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Integrated Battery System to Control Fused Energy for Grid Flexibility

Maineni Vijayasanthi, P. Nikhitha, G. Abhiram, N. Varun, S. Krishna

Assistant Professor, Dept. of Electrical and Electronics in Engineering, CMR College of Engineering and Technology
(Medchal), Hyderabad, India

Dept. of Electrical and Electronics in Engineering, CMR College of Engineering and Technology (Medchal),
Hyderabad, India

ABSTRACT: The inclusion of viable energy similar as solar energy into the grid presents provocations due to irregular downfall conditions leading to grid insecurity the fused energy control and handling system for enhanced stability addresses this confrontations by integrating solar energy with non renewable sources and battery storehouse this system prioritizes sustainable energy while icing a smooth transition by incorporating non renewable energy when demanded a stabilized battery operation system BMS optimizes stored energy operation icing effective distribution real- time monitoring and prophetic analytics anticipate energy conditions optimizing resource allocation and reducing its dependence on archconservative powers fresh features similar as fault discovery environmental monitoring and enhanced security measures insure energy responsibility and unborn scalability.

KEYWORDS: Grid, Fused Energy, Battery Management System.

I. INTRODUCTION

A Integrated Battery system to control Fused energy for enhancing stability is an extensive method to address the challenges caused by growing electricity demand and integration of viable energy sources. Solar energy, a widely used renewable source, has an unpredictable and variable nature of energy production due to weather conditions, posing challenges for grid stability and reliability. The grid may become unstable due to changes in voltage and frequency. To overcome this, a hybrid energy management system combines sustainable and conventional energy sources with advanced storage and distributed technology.

Sustainable energy alone cannot adequately supply a stable and consistent power supply due to its dependency on ecological factors. Established power grids rely entirely on conventional energy sources, which emit carbon and other harmful gases that are harmful to the atmosphere. This system for enhancing grid stability effectively manages both sustainable and conventional energy sources, ensuring grid stability, reliable energy access, and eco-friendliness.

The main purpose is for enhancing grid stability includes developing a system that integrates sustainable solar energy with conventional sources, implementing a dynamic energy balancing system that prioritizes solar power while supplementing it with thermal power and battery storage, and designing an intelligent Battery Management System (BMS) for optimal energy utilization and battery lifespan extension. Furthermore, predictive analytics are incorporated for energy production and consumption forecasting, ensuring seamless integration with the existing power grid while maintaining stability during peak load periods.

This also involves critical functions such as fault detection, load levelling, grid auditing, and enhanced security measures. These capabilities improve operational efficiency, minimize dependency on fossil fuels, and support the smooth adoption of additional sustainable energy sources in the future by optimizing energy resource utilization. This plays an important role in encouraging sustainability and enhancing grid flexibility.

II. LITERATURE SURVEY

India is exploring Non conventional energy sources such as wind and solar as viable alternatives for its future energy requirements. As of March 31, 2012, the grid-connected power generation from RES stood at 24,914 MW, representing approximately 12.1% of the total installed energy capacity. The Ministry of New and Renewable Energy (MNRE) of the Government of India has set goals to achieve 20,000 MW of grid-connected solar power and 38,500 MW from wind energy by 2022. However, various challenges related to the combinations of RES into the grid must be addressed. Given these trends, it is essential to explore potential solutions to these challenges. The integration of Non conventional energy sources into the utility grid is influenced by the scale of power generation; large-scale generation connects to transmission systems, while small-scale distributed generation links to distribution systems. There are specific provocations associated with the direct integration of both types of systems. This paper discusses the issues and challenges faced during the grid integration of various Non conventional energy sources, along with some proposed solutions. As of March 31, 2012, India had a renewable energy capacity of 24,914 MW, which constituted about 12.1% of the nation's total installed energy capacity. The Indian government, through the Ministry of New and Renewable Energy (MNRE), has set ambitious targets to further enhance renewable energy capacity, aiming for 20,000 MW of solar power and 38,500 MW of wind power by 2022.[1]

