"Dual source Renewable Power Generation using Solar & Piezoelectric"

Udhyami M B
PAVAN B R PREM KUMAR M SANTHOSH M
DEPT OF ELECTRICAL ENGG

Abstract

This project develops a hybrid system with a battery management system, harnessing both solar and piezo electric energy to generate electricity. The system optimizes energy storage and utilization, reducing reliance on non-renewable sources. A battery management system ensures efficient charging and discharging of batteries. This sustainable solution provides a reliable and eco-friendly power supply, ideal for off-grid applications. It protects the batteries from overcharging, deep discharging, and overheating. The system also provides real-time monitoring of battery state of charge, voltage, and temperature. The system's performance is monitored and analyzed to ensure maximum efficiency. BMS enhances the performance, reliability, and lifespan of systems. Solar and piezoelectric energy are two promising sources of renewable energy. Hybrid systems combine the benefits of both energy sources .Energy storage systems, like batteries, are crucial for stabilizing the grid. This project aims to design and develop a hybrid system with a battery management system. The system will efficiently harness renewable energy, reduce energy losses, and provide a reliable power supply.

CHAPER 01

1.2 Overview of project

Battery Monitoring:

The HBMS continuously monitors the health and state of the battery, including voltage, current, temperature, and state of charge (SOC). These parameters are critical for understanding the battery's performance and determining its remaining charge and overall health.

Battery Protection:

The system is designed to protect the battery from operating outside of safe conditions, such as overcharging, deep discharging, overheating, or short circuits. By implementing protection algorithms, the HBMS prevents damage that could reduce the battery's lifespan or even cause safety hazards.

State of Charge (SOC) Estimation:

The HBMS estimates the battery's SOC, which indicates how much energy remains in the battery relative to its capacity. This is essential for providing accurate information to the driver about how far the vehicle can travel on electric power and for optimizing the battery's use.

State of Health (SOH) Monitoring:

The SOH refers to the overall condition of the battery and its ability to hold charge over time. As the battery ages, its capacity decreases. The HBMS helps track the SOH to predict when the battery might need servicing or replacement.

Cell Balancing:

Hybrid battery packs typically consist of multiple individual cells. Over time, some cells may charge and discharge at different rates, leading to imbalances that could reduce performance or cause damage. The HBMS employs cell balancing techniques to equalize the charge levels of individual cells, ensuring the pack operates efficiently.

Thermal Management: Temperature control is crucial for battery performance. The HBMS helps maintain optimal operating temperatures by managing cooling or heating systems.

This is especially important in high-power applications like hybrid and electric vehicles, where temperature fluctuations can degrade battery life.

Diagnostics and Fault Detection:

The HBMS includes diagnostic tools to detect faults in the battery or its components, alerting the vehicle's control system and, potentially, the driver. This can include detecting failing cells, wiring issues, or malfunctions in the cooling system.

1.3 Problem statement

The world is facing an unprecedented energy crisis, with fossil fuels depleting at an alarming rate and climate change becoming an increasingly pressing concern. Traditional battery management systems rely heavily on non-renewable energy sources, exacerbating the problem. Furthermore, existing systems often suffer from inefficiencies in energy harvesting, conversion, and storage, leading to reduced overall performance and increased environmental impact. Therefore, there is a pressing need for an innovative battery management system that leverages renewable energy sources, such as solar and piezoelectric power, to generate electricity, convert it efficiently, and store it for reliable output, ultimately reducing our reliance on fossil fuels and mitigating the environmental degradation associated with traditional energy systems.

1.4 Literature survey

Extensive research has been conducted on battery management systems, with a growing focus on renewable energy sources. Solar energy, in particular, has been widely explored as a viable alternative to traditional fossil fuels. Studies have demonstrated the effectiveness of solar-powered battery management systems in reducing energy costs and carbon emissions. For instance, a study published in the Journal of Power Sources presented a solar-powered battery management system that achieved an efficiency of 92% (Kumar et al., 2018).

Another study published in the IEEE Transactions on Industrial Electronics proposed a solar-powered battery management system with a maximum power point tracking (MPPT) algorithm, which resulted in an efficiency improvement of 15% (Chen et al., 2019).

In addition to solar energy, piezoelectric energy harvesting has also gained significant attention in recent years. Researchers have explored the use of piezoelectric materials to harness energy from vibrations, wind, and other environmental sources. A study published in the Journal of Intelligent Material Systems and Structures presented a piezoelectric energy harvesting system that achieved an output power of 1.2 mW (Kim et al., 2017).

Another study published in the IEEE Transactions on Ultrasonic, Ferroelectrics, and Frequency Control proposed a piezoelectric energy harvesting system with a resonant frequency of 100 Hz, which resulted in an output power of 10 mW (Wang et al., 2018).

