WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Hybrid Inverter with Solar Battery Charger

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ABST RACT

In today's interconnected world, nearly every aspect of life depends on a steady electricity supply to function smoothly. However, extreme weather conditions, vehicle accidents, fallen trees, surges in power demand, or even animal interference can disrupt local or regional electrical grids, sometimes leaving homes without power for hours. This has led to the widespread use of inverters in both residential and industrial settings as a reliable secondary power source. A solar inverter primarily functions to convert the DC power generated by photovoltaic cells into AC power. Hybrid inverters extend this capability by integrating batteries, which store excess energy. However, traditional solar inverter systems face challenges, particularly in cloudy weather, as they struggle to efficiently charge the battery. The battery requires more than 1 ampere of current for proper charging, and with low capacity, it quickly depletes when powering heavy appliances in the absence of solar power.

Keywords: Hybrid inverter, Solar, Grid, Battery, MCB, MOSFET

Introduction

Introduction: An intelligent hybrid inverter or smart grid inverter is a new generation of dedicated U.P.S. (Uninterruptible Power Supply) system which can use both electrical as well as solar energy to charge the system storage battery which can be used to generate electricity in the absence of either or both of energy sources. Usually, electricity from solar panels is generated only during the day, with peak production around midday. This electricity is fluctuating and not synchronized with the electric consumption of the household. To overcome this gap between what is produced and what is required during the evening when there is no solar electricity production, it is necessary to store energy for later use and manage energy storage and consumption in an intelligent way.

Special Features:

• Automatically battery charging by two ways (Solar Power Supply/Main Power Supply). When solar power supply is not available then battery charging is done by main power supply (AC mains). Otherwise, battery charging occurs through solar power supply.

• Uninterrupted power supply. In case of power outage from either or both the power sources (Solar power and AC mains) the battery provides backup and continues to supply the load.

• Low maintenance cost. This inverter does not require frequent servicing

Structure

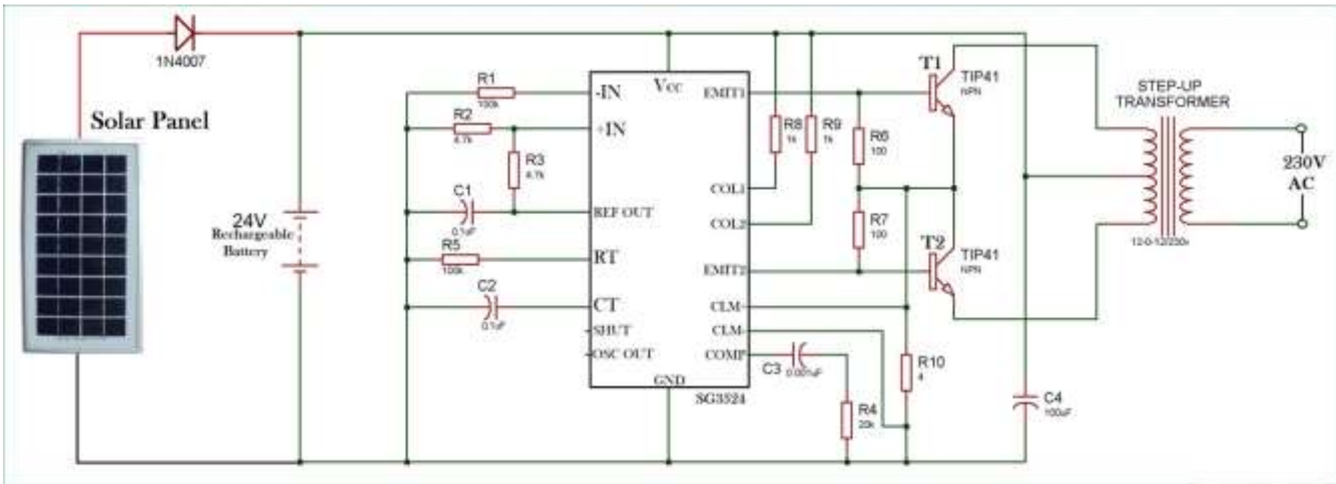
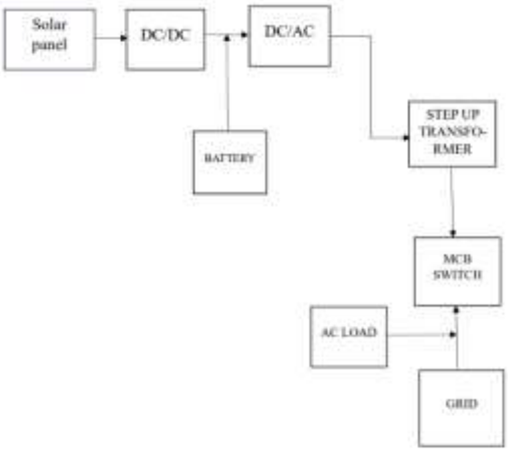


