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Implementation and Fabrication of Hybrid Solar Inverter

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***Abstract*: Inverters are frequently utilized in home and industrial settings to act as an alternative source of electricity in case the utility network's electrical supply is interrupted. However, due to the low capacity of the battery, the inverter was shut down for the heavy-load appliances. This endeavour is constructed in a way that uses solar energy to get around this restriction. An inverter powered by a battery makes up the hybrid inverter with a solar battery charging system. It incorporates maximum power point tracking (MPPT) to extract maximum power from the solar panels and efficiently charge the batteries. With the assistance of driver circuitry and a transformer, this inverter can generate up to 230V. The solar power source itself and the grid power supply are used to charge the battery. If the solar power supply is available, the relay circuitry uses the solar power to supply the load. Otherwise, the load connects to the grid power supply. The battery is also charged by this solar power source to be used as a backup in the future. When solar power is unavailable, charging the battery with the main supply is a pleasant option. As a result, this inverter may last longer and give the consumer an uninterrupted power supply.**

Keywords: Inverters, maximum power point tracking, batteries, solar power.

I. INTRODUCTION

The world is moving towards renewable energy sources due to the increasing concern for environmental degradation and the finite availability of fossil fuels. Solar energy has gained significant attention among renewable sources due to its abundance and wide availability. Solar energy is harnessed using photovoltaic (PV) panels, which generate direct current (DC) electricity. However, the generated DC electricity needs to be converted into alternating current (AC) electricity before households and industries can use it. This is where the inverter comes into play [1-5].

The use of solar energy as a source of electricity has been increasing rapidly in recent years. This has been driven by the need for clean and sustainable energy sources to mitigate the impact of climate change. Solar energy is particularly attractive because it is abundant, free, and available in almost every part of the world. However, the intermittent nature of solar energy presents a challenge, particularly in areas where the power grid could be more reliable [1, 6-11].

To address this challenge, hybrid solar inverters have been developed. Hybrid solar inverters combine the functionality of a solar inverter and a battery inverter in a single device. They are designed to enable solar energy to be stored in batteries and used when solar does not produce electricity. This provides a more reliable and constant source of electricity, even in areas with unreliable power grids [12-20].

This final-year project aims to implement and fabricate a hybrid solar inverter. The hybrid solar inverter will be designed to enable the seamless integration of solar panels, batteries, and the power grid. It will be capable of managing the flow of energy between these sources, ensuring that energy is stored efficiently and used when needed.

II. LITERATURE REVIEW

Much research has been done to improve the quality work in the field of inverter [3-5]. Various methods are applied in various regions. Some are working on the biogas and others working on the wind energy. But most of the known process is the solar power technology. The main advantage of the solar is the availability of the heat energy most of the time. At night time, the batteries are used and in this way, the consumers can get energy free of cost. The main component of the research is to devise a method of producing the energy with zero cost and many methods are proposed in the literature [21-24].

III. WORKING

The hybrid solar inverter project utilizes an Arduino Mega and LCD for control and monitoring. It incorporates two power inputs: one from the grid and the other from solar panels. The grid input is converted from AC to DC, producing a 20V DC voltage for battery charging. The solar input is connected to an MPPT (Maximum Power Point Tracking) circuit, which regulates the output voltage and current from the solar panels to maximize efficiency. MPPT can improve the efficiency of a hybrid inverter by up to 30% by ensuring that the solar panels operate at their maximum power point, regardless of variations in solar radiation and temperature [2]. In the system, the Arduino Mega is essential. It examines the battery voltage and compares it to a predefined minimum value (i.e., 11V) to determine whether charging is required. The Arduino permits the battery to charge using solar energy if the solar input voltage is within the appropriate range, indicating sufficient solar power. However, the Arduino changes the charging source to grid power if the solar input voltage is outside the designated range. However, Arduino runs on 5V DC. So, there's a buck converter used to power the Arduino and LCD to make the voltages 5V and then to measure the real voltages and display it to the LCD. We have used a formula in the code.

For voltages:

$$Vdc * \left(\frac{4.5}{1023}\right) * 60 \qquad (1)$$

for current

$$Vdc * \left(\frac{4.5}{1023}\right) * 0.6 \qquad (2)$$

Where Vdc is the voltage (direct current) and the multiplier is the constant, which can be studied from the literature [4-8].

IV. METHODOLOGY

The battery is connected to the inverter circuit, which transforms the DC voltage into AC voltage, typically a sine wave. Using a step-up transformer, the desired 220V output is produced. The Arduino continuously monitors the total load. The Arduino manages a relay that decides whether the output power comes from the inverter (if the load is less than 200W) or the grid (if the load is 300W) based on the load demand.
The Arduino is programmed to continuously monitor the total load power to prevent the system from overloading. The Arduino activates an overload protection relay, which causes the inverter to shut down, if the load reaches 500W, signaling an overload problem.
The project utilizes inputs from the grid and solar panels, controls battery charging according to solar availability, regulates inverter output by load demand, and assures safety through protection systems. The hybrid solar inverter system is optimized thanks to control, monitoring, and user interaction made possible by the Arduino Mega and LCD.

