Micro Grid Hybrid PV Wind Battery Management System

Mr.N.MohanasundaramAssistant

Professor/EEEPaavai College of Engineering
Pachal,Namakkal,Tamilnadu

sundramnatesanpce@gmail.com

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Ms.M.Roshini
UGStudent/EEE
Paavai College of Engineering
Pachal,Namakkal,Tamilnaduroshinimanikandan69@gmail.com

Mr.M.KirthickRoshan
UG Student/EEE
Paavai College of Engineering
Pachal,Namakkal,Tamilnadum.roshan082003@gmail.com

Mr.K.Ruthraprasath
UG Student/EEE
Paavai College of Engineering
Pachal,Namakkal,Tamilnaduk.ruthraprasath2004@gmail.com

Mr.C.SudharshanabalajiUG Student/EEE
Paavai College of Engineering
Pachal,Namakkal,Tamilnadusudharshanbalaji2004@gmail.com

***Abstract*—This paper proposes a comprehensive management system for a microgrid integrating hybridphotovoltaic (PV) and wind power sources with battery storage. The system optimizes energyharvesting, reduces power fluctuations, and ensures a stable supply of electricity. Ahierarchical control strategy is employed, incorporating maximum power point tracking, battery state of chargemanagement, and grid synchronization. Simulation results demonstrate the effectiveness of theproposed system in mitigating intermittency, improving power quality, and enhancing overall efficiency. The developed management system offers a reliable and sustainable solution for remotecommunities, off-grid applications, and future smart grid infrastructure.**

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I. Introduction

As the world transitions toward sustainable enerYsolutions, microgrid systems integrating renewable energy sources have gained prominence. The hybrid microgrid concept combines photovoltaic (PV) and wind energy with advanced battery management to create a reliable and efficient power system. This approach leverages the complementary nature of solar and wind energy, ensuring consistent energy production regardless of weather variations. The inclusion of a battery management system (BMS) further enhances the microgrid's functionality by efficiently storing energy and maintaining its availability during peak demand or when renewable generation is insufficient.

The hybrid PV-wind microgrid not only minimizes dependence on fossil fuels but also addresses challenges such as grid instability and energy access in remote or off-grid areas. Solar panels generate energy during daylight hours, while wind turbines complement this by producing power during windy conditions, including nighttime. The BMS ensures optimal energy utilization, managing charging and discharging cycles to prolong battery life and prevent energy losses. Such systems are particularly beneficial for small communities, industrial plants, and rural areas seeking to reduce energy costs and carbon footprints.

The integration of IoT-based monitoring further enhances the efficiency and adaptability of these systems. Real-time data acquisition from PV panels, windturbines,andbatteriesprovidesinsightsintosystemperformance,allowing users to make informed decisions and detect faults proactively. This smart monitoringcapabilitymakesthehybridPV-windmicrogridascalableandfuture- ready solution to meet the growing demand for clean, reliable, and sustainable energy

2.LITERATURE SURVEY

A.BatteryManagementSystemImplementationwithPasiveControl

Enhancing Battery Safety:

The primary objective of implementing a Battery ManagementSystem (BMS) withpassive control methods is to enhancebatterysafety.Byemployingpassivecontroltechniquessuchaspassivebalancing circuits or passive temperature management systems, the BMS aims to prevent hazardous conditions such as overcharging, over-discharging, and thermal runaway. The objective is to design a BMS that can mitigate potential risks withoutrelyingsolelyonactivecontrol,therebyensuringthesafety ofthebattery pack and its surroundings.Optimizing Cost-effectiveness:Another objective is to optimize the cost-effectiveness of the BMS implementation.Passivecontrolmethodsofteninvolve simplercircuitrytandcomponenscomparedtoactivecontrolmethods,leadingto lower manufacturing and maintenance costs. By utilizing passive balancing techniques or passive thermal management solutions, the objective is to achieve effective battery management while keeping the overall system costs within budget constraints, making battery-powered technologies more accessible and economically viable.

