OPTIMIZED BASED ENERGY - EFFICIENT CLUSTERING PROTOCOLS FOR WSN

Mr. M. Srinivasan, M.E, Asst. Professor/ ECE

M. Kokilavani, D. Nandhini, G.A. Nandhinidevi, D. Sweatha

Salem College of Engineering and Technology, Salem

srinivazu@gmail.com,kokikoki17219@gmail.com,n3163910@gmail.com,

nandhinideviga@gmail.com,sweathas23@gmail.com

ABSTRACT

The proposed system focuses on efficient renewable energy storage and battery management by integrating a **Wireless Sensor Network (WSN)** based monitoring approach. In renewable energy systems, proper storage and management of energy are essential to ensure stable and reliable power delivery. In this system, a battery is used to store the generated renewable energy and distribute it effectively to connected components, maintaining continuous and stable system operation.

An **ESP32 microcontroller** acts as the central controller of the system. It processes and manages the data received from multiple sensors installed in the battery monitoring unit. A voltage sensor is used to continuously monitor the battery voltage level, helping to detect overvoltage or undervoltage conditions that may affect battery life. A temperature sensor is also integrated to measure the battery temperature in degrees Celsius. Monitoring battery temperature is important to prevent overheating, which can reduce battery efficiency and cause potential safety risks.

To regulate battery temperature, a **DC fan** controlled through a **motor driver** is incorporated in the system. When the temperature exceeds the predefined limit, the fan automatically increases its cooling speed to maintain a safe operating temperature. Additionally, a **buzzer** is included to provide immediate warning alerts when abnormal conditions such as excessive heat or voltage fluctuations occur.

For user interaction and monitoring, an **LCD display** is used to continuously show real-time sensor values including voltage

and temperature. Furthermore, the system integrates **IoT technology using the Blynk platform**, which enables wireless transmission of sensor data and real-time notifications to authorized users. The WSN-based communication ensures energy-efficient data transfer, reliable monitoring, and improved safety in renewable energy battery storage systems.

INTRODUCTION

The proposed system focuses on efficient renewable energy storage and intelligent battery management by integrating advanced monitoring, control, and communication technologies. In this system, a rechargeable battery acts as the primary energy storage unit, storing power generated from renewable sources and distributing it effectively to different components of the system. This ensures stable power delivery, improved energy utilization, and reliable system performance under varying conditions.

An ESP32 microcontroller serves as the central controller, coordinating the overall operation of the system. It continuously processes data collected from multiple sensors and manages connected devices accordingly. Voltage sensors are used to monitor the battery voltage level, while temperature sensors measure the battery temperature in degrees Celsius. These sensors operate through a Wireless Sensor Network (WSN) approach, allowing accurate, real-time monitoring of battery parameters to maintain safe and efficient operation.

The system also incorporates IoT technology to enable wireless communication and remote monitoring. Sensor data is transmitted through the network and clustered within the IoT platform, allowing authorized personnel to receive real-time notifications and system updates through the Blynk application. This remote accessibility improves monitoring efficiency and allows quick responses to abnormal battery conditions.

An LCD display is included to provide real-time visualization of system parameters such as voltage and temperature. A buzzer is used as an alert mechanism to warn users whenever abnormal conditions such as overheating or voltage fluctuations occur. Additionally, a motor driver controls the speed of a DC motor when required, while a DC fan helps regulate battery temperature by providing cooling. A chemical sensor is also integrated to detect harmful substances, ensuring enhanced safety and reliable battery management.

RELATED WORKS

Recent research has focused extensively on improving renewable energy storage and battery management systems to enhance efficiency, reliability, and safety in energy distribution. Renewable energy sources such as solar and wind are inherently intermittent, which makes effective energy storage systems essential for maintaining a stable power supply. Several studies have explored intelligent battery monitoring techniques that ensure optimal charging, discharging, and temperature regulation to prolong battery life and maintain system stability.

One important approach highlighted in earlier works is the integration of Wireless Sensor Networks (WSN) for monitoring battery parameters. These systems employ multiple sensors to continuously measure parameters such as voltage, temperature, and environmental conditions. By using distributed sensing nodes, WSN-based monitoring systems provide accurate real-time data that helps detect abnormal conditions such as overheating, overvoltage, or battery degradation. This method significantly improves operational efficiency and enables early fault detection, preventing system failures.