Figure 1 shows the block diagram elaborates the complete working of the fabrication of a hybrid solar inverter.

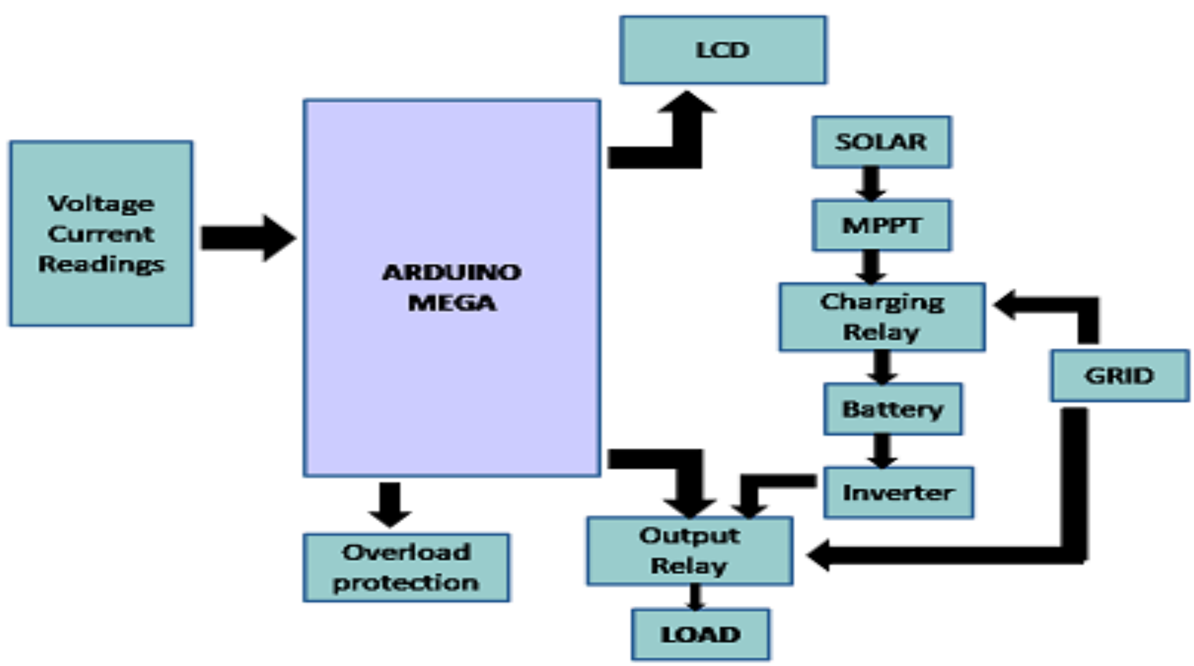

Figure 1: Block diagram of the proposed system.

V. RESULT

We have successfully designed a hybrid solar inverter with a pure sine wave. A relay or contactor connects the inverter's output to either the grid or loads in the system. Monitoring the relay's state makes it possible to determine whether the inverter is generating power. This information can be shared in real-time with a controller or monitoring system, which can then be used to adjust the inverter's operation, depending on the system's needs. If the system is experiencing a power outage, Arduino will sense the situation, and relays can switch the inverter to an off-grid mode and power critical loads. Our hybrid solar inverter system is well-optimized thanks to control and monitoring by the Arduino Mega and LCD.

VI. DISCUSSION

The existing solar inverter systems need more efficiency and reliability when seamlessly integrating solar power with the grid and backup energy sources. This creates challenges in maximizing the utilization of renewable energy, ensuring uninterrupted power supply, and managing the grid connection efficiently. Consequently, there is a need for an advanced solar hybrid inverter that overcomes these limitations and provides a robust solution for efficient integration of solar power, grid connectivity, and backup energy sources.

Project scope

The project goals of implementing and fabricating hybrid solar inverters using relays may include: Increasing the efficiency of solar power conversion: Hybrid solar inverters are designed to optimize the conversion of solar power into usable AC power. By using relays, the inverter can switch between different power sources, such as solar panels, batteries, or the grid, to ensure that the system is always running at maximum efficiency.

VII. HARDWARE IMPLEMENTATION

Relays are a reliable way to switch between power sources in an inverter system. The system can quickly and easily switch between different power sources by using relays, improving overall reliability and longevity.

Enhance system flexibility: Hybrid solar inverters using relays can be designed to operate in various configurations, enhancing the system's flexibility. For example, the inverter could be configured to operate solely on solar power during the day and switch to battery or grid power at night. Hardware implementation is shown in Fig. 2, and the results are given in Fig. 3.

Reduce overall system cost: By using relays instead of more expensive electronic components, the overall cost of the inverter system can be reduced. This can make the technology more accessible and affordable for consumers and businesses looking to switch to solar power. Promote renewable energy adoption: By improving the efficiency, reliability, and affordability of hybrid solar inverters using relays, the technology can help promote the adoption of renewable energy sources like solar power. This can have a positive impact on the environment and help reduce reliance on fossil fuels.

VIII. CONCLUSION AND FUTURE WORK

The following enhancements will significantly improve the system's efficiency, reliability, and user experience.

