Volume 9, Issue 5, May – 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY721

Hybrid and Smart Energy Management System using Arduino

Ayush Gautam, Vidhi Shrivastav
Dr. Vinay Kumar
Department of ECE,
GL Bajaj Institute of Technology and Management, Greater Noida

Abstract:- An innovative solution to the ever-increasing efficiency of energy and challenges is presented in the Smart and Hybrid of Energy Management System using Arduino. At the heart of a system is the use of Arduino as a central control unit, offering a cost-effective and flexible framework for real-time should be monitored and control of energy used. The integration of renewables, with a particular focus on photovoltaics, is a very important feature of this scheme. To ensure the best possible use of solar, Arduino controllers have the best role in gathering real-time data on Solar Energy Production. At the same time, by monitoring charge and discharging cycles, the system effectively manages the storage of batteries. In periods of reduced renewable energy production or increased demand, this drastic change in the control mechanism ensures that storage energy is used efficiently. The system shall control and monitor the distribution of electricity to each load, to further increase energy efficiency. The system optimizes energy that should be consumed and reduces both costs and the impact on the environment through the adaptation of power supply to need.

Keywords:- *Nearest level control (NLC), Total harmonic distortion (THD), Single switch open fault (SSOF), Multilevel inverter (MLI), Phase opposition disposition pulse width modulation (POD PWM),), Symmetric T-type Cross connected source (STTCCS).*

I. INTRODUCTION

In the need to sustain an effective use of resources, "a smart and hybrid energy management system using Arduino" introduces a revolutionary idea in this area. This system gives out an innovative solution in the face of increasing energy demand and a critical need to move towards renewable sources. The Arduino microcontrollers, which serve as an intelligent core that is real-time monitored and controlled, are central to its functionality. This system provides a dynamic and flexible framework for efficiency of energy optimization, responding to the problems of traditional energy management methods. It adopts a cost-effective and flexible approach to align with the growing trend of the IoT in smart systems through the integration of the smart system of work Arduino microcontrollers. Integration of renewable energy, in Solar panels is the of this system. By taking and analyzing real-time energy production data, Arduino controllers play an important role in ensuring the best use of solar power. At the same, the system intelligently manages the energy storage of the batteries, ensuring that energy is stored. Moreover, this system emphasizes the monitoring and control of load to increase energy efficiency in the real world. The ability to dynamically adapt the distribution of the energy for each load is a step towards optimized energy consumption, which leads to cost savings and low impact on the environment. With the help of Arduino, users will gain valuable into energy trends and be able to make informed decisions using real-time data logging and visualizing capabilities. The system's adaptive control algorithms, which are capable of drastic changes in the energy demand, supply, and storage conditions, give it a level of sophistication. The smart and hybrid energy of the management system with Arduino is emerging as a beacon for innovation in today's complicated energy scene. The system's potential to recast energy management paradigms in different contexts is illustrated and sets the stage for an examination of it.

II. LITERATURE REVIEW

The literature review provides a considerable survey of research and developments in hybrid renewable systems, grid integration, and battery management. In the domain of renewable energy, solar stands as a good source, studies show its potential for wide adoption and grid integration. Research has highlighted the problems connected with the variability inherent to solar generation and the critical role of energy storage in making these issues. Various types of battery technologies , range from traditional lead-acid batteries to more advanced lithium-ion and flow battery systems. the efficiency, performance, and cost-effectiveness of this technology in renewable energy setup, shedding light on their suitability for applications and operation situations.