B.**DaptiveDynamicProgrammingMethodforOptimalBatteryManagement of Battery Electric Vehicle**

DynamicProgrammingMethodforOptimalBatteryManagement of Battery Electric Vehicle the practicality and usability of BEVs for daily commuting and long-distance travel.Battery Lifespan:Another key objective is to enhance the lifespan of the battery pack. ADP algorithms consider factors such as battery chemistry, temperature, and charging/discharging rates to develop energy management strategies that minimize stress on the battery cells. By optimizing charge and dischargeprofiles,theobjectiveisto reducedegradationandprolongtheoverall lifespanofthebattery,thusloweringthetotalcostofownershipforBEVowners and improving the sustainability of electric mobility.

C.Design of Hardware-in-the-Loop Test System for New Energy Vehicle Battery Management System

Optimizing Energy Efficiency: The primary objective of employing Adaptive Dynamic Programming (ADP) methods for battery management in Battery Electric Vehicles (BEVs) is to optimize energy efficiency. ADP algorithms continuously learn and adapt to driving patterns, traffic conditions, and terrain, allowing the BMS to dynamically adjust power distribution and energy usage for maximum efficiency. The objective is to develop a BMS that intelligently manages the battery to extend vehicle range and maximize energy utilization, thus enhancing the overall efficiency of BEVs.Maximizing Battery Lifespan: Another key objective is to maximize the lifespan of the vehicle's battery pack. ADP methods optimize charging and discharging profiles based on battery health and degradation models, ensuring that the battery operates within safe limits. By dynamically adjusting charging .

3.PROPOSED METHOD

The proposed system integrates solar and wind energy as primary renewable sources to form a hybrid power generation unit, ensuring continuous energy supply even during varying environmental conditions. Solar panels capturesunlightandconvertitintoelectricalenergy,whilewindturbinesharness wind energy. Abatterysystemserves as theprimary energy storage component,storing surplus energy generated during periods of high renewable availability. The voltage regulator ensures stable voltage output from the battery, protecting sensitive components and maintaining consistent operation.To supplyAC loads and interface with the grid, a DC-AC converter is incorporated. This inverter transforms the stored DC energy into grid-compatible AC power, enabling seamless integration of the microgrid with the local power grid or standalone operation for isolated systems.The system incorporates a voltage sensor and a central controller to monitor and manage the flow of energy. The voltage sensor provides real-time data on energy generation, storage levels, and consumption. The controller uses this data to regulate the power distribution between the renewable sources, the battery,andthegrid.Itprioritizeslocalconsumption,batterycharging,andexcess energy export to the grid. In case of energy deficits, the grid acts as a backup, ensuring uninterrupted power supply. The controller also implements load- balancing strategies to optimize efficiency and extend battery life.

4.HARDWAREDESCRIPTION

ARDUINO

ArduinowasaprojectstartedatInteractionDesignInstituteIvrea(IDII)in Ivrea, Italy, with its primary goal being creating affordable and straightforward tools for non-engineers to use and create digital projects. During its infancy, the projectconsistedofjustthreemembers-HernandoBarragán,MassimoBanzi,and Casey Reas. Hernando Barragán worked under the guidance of Massimo Banzi andCaseyReasandcreatedadevelopmentplatformcalledWiringashismasters' thesis project at IDII. The development platform consisted of the ATMega168 microcontrollerasitsbrainsandusedanIDEbasedonProcessing,whichwasco-createdbyCasyReas.Later,MassimoBanzi,alongwithtwootherstudentsfrom IDII,namely-DavidMellisandDavidCuartielles,addedsupportforthecheaper ATMega8 microcontroller. The three, instead of working on developing and improvingWiring,they forkedit and renamedtheprojecttoArduino.Theinitial core Arduino team consisted of Massimo Banzi, David Cuartielles, Tom Igoe, Gianluca Martino, and David Mellis, but Barragán was not included.