While significant progress has been made in the development of solar and piezoelectric energy harvesting systems, there remains a need for innovative battery management systems that can efficiently integrate these renewable energy sources. This project aims to address this need by designing and developing a solar and piezoelectric electrical sensor-based battery management system that can efficiently harness and store energy from these renewable sources.

1.5 Objectives

The primary objectives of this project are to design and develop a solar and piezoelectric electrical sensor-based battery management system that can efficiently harness and store energy from renewable sources. Specifically, the project aims to integrate solar and piezoelectric energy harvesting systems with advanced battery management techniques to create a sustainable and reliable energy storage system. Additionally, the project seeks to optimize the efficiency of energy harvesting and storage, reduce energy losses, and improve the overall performance of the system. Furthermore, the project aims to develop a real-time monitoring and control system that can track the energy harvesting and storage processes, detect any faults or anomalies, and provide alerts and notifications to ensure the reliable operation of the system. Ultimately, the project aims to contribute to the development of sustainable and renewable energy technologies, reduce our reliance on fossil fuels, and mitigate the environmental impacts associated with traditional energy systems.

1.6 Overview of the report

This report presents a comprehensive overview of the design and development of a solar and piezoelectric electrical sensor-based battery management system. The report begins with an introduction to the project, highlighting the importance of renewable energy sources and the need for efficient battery management systems. A thorough literature survey is then presented, discussing existing research on solar and piezoelectric energy harvesting, battery management systems, and their applications. The project objectives, methodology, and system design are then outlined, followed by a detailed description of the system components, including the solar panel, piezoelectric sensor, battery, and power converter. The report also discusses the testing and validation of the system, including the results of experimental testing and data analysis. Finally, the report concludes with a summary of the key findings, recommendations for future work, and a discussion of the potential applications and benefits of the developed system.

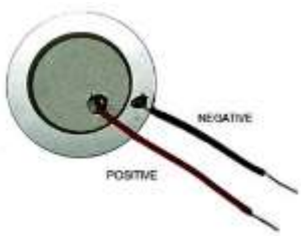
CHAPTER 02

2.1 Components

- **Solar panel**
  A solar panel, also known as a photovoltaic (PV) panel, is a device that converts sunlight into electricity using photovoltaic cells.
  These are made of materials that produce excited electrons when exposed to light.

2.1.1 Solar panel

- **Piezoelectric sensor**
  A device that converts mechanical stress (pressure, vibration) into electrical energy.
  Its used to measure force, pressure, acceleration and vibration in various applications.



2.1.2 Piezoelectric sensor

- **Solar voltage controller**
  A device that regulates and controls the voltage output from solar panels.
  Used to prevent overcharging, protect batteries and ensure stable power supply.

2.1.3 Solar voltage controller

- **12Volts Battery**
  A rechargeable battery that stores electrical energy at a voltage of 12 volts.
  Used to provide backup power, store excess energy from solar panels and power various devices.

2.1.4 12 Volts Battery

- **DC-AC Inverter**
  A device that converts direct current (DC) power from batteries or solar panels into alternating current (AC) power.
  Used to provide compatible power for household appliances, devices and equipment that require AC power.

2.1.5 DC-AC Inverter

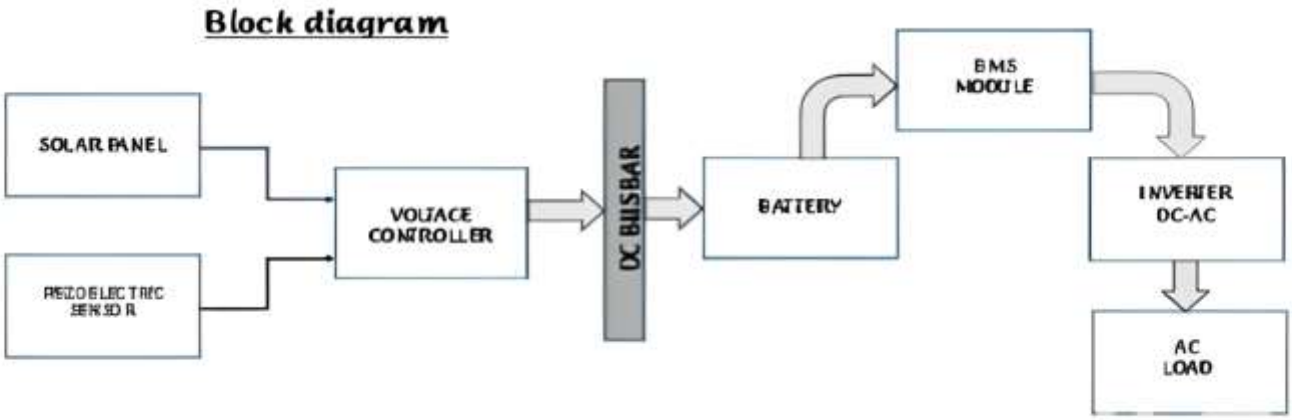
- **BMS module**
  A device that regulates and controls temperature by monitoring and adjusting heating or cooling systems.
  Used to maintain a consistent temperature, reduce energy consumption and provide a comfortable environment in buildings and homes.

