MICRO-CONTROLLER BASED AUTOMATIC POWER MANAGEMENT SYSTEM FOR MULTIPLE ENERGY SOURCES

19EEE381 – Open Lab

Report

Submitted by

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MARCH-2025

Amrita School of Engineering

Department of Electrical and Electronics Engineering

Program Educational Objectives (PEOs)

PEO1: Graduate can demonstrate electrical and electronics engineering problem solving skill along with proficiency in communication and professional excellence in project management and execution.

PEO2: Graduate can be employable in engineering services including ICT enabled sectors and also motivated for entrepreneurship.

PEO3: Graduate will be competent for higher studies in world class universities and research in industrial organizations.

PEO4: Graduate will manifest social commitment, environmental awareness and moral and ethical values in professional and other discourses.

Program Specific Outcomes (PSOs)

PSO1: Build and manage electro dynamic systems using Knowledge on electrical technology and semiconductor devices for allied services.

PSO2: Use computational tools and network dynamics for design, analysis and control of power systems integrated with renewable energy and Electric Vehicle.

PSO3: Leverage digital technologies employing state-of- the art control techniques and embedded controllers for industrial applications.

BONAFIDE CERTIFICATE

This is to certify that the open lab project report entitled Micro-controller based Automatic Power Management system for multiple energy sources

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submitted by

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is in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology **in** "Electrical and Electronics Engineering" **is a bonafide record of the work carried out at Amrita School of Engineering, Coimbatore.**

Internal Examiner

External Examiner

CONTENTS

ABSTRACT

The growing demand for efficient and reliable power distribution necessitates an intelligent energy management system capable of seamlessly switching between multiple power sources. This paper presents a microcontroller-based automatic power management system that efficiently selects and prioritizes available energy sources, including solar power, DC regulated power supply (DCRPS), and battery storage, to ensure uninterrupted power delivery to critical loads.

By employing an Arduino microcontroller, the system continuously monitors power availability and automates source selection through a relay-based switching mechanism, eliminating the need for manual intervention. Additionally, load prioritization ensures that essential loads receive power even during limited energy availability. Designed for autonomous operation, this solution is well-suited for renewable energy integration, smart energy grids, and off-grid power applications. Its cost-effective and scalable architecture makes it a viable choice for modern power management challenges, ensuring efficient and optimized energy utilization.

INTRODUCTION

The challenges of environmental sustainability and energy efficiency are global concerns, affecting both developed and developing nations. The increasing dependence on electrical power for industrial, commercial, and residential applications has emphasized the need for reliable and uninterrupted power supply systems. However, power outages, fluctuations, and maintenance-related interruptions remain persistent issues, impacting critical sectors such as hospitals, industries, educational institutions, and households. The need for an efficient automatic power management system has become imperative to ensure seamless energy availability while integrating sustainable energy sources.

In many parts of the world, including developing regions, energy infrastructure struggles to meet rising demands, resulting in frequent power disruptions. While industrialized nations have advanced energy management systems, many regions still rely on conventional, manually operated power switching mechanisms, which are inefficient and prone to delays. The adoption of automated power management systems offers a transformative solution by dynamically switching between multiple energy sources, optimizing energy utilization, and reducing dependency on any single source.

Unlike conventional systems that rely primarily on single-source solar energy, which may suffer from efficiency limitations and high costs, the proposed system employs a hybrid energy approach to enhance efficiency and reliability. By utilizing a microcontroller-based decision-making system, the project ensures seamless transition between power sources, minimizing energy wastage and preventing load interruptions.

The development of such an automated power switching mechanism not only improves energy security and efficiency but also contributes to the goal of sustainable energy management. The subsequent sections of this paper provide a detailed discussion of the system architecture, operational methodology, implementation strategies, and results.

PROBLEM STATEMENT

The challenges of environmental sustainability and energy efficiency are global concerns, affecting both developed and developing nations. The increasing dependence on electrical power for industrial, commercial, and residential applications has emphasized the need for reliable and uninterrupted power supply systems. However, power outages, fluctuations, and maintenance-related interruptions remain persistent issues, impacting critical sectors such as hospitals, industries, educational institutions, and households. The need for an efficient automatic power management system has become imperative to ensure seamless energy availability while integrating sustainable energy sources.

In many parts of the world, including developing regions, energy infrastructure struggles to meet rising demands, resulting in frequent power disruptions. While industrialized nations have advanced energy management systems, many regions still rely on conventional, manually operated power switching mechanisms, which are inefficient and prone to delays. The adoption of automated power management systems offers a transformative solution by dynamically switching between multiple energy sources, optimizing energy utilization, and reducing dependency on any single source.

