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Hybrid Inverter with Monitoring and Protection

Prof. Vrushali K. Jadhav[1], Janhavi D. Shinde[2], Yash V. Rane[3], Ruchali B. Rahinj[4]
Guide, Department of Electronics & Telecommunication Engineering[1]
Student, Department of Electronics & Telecommunication Engineering[2,3,4,5]
Pune Vidhyarthi Griha's College of Engineering & S. S. Dhamankar Institute of Management, Nashik, India
vrushali.jadhav@pvgcoenashik.org, janhavishinde888@gmail.com
yashrane388@gmail.com, ruchalirahinj360@gmail.com

Abstract: *The conservation and efficient management of energy have become crucial to maintaining industrial productivity, profitability, and competitiveness. The ever-increasing energy demands pose a significant challenge, making energy efficiency and conservation more essential than ever. A major concern in energy generation is the wastage of energy due to inefficient storage systems. Many times, the generated energy goes unutilized due to a lack of proper storage mechanisms. To address this issue, we are developing an autonomous hybrid energy generation and storage system that is both affordable and efficient, making it accessible to smaller loads.*

This project integrates a solar panel and an AC grid as energy sources. The system will automatically select the appropriate power source to charge the battery, ensuring optimal energy utilization. A DC-AC inverter system will be implemented to convert stored DC power into AC for usage. The system is designed to monitor solar power generation and battery voltage in real-time. When the battery reaches full charge, the system will disconnect the battery from the solar panel to prevent overcharging and extend battery life. The key parameters, including solar power and battery voltage, will be displayed on a 16x2 LCD screen with the help of an Atmega328 microcontroller. This innovative energy solution aims to improve energy efficiency, reduce wastage, and provide a reliable power source in areas with frequent power fluctuations.

Keywords: Hybrid Energy, Energy Saving, Automation

I. INTRODUCTION

Energy conservation and efficient management are essential in today's world due to the increasing demand for power in industrial, commercial, and residential sectors. With the rising global population and technological advancements, the requirement for electricity is at an all-time high. The conventional power generation methods heavily rely on fossil fuels, which contribute to environmental pollution and depletion of natural resources. Renewable energy sources like solar energy have gained significant attention as sustainable and eco-friendly alternatives.

One of the major challenges in renewable energy systems is energy wastage due to inadequate storage solutions. Solar energy, for instance, is only available during the daytime, making it necessary to store excess energy for nighttime usage. Similarly, in areas with an unstable power supply, an effective hybrid energy system can provide a continuous power source.

This project aims to develop a hybrid energy generation and storage system that utilizes both solar and AC grid power. The system will automatically switch between these energy sources based on availability and efficiency. A smart battery charge controller will ensure that the battery is neither overcharged nor discharged beyond a safe level. Additionally, the integration of a DC-AC inverter will allow the stored DC power to be used for AC-powered appliances.

By implementing this system, households and small businesses can achieve a reliable and cost-effective energy solution. The real-time monitoring of power generation and battery status will enhance user control and awareness, promoting better energy utilization. This project aims to bridge the gap between energy demand and supply by providing an efficient, affordable, and sustainable hybrid energy solution.

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II. LITERATURE SURVEY

Solar Hybrid Inverter

Solar hybrid inverters play a crucial role in solar energy systems, efficiently converting solar power into usable electricity while managing power from multiple sources. Research in this field has focused on the design, implementation, and performance evaluation of solar hybrid inverters as part of final project completions. Studies delve into the technical aspects, challenges encountered, solutions devised, and the overall impact of these projects.

