. The regulated power is distributed to the control and sensing circuits mounted on the PCB boards. The sensing section consists of components and coils that help measure electrical parameters such as voltage and current. These signals are processed by the control circuit, which ensures proper battery charging and protection from abnormal conditions. The system also integrates monitoring and communication features through IoT and GPS modules to transmit battery information and vehicle location data. The collected data can be viewed through a mobile or web application, allowing users to monitor battery performance and identify nearby charging or fuel stations. This overall system design ensures safe power conversion, efficient battery monitoring, and real-time tracking for electric vehicle applications.

8. Prototype

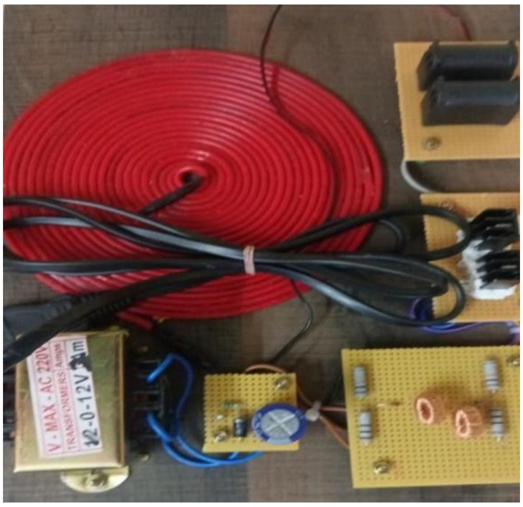

Figure 2: Prototype setup

The prototype is developed to demonstrate the working of the electric vehicle battery management and monitoring system using

E-ISSN: 3107-5843
International Journal of Advanced Engineering and Management System
Volume 02, Issue 02, April-June 2026, pp. 19-26

power supply and sensing circuits.

9. Matlab/Simulink Model

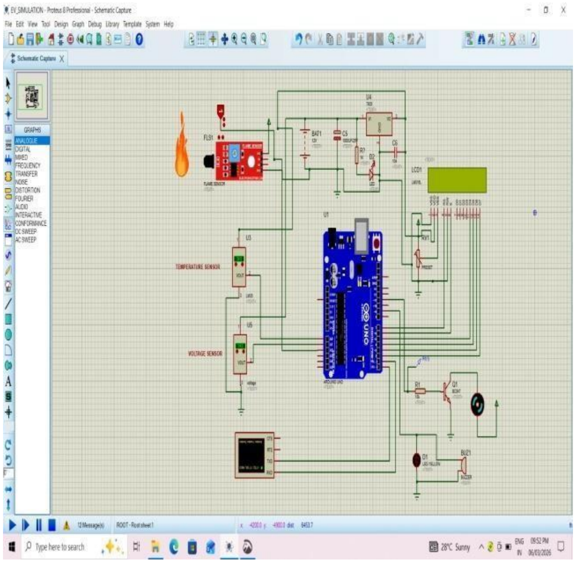

Figure 3: Simulation Model

The simulation of the proposed system is designed using a microcontroller-based platform to demonstrate the operation of the electric vehicle battery monitoring and management system. In the simulation, sensors such as the voltage sensor and temperature sensor are connected to the microcontroller to continuously monitor battery parameters. The sensed data is processed by the controller to ensure safe battery operation and to detect abnormal conditions such as high temperature or voltage variations. The measured parameters are displayed on an LCD display for real-time monitoring. The system also includes a GPS module that provides the real-time location of the electric vehicle. The GPS data is processed by the microcontroller and can be used to identify the vehicle position and assist in locating the nearest fuel or EV charging stations. Additional components such as a buzzer and indicator circuits are used to provide alerts when abnormal battery conditions occur. This simulation verifies the proper functioning of battery monitoring, protection mechanisms, and GPS-based location tracking before implementing the system in the hardware prototype.

10. Matlab/Simulink Model Result

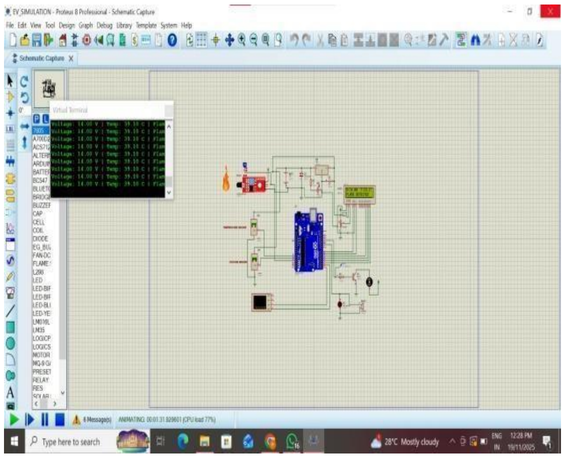

Figure 4: Simulation Model

The simulation of the proposed system was carried out using Proteus software to verify the operation of the battery monitoring and safety system. In the simulation, sensors such as the voltage sensor and temperature sensor continuously measure the battery parameters. The measured values are sent to the microcontroller, and the real-time readings are displayed on the LCD display and virtual terminal. The system successfully detects abnormal conditions such as high temperature or flame presence. When such conditions occur, the microcontroller processes the sensor data and activates safety indicators such as a buzzer and alert messages on the display. This helps in ensuring the safety and protection of the battery system. The simulation also includes a GPS module that provides the real-time location of the electric vehicle. The location data can be used for vehicle tracking and to assist the user in identifying nearby fuel or EV charging stations. The successful simulation confirms that the system can effectively monitor battery conditions, provide safety alerts, and support location tracking.