The increase in demand for electrical energy has predominantly been satisfied through the combustion of fossil fuels and the subsequent conversion of the heat produced. This ongoing reliance on fossil fuels has raised notable concerns regarding greenhouse gas emissions, particulate pollution, and their detrimental effects on the environment. Additionally, it highlights the sustainability of energy generation to meet future demands, specified that these fuels are not renewable. Non Conventional energy sources, such as solar, wind, and tidal power, present viable alternatives to address these challenges. The declining costs associated with solar and wind energy technologies have further enhanced their economic feasibility. Many governments are also incentivizing the adoption of clean energy through supportive policies. However, the widespread implementation of renewable energy sources introduces various technical challenges for power system engineers. It is essential to address these challenges before integrating renewable sources with traditional fossil fuel-based generation. This paper aims to identify the issues that arise from the incorporation of renewable energy sources into existing power grids and to explore potential solutions, particularly concerning voltage stability through the management of reactive and active power.[2]

The urgent need to reduce environmental impact is driving the rapid incorporation of renewable energy sources into the electrical grid. The fluctuated nature of renewable energy generation can lead to unpredictable electricity demand, which poses confrontations for system security and operation. To address the fluctuations in power generation caused by external factors such as wind speed, solar radiation, and climate changes, the establishment of a storage system is vital. An intelligent battery management system plays a key role in modern battery-operated devices, including electric vehicles, transferable electronics, and renewable energy storage solutions. It also contributes to extending the battery's lifespan, health, and efficiency. A fundamental component of battery management systems is the monitoring of the battery's state of charge. This study concentrates on tracking the battery's state of charge, temperature, and current within a solar panel system paired with a battery for residential applications. A microcontroller is employed for control functions, while analog sensors are used to measure voltage and current parameters. Furthermore, the research highlights the improvement of an adaptive IoT communication protocol to make possible of efficient data transfer between the battery management system and Thing Speak, thereby improving energy consumption in IoT settings.[3]

III. METHODOLOGY

The Integrated battery system to control fused energy for grid flexibility for enhanced grid stability integrates sustainable battery storage with Non Renewable energy sources to ensure reliable power distribution. It manages three battery packs, with two supplying power to the grid while the third undergoes charging. A relay switch dynamically alternates between battery packs based on their energy levels.

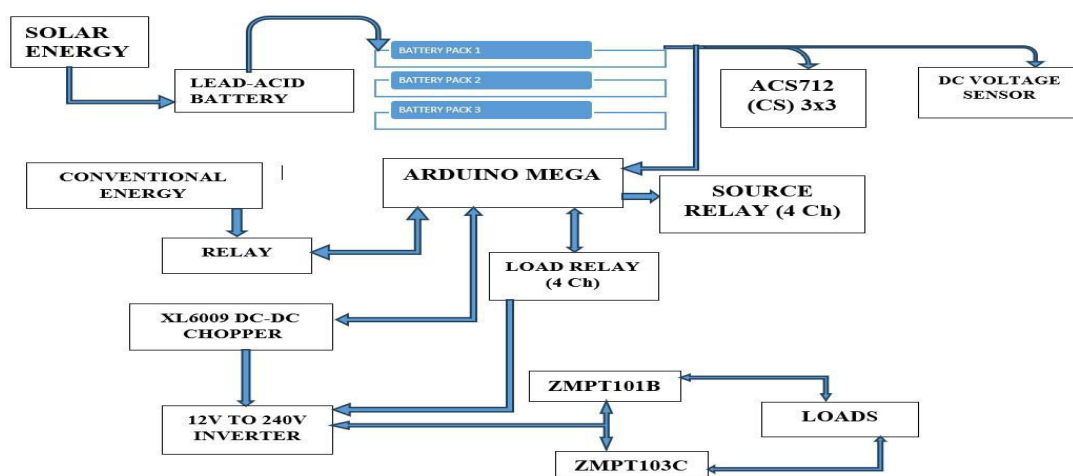
In the event of insufficient power, the system activates a conventional energy source to stabilize the load management system, facilitating controlled charging and discharging to prevent overloading, deep discharge, and overheating. The system continuously monitors battery voltage and current, optimizing power efficiency through a real-time monitoring system.

An LCD display and an ESP module enable remote monitoring and data logging, enhancing predictive energy management. This intelligent and scalable solution prioritizes sustainable energy utilization while relying on conventional sources only during peak load periods. Improving grid resilience, it reduces dependence on fossil fuels and promotes a transition toward sustainable energy sources.