Implementation & Fabrication of Hybrid Solar Inverter

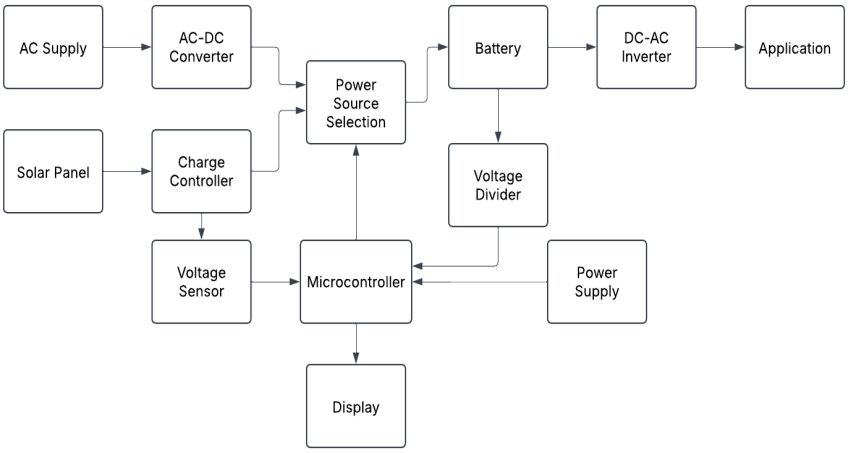
A significant limitation in conventional inverters is their shutdown under heavy loads due to low battery capacity. To address this issue, hybrid solar inverters have been developed with integrated solar battery charging systems. These systems utilize maximum power point tracking (MPPT) to extract maximum power from solar panels and efficiently charge batteries. The inverter generates up to 230V AC using driver circuitry and a transformer, with dual power sources: solar and grid power supply. The relay circuitry ensures priority use of solar power, switching to grid power when solar energy is unavailable. This setup provides an uninterrupted power supply and extends the inverter's operational life.

Technical Evaluation of Hybrid Iverter Systems

Renewable energy applications, particularly solar panels, widely utilize hybrid inverters to convert DC voltage from photovoltaic cells into AC for powering loads. A comparative analysis of inverter circuits by Russian and international manufacturers has identified technical contradictions in existing designs. To address these issues, an alternative hybrid inverter circuit has been proposed, incorporating microprocessor-controlled configurations for enhanced flexibility. Additionally, an advanced battery charge controller has been introduced to extend battery service life, improving overall system efficiency and reliability.

III. METHODOLOGY

- Selection of solar panel and battery based on power requirements.
- Integration of an AC grid as an alternative power source.
- Development of an automatic source selection circuit.
- Implementation of a battery charge controller.
- Use of Atmega328 microcontroller for system control.
- Display of power parameters on a 16x2 LCD.
- Testing and evaluation of system efficiency.