This project proposes a Microcontroller-Based Automatic Power Management System that integrates multiple energy sources, including solar power, DC regulated power supply (DCRPS), and battery storage, to ensure a continuous and stable power supply. Unlike conventional systems that rely primarily on single-source solar energy, which may suffer from efficiency limitations and high costs, the proposed system employs a hybrid energy approach to enhance efficiency and reliability. By utilizing a microcontroller-based decision-making system, the project ensures seamless transition between power sources, minimizing energy wastage and preventing load interruptions.

The development of such an automated power switching mechanism not only improves energy security and efficiency but also contributes to the broader goal of sustainable energy management. The proposed system can be deployed in smart energy grids, renewable energy applications, and standalone power management systems, making it a viable solution for both urban and rural electrification challenges. The subsequent sections of this paper provide a detailed discussion of the system architecture, operational methodology, implementation strategies, and performance evaluation of the proposed model.

METHODOLOGY

The Microcontroller-Based Automatic Power Management System is designed to ensure an uninterrupted power supply by dynamically selecting the most efficient energy source from multiple available inputs. The system integrates solar power, DC regulated power supply (DCRPS), and battery storage, with an Arduino microcontroller serving as the central control unit. The methodology for implementing this system is structured as follows:

1. System Architecture Design

The proposed system consists of three primary components:

- Power Sources: The system integrates multiple power sources, including solar panels, DCRPS, and battery storage, each connected to the load through a relay-based switching mechanism.
- Control Unit: An Arduino microcontroller is programmed to monitor the voltage levels of each source and make real-time switching decisions based on availability and priority.
- Load Management: A relay driver circuit ensures the correct source is selected and supplies power to the load without interruption.

2. Power Source Monitoring and Decision Algorithm

- Voltage sensors are used to measure the availability and condition of each power source.
- The microcontroller processes this data and compares it against predefined threshold values to determine which source should be activated.
- A priority-based algorithm is implemented, where:
  - Primary Source: Solar power (if available) is prioritized for sustainability.
  - Secondary Source: DCRPS is selected in case of solar power failure.
  - Backup Source: Battery storage is activated only when both primary and secondary sources are unavailable.

3. Relay-Based Automatic Switching Mechanism

- The system employs electromechanical relays to facilitate the transition between different energy sources.
- The relay driver circuit receives control signals from the microcontroller and activates the corresponding power source without delay.
- This ensures seamless switching without manual intervention, preventing downtime and power disruptions.

4. System Implementation and Hardware Integration

- The Arduino microcontroller is programmed using Embedded C within the Arduino IDE environment.

- Voltage readings from sensors are continuously monitored, and switching decisions are executed in real-time.
- An LCD display provides live updates on the active power source, enhancing system transparency.

5. Testing and Performance Evaluation

- The system undergoes multiple test scenarios to validate its reliability, including:
    - Simulating power failures to evaluate automatic source switching.
    - Measuring response time during power source transitions.
    - Assessing energy efficiency under varying load conditions.
- Data from these tests is analyzed to ensure optimal functionality and system stability.