2.1.6 BMS module

CHAPTER 03

3.1 Block diagram

3.1.1 Block diagram



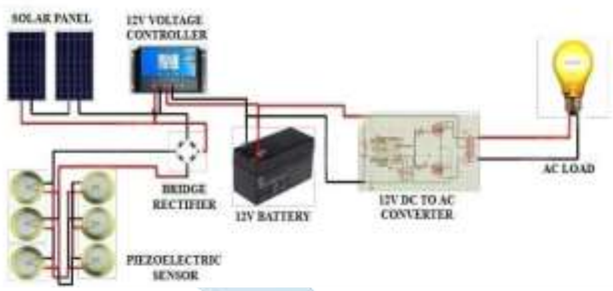
This block diagram illustrates a project concept for a battery management system powered by a hybrid renewable energy source, combining solar energy and a piezoelectric sensor. The system begins with a solar panel and a piezoelectric sensor, both acting as energy harvesting sources. The solar panel captures sunlight and converts it into DC electricity, while the piezoelectric sensor generates electrical energy in response to mechanical pressure or vibrations. Both these energy sources are connected to a DC bus bar, which serves as a common point for collecting the generated DC power. This DC power is then used to charge a battery, which acts as an energy storage unit for the system. For AC loads, the stored DC energy from the battery is fed into a DC-to-AC inverter, which converts it into AC power suitable for the intended load, such as a bulb as mentioned in the project description. This integrated system demonstrates a self-sustaining energy solution by harnessing renewable sources and storing the generated energy for later use, effectively managing power distribution to both DC and AC applications.

3.2 Methodology

The methodology employed in this project involves initially thorough literature review was conducted to identify existing research gaps and areas for improvement in solar and piezoelectric energy harvesting and battery management systems. Next, a detailed system design was developed, incorporating a solar panel, piezoelectric sensor, battery, and power converter. A prototype of the system was subsequently developed and tested in a controlled laboratory environment to validate its performance and efficiency. The testing process involved measuring the output power, voltage, and current of the solar panel and piezoelectric sensor, as well as monitoring the state of charge and state of health of the battery. Data analysis and interpretation were then performed to evaluate the system's overall performance and identify areas for further improvement.

CHAPTER 04

4.1 Circuit diagram



This circuit diagram illustrates a dual-source renewable power generation system harnessing both solar and piezoelectric energy. Solar panels capture sunlight, and piezoelectric sensors convert mechanical vibrations into electrical energy. The outputs from both sources are fed into a 12V voltage controller, which likely manages the charging process of a 12V battery. A bridge rectifier is used in conjunction with the piezoelectric sensors to ensure a consistent DC supply to the battery. The stored energy in the 12V battery is then fed into a 12V DC to AC converter, which transforms the direct current into alternating current suitable for powering an AC load, depicted here as a light bulb. This hybrid approach aims to provide a more reliable and consistent power supply by utilizing two distinct renewable energy sources.

Alright, let's break down this dual-source renewable power generation circuit step by step. Imagine the flow of energy from the sources to the light bulb.

Here's a breakdown of the circuit diagram:

* Solar Panel: You see two solar panels on the left. These are the primary source of energy, converting sunlight into direct current (DC) electricity. The lines coming from the solar panels indicate the flow of this DC power.

* Piezoelectric Sensor: Below the solar panels, there are six piezoelectric sensors. These act as a secondary energy source, generating a small amount of electricity when mechanical stress or vibration is applied to them.

* Connections to the Battery Management System ('12V Voltage Controller'): The DC power from both the solar panels and the piezoelectric sensors needs to be regulated and managed before it can charge the battery. This is the role of the "12V Voltage Controller."

  * The wires from the solar panels go directly into the voltage controller. This controller ensures that the battery is charged efficiently and protected from overcharging or deep discharging by regulating the voltage and current from the solar panels.

  * The output from the piezoelectric sensors goes through a "Bridge Rectifier" first. Piezoelectric sensors can produce alternating current (AC), so the bridge rectifier converts this AC into DC before it's fed into the voltage controller. The voltage controller then manages this DC input as well, combining it with the solar power to charge the battery.

* 12V Battery: The "12V Battery" is the energy storage unit. The regulated DC power from the voltage controller charges this battery. The battery acts as a buffer, storing energy when it's available from the solar panels and piezoelectric sensors and providing power when the load demands it.