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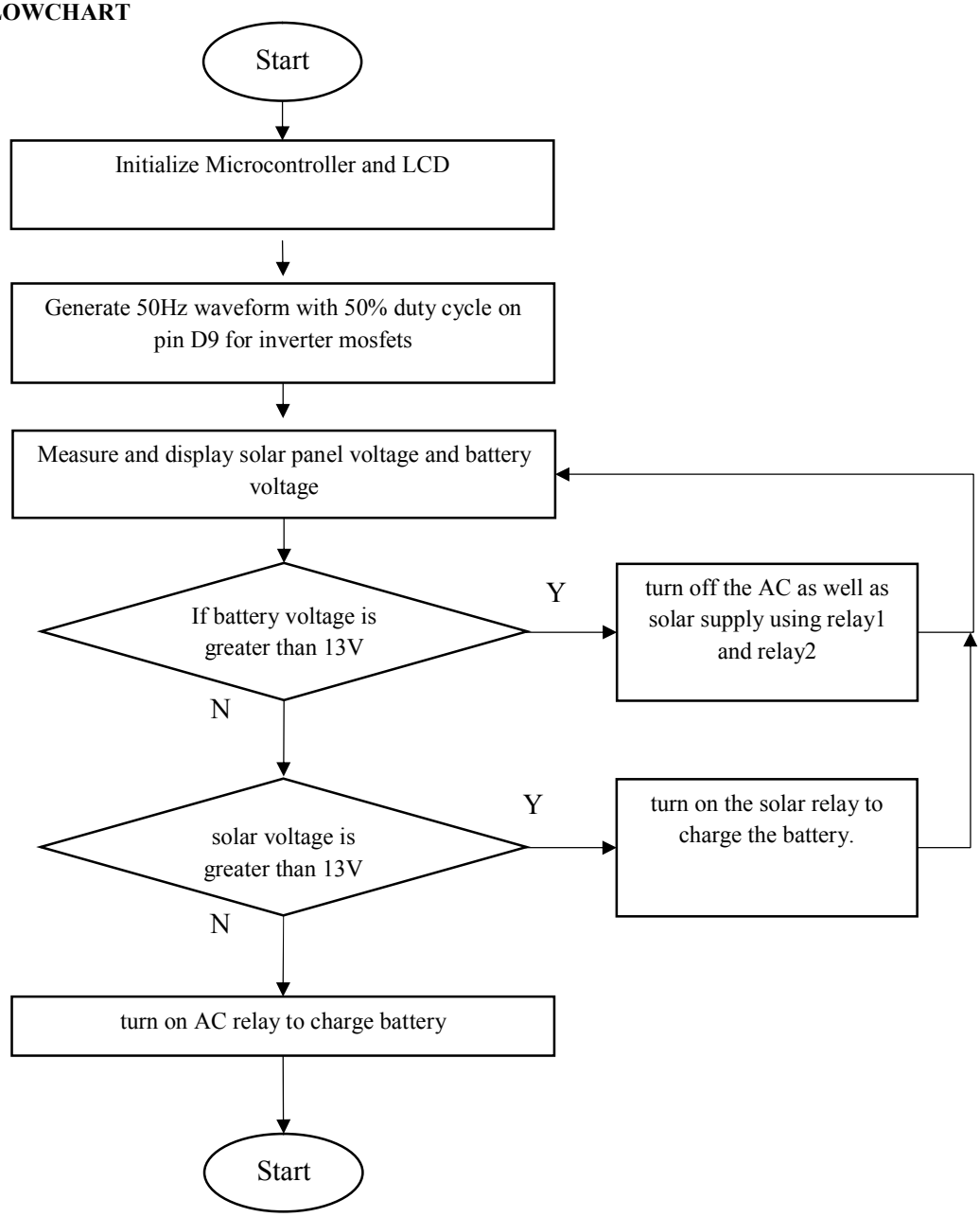
IV. SYSTEM DEVELOPMENT

The block diagram of the hybrid energy system consists of several key components. The solar panel serves as the primary renewable energy source, while the AC grid acts as a secondary source. The automatic source selection circuit determines the best available power source for charging the battery. The charge controller ensures the battery is charged safely without overcharging or deep discharging.

The Atmega328 microcontroller acts as the brain of the system, processing real-time data and controlling power distribution. The 16x2 LCD displays crucial information such as solar power output, battery voltage, and power source status. A DC-AC inverter is incorporated to convert the stored DC energy into AC power for practical usage.