The evolution of battery management systems (BMS) witnessed many advancements driven by the requirement for better and adaptive control solutions. In old BMS primarily focused on basic things such as voltage monitor and overcharge protection. However, the advent of smart BMS solutions in a new era of energy manages by real-time monitoring, analytics, and grid interaction capabilities. These smart BMS systems leverage control algorithms to energy utilization, extend battery span, and make better grid stability. While existing literature says the potential of smart BMS in improving energy efficiency and reliability, challenges such as scalable, interoperable, and necessary further innovation and research in the work.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY721

Moreover, the hybrid of renewable energy sources with the grid introduces additional and more opportunities. Studies have explored various grid strategies, including grid-tied and off-grid systems, microgrid deployed, and demand-side management techniques. Grid systems allow for a bi-directional flow of power between renewable sources energy, battery, and the grid, enabling more energy to be exported or imported depending on demand and need of signals. In contrast, off-grid and microgrid and resilience, cater to isolated communities and hard infrastructure. In addition, demand-side management techniques such as load shift, and peak shaving have been investigated to optimize energy consumption and give stress on the grid during peak demand periods.

A. System Architecture:

The Smart Hybrid Battery Management System is developed to provide the linchpin in solar-to-battery and grid setups. It is made up of Arduino board microcontrollers for real-time monitoring and controlling, sensors for data making, switch relays between solar panels, batteries ensured by the modular architecture, and grid energy sources, all the communication models that communicate with each other. Flexibility, scale, and interoperability with the existing infrastructure.