COMPARISON

MANUAL SYSTEM	INTEGRATED AUTOMATED SYSTEM
Switching circuits like relays, converters and switch gears are operated manually.	ArduinoUNO/micro processors are used for automated switching
Delay operation while operating switch gears in the period of over loads and relay switching	Fast and efficient operation by Arduino code which make system more stable and flexible
Maintenance and repairs are high compared to integrated system	No maintenance and low repairs due to automated system and fast switching
Calibration of voltage and current across grid is difficult	Calibration of voltage and current across grid is simple and easy
Old method for switching circuits	Advanced method for switching circuit
No efficient battery management system	Efficient battery management system

BLOCK DIAGRAM



IV. DESCRIPTION OF COMPONENTS

Arduino: The Arduino Mega board serves as the central processor for the system. It operates data from sensors, communicates with the ESP module, and controls the relay mechanism. Arduino takes instructions from the code and processes the required data as the output.

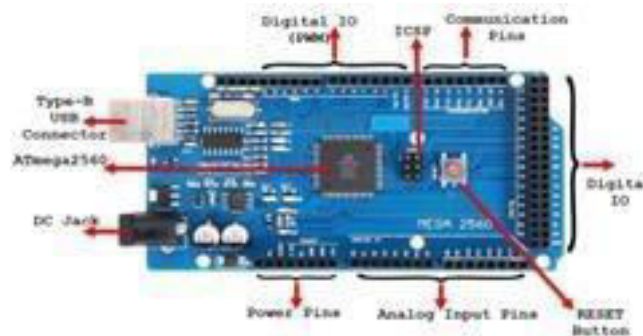


Fig 1: Arduino Mega.

Power supply: We require a appropriate power supply to dispense power for the Arduino Mega, “lithiumion” battery, “lead-acid” battery charging, sensors, and other components. A solidity chopper and inverter are also essential. warrant that the power supply can provide the necessary voltage and current.

LCD (Liquid Crystal Display): The LCD can display essential information about charging in battery pack, load current required, sensors reading and other components.



Fig 2: LCD display

Battery: We use lithium-ion battery pack, contain 6 cells connected in parallel to each other and. Also we utilizes lead acid battery for maintainable energy storage from solar panel.



Fig 3: li-ion battery.



Fig 4: lead acid battery

XL6009 Buck-Boost Chopper: This use to Step-up and step-down the voltage as per required output. Common terminal from all battery pack is connected to chopper to avoid fluctuation.

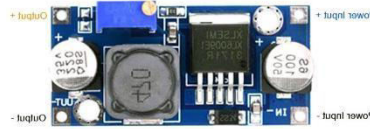


Fig 5: Buck-Boost chopper

Relay Module: The relay module is used to control both source and load side battery. It switch the conventional energy at peak loads.

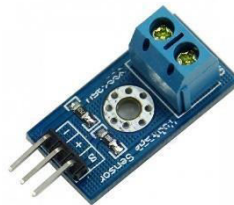


Fig 6: Relay module

ZMPT101B Voltage Sensor: It handle the required voltage to grid for satisfy the load.

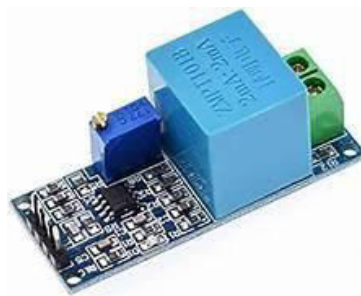


Fig 7: ZMPT101B Voltage sensor.

ZMPT103C Current sensor: This sensor predict required load to grid and course the data to micro processor which perform load stability.

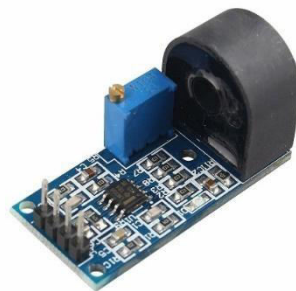


Fig 8: ZMPT103C current sensor

DC voltage and current sensors: We will use both (ACS712) current sensor and Voltage sensor to perceive the charging of battery to switch for better efficiency.



Fig 9: DC current sensor.