- Real-time power mixing between grid and solar can be explored using zero-crossing techniques.
- The system can automatically take appropriate actions by integrating fault detection mechanisms, such as isolating faulty components or notifying the user of necessary maintenance or repairs.

Integration of a Wi-Fi module can enable remote monitoring and control of the system. This enhances user convenience, allows for better system management, and facilitates proactive maintenance.

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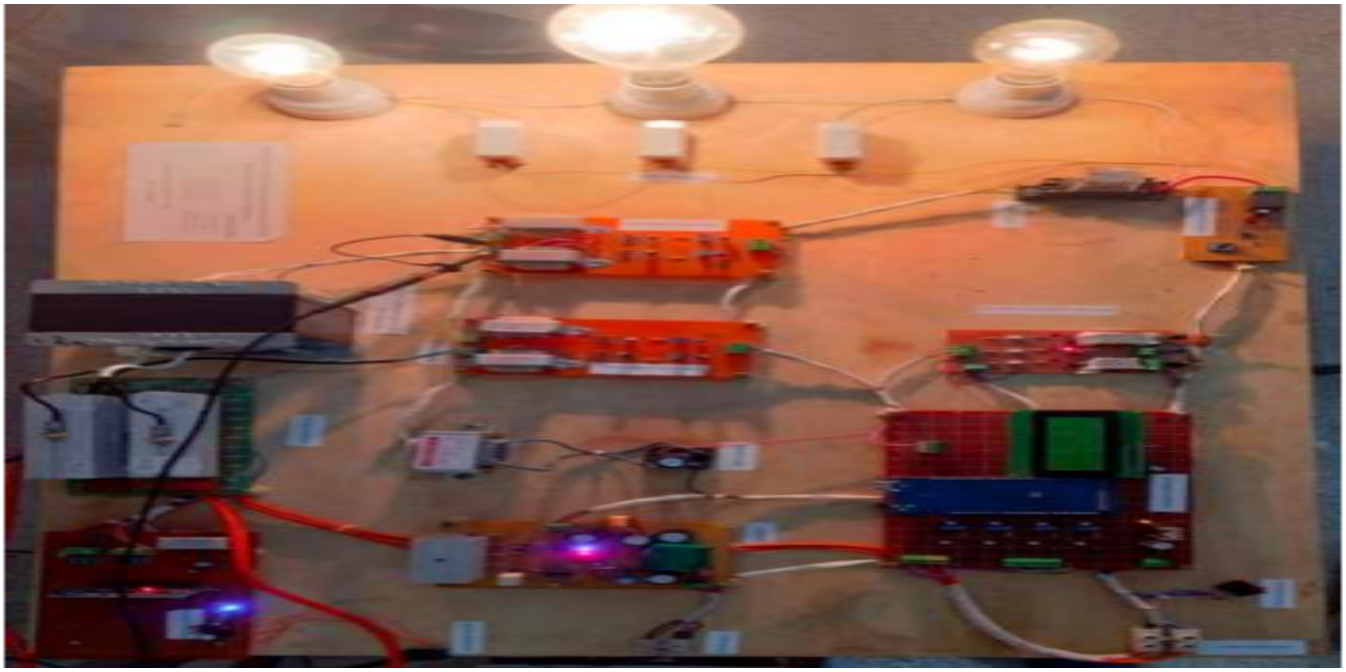

Figure 2: Hardware Implementation

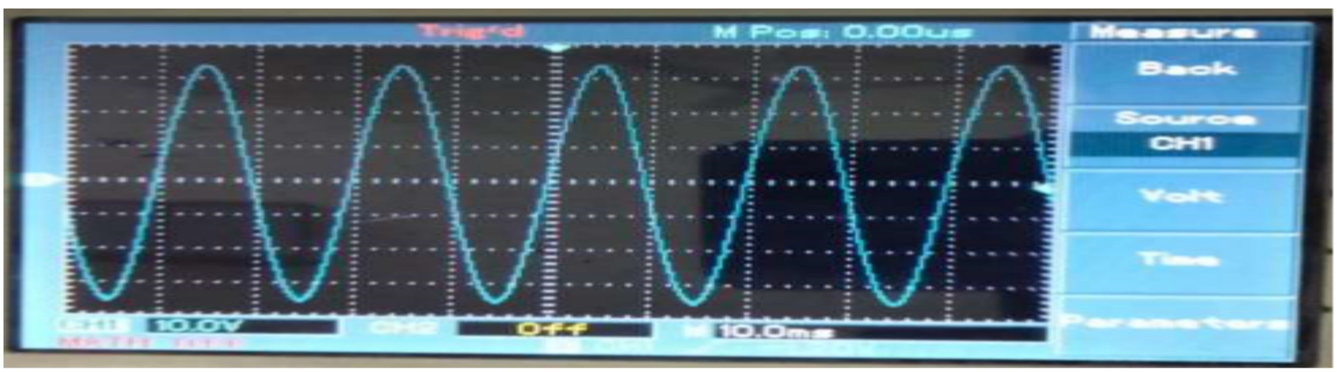

Figure 3: Oscilloscope results.