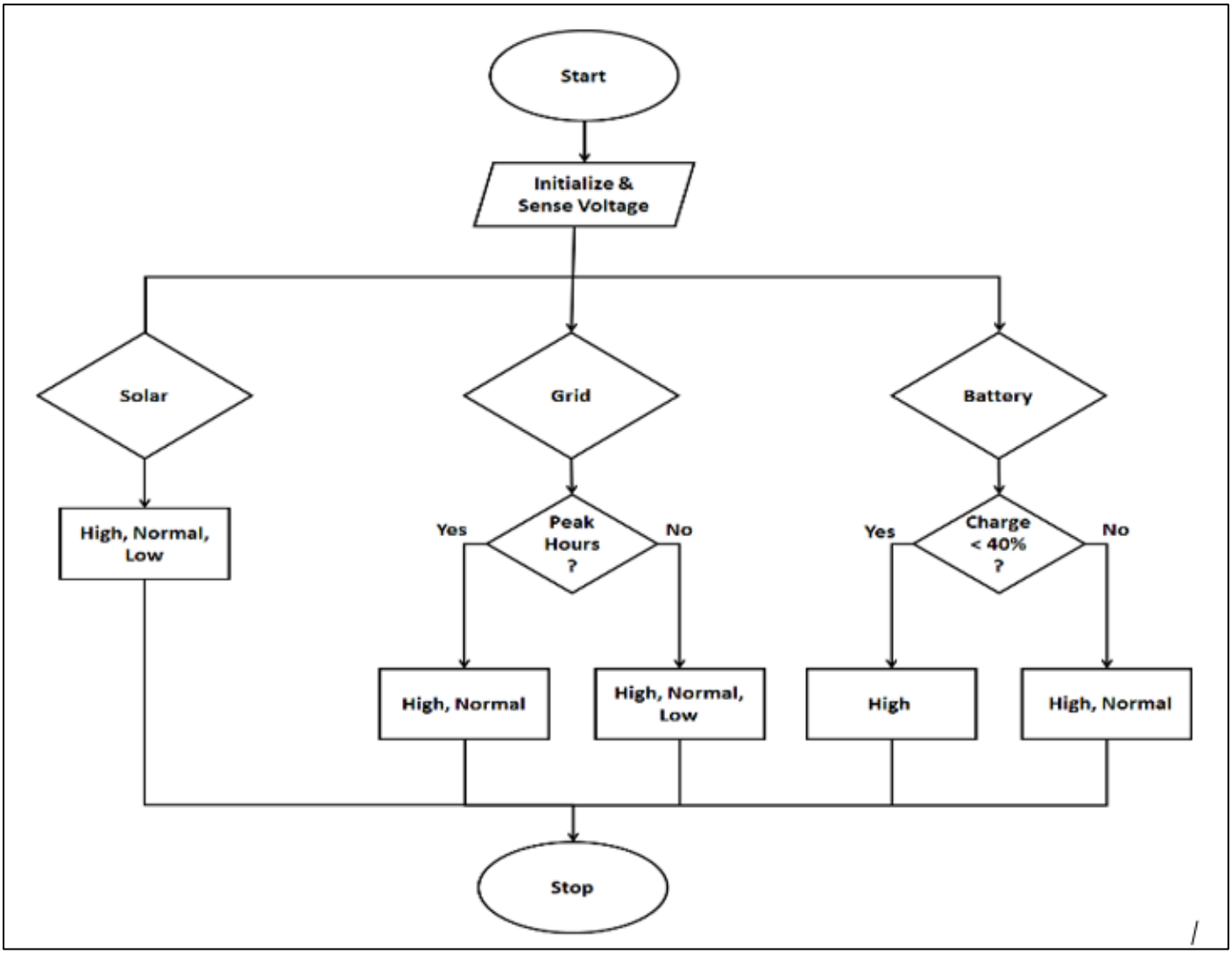

Fig 1: Flowchart

B. Functionality:

The function of the Smart Hybrid Battery management system spans many domains including:

- **Real-time monitoring**: Sensors monitor parameters such as battery voltage, battery, temperature, and solar irradiance.
- **Intelligent control:** Arduino kept sophisticated algorithms to optimize discharge and charging processes, giving importance to energy sources, and ensuring a seamless grid to integrate.
- **Grid integration:**
- Communication of the modules allows interoperability within the grid, allowing the exchange of power and demand main to get the functions implemented.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY721