Fig1: Circuit diagram

This circuit is a solar-powered inverter that converts 24V DC from a solar panel and rechargeable battery into 230V AC using an SG3524 PWM controller IC and a step-up transformer. The diode (1N4007) prevents reverse current flow from the battery to the panel. The SG3524 generates alternating PWM signals to drive two TIP41 NPN transistors (T1 and T2) in a push-pull configuration. These transistors switch the 24V DC through the center-tapped primary of a step-up transformer, producing a 230V AC output. Additional components like resistors and capacitors help set the oscillation frequency, stabilize the signal, and filter out noise, ensuring efficient and stable operation of the inverter system.

Methodology:



This block diagram represents a **solar power-based grid-connected system with backup battery storage**. The process begins with a **solar panel** that captures sunlight and converts it into DC electricity. This DC power is regulated through a **DC-DC converter**, which stabilizes the voltage and charges the **battery** for energy storage. The regulated DC power is also fed to a **DC-AC converter (inverter)**, which transforms it into AC electricity suitable for household or grid use. The AC output is then sent to a **step-up transformer**, which increases the voltage to match the grid standards. The transformed AC power passes through an **MCB (Miniature Circuit Breaker) switch**, ensuring safety and protection against overcurrents. From here, the electricity is either supplied to the **AC load** (household appliances) or fed into the **electricity grid**, depending on demand and system configuration. This setup allows efficient utilization of solar energy while providing backup power and grid integration.

Components used:

1. 12 V, 10W Solar Panel:

A solar panel rated at 12 V and 10 W is a type of photovoltaic (PV) module that captures sunlight to produce electrical energy. As depicted in Figure 1, these panels are composed of numerous photovoltaic cells, often arranged in a grid pattern, such as 6 rows of 10 cells.

Photovoltaic modules are vital components of solar energy systems, forming the photovoltaic array that generates electricity for various applications, including both residential and commercial settings. Each module's performance is typically rated based on its direct current (DC) output power under standard test conditions (STC). The output power of these modules can range from approximately 100 to 365 Watts (W), depending on their specific design and efficiency.

In essence, a 12 V, 10 W solar panel is instrumental in converting solar energy into usable electricity, supporting the transition to renewable energy sources.

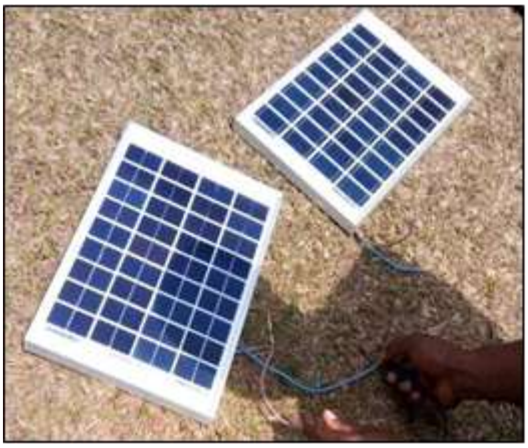


Fig.1

2. 12 V,8Ah Rechargeable Battery:

Figures 2a illustrate a rechargeable battery, commonly known as a lead-acid battery, secondary cell, or accumulator. This type of electrical battery is designed to be charged, discharged to power a load, and recharged multiple times, in contrast to primary batteries, which are precharged and intended for single use before disposal.