11. Conclusion

The proposed solar-powered IoT-based battery management system offers a comprehensive solution to improve the safety, efficiency, and sustainability of electric vehicles. By ensuring controlled and optimized charging using solar energy, the system minimizes risks such as overcharging, overheating, and deep discharge, thereby extending battery lifespan and enhancing overall vehicle reliability. The integration of IoT technology enables continuous real-time monitoring, remote supervision, and data logging of critical battery parameters, allowing for timely fault detection and preventive maintenance. Furthermore, the use of renewable solar energy reduces dependence on conventional grid power and lowers environmental impact.

The system also incorporates a Global Positioning System (GPS) module that enables real-time vehicle location tracking. This feature helps users identify nearby fuel or EV charging stations and supports efficient navigation and vehicle management.

Overall, the integration of solar energy, IoT-based monitoring, and GPS tracking creates a smart and efficient battery management system for electric vehicles. These combined technologies enhance battery safety, improve energy utilization, and provide location-based services, making the system suitable for future electric mobility and intelligent transportation applications.

12. Future Scope

Future work may focus on incorporating machine learning–based algorithms for accurate battery health prediction and remaining useful life estimation, enabling predictive maintenance and improved reliability. Hardware implementation and real time experimental validation can be carried out to assess the practical feasibility of the proposed system. In addition, integration with fast-charging stations and smart grid infrastructure can be explored to support high power charging, enhance energy management, and improve scalability for widespread electric vehicle adoption.

References

[1] P. Karuppsamy, C. Dinesh, R. Arulsurya and R. Mohana Selvam, “Applying IoT to an Electric Vehicle Battery Monitoring System,” International Journal of Engineering Research & Technology (IJERT), vol. 12, no. 3, 2023.

[2] T. T. Salsabila, H. F. Ramadhan, I. Imawati and D. A. R. Wati, “EM-IoT: IoT-Based Battery Monitoring System and Location Tracking on Electric Vehicles,” Buletin Ilmiah Sarjana Teknik Elektro, vol. 5, no. 2, pp. 218–229, 2023.

[3] S. Chatterjee, S. S. Kanojia, J. Ven and U. K. Mishra, “Solar Energy-Supported User-Friendly EV Charging Solution Based on IoT,” Journal of the Institution of Engineers (India): Series B, vol. 105, pp. 999-1004, 2024

[4] S. Iqbal, N. F. Alshammari, M. Shouran and J. Massoud, “Smart and Sustainable Wireless Electric Vehicle Charging Strategy with Renewable Energy and IoT Integration,” Sustainability, vol. 16, no. 6, 2024.

[5] S. Badgire, G. Suryawanshi, R. Jadhav and V. Tathe, "IoT-Based Smart Electric Vehicle with Battery Monitoring System," International Journal for Research in Applied Science and Engineering Technology, 2025.

[6] P. Gound, B. Lad, A. Poojary and H. Patil, "Smart Green Electric Vehicle Charging Station Using Renewable Energy," International Journal for Research in Applied Science and Engineering Technology, 2024.

[7] V. Radha Krishna, K. Vijaya, M. Hrishithi and V. Richa Sanjitha, "Smart Solar-Powered Battery System for Electric Vehicles with IoT Monitoring," International Journal for Research in Applied Science and Engineering Technology, 2023.

[8] T. Mariprasath and M. Venkatanaraya, "Design and Development of a New Charge Controller for GPS Tracker in Electric Vehicles," Discover Electronics, Springer, 2024.

[9] S. Gnana Swathika and O. V. Sheela, "IoT-Enabled Solar EV Charger with Intelligent MPPT Controller," Frontiers in Energy Research, 2026.

[10] M. Aldossary, H. A. Alharbi and N. Ayub, "Optimizing Electric Vehicle Charging with Integrated Renewable Energy Sources," Mathematics Journal, 2024.

[11] H. Fang, D. Wu and Y. Wang, "A Novel Modular Reconfigurable Battery Energy Storage System: Design and Control," IEEE Energy Storage Systems Research, 2023.

[12] J. Fan, H. Wang and A. Liebman, "Decentralized Electric Vehicle Charging Coordination Using Multi-Agent Reinforcement Learning," IEEE Smart Grid Research, 2023.