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Hybrid Inverter using Solar Battery Charger with Solar Tracking using Arduino

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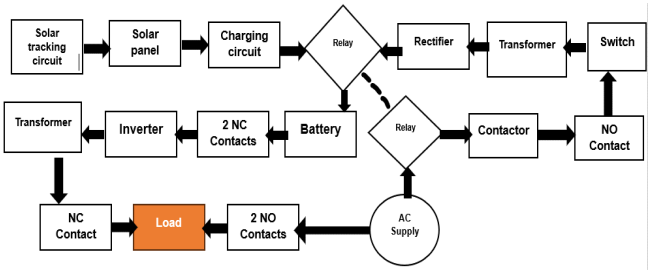
***Abstract*—In this paper, a hybrid inverter using a solar battery charger with tracking using Arduino is designed to give an uninterrupted supply to the load by using solar energy with the help of a hybrid inverter. A Hybrid Inverter with a Solar Battery Charging System consists of an inverter powered by a 12V Battery. This inverter is designed to generate up to 240V AC with the help of driver circuitry and a heavy-load transformer. This battery gets charged from two sources, the first being solar energy and the other the mains power supply itself. If the solar power supply is unavailable, the relay switches to the connection using the mains power supply to supply the load. This power supply also charges the battery for using it as backup the next time when there is a power outage. In any abnormal situation, we can also run the load normally with an AC supply employing a contactor.**

***Index Terms*— Hybrid inverter, Dual module relay, Arduino mega 2560, Motor driver circuit, LDR Sensor, Contactors, Solar panel, Charging circuit, single axis solar tracking.**

I. INTRODUCTION

Solar energy is an unlimited source of energy by nature that can be used to generate electricity and is also easy to store in batteries. It is a clean form of energy that reduces the dependency on conventional sources to produce electrical energy. The hybrid inverter is a perfect solution to run the loads as desired with solar or AC according to its availability. Using solar tracking with Arduino increases the efficiency of solar panel output by sensing the maximum solar energy through sensors. This project has been designed to provide uninterrupted supply to the load by using both solar and AC supply and a battery to store power outages.

II. BLOCK DIAGRAM



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III. Solar Tracking

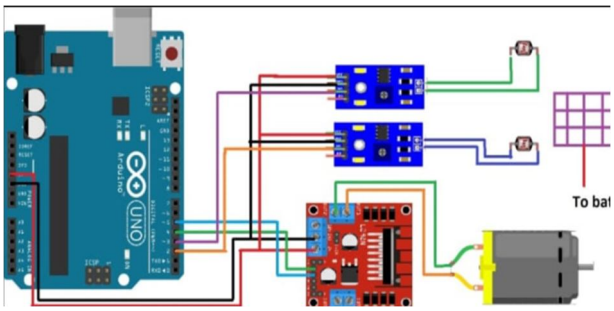

Fig.2 Solar tracking

Solar tracking system is commonly **used for positioning solar panels** to maximize sunlight exposure. When the sunlight intensity increases, **the panel activates and sends information with the help of sensors. Next,** it then transfers the data to the motor driver which compares the data and generates an output to power the motor, **rotating the panel to align it with the sun.** A solar panel is placed perpendicular to the sun to produce more power than one not aligned. The **main application** of solar tracking systems is to position solar photovoltaic (PV) panels towards the Sun.

IV. Arduino Mega 2560

Arduino is a prototyping Internet of Things (IoT) based on easy-to-use hardware and software. Arduino boards are built in such a way that they can read inputs for example a light on a sensor, a finger on a button, or a Twitter message - and turn them into an output - activating a motor, and turning on an LED. All Arduino boards use a software programming language, Arduino MEGA 2560 uses Arduino IDE. This IDE supports C programming language so we have to develop and write programs in C language. We can type our program in it, and then upload that code into our microcontroller which is inbuild in the Arduino board, and we can also change it according to requirements.

V. Single-Axis Solar Tracking

The single-axis solar tracker is a newly developed technology that tracks the direction of the Sun when placed within the panel. By the name, it rotates on a single axis. These trackers help the photovoltaic (PV) module transition from one point to the other, notably from East to West. Since it helps the PV module move as per the direction of the sunlight, unlike the rigid solar panels, it can provide up to 25-35% more energy.

VI. Hybrid Inverter

A hybrid inverter (sometimes referred to as a multi-mode inverter) is an all-in-one solution that contains three different functions. It has a unified solar charge controller that connects to the solar panel(s) and serves to regulate the voltage from the output of the solar panel to the loads and/or batteries.
This product “inverts” the current from direct current (DC) received from the solar panels to alternating current (AC) so typical home and business appliances and equipment can be utilized. If approved in the local areas, the utility grid will be able to use the energy created by the solar panels. This alternating current can normally be 50 or 60 cycles per second or Hertz (Hz), and as each cycle has a rise and fall, the AC would pass by zero 100 or 120 times per second. The hybrid inverter also serves as a battery charger, taking power from (Photo voltaic) PV cells or an AC source to charge the batteries. The energy stored in the batteries can then be used later for various applications.