Another major development in this area is the use of microcontroller-based IoT platforms for energy management. Microcontrollers such as ESP32 have gained popularity due to their high processing capability, built-in Wi-Fi connectivity, and low power consumption. Many existing studies have implemented IoT-enabled battery monitoring systems where sensor data is collected and transmitted wirelessly to cloud platforms for remote monitoring. These systems allow authorized users to track battery health, energy levels, and environmental conditions in real time, improving the overall management of renewable energy systems.

In addition, visualization and alert mechanisms have been incorporated into several proposed models. LCD displays are commonly used to present real-time sensor readings such as voltage levels and temperature values, allowing users to easily monitor system performance. Alert systems such as buzzers or notifications are also integrated to provide immediate warnings when abnormal conditions occur. These safety mechanisms are essential in preventing damage to batteries and connected devices.

Some studies have further improved system safety by including cooling and environmental monitoring components. For example, DC fans are used to regulate battery temperature during high load conditions, ensuring thermal stability. Chemical or gas sensors are also integrated in certain systems to detect harmful substances that may indicate battery leakage or chemical reactions.

Overall, existing research demonstrates that combining IoT technology, WSN-based monitoring, and intelligent control systems can significantly improve renewable energy storage management. These approaches provide real-time monitoring, enhanced safety, and efficient energy utilization, forming the foundation for advanced smart battery management systems.

PROPOSED METHODOLOGY

The proposed system is designed to provide efficient renewable energy storage and intelligent battery management by integrating advanced monitoring, control mechanisms, and IoT communication technologies. The main objective of the system is to ensure safe battery operation, efficient energy utilization, and real-time monitoring of battery health parameters.

In this system, a rechargeable battery is used as the primary energy storage unit to store renewable energy generated from external sources such as solar or other sustainable power supplies. The stored energy is distributed to different components of the system to maintain stable and reliable operation. Proper battery monitoring is essential to prevent issues such as overcharging, overheating, and energy loss, which can affect system performance and battery lifespan.

An ESP32 microcontroller acts as the central processing unit of the system. It collects and processes data from various sensors and controls the connected devices accordingly. Voltage sensors continuously measure the battery voltage level to ensure that it operates within a safe range. At the same time, temperature sensors monitor the battery heat in degrees Celsius to detect abnormal temperature rises that may lead to battery damage or safety hazards. These sensors communicate with the controller through a Wireless Sensor Network (WSN) method, enabling efficient and reliable data transfer within the system.

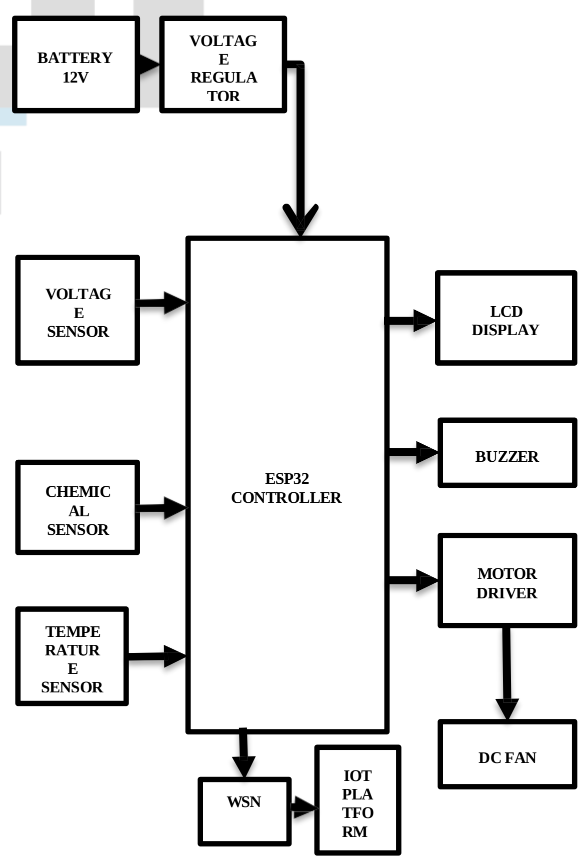
To enable remote monitoring and smart communication, the system integrates Internet of Things (IoT) technology. The ESP32 transmits the collected sensor data wirelessly to the cloud platform. Through IoT-based clustering within the network, the system can efficiently manage data communication and notify authorized personnel in real time using the Blynk platform. This allows users to monitor battery parameters remotely through a mobile application.

