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Priority Based Hybrid Renewable Energy Monitoring And Management System With Scada Autonomous Operation Based On Demand Response

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Abstract:

As the increasing demand for energy and the integration of renewable sources necessitate efficient energy management strategies. This paper presents a Hybrid Optimization of Multiple Energy Resources (HOMER) approach, integrating solar panels and windmills with a priority-based load setting for peak and lean times. The proposed system employs a DC-DC chopper controlled by a microcontroller to regulate and boost the voltage from renewable sources. The microcontroller measures input voltage levels and generates gate pulses to optimize the chopper's operation. The boosted output is stored in a battery via a supercapacitor, enhancing energy storage efficiency and stability. The stored energy is then intelligently distributed to various loads based on a priority-based scheduling algorithm that dynamically adjusts according to peak and lean demand periods. The optimization framework ensures maximum utilization of available energy, reducing dependency on conventional grids while enhancing system reliability. The incorporation of real-time monitoring and control improves energy efficiency and prolongs battery life. The hybrid renewable system effectively addresses fluctuations in energy generation through intelligent switching and storage

***Index Terms* - Enery Management, Demond response ,Real monitoring , Battery Performance Optimization.**

I. INTRODUCTION

The growing global energy demand and the shift towards renewable energy sources have driven significant advancements in energy management and optimization techniques. Solar and wind energy are among the most promising renewable sources due to their sustainability and abundance. However, the intermittent nature of these sources presents challenges in ensuring a stable and reliable power supply. To address this issue, an efficient Hybrid Optimization of Multiple Energy Resources (HOMER) strategy is required, integrating solar panels and windmills with intelligent load management.In hybrid renewable energy systems, effective power conversion and storage mechanisms play a crucial role in maximizing energy utilization. A DC-DC chopper circuit is employed to regulate and boost the voltage generated by the renewable sources. A mierocontroller-based control system continuously monitors the input voltage and generates appropriate gate pulses for the chopper circuit to enhance efficiency. The boosted energy is then stored in a battery through a supercapacitor, which helps in stabilizing fluctuations and improving the system's overall performance.

To optimize energy usage, a priority-based load management strategy is implemented. The system dynamically power allocates power to different loads based on peak and lean demand periods, ensuring critical loads receive power during peak times while less critical loads operate during lean periods. This approach enhances energy efficiency, minimizes wastage, and extends battery life. The proposed hybrid system effectively addresses the challenges of power intermittency and fluctuation by integrating intelligent storage and control mechanisms.

II. OBJECTIVES

To develop a Hybrid Optimization of Multiple Energy Resources (HOMER) system integrating solar panels and windmills for efficient energy utilization.To design and implement a DC-DC chopper controlled by a microcontroller for voltage regulation and boosting. The enhance energy storage efficiency using a supercapacitor and battery system for stable power delivery.optimize the utilization of renewable energy sources by minimizing power wastage and improving reliability.

III. ARDUINO UNO

The Arduino Uno is a microcontroller board. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

IV. PROPOSED SYSTEM

The proposed Hybrid Optimization of Multiple Energy Resources (HOMER) system integrates solar and wind energy sources with a priority-based load management strategy to enhance energy efficiency. A DC-DC chopper circuit controlled by a microcontroller regulates and boosts the input voltage, ensuring stable and optimized power delivery. The system incorporates a supercapacitor alongside a battery to improve energy storage efficiency and reduce power fluctuations. A real-time monitoring mechanism dynamically adjusts energy distribution based on peak and lean demand periods, ensuring optimal resource allocation. The intelligent control system prevents battery overcharging and deep discharge, thereby extending its lifespan. The hybrid setup minimizes dependence on conventional grids, making it suitable for off-grid and remote applications. By implementing adaptive energy utilizationa and intelligent switching mechanisms, the proposed system ensures reliable, cost effective, and sustainable power management.