During the charging process, the positive active material undergoes oxidation, resulting in the release of electrons, while the negative active material experiences reduction, which involves the consumption of electrons. This flow of electrons generates the current that powers the external circuit.

The electrolyte in these batteries can function in different ways: in some types, such as lithiumion and nickel-cadmium batteries, it acts primarily as a medium for ion movement between the electrodes. In contrast, in lead-acid batteries, the electrolyte plays a more active role in the electrochemical reactions that occur during both charging and discharging.

Fig.2

3.12 V Single Changeover Relay:

Figure 2 depicts a relay, which functions as an electrically controlled switch. While many relays operate using an electromagnet to mechanically engage a switch, there are also other types, such as solid-state relays, that utilize different operating principles. Relays are particularly useful in situations where a low-power signal is needed to control a circuit or when multiple circuits need to be managed by a single signal. The initial applications of relays were found in long-distance telegraph systems, where they served as amplifiers by receiving a signal from one circuit and retransmitting it on another. Over time, relays became widely utilized in telephone exchanges and early computing systems to carry out logical operations.

Fig.3

4. Step up Transformer (12-0-12 V/230 V/6A):

Figure 4 illustrates a transformer, which is a static device that operates without any moving components. Its primary function is to transfer electrical power between two circuits while altering the voltage and current, all without changing the frequency.

A step-down transformer reduces the voltage from the primary circuit to the secondary circuit, characterized by having fewer turns of wire in the secondary winding compared to the primary winding. Conversely, a step-up transformer increases the voltage from the primary to the secondary circuit, featuring more turns in the secondary winding than in the primary winding.

The operation of an electrical transformer is based on the principle of mutual induction.

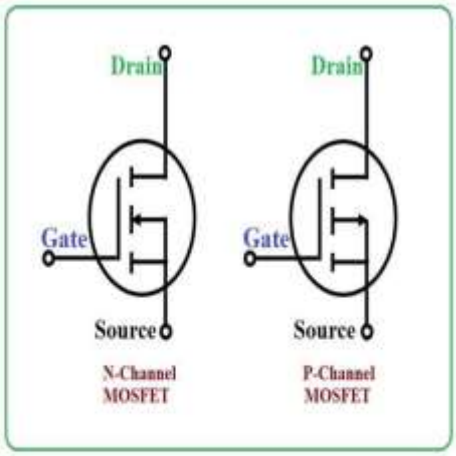
Fig. 4 .

5. MOSFET (IRFZ44N):

Figure 5 depicts the MOSFET (IRFZ44N), which stands for Metal Oxide Semiconductor Field Effect Transistor. This power electronic device is known for its high current-carrying capacity and significant blocking voltage in the OFF state. MOSFETs can switch at very high frequencies, typically around 100 kHz. As a voltage-controlled device, they require minimal input current, and their switching speeds are measured in nanoseconds, effectively avoiding the issue of second breakdown.

MOSFETs can be categorized into two main types:

1. Depletion MOSFET
2. Enhancement MOSFET



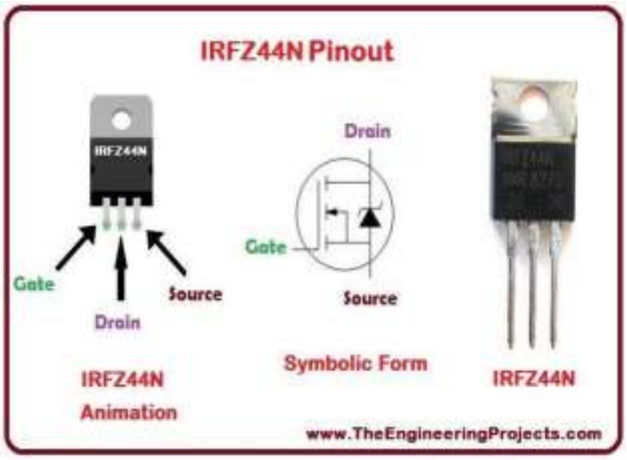


Fig:5 Fig:6

6.AC-DC Converter:

An AC-DC converter, commonly referred to as a rectifier, is an electronic device designed to transform alternating current (AC) from the electrical mains into direct current (DC), which is required by most electronic devices and circuits. This conversion is crucial because components such as batteries, microcontrollers, and LEDs function exclusively on DC power.