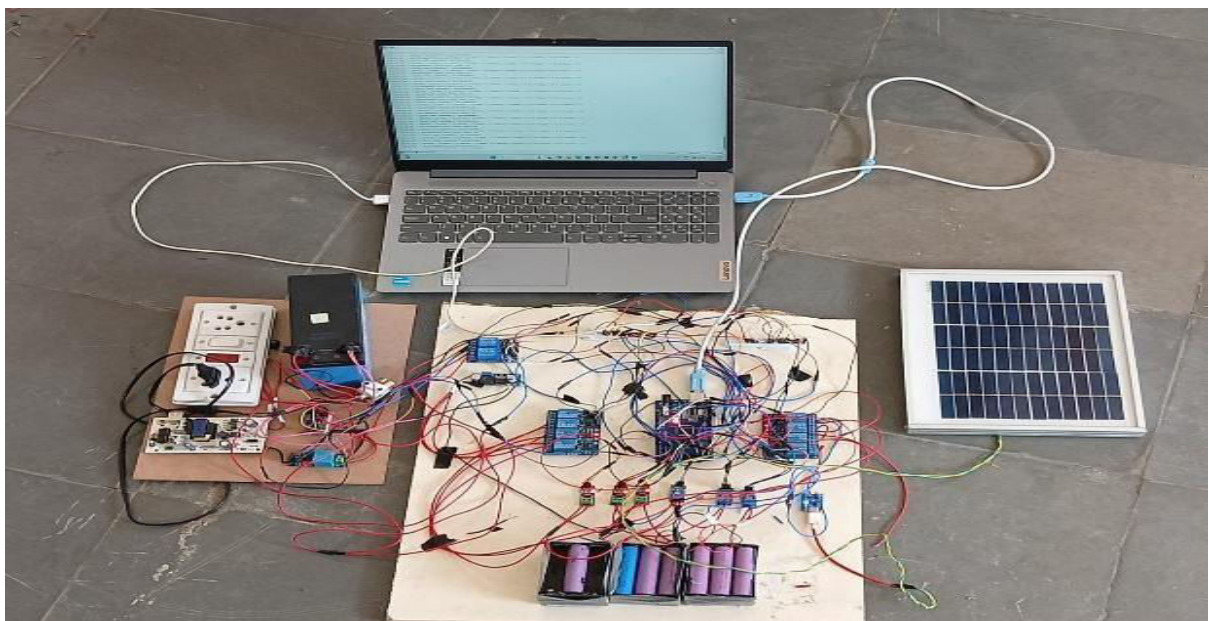
Fig 10: DC voltage sensor.

Solar panel: Solar panel is popular sustainable energy source. We use solar panel as renewable source for power supply to grid.