VII. Advantages and Disadvantages of Hybrid Inverter

Hybrid inverters with solar battery charging offer several advantages that make them an attractive option for those looking to harness solar energy efficiently. Here are some key benefits:

1. **Energy Independence and Reliability**: Hybrid inverters allow you to store surplus solar energy in batteries, ensuring a continuous power supply even during grid outages or at night.

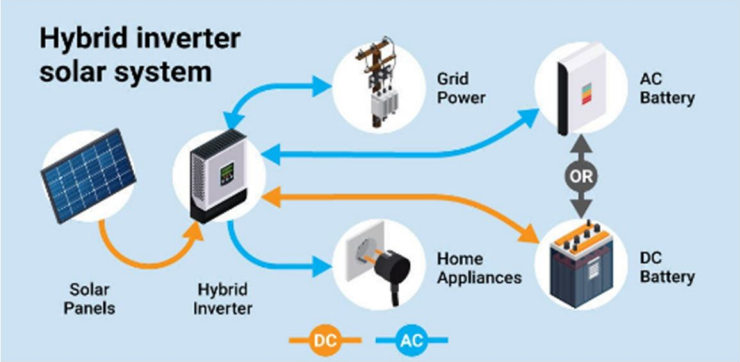

Fig.3 Hybrid inverter solar system

2. **Enhanced Energy Utilization**: They use Maximum Power Point Tracking (MPPT) technology to optimize the performance of solar panels, extracting the maximum available power from the sun, which leads to higher energy production and saves electricity bills.
3. **Grid Interaction and Selling Excess Energy**: These inverters can draw power from the grid during peak times and feed excess energy back into the grid, potentially earning credits or monetary benefits.
4. **Cost Savings and Quick ROI**: The initial investment may be substantial, but the long-term savings from reduced energy bills and potential revenue from selling excess energy, along with extended battery and inverter lifespans, contribute to a quick return on investment.
5. **Environmental Benefits and Sustainability**: By reducing reliance on fossil fuels and decreasing greenhouse gas emissions, hybrid inverters contribute to a more sustainable energy ecosystem.

These advantages highlight why hybrid inverters with solar battery charging are considered game-changer in the renewable energy landscape.

VIII. Two Module Relay

A 2-channel relay module consists of two independent electrical relays mounted on a single circuit board. Each relay operates independently and can be controlled by an external signal. These modules are ideal for home-brew projects that require switching modest amounts of AC or DC power. In the core of a relay is an electromagnet a coil that becomes a temporary magnet when electricity passes through it. Each relay operates independently and it can be controlled by an external signal. A single relay is capable of controlling two AC or DC devices simultaneously, so a 2 relay module can control four AC or DC devices at the same time.

IX. Hardware Setup

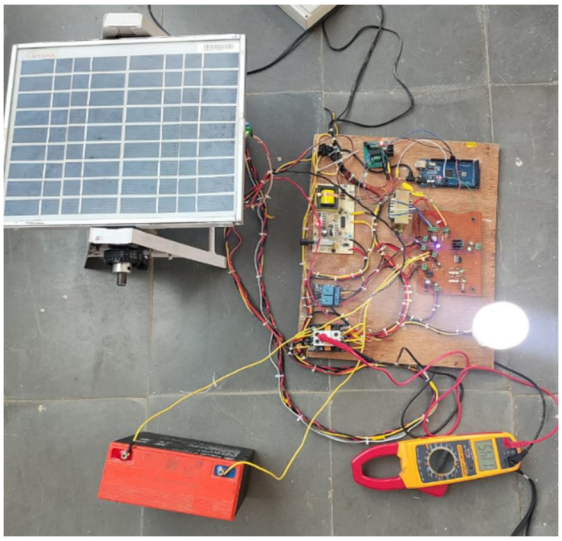

Fig.4 Hardware setup to run with solar power

Output results from solar power: (Input= 238.87)

TABLE I. OUTPUT FROM SOLAR POWER

Sl. no	Load (in watts)	Voltage (v)	Current (mA)	Efficiency (%)
1.	9	218	12.8	91.263
2.	15	210	35.36	87.91

Working with AC power

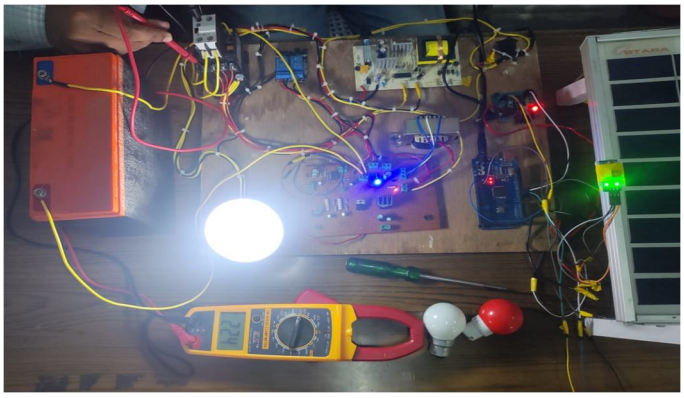

Fig 5. Hardware setup to run the load with AC power

Output results from AC power: (Input= 240)