The fundamental operation of an AC-DC converter involves the process of rectification, which is typically achieved using diodes or bridge rectifiers. These components allow current to flow in a single direction, effectively removing the negative portion of the AC waveform. The result of this rectification is a pulsating DC output, which is then smoothed out using filter capacitors to minimize voltage ripples.

In more sophisticated AC-DC converters, additional components like voltage regulators or switch-mode power supplies (SMPS) are incorporated to ensure a consistent DC output voltage, even when there are fluctuations in the input voltage or load conditions.

AC-DC converters are extensively utilized in various applications, including power adapters, battery chargers, LED drivers, and internal power supplies for electronic devices such as computers, televisions, and industrial machinery. They play a vital role in enabling DC powered devices to operate from standard household AC outlets

Fig.7

7)AT mega Microcontroller:

The AT mega microcontroller, developed by Microchip Technology (previously known as Atmel), is a popular choice among developers due to its effective combination of performance, low power usage, and user-friendly design. It is built on the AVR RISC architecture, which enables efficient instruction execution with a reduced number of clock cycles.

Notable models, such as the ATmega328P, are frequently utilized in Arduino boards, making them well-suited for applications in embedded systems, automation, robotics, and various DIY electronics projects. These microcontrollers typically come equipped with flash memory, SRAM, and EEPROM, as well as a range of features including multiple input/output ports, timers, PWM outputs, and communication protocols like UART, SPI, and I²C.

The AT mega family also supports in-system programming, allowing users to modify the code without needing to remove the chip from the circuit. Its straightforward architecture and extensive community support make it an excellent option for both novices and experienced professionals engaged in embedded system development

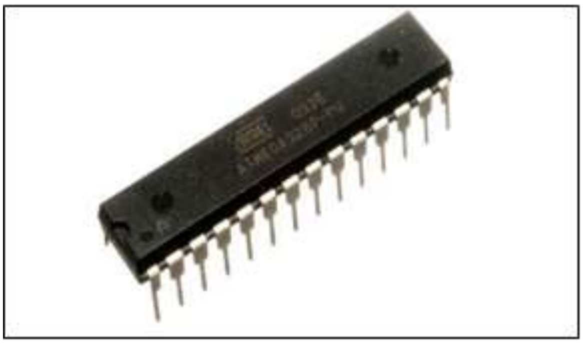


Fig.8

8. LCD Display:

A Liquid Crystal Display (LCD) is a type of flat-panel display technology widely utilized in various electronic devices to convey information, including text, numbers, and graphics. The operation of an LCD involves the manipulation of liquid crystals, which align in response to an electric current, thereby controlling the passage of light.

In the realm of embedded systems and microcontroller projects, alphanumeric LCDs, such as the well-known 16x2 or 20x4 models, are frequently employed to display data such as sensor outputs, menu selections, or system statuses. These displays are known for their energy efficiency, lightweight design, and straightforward interfacing with microcontrollers through parallel or I2C communication protocols.

Since LCDs do not produce light by themselves, they are typically equipped with a backlight to enhance visibility in dimly lit environments. Their low power consumption and excellent readability make LCDs particularly suitable for applications in handheld devices, industrial control systems, digital meters, and home automation solutions.

Fig.9

9.MCB:

A **Miniature Circuit Breaker (MCB)** is a protective device used in electrical circuits to guard against hazards like overloads and short circuits. Unlike traditional fuses that need to be replaced once blown, MCBs offer the advantage of being easily reset, making them more user-friendly and cost-effective over time.

MCBs work by automatically cutting off the power supply when they sense abnormal current flow, such as a spike due to an overload or a sudden surge from a fault. This interruption helps safeguard connected devices and minimizes the risk of electrical fires. As a result, they are widely used in households, offices, factories, and other buildings.