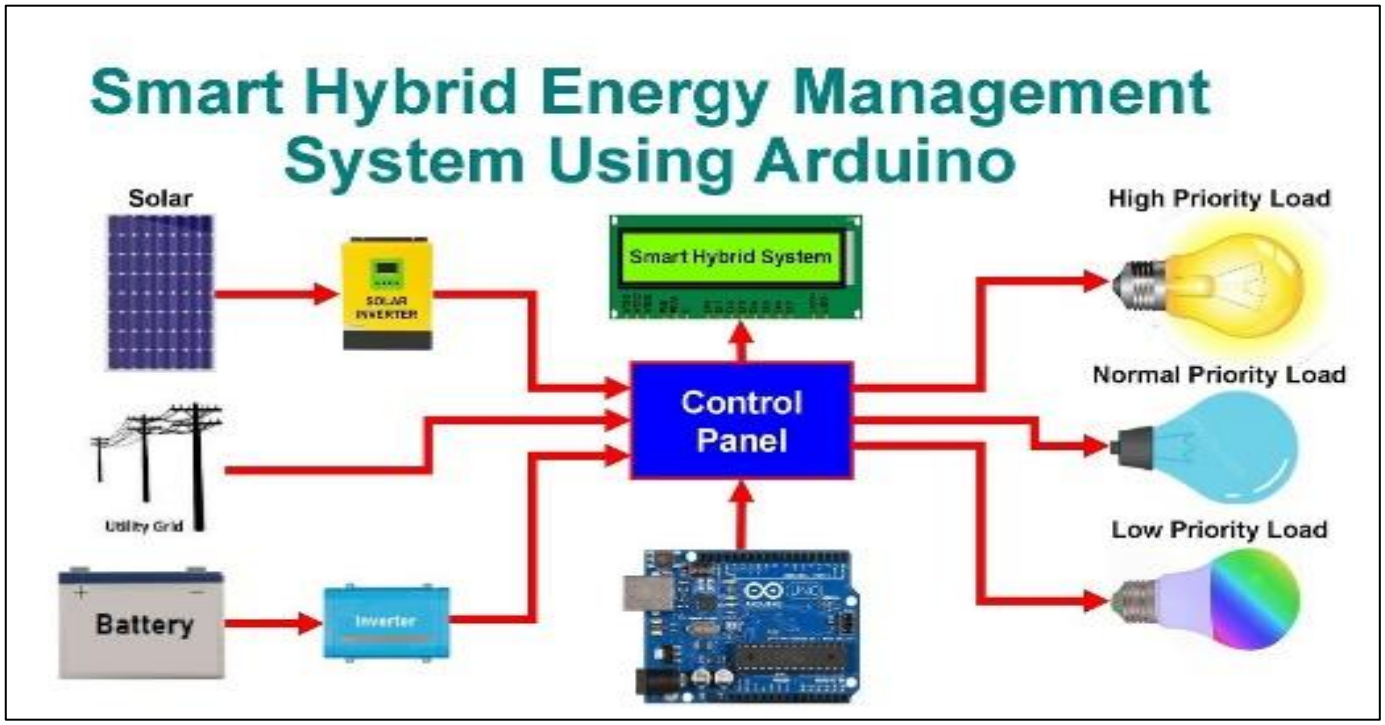

Fig 2: Smart Hybrid Energy Management System using Arduino

C. Implementation:

Assembly of hardware and sensor calibration, development of firmware, and integration of the system should be part of the establishing stage. Versatile programming of the Arduino environment is being harnessed to develop the firmware custom-tailored to the requirement of solar panel to battery and then to grid integration scene.