SYSTEM FLOWCHART



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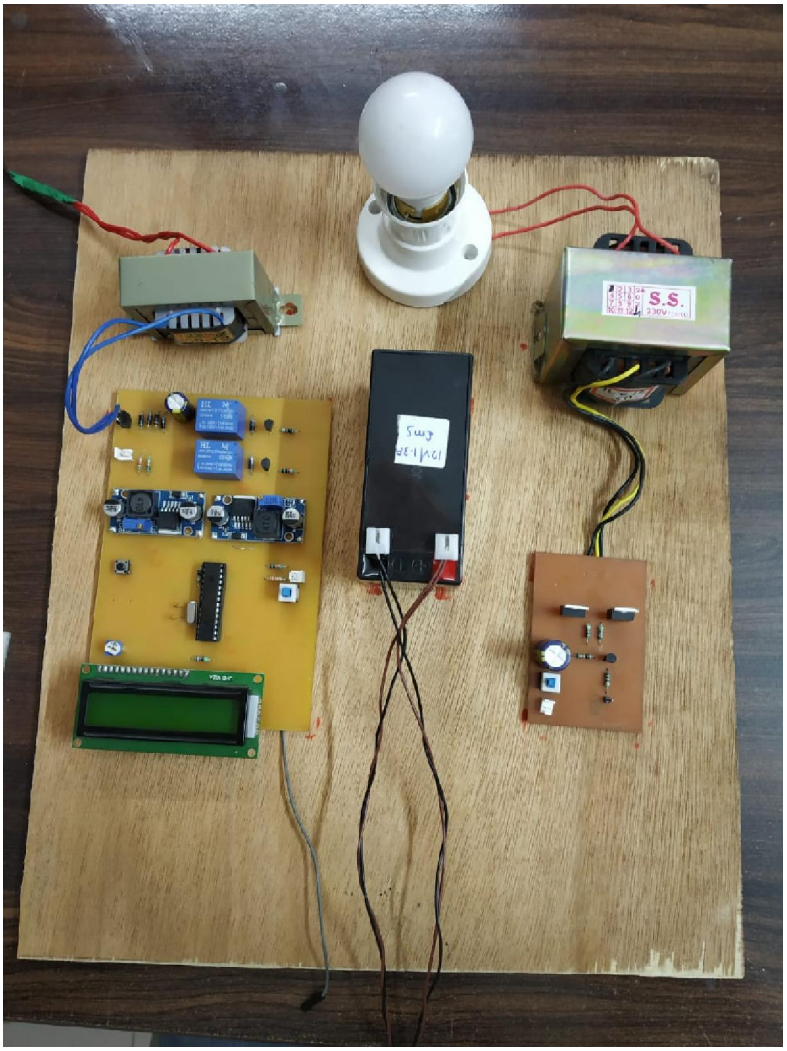
HARDWARE ASSEMBLY



Precautions:-

- Careful mounting of the components increases the reliability of the assembly and decrease the size of PCB.
- Components leads must be cleaned before they are inserted in PCB holes.
- Avoids asymmetric lead bending, otherwise they can't be soldered easily.
- Do not keep large distance between components and the PCB.
- For mounting ICs or any other package, special socket must be used for easy insert.
- Number of jumper wires should be minimum.

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V. TESTING & RESULTS

HARDWARE TESTING

1. Supply Testing

For supply test, power up the project model and ensure that every supply point is getting the right voltage values. And it's in a stable operating condition. For control circuit the voltage at every supply point is measured by voltmeter and it shows stable 4.9V as expected. Whereas after attaching all the devices, the current consumption varies between 220mA to 240mA. These values proves that the consumption is normal as calculated and no short circuit or over voltage is detected. Also there is no heating detected for any component.

2. Noise Testing

To test the system in noisy environment, it is place near to AC water pump motor. With close range of 5ft system working fine and no any fluctuation detected in output. In another test, it is placed near to welding machine in working state and all parameters are observed. It is observed that system works properly with 5feet distance from source. But when distance decrease from 5ft, sometimes noise affects the system and display start to show random characters. Since the welding machines are very powerful source of EMI, it is observe that in close range of EMI, system may misbehave depending on the strength of EMI.

3. Final System Specifications

- Inverter output: 230V AC, 50Hz
- System power input option: AC grid, Solar Panel
- Battery: 12V, 1.3Ah Sealed Lead Acid (SLA)
- Charging Method: Step-down (buck) converter
- Battery Cutoff: Controlled by relay module
- Solar Panel: 5 Watt, 12V
- Charge Time~3.5 to 4 hours (For solar as well as AC supply)
- Output Power: ~28.8W (80% efficiency)
- Battery Backup Time: for 10W Load ~1.25 hours
- Controller Used: ATmega328
- Output on 16x2 LCD display
- Audio alert type: Single tone pizo buzer
- Working temperature range: 0 to 70 ℃.