LCD

ThetermLCDstandsforliquidcrystaldisplay.Itisonekindofelectronic displaymoduleusedinanextensiverangeofapplicationslikevariouscircuits& devices like mobile phones, calculators, computers,TVsets, etc.These displays aremainlypreferredformulti-segmentlight-emittingdiodesandsevensegments. The main benefits of using this module are inexpensive; simply programmable, animations,andtherearenolimitationsfordisplayingcustomcharacters,special and even animations, etc.

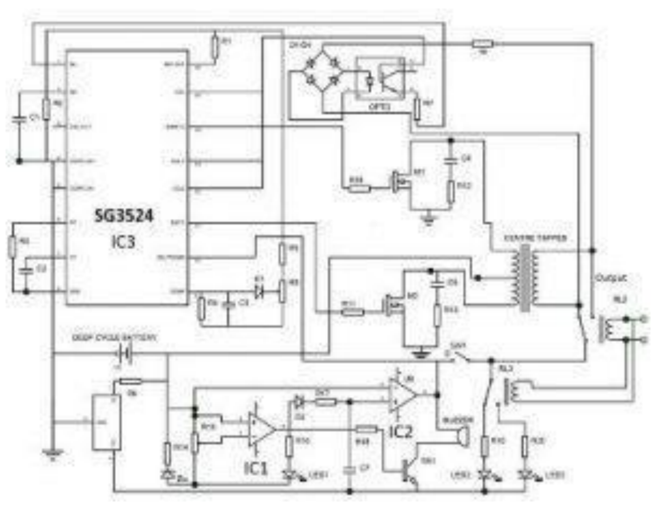
PHOTOVOLTAIC(PV)ARRAY

A Photovoltaic (PV) Array is a collection of interconnected solar panels designed to capture sunlight and convert it into electrical energy. The term "photovoltaic"comesfromtheprocessbywhichthesepanelsgenerateelectricity.

Whenexposedtosunlight,photovoltaiccellswithineachsolarpanelproducean electric current through the photovoltaic effect. This effect involves the absorption of photons from sunlight, causing the release of electrons and the generationofanelectricvoltage.PVArraysareakeycomponentinsolarenergy systems, providing a sustainable and renewable source of power.

INVERTER

Aninverterwhosefunctionalitydependsuponthepulsewidthmodulation technologyisreferredtoasPWMinverters.Thesearecapableofmaintaininigthe outputvoltagesastheratedvoltagesdependingonthecountryirrespectiveo



fthe type of load connected. This can be achieved by changing the switching frequency width at the oscillator.

BATTERY

While the battery is discharging and providing an electric current, the anode releaseslithiumionstothecathode,generatingaflowoffromoneside totheother.Whenplugginginthedevice,theoppositehappens:Lithiumionsare releasedbythecathodeandreceivedbytheanode.Alithium-ionorLi-ionbattery is atype ofrechargeablebatterythatuses thereversibleintercalation ofLi+ions into electronically conducting solids to store energy. In comparison with other commercial rechargeable batteries, Li-ion batteries are characterized by higher specific energy, higher energy density, higher energy efficiency, a longer cycle life, and a longer calendar life. Also noteworthy is a dramatic improvement in lithium-ion battery properties after their market introduction in 1991: within the next30years,theirvolumetricenergydensityincreasedthreefoldwhiletheircost dropped tenfold.

CONCLUSION

In conclusion, a microgrid hybrid PV-wind-battery management system represents a transformative innovation in the energy sector. It provides a sustainable, eco-friendly, and economically viable alternative to conventional energy systems. By enhancing energy security, reducing greenhouse gas emissions, and supporting renewable energy integration, this system aligns with global objectives for climate action and sustainable development

RESULT AND DISCUSSION

The results of the Micro Grid Hybrid PV-Wind Battery Management System indicate that the integration of a 12V 20W solar panel, GEAR motor-based wind generator, and a lithium-ion battery (11.1V) provides a reliable, renewable energy solution with efficient power generation and storage.The solar panel performs optimally under direct sunlight, generating up to 20W, while the wind generator supplements the power, especially during low sunlightconditions or at night.The lithium-ion battery efficiently even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols. For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation

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