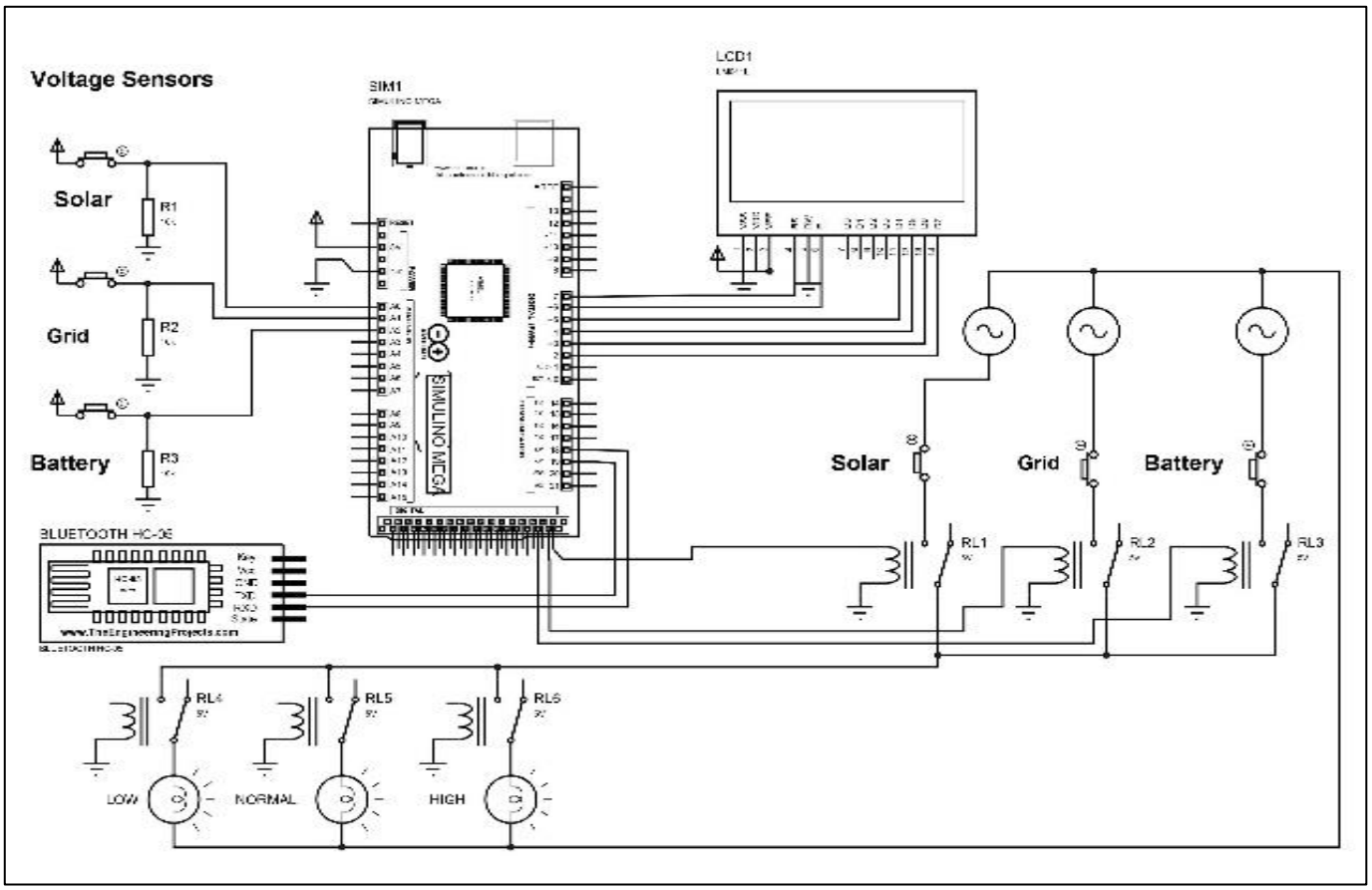

Fig 3: Implementation

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY721

D. Performance Evaluation:

Testing in the real world and the study of simulation are taken out rigidly to assess the performance of Smart and Hybrid battery management systems. To verify the presence of the given solution, important performance metrics are grid stability of energy and enhancement of efficiency, and the response time should be calculated from different perspectives of operational conditions.

III. CONCLUSION

In conclusion, an important step towards realizing the full efficiency of a hybrid system of renewable systems is taken with the implementation and development of an intelligent BMS. This solution set the stage for the sustainable production of energy, grid, and energy independence through the seamless integration of solar with the battery and networks. To improve system scale interoperability and efficiency further research and development efforts are granted.

FUTURE DIRECTION

Future research efforts should be on improving BMS intelligence by developing the edge cutting of learning machine algorithms researching new energy-storing technology and expanding the grid interaction and functionalities. It would be easy for the widespread integration and adaptation of BMS into energy infrastructure. If efforts are made to interoperability standards and harmonize protocols, then it becomes easier to establish things adequately.

REFERENCES

[1]. M.H. Rashid, Power Electronics Circuits, and the Devices and Applications, India: Pearson Education Inc.,2004.

[2]. Gupta, K. K., Ranjan, A., Bhatnagar, P., Sahu, L. K., & Jain, S. (2016). Multilevel inverter topology with the reduced device of count: A review. *IEEE Transactions on Power Electronics*, *31*(1), 135–151.

[3]. Gupta, K. K., & Jain, S. (2014). A multilevel inverter based on switched DC sources. *IEEE Transactions on the Industrial Electronics*, *61*(7), 3269–3278.

[4]. Agrawal, R., & Jain, S. (2017). *IET Renewable Power can be Generated. 11*(14), 1822–1831.

[5]. A, M. R., & Sivakumar, K. (2015). A Fault-Tolerant Single-Phase Five-Level Fault-Tolerant Single-Phase Inverter for Grid-Independent PV Systems. *IEEE Transaction of the Industry Electronics*, *62*(12), 7569– 7577.

[6]. Chen, A., Hu, L., Chen, L., Deng, Y., Yao, G., & He, X. (2004). A fault-tolerant ability. *Conference for the Proceedings of* Multilevel Converter Topology. – *IEEE APPLIED POWER ELECTRONICS CONFERENCE- APEC*, *3*(2), 1610–1616.

[7]. Haji-Esmaeili, M. M., Naseri, M., Khoun-Jahan, H., & Aba pour, M. (2017). Fault-tolerant structure for cascaded h-bridge multilevel inverter and reliability evaluation. *IET Power Electronics*, *10*(1), 59–70.

[8]. Saadian & Hosseini S.M. (2017). Cascaded multilevel inverter based on symmetric-asymmetric DC sources with fewer components. *IET Power Electronics*, *10*(12), 1468–1478.

[9]. Axelrod, B., Berkovich, Y., & Voinovich, A. (2003). Fault Tolerant H-Bridge for New Circuit Topology. *Proceedings in the year of 2003 an International conference on System and Circuits, in 2003. ISCAS '03.*, *3*(6), 1509–1516.