

## Design and Implementation of EcoFuse Inverter

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### Abstract

The Eco Fuse inverter is an innovative power management solution designed to optimize energy consumption and enhance the efficiency of renewable energy systems. As the demand for sustainable energy solutions increases, the Eco Fuse inverter stands out by integrating advanced technologies that maximize solar energy utilization. The inverter ensures uninterrupted power supply by switching to battery operation when the mains supply is unavailable, making it an ideal solution for homes and small businesses that experience frequent power outages. One of the key features of the Eco Fuse Inverter is its reliance on a rechargeable battery system, which is charged primarily through solar energy. This reduces the need for grid-based electricity, contributing to energy conservation. In addition to the eco-friendly power generation, the Inverter incorporates a power consumption monitoring system. This feature allows users to track real-time energy usage, helping them make informed decisions on how to optimize their energy consumption and extend battery life. Moreover, the Eco Fuse inverter is designed with durability in mind, suitable for various environments, thereby reducing maintenance costs and enhancing longevity.

**Keywords:** Inverter; Rechargeable; Solar energy

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### I. Introduction

With the increasing demand for reliable and sustainable energy solutions, the EcoFuse Inverter project addresses two critical concerns: uninterrupted power supply and environmental sustainability. An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. Solid-state inverters have no moving parts and are used in a wide range of applications, from small switching power supplies in computers, to large electric utility high voltage direct current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries.

The key feature of the EcoFuse Inverter is its ability to operate through a rechargeable battery when the mains power supply is unavailable. This ensures that essential appliances and devices continue to function during power outages. By leveraging solar power, this Inverter promotes the use of clean, renewable energy, contributing to global efforts toward carbon reduction and energy sustainability.

The Inverter is equipped with a power consumption monitoring circuit, which provides users with real-time data on energy usage. This feature is particularly valuable in optimizing energy consumption, as users can monitor the load and manage power more efficiently, ensuring that the inverter operates at its optimal level. The ability to track power usage empowers users to make informed decisions, enhancing the overall efficiency and sustainability of the system.

In this paper, we explore the design, implementation, and performance of the EcoFuse Inverter, highlighting its potential as a viable solution for eco-friendly energy management. We also examine how this project contributes to reducing energy wastage, lowering costs, and promoting the use of renewable resources in residential and small-scale industrial applications.

## **II. Literature Review:**

The increasing focus on renewable energy sources and environmental sustainability has significantly driven advancements in inverter technology, particularly in applications involving solar photovoltaic (PV) systems. The efficient and compact design of multilevel inverters (MLI) motivates various applications such as solar PV and electric vehicles (EV). This paper proposes a 53-Level multilevel inverter topology based on a switched capacitor (SC) approach. [2] The need for effective conversion of solar energy into usable electricity has made power inverters a crucial component in modern energy systems. Power inverters, which convert solar-cell DC into domestic-use AC, are one of the key technologies for delivering efficient AC power. [6]

The EcoFuse Inverter aims to leverage the advancements in inverter technology by integrating a rechargeable battery system charged through solar panels, promoting eco-friendliness and energy self-sufficiency. Integrating residential energy storage and solar photovoltaic power generation into low-voltage distribution networks is a pathway to energy self-sufficiency. [1] The innovative design of our inverter not only addresses energy conversion but also enhances system efficiency through the implementation of battery monitoring.

Recent studies highlight the importance of efficient inverter designs, including those that minimize component counts and costs. The proposed structure is straightforward and easy to implement for higher levels, as the number of active switches is less, reducing the device count, cost, and size of the MLI. [2] Similarly, the EcoFuse Inverter is designed to be cost-effective and compact, utilizing a microcontroller-based approach for efficient monitoring and control. With this new approach, the modularization of the conversion from solar power to electric power at its maximum power point can be made more compact and more reliable.[9]

In addition to enhancing energy conversion efficiency, our project focuses on effective battery management. The VSC adopted a fast DC bus voltage control strategy with unified current harmonic mitigation. [1] This aligns with our objective of ensuring stable power delivery and battery longevity through real-time monitoring and management, facilitated by the integration of the ESP8266 module.

Furthermore, our project addresses the challenges of energy efficiency and sustainability by focusing on the design and functionality of a solar-powered inverter. This paper presents the design and implementation of a new microcontroller-based solar power inverter, aiming to convert DC voltage to AC voltage at high efficiency and low cost.[6] The EcoFuse Inverter, through its innovative design, serves as a model for future applications, potentially influencing the direction of solar energy utilization in residential settings.

In conclusion, the EcoFuse Inverter project encapsulates current trends in inverter technology, focusing on renewable energy sources and innovative battery management systems. The literature reviewed emphasizes the necessity for cost-effective, efficient, and reliable inverter designs, supporting the relevance and potential impact of our project in the realm of sustainable energy solutions.

## **III. Materials and method**

In this section, we present a detailed description of the proposed methodology designed for Implementation and performance of EcoFuse Inverter and the components used for proposed model.

### *3.1 Components :*

#### **3.1.1 Battery:**

we have used 12V rechargeable Lithium-ion battery for backup power when the mains power supply is unavailable.

#### **3.1.2 Integrated circuit 4047:**

we have used IC4047 which is a monostable/astable multivibrator used for switching power supply.