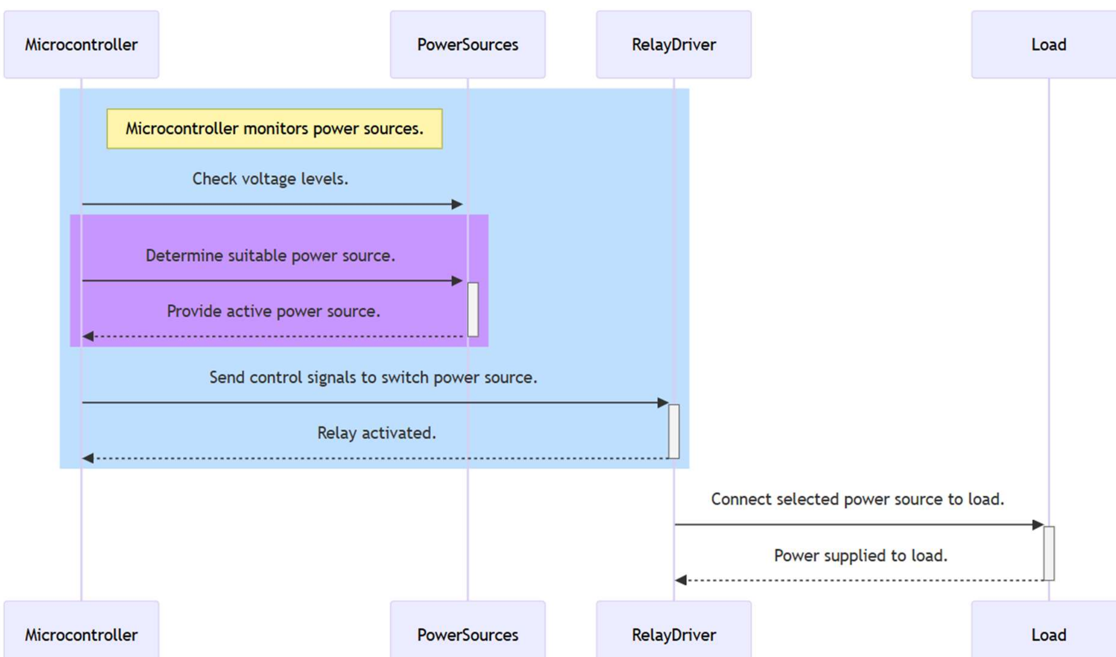


Fig.1

Fig.1 represents the flowchart of the methodology of Automatic power management

RESULTS

SIMULATION RESULTS:

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. This simulation is used in order to demonstrate the project in software model.

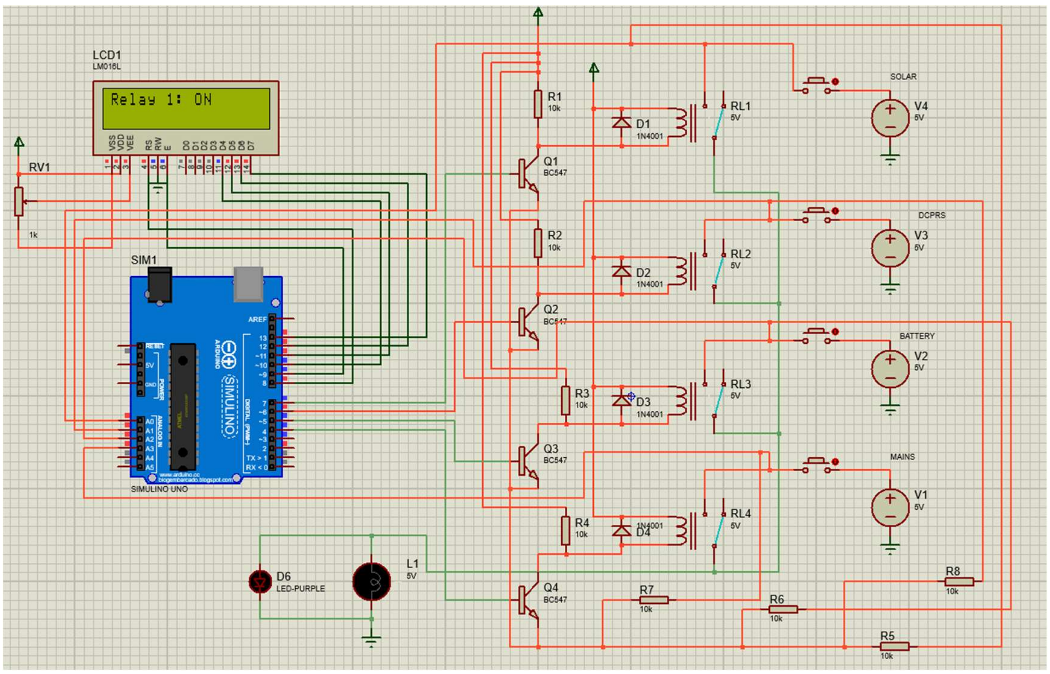
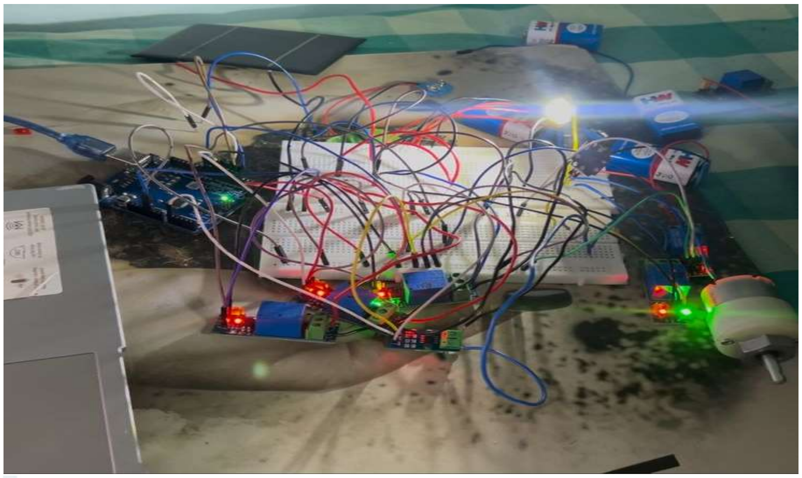


Fig.2

Fig.2 demonstrates that the power automatically switches through the relay and each times the relay switches, it will be displayed on the LCD.