RESULTS

This project presents, an cost effective and compact system which will work as an solar and AC supply. It selects power source automatically and also shows the system parameters on LCD. The above image shows the complete hardware of system. Other outcomes of the project are:

- The system successfully integrates solar and AC grid power.
- Automatic source switching ensures uninterrupted charging.
- The charge controller prevents battery overcharging and over-discharging.
- The LCD display provides accurate real-time data.

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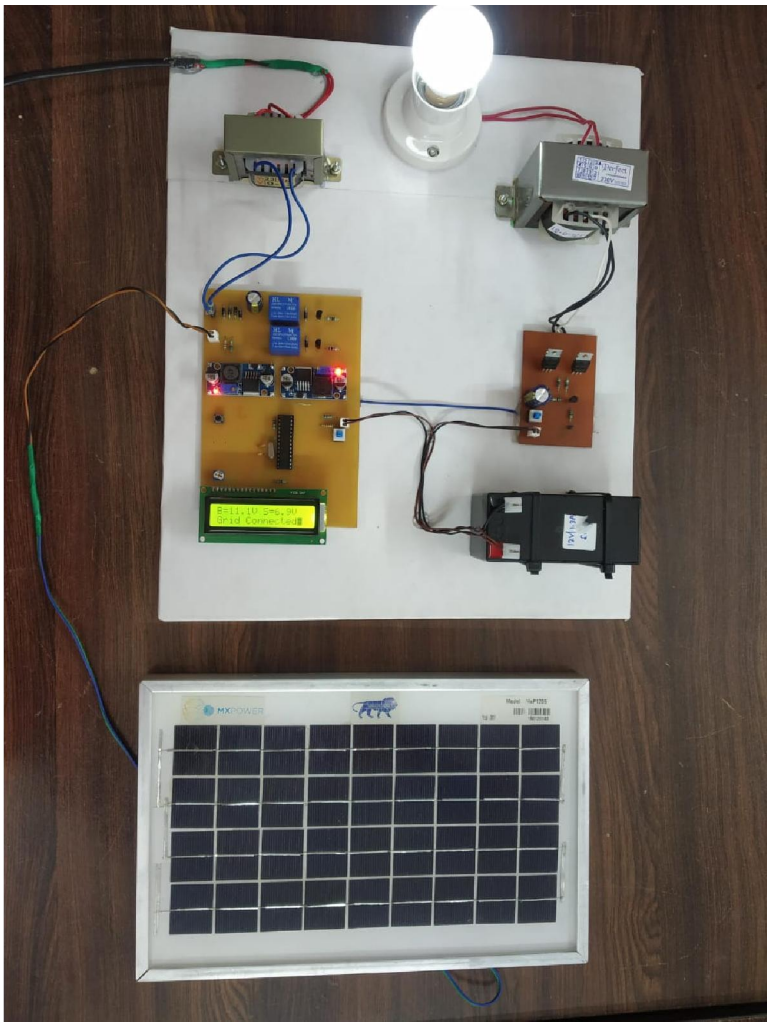

SCOPE OF PROJECT

Though design system fulfills all the defined objectives, there is always scope to advancement in future. Since improvement is endless process, in future, system can also be integrated with other natural resources of energy like windmill. This will help to run systems on natural energy throughout the day.

VI. ADVANTAGES, LIMITATIONS, APPLICATIONS

ADVANTAGES

- Cost-effective and energy-efficient.
- Reduces dependency on conventional power sources.
- Enhances battery life and system reliability.
- Provides real-time monitoring.

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LIMITATIONS

- Solar energy availability depends on weather conditions.
- Battery life is limited and requires periodic replacement.

APPLICATIONS

- Residential power backup.
- Small industries and businesses.
- Remote and rural electrification.
- Renewable energy utilization.

VIII. CONCLUSION

This hybrid energy system offers a sustainable and efficient solution to meet energy demands while reducing dependency on fossil fuels. By integrating solar and AC grid power, the system ensures uninterrupted energy availability. The automatic source selection and battery charge controller enhance system efficiency, making it a practical choice for households and small businesses. The implementation of such a system promotes renewable energy adoption, reduces electricity costs, and contributes to environmental conservation.

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