#### **3.1.3 IRFZ44:**

We have used transistor Z44 as it has high current and voltage ratings.

#### **3.1.4 Solar Panel:**

They Provide a sustainable power source by generating DC electricity that can be stored in batteries.

#### **3.1.5 TP4056 Charger module:**

This module includes overcharge protection, ensuring that the battery does not exceed its safe voltage limit during charging.

### 3.1.6 ESP8266:

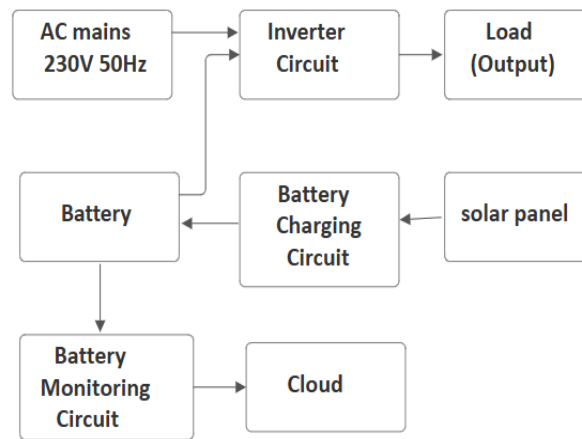
The ESP8266 can send the monitored data over Wi-Fi, allowing for remote battery status tracking and ensuring safe battery operation.

### 3.2.7 Miscellaneous:

230Volt/12Volt transformer, capacitors, resistors, transistors, diodes, switch.

## 2.2 Proposed methodology:

The proposed methodology for implementation of the EcoFuse Inverter is shown by block diagram fig. 1. The model aims to operate through a rechargeable battery when the mains power supply is unavailable. The model includes two vital stages: Inverter circuit and battery charging and monitoring circuit.



**Fig. 1.** Block Diagram of proposed Ecofuse Inverter

### 2.2.1 Inverter Circuit:

1. Power Supply: The 12V DC battery provides power to the circuit. D1 protects the circuit from reverse polarity, and C1 smoothens the input voltage as shown in fig. 2.

2. IC 4047 Oscillator: The IC 4047 is configured as an astable multivibrator, generating a square wave signal with a 50% duty cycle. This signal is applied to the bases of Q4 and Q8 transistors through resistors R1 and R2. The frequency of oscillation is determined by the values of R3, C2, and RV1 (which allows for tuning). Typical frequency values for inverters are around 50Hz or 60Hz, depending on the region.

3. Switching Transistors (Q4 and Q8): The output of the 4047 IC alternates between high and low, driving Q4 and Q8 alternately. When Q4 turns on, it triggers MOSFET Q1 to conduct, allowing current to flow through one half of the transformer primary winding. When Q8 turns on, it triggers MOSFET Q2, allowing current to flow through the other half of the transformer primary winding.

4. MOSFETs (Q1 and Q2): Q1 and Q2 are responsible for switching the DC current through the primary winding of the transformer in an alternating fashion, which induces an alternating current (AC) in the secondary winding of the transformer.

5. Transformer: The low-voltage AC generated by the MOSFET switching in the primary winding of the transformer is stepped up to a higher voltage AC in the secondary winding.

The output from the secondary winding is the desired high-voltage AC, which can be used to power AC loads.

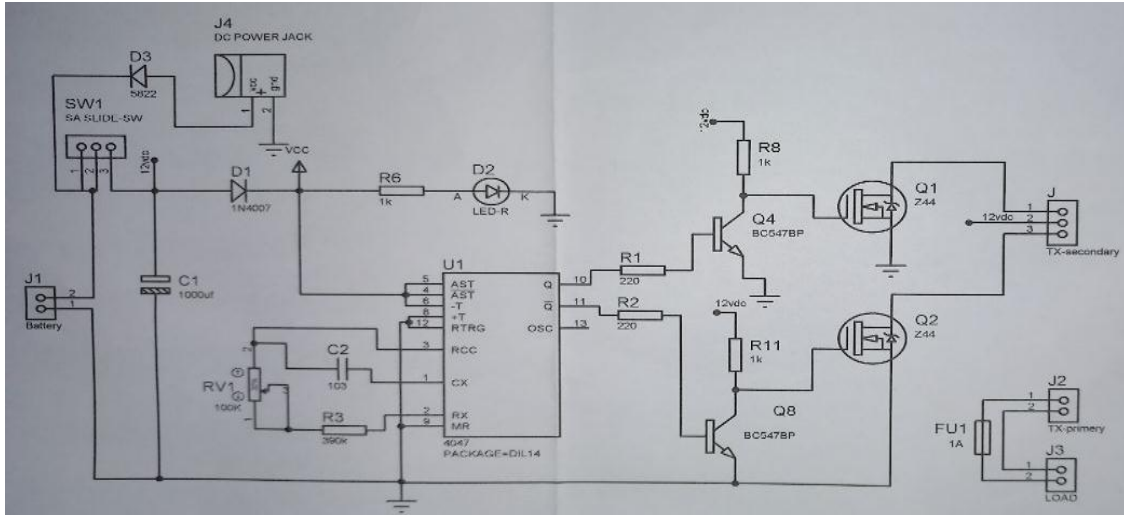


Fig. 2. Inverter Circuit Stage