V. BLOCK DIAGRAM

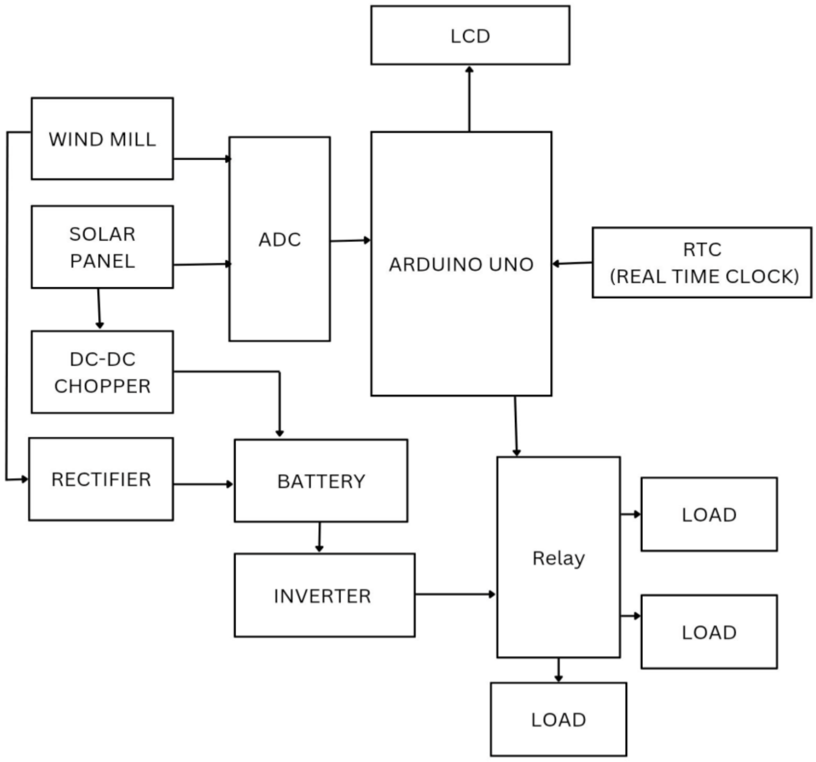

Figure 1 Block diagram

VI.HARDWARE DESIGN

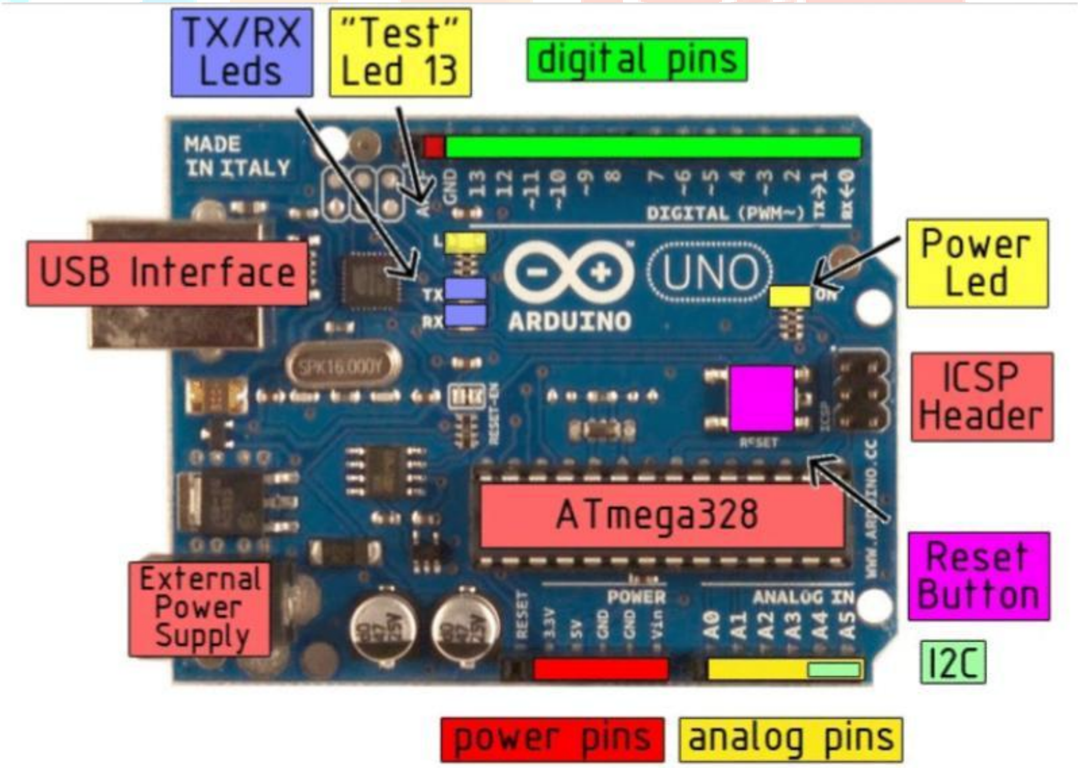

Figure 2 Arduino hardware design

VII. WORKING

The Priority-Based Hybrid Renewable Energy Monitoring and Management System with SCADA Autonomous Operation Based on Demand Response is designed to efficiently manage multiple energy sources such as solar, wind, and biomass, along with conventional backups. It operates on a priority basis, selecting energy sources according to their availability, cost-effectiveness, and environmental impact. A SCADA system is employed for real-time monitoring and control, collecting data on power generation, storage status, and varying load demands. The system utilizes demand response strategies to classify and prioritize loads, ensuring critical demands are met first. Based on this data, it autonomously allocates power from the most appropriate source, switching to backup sources only when necessary. Energy storage systems are integrated to store surplus energy and support loads during peak demand or low generation periods. The system functions with minimal human intervention, making intelligent decisions to balance supply and demand. This approach enhances energy efficiency, reduces reliance on non-renewable sources, and ensures reliable power delivery.

VIII. EXPERIMENTAL SETUP

Figure 3 and 4 shows the experimental setup of the battery management and wireless charging system. An Arduino Uno microcontroller runs the main code, managing sensors and controls. An ultrasonic sensor measures distance to detect the vehicle’s position. The TX coil sends power wirelessly using a magnetic field, while the RX coil receives and converts it back to electricity. An oscillator ensures proper timing for the microcontroller. A relay driver and relay switch control high-power devices. The power supply and rechargeable battery provide energy to the whole setup.