For local monitoring, an LCD display is incorporated to show real-time values such as battery voltage, temperature, and system status. A buzzer is also included to generate warning alerts whenever abnormal conditions such as excessive heat or voltage fluctuations are detected.

Additional components enhance system functionality and safety. A motor driver is used to regulate the speed of connected motors when required, while a DC fan provides cooling to maintain an optimal battery temperature. Furthermore, a chemical sensor is integrated to detect harmful chemical substances that may be released during battery malfunction or degradation.

By combining intelligent sensing, wireless communication, and automated control, the proposed system ensures reliable, safe, and efficient renewable energy battery management.

BLOCK DIAGRAM



RESULTS

The experimental results demonstrate that the proposed renewable energy storage and intelligent battery management system operates effectively with reliable monitoring and control. The integration of the ESP32 controller with voltage and temperature sensors successfully measured battery parameters in real time, ensuring safe battery operation. The Wireless Sensor Network (WSN) approach enabled efficient data communication between system components, reducing energy loss and improving overall performance. Sensor readings were continuously displayed on the LCD, allowing users to easily observe battery status and environmental conditions. The IoT-based monitoring through the Blynk platform provided instant notifications to authorized users whenever abnormal voltage, temperature rise, or chemical presence was detected. The buzzer alert system responded quickly to critical conditions, improving system safety. Additionally, the motor driver regulated the motor speed effectively, while the DC fan maintained proper battery temperature through automatic cooling. The chemical sensor further enhanced safety by detecting harmful gases. Overall, the system achieved stable performance, efficient energy management, and improved operational safety.

CONCLUSION

The proposed system successfully demonstrates an intelligent and efficient approach to renewable energy storage and battery management by integrating advanced sensing, control, and IoT technologies. The system utilizes a rechargeable battery to store renewable energy and distribute it effectively to various system components, ensuring stable power delivery and improved energy utilization. By incorporating an ESP32 microcontroller as the central controller, the system is capable of processing sensor data in real time and coordinating the operation of all connected modules with high reliability.

Continuous monitoring of battery parameters plays a crucial role in maintaining safe operation. The voltage sensor and temperature sensor measure battery voltage levels and thermal conditions in degrees Celsius using a Wireless Sensor Network (WSN) approach, enabling early detection of abnormal conditions such as overheating or voltage fluctuations. This helps prevent battery damage and enhances the overall lifespan of the energy storage unit.

The integration of IoT technology further strengthens the system by enabling wireless data transmission and real-time monitoring through the Blynk platform. Authorized users can remotely monitor battery status and receive immediate alerts when irregular conditions occur. The LCD display provides instant visualization of system parameters, while the buzzer serves as an audible warning mechanism for critical situations.

Additional safety and operational features enhance system reliability. The motor driver ensures controlled motor operation, and the DC cooling fan maintains optimal battery temperature during operation. Furthermore, the chemical sensor improves safety by detecting hazardous gases or chemical substances associated with battery conditions.

Overall, the proposed system offers a reliable, safe, and intelligent battery monitoring solution that supports efficient renewable energy storage, enhances system safety, and enables real-time remote monitoring for improved energy management.

FUTURE SCOPE

The future scope of the proposed renewable energy storage and intelligent battery management system can be further expanded by integrating advanced technologies to improve efficiency, reliability, and scalability. In future developments, the system can incorporate machine learning algorithms to predict battery health, optimize charging–discharging cycles, and extend battery lifespan. The integration of cloud-based data storage and analytics can enable long-term monitoring, historical data analysis, and predictive maintenance of energy storage systems. Additionally, the system can be enhanced by supporting multiple renewable energy sources such as solar and wind, creating a hybrid energy management platform. The use of more advanced sensors can improve accuracy in monitoring parameters like battery state of charge, chemical leakage, and environmental conditions. Mobile application integration and smart dashboards can provide more user-friendly remote monitoring and control. Furthermore, the system can be scaled for smart grid and microgrid applications.

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