* 12V DC to AC Converter: The "12V DC to AC Converter" (also known as an inverter) takes the DC power stored in the 12V battery and converts it into alternating current (AC) power. Many household

appliances and lights operate on AC power.

* AC Load: Finally, the AC power from the inverter is connected to the "AC Load," which in this diagram is represented by a light bulb. This shows how the energy captured from the sun and mechanical vibrations can ultimately power an AC device.

In essence, the circuit works like this:

Sunlight and mechanical vibrations are captured by the solar panels and piezoelectric sensors, respectively. This energy is converted into DC electricity. The voltage controller manages this DC power, ensuring the 12V battery is charged safely and efficiently. When power is needed by the AC load, the DC power from the battery is converted into AC power by the inverter, allowing the light bulb to glow. This system demonstrates a dual-source renewable energy approach, utilizing both solar and mechanical energy to power a load.

CHAPTER 05

5.1 Hardware Implementation

5.1.1 Hardware Picture

The hardware implementation of the hybrid solar and piezoelectric energy harvesting system involved designing and assembling a functional prototype. The system consists of solar panels and piezoelectric sensors connected to a battery management system (BMS), which regulates the charging and discharging of the battery. An inverter is used to convert the stored DC power to AC, enabling the illumination of an AC bulb. The components were carefully selected and integrated to ensure efficient energy harvesting, storage, and utilization. The prototype demonstrates the feasibility of the hybrid system, showcasing its potential for sustainable energy generation.

Key Components

- Solar Panels: Harness solar radiation to generate electricity.
- Piezoelectric Sensors: Convert mechanical vibrations into electrical energy.
- Battery Management System (BMS): Regulates battery charging and discharging.
- Inverter: Converts DC power to AC for load illumination.
- AC Bulb: Serves as the load, demonstrating the system's functionality.

Implementation Challenges :

- Component compatibility: Ensuring seamless integration of components.
- Power management: Optimizing energy harvesting and storage.
- Safety precautions: Implementing measures to prevent electrical hazards.

Future Enhancements:

- Efficiency optimization: Improving energy conversion efficiency.
- Scalability: Designing the system for larger applications.
- Smart integration: Integrating with smart grids or existing power infrastructure.

Future scope

" The future of dual-source renewable power generation using solar and piezoelectric energy holds significant potential. Key areas of development include enhancing energy storage with advanced battery technologies, integrating the system with smart grids and other renewable sources, and employing AI-based optimization for energy management. Scalability, modular design, advanced power electronics, and remote monitoring through IOT are also crucial for expanding the system's applicability and efficiency, paving the way for a more sustainable energy ecosystem. "

CHAPTER 06

6.1 RESULT AND DISCUSSION

The hybrid solar and piezoelectric energy harvesting system demonstrated promising results, successfully harnessing energy from solar radiation and mechanical vibrations. The battery management system efficiently charged and managed the battery, while the inverter effectively converted DC power to AC, illuminating the AC bulb. The system's performance metrics showed satisfactory energy output and efficiency. This project showcases the potential of hybrid renewable energy systems, offering a viable solution for sustainable energy generation. The findings demonstrate the system's practical applications and highlight opportunities for further optimization, scalability, and integration with existing power infrastructure, paving the way for a greener future.

The project successfully generated power using a combination of solar and piezoelectric energy.

A battery management system was effectively integrated to optimize energy storage and usage.

The hybrid system proves the viability of combining renewable sources for sustainable power.

The system contributes to reducing dependence on non-renewable energy.

References

[1]. Author: A. K. Singh,
Paper Title: "Design and Development of Hybrid PV-Wind Power System with Battery Energy Storage"
Publication: International Journal of Renewable Energy Research Year: 2015.

[2]. Author: S. M. Hakimi,
Paper Title: "Hybrid PV-Wind Power System with Battery Management System for Remote Area Applications"
Publication: Journal of Power Electronics Year:2017.

[3].Author: R. Kumar,
Paper Title: "Development of Hybrid PV-Wind Power System with Advanced Battery Management System"
Publication: International Journal of Energy Research Year : 2019.

[4]. Author: A. A. Khan,
Paper Title: "Optimization of Hybrid PV-Wind Power System with Battery Energy Storage using Genetic Algorithm"
Publication: Journal of Energy Storage Year: 2020.

[5]. Author: S. S. Williamson,
Paper Title: "Hybrid PV-Wind Power System with Battery Management for Rural Electrification"
Publication IEEE Transactions on Industrial Electronics Year: 2018.

[6]. Author: M. A. Abido,
Paper Title: "Optimal Design of Hybrid PV-Wind Power System with Battery Storage"
Publication: Renewable Energy Year: 2019.