TABLE II. OUTPUT FROM AC POWER

Sl. no	Load (in watts)	Voltage (V)	Current (mA)	Efficiency (%)
1.	9	229	39.47	95.41
2.	15	228	65.7	95.0

X. WORKING

- There are two light-sensing modules. For the east and west directions.
- Both sensors send digital information about the presence and absence of light intensity to the Arduino.
- The Arduino decides the output signals for the motor driver to drive the motor in the CW or ACW direction.
- The motor driver module receives the signals from the Arduino and drives the motor in the specified direction with the specified speed. The motor helps in controlling the orientation of the solar panel mounting structure. Thus, providing constant exposure to sunlight throughout the day.
- The load can be fed in three ways according to the requirements and availability
- First, solar power can be stored in a battery and fed to AC loads by inverting it.
- The 2-module relay allows only either DC or AC to supply the load. It gets connected automatically to the AC supply if solar is not generating the desired output.
- Second, directly from the AC supply to the load by interlocking method (Using relay and contactor).
- Third, from the battery through the inverter then supplying to the load.
- Charging circuit: The charging circuit offers 12v of supply to the battery from solar panel and it doesn't allow different voltages other than the limit of 5% variation.
- Rectifier circuit: The rectifier circuit converts the AC supply of 230v 50Hz into 12v DC, This circuit can charge the battery whenever required by turning on the switch.
- Inverter circuit: This circuit helps to invert the 12v DC to 230v AC to operate the loads.

XI. ADVANTAGES

- The daily output will be more stable- since the inverter is run by two sources. Both energy sources may fulfil the demand for output mutually.

- Providing uninterruptable power supply- when the solar power supply is not available load connects with the main power supply and when both solar and mains power supply is not available load connects to the battery backup.
- It utilizes clean energy and doesn't involve any non-renewable or conventional fuel. So, there is no chance of pollution by any means and it is a clean form of energy.
- The efficiency of the process is more as no moving parts are involved. Also, this hybrid inverter has higher efficiency than conventional inverters as it mainly uses solar energy and takes power from AC mains only when it is necessary.
- It doesn't require frequent maintenance and operating costs are also less.

XII. Disadvantages

- One of the main problems in Solar Inverter systems is the inefficient charging of Batteries during cloudy weather conditions.
- Initial cost is high and the area required for installation is high.
- If the battery is dead the entire circuit fails.
- The battery needs to be monitored and serviced regularly and also, we have to replace the battery after 2-3 years

XIII. Applications

- **Residential Energy Storage**: Hybrid inverters can store excess solar energy in batteries for later use, making them ideal for residential applications where energy demand varies throughout the day
- **Backup Power**: In the event of a power outage, hybrid inverters can provide an uninterrupted power supply from the stored energy, ensuring that critical loads are always powered
- **Energy Cost Savings**: With the ability to store solar energy, hybrid inverters allow homeowners to use solar power during peak tariff hours, reducing electricity bills
- **Grid Services**: Hybrid inverters can support the grid by providing services such as peak shaving, load shifting, and voltage support, which can be financially incentivized by utilities
- **Commercial and Industrial Use**: Businesses can benefit from hybrid inverters by reducing their reliance on the grid, lowering operational costs, and potentially earning from energy sent back to the grid
- **Remote and Off-Grid Applications**: For locations without reliable grid access, hybrid inverters with solar tracking can maximize energy harvest and provide a consistent power supply

XIV. Future Scope

- Advancements will likely focus on improving charging efficiency, extending battery life, and integrating smart charging algorithms that respond to energy demands and availability.
- The use of Arduino microcontrollers for solar tracking allows for precise and automated adjustment of solar panels to follow the sun's path. Future iterations may see improvements in the tracking algorithms, more robust and weather-resistant hardware designs, and integration with IoT for remote monitoring and control.

XV. Conclusion

Sun, being a source of clean, pollution-free energy and Photovoltaic power production is gaining more significance as a renewable energy source due to its various advantages. The advantages include an everlasting production scheme, ease of maintenance, and direct sunbeam to electricity conversion. However, the high cost of installations still forms a difficulty for this technology. Moreover, the PV panel output power varies with the weather conditions, such as the luminous intensity of the solar beam, cell temperature, etc.
The project described is valuable for the promising potential it holds. Ranging from the long-run economic benefits to the important environmental advantages. This work will mark an attempt and contribution to the field of renewable energy and can be implemented extensively.

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