Fig 11: Solar panel

V. RESULTS



The serial monitor shows the battery capacity of charging and discharging, AC voltage, AC current, switching of relay as per requirement and non-renewable energy supply distribution.

```
11:52:15.058 -> Source Used: Renewable + Non-Renewable
11:52:16.096 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.69 AC Voltage: 9.46 AC Current: 1.17
11:52:16.190 -> Non-Renewable Source Relay State: ON
11:52:16.190 -> Source Used: Renewable + Non-Renewable
11:52:17.230 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.69 AC Voltage: 9.38 AC Current: 1.03
11:52:17.324 -> Non-Renewable Source Relay State: ON
11:52:17.372 -> Source Used: Renewable + Non-Renewable
11:52:18.361 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.69 AC Voltage: 9.43 AC Current: 1.03
11:52:18.455 -> Non-Renewable Source Relay State: ON
11:52:18.503 -> Source Used: Renewable + Non-Renewable
11:52:19.494 -> Battery 1 Voltage: 4.72 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.69 AC Voltage: 9.43 AC Current: 1.17
11:52:19.588 -> Non-Renewable Source Relay State: ON
11:52:19.635 -> Source Used: Renewable + Non-Renewable
11:52:20.625 -> Battery 1 Voltage: 4.72 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.69 AC Voltage: 9.41 AC Current: 1.17
11:52:20.720 -> Non-Renewable Source Relay State: ON
11:52:20.767 -> Source Used: Renewable + Non-Renewable
11:52:21.758 -> Battery 1 Voltage: 4.72 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.69 AC Voltage: 9.53 AC Current: 1.03
11:52:21.899 -> Non-Renewable Source Relay State: ON
11:52:21.899 -> Source Used: Renewable + Non-Renewable
11:52:22.938 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.69 AC Voltage: 9.43 AC Current: 1.17
11:52:23.032 -> Non-Renewable Source Relay State: ON
11:52:23.080 -> Source Used: Renewable + Non-Renewable
11:52:24.072 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.38 AC Current: 1.17
11:52:24.166 -> Non-Renewable Source Relay State: ON
11:52:24.213 -> Source Used: Renewable + Non-Renewable
11:52:25.205 -> Battery 1 Voltage: 4.72 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.53 AC Current: 1.03
11:52:25.299 -> Non-Renewable Source Relay State: ON
11:52:25.346 -> Source Used: Renewable + Non-Renewable
11:52:26.338 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.67 AC Voltage: 9.36 AC Current: 1.03
11:52:26.432 -> Non-Renewable Source Relay State: ON
11:52:26.479 -> Source Used: Renewable + Non-Renewable
11:52:27.473 -> Battery 1 Voltage: 4.72 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.41 AC Current: 1.03
11:52:27.567 -> Non-Renewable Source Relay State: ON
11:52:27.615 -> Source Used: Renewable + Non-Renewable

11:52:37.914 -> Source Used: Renewable + Non-Renewable
11:52:38.904 -> Battery 1 Voltage: 4.72 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.69 AC Voltage: 9.36 AC Current: 0.73
11:52:38.999 -> Non-Renewable Source Relay State: ON
11:52:39.047 -> Source Used: Renewable + Non-Renewable
11:52:40.039 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.67 AC Voltage: 9.38 AC Current: 0.88
11:52:40.133 -> Non-Renewable Source Relay State: ON
11:52:40.180 -> Source Used: Renewable + Non-Renewable
11:52:41.174 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.43 AC Current: 0.73
11:52:41.269 -> Non-Renewable Source Relay State: ON
11:52:41.316 -> Source Used: Renewable + Non-Renewable
11:52:42.305 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.67 AC Voltage: 9.43 AC Current: 0.73
11:52:42.447 -> Non-Renewable Source Relay State: ON
11:52:42.447 -> Source Used: Renewable + Non-Renewable
11:52:43.446 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.41 AC Current: 0.73
11:52:43.590 -> Non-Renewable Source Relay State: ON
11:52:43.590 -> Source Used: Renewable + Non-Renewable
11:52:44.596 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.34 AC Current: 0.88
11:52:44.691 -> Non-Renewable Source Relay State: ON
11:52:44.739 -> Source Used: Renewable + Non-Renewable
11:52:45.822 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.46 AC Current: 0.88
11:52:46.485 -> Non-Renewable Source Relay State: ON
11:52:46.485 -> Source Used: Renewable + Non-Renewable
11:52:46.893 -> Battery 1 Voltage: 4.67 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.67 AC Voltage: 9.41 AC Current: 1.03
11:52:46.988 -> Non-Renewable Source Relay State: ON
11:52:47.035 -> Source Used: Renewable + Non-Renewable
11:52:48.026 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.74 Battery 3 Voltage: 4.67 AC Voltage: 9.38 AC Current: 0.88
11:52:48.120 -> Non-Renewable Source Relay State: ON
11:52:48.167 -> Source Used: Renewable + Non-Renewable
11:52:49.163 -> Battery 1 Voltage: 4.69 Battery 2 Voltage: 4.72 Battery 3 Voltage: 4.69 AC Voltage: 9.48 AC Current: 0.88
11:52:49.258 -> Non-Renewable Source Relay State: ON
```

The primary battery charging in each individual battery pack B = 70 %, B2 = 95% & B3 = 99% in which charging fluctuates with respective battery discharge automatically with relay switching. AC voltage & AC current sensors are used to obtain load/grid voltage and current as required at load. B1, B2, & B3 are having its capacity of 6000mAH, 9000mAH & 10000mAH respectively. The paramount amount of energy is taken from renewable energy with the

detection of load required and then from non-renewable energy sources to maintain the reliability. The continuous readings are obtained from monitor and also can be view with mobile using ESP module.

VI. CONCLUSION

The project Integrated Battery System to control Fused Energy for Grid Flexibility is a progressive technique to challenge in periodic flow, commonly linked with sustainable energy source Especially the solar energy in inclusion of solar energy with conventional energy are employed as smart to assigning precedence sustainable energy with enhancement of Non Renewable when essential. This project warrant stability, sustainability and overall efficiency by balancing the integration of both energies. A main attribute is the battery management system. BMS which certify battery safety, durability and reliability also monitoring from the real time energy auditing ,efficiency optimization with help in energy saving practises across various applications service and decreases carbon emission, engaging in climate changes mitigation also encompass, the function like monitoring battery performance to prevent overheating, overcharging and other safety risk validating, whether the batteries are functioning optimally, enhance their lifespan and efficiency, starting the change of the batteries and tracing the performance to maximise their useful life glands into the future. The swap of the project is promising future development wild.

Expand the system capability in summary, this project will achieve increasing smarter, more sustainable energy system that can handle the fluctuations of Non Conventional energy products while maintaining stability and efficiency.

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