Key Characteristics of MCBs:

1.**CurrentCapacity**

MCBs are manufactured in various current ratings to suit different applications, ensuring the device matches the circuit's expected load.

2. Tripping Action:

These breakers trip using two core mechanisms:

- **Thermal tripping** for protection against overloads.
- **Magnetic tripping** to handle sudden current spikes due to short circuits.

3. Pole Configurations:

MCBs come in single, double, triple, and four-pole options, allowing them to be integrated into a variety of electrical systems based on phase and load requirements.

Fig.10

10.1N4148 DIODE:

The 1N4148 is a fast-switching diode commonly used in circuits requiring rapid switching performance. It operates like a typical switch—providing high resistance when the voltage is below a specific level and low resistance once that level is surpassed. Known for its small size, affordability, and reliability, the 1N4148 is frequently chosen for a wide range of electronic applications.

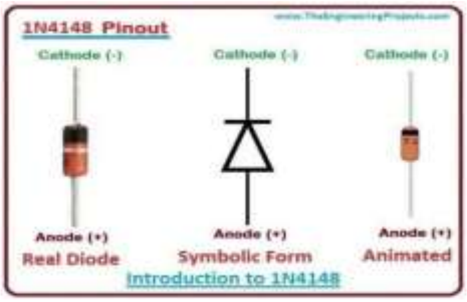


Fig.11

11.BC547 Transistor:

Figure 12 illustrates the BC547 transistor, which is a common NPN-type bipolar junction

transistor (BJT). It is widely used in various electronic circuits for switching and amplification purposes. When combined with other components such as resistors, inductors, and capacitors, it serves as an essential active element in electronic designs.

The BC547, like other NPN transistors, has three primary terminals: the **emitter**, the **base**, and the **collector**. The base functions as the control terminal. In standard operation, a small current flowing from the base to the emitter regulates a larger current flowing from the collector to the emitter.

In circuit diagrams, an NPN transistor is usually represented with a symbol where the base is a short horizontal line, and the emitter is shown as a diagonal line with an arrow pointing outward—indicating the direction of conventional current flow away from the base.

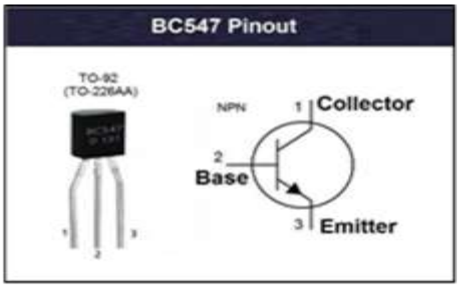


Fig.12

Results:

The results clearly show that the newly designed inverter successfully addresses many of the common limitations seen in traditional models. A major improvement is the significant decrease in harmonic distortion, which reflects the effectiveness of the advanced control strategies and optimized switching techniques used in the design. This improvement results in a cleaner and more stable power output, making the inverter ideal for sensitive electronics and inductive loads. Additionally, the inverter operates reliably across various load conditions, demonstrating consistent performance in practical applications. Its high efficiency in different operating modes indicates reduced energy losses, which is particularly beneficial for renewable energy systems and battery storage solutions. The design also incorporates robust safety mechanisms that quickly respond to fault situations, thereby improving the system's durability and dependability. Overall, these findings suggest that this hybrid inverter design is well-suited for applications that demand reliable, efficient, and high-quality power supply.

Conclusion:

Solar energy is a clean and renewable resource that has gained considerable importance due to its environmentally friendly nature and long-term availability. Photovoltaic (PV) systems, which convert sunlight directly into electricity, are especially attractive because they require minimal maintenance and offer a sustainable way to generate power. Despite these benefits, the high initial cost of installation remains a barrier to widespread adoption. Additionally, the power output of PV panels can be inconsistent, as it depends heavily on external factors like sunlight intensity and temperature. The system developed in this project is designed to deliver consistent AC power by efficiently converting energy from a DC source. This approach not only ensures functional performance but also offers long-term economic and environmental advantages. Ultimately, the project represents a meaningful step forward in the advancement and application of renewable energy technologies

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