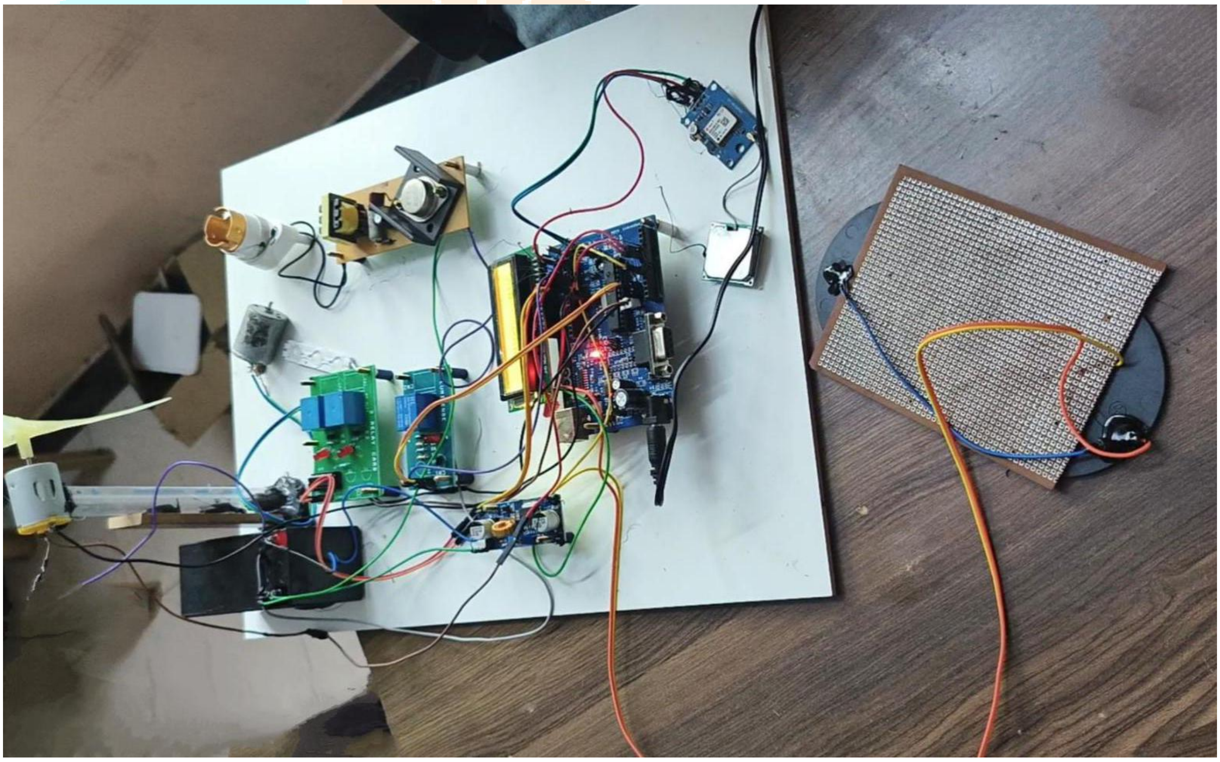

Figure 3 Project kit

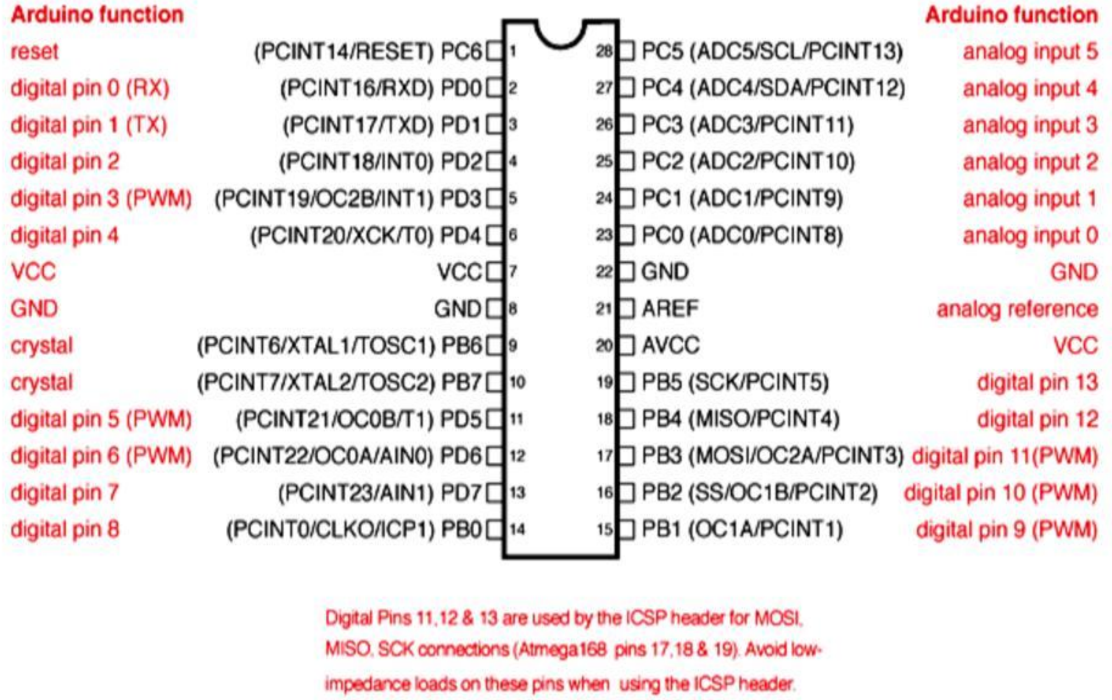

Figure 4 Pin diagram

IX. POWER SUPPLY

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

X. SOFTWARE REQUIREMENT

Arduino is a prototype platform (open source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programed (referred to as a microcontroller) and a ready-made Many applications can be solved more easily and efficiently with C than with other more specialized languages. The Cx51 optimizing C Compiler is a complete implementation of the American national Standards Institute (ANSI) standard for the C Language. Cx51 is not a universal C compiler adapted for the 8051 target. It is a ground-up implementation dedicated to generating extremely fast and compact code for the 8051microprocessor. Cx51 provides you the flexibility of programming in C and the code efficiency and speed of assembly language. Since Cx51 is across compiler, some aspects of the C programming language and standard libraries are altered or enhanced to address the peculiarities of an emb

XI. TECHNICAL SPECIFICATIONS ARDUINO UNO

Operating Voltage 5V

Input Voltage (recommended) 7-12V

VIN: The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V. The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply. 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA. GND - Ground pins.

XII. PHYSICAL CHARACTERISTICS

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins and high- quality "ingredients" (components) as per following receipt: Input Voltage (limits) 6-20V

Digital I/O Pins 14 (of which 6 provide PWM output)

Analog Input Pins 6

DC Current per I/O Pin 40 mA DC Current for 3.3V Pin 50 mA

Flash Memory 32 KB of which 0.5 KB used by bootloader

SRAM 2 KB

EEPROM 1 KB

Clock Speed 16 MHz Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to- DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center- positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

Conclusion

The Smart Energy Optimization System for a Solar-Wind Hybrid System with Load Scheduling provides an efficient, reliable, and sustainable approach to energy management. By integrating IoT-based monitoring, AI-driven forecasting, and intelligent load scheduling, the system ensures optimal utilization of renewable energy sources while minimizing energy wastage. The proposed approach enhances the stability of hybrid power generation, ensuring a continuous power supply even under fluctuating weather conditions. The use of predictive machine learning algorithms improves energy distribution by dynamically adjusting load priorities based on real-time availability. Additionally, smart grid integration and energy storage solutions contribute to cost-effectiveness and reduced dependency on fossil fuels.

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