HARDWARE RESULTS



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🔋 Active Power Source: Solar
⚡ Current: 1.10 A
⚠ Overcurrent protection is inactive (Not on Battery Mode)
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🔋 Active Power Source: Solar
⚡ Current: 0.90 A
⚠ Overcurrent protection is inactive (Not on Battery Mode)
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---------------------------------
🔋 Active Power Source: Grid Mains
⚡ Current: 1.00 A
⚠ Overcurrent protection is inactive (Not on Battery Mode)
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---------------------------------
🔋 Active Power Source: Grid Mains
⚡ Current: 0.76 A
⚠ Overcurrent protection is inactive (Not on Battery Mode)
---------------------------------
---------------------------------
🔋 Active Power Source: Battery
⚡ Current: 0.76 A
❌ Overcurrent on Battery! Load is OFF (Relay 4: OFF, Relay 5: ON)
---------------------------------

---------------------------------
🔋 Active Power Source: Battery
⚡ Current: 0.46 A
❌ Overcurrent on Battery! Load is OFF (Relay 4: OFF, Relay 5: ON)
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CONCLUSIONS & FUTURE WORK

In modern power systems, ensuring a reliable and uninterrupted energy supply is crucial, particularly in applications where downtime can have severe consequences. This project successfully implements an automated power management system that eliminates the inefficiencies of traditional manual switching methods by integrating a microcontroller-controlled decision-making process. The system intelligently selects the most suitable energy source, whether solar power, DC regulated power supply (DCRPS), or battery storage to optimize energy utilization and maintain continuous operation.

The experimental results validate the system's ability to seamlessly transition between energy sources, ensuring stability and efficiency under varying power conditions. By automating source selection, this approach minimizes energy wastage, reduces dependency on human intervention, and enhances power reliability. Furthermore, the system's adaptability makes it a viable solution for diverse applications, including renewable energy integration, off-grid electrification, and smart energy grids. As energy demands continue to rise, intelligent management systems like this will play a key role in sustainable and efficient power distribution.

REFERENCES

[1] Kim, H.S. and Yoon, J., "Hybrid distributed stochastic addressing scheme for ZigBee/IEEE 802.15. 4 wireless sensor networks", Etri Journal, 33(5), pp.704-711, 2011.

[2] Fakharuddin, Azhar & Abdalla, Ahmed & Rauf, Muhammad & Kamil, Nik & Ahmad, Salman & Mustufa Y., S., A smart energy management system for monitoring and controlling time of power consumption. Scientific Research and Essays. 7. 10.5897/SRE11.160, 2012.

[3] XIAOYU YANG, (2021), "Power Grid Fault Prediction Method Based On Feature Selection And Classification Algorithm" Int. J. of Electronics Engineering and Applications, Vol. 9, No. 2, pp. 34-44, DOI 10.30696/IJEEA.IX.I.2021.34-44..

[4] Zmieva K.A., Kuznetsova E., Intelligent Power Consumption Management Systems Ugleva E.M., V. Research and Education Center «Energy Efficiency in Industry», Moscow State University of Technology «STANKIN», Moscow, Russian Federation, 127994.

[5] Asare-Bediako, B., Ribeiro, P.F. and Kling, W.L., "Integrated energy optimization with smart home energy management systems. In innovative Smart Grid Technologies (ISGT Europe)", 3rd IEEE PES International Conference and Exhibition on (pp. 1-8). IEEE, Oct 2012.

[6] Li, T.K., Hing, K.C.T., Tin, C.C., Cheun, A.H.L., Wei, T.R. and Dat, C.Y., "Development of an automated multiple power sources switching and monitoring system. In Sustainable Utilization and Development in Engineering and Technology (STUDENT)", IEEE Conference on (pp. 271-276). IEEE Oct. 2012.

[7] Kulkarni, P.H., Wafgaonkar, M.R., Gujarathi, M.S.S. and Ahirrao, M.G., Alcohol Detection and Automatic Drunken Drive Avoiding System. International Journal of engineering Research and Applications, 1(4), pp.21-24, April 2014.

[8] Jagan K, Parthiban E Manikandan B,(2021), "Engrossment of Streaming Data with Agglomeration of Data in Ant Colony" Int. J. of Electronics Engineering and Applications, Vol. 9, No. 1, pp. 19-27, doi 10.30696/IJEEA.IX.I.2021.19-27.

[9] Due-Man Han and Jae-Hyun Lim, Member, IEEE," Design and Implementation of Smart Home Energy Management System based on ZigBee," IEEE Transactions on Consumer Electronics, Vol. 56, No. 3, August 2010.

[10] Due-Man Han and Jae-Hyun Lim, Member, IEEE," Design and Implementation of Smart Home Energy Management System based on ZigBee," IEEE Transactions on Consumer Electronics, Vol. 56, No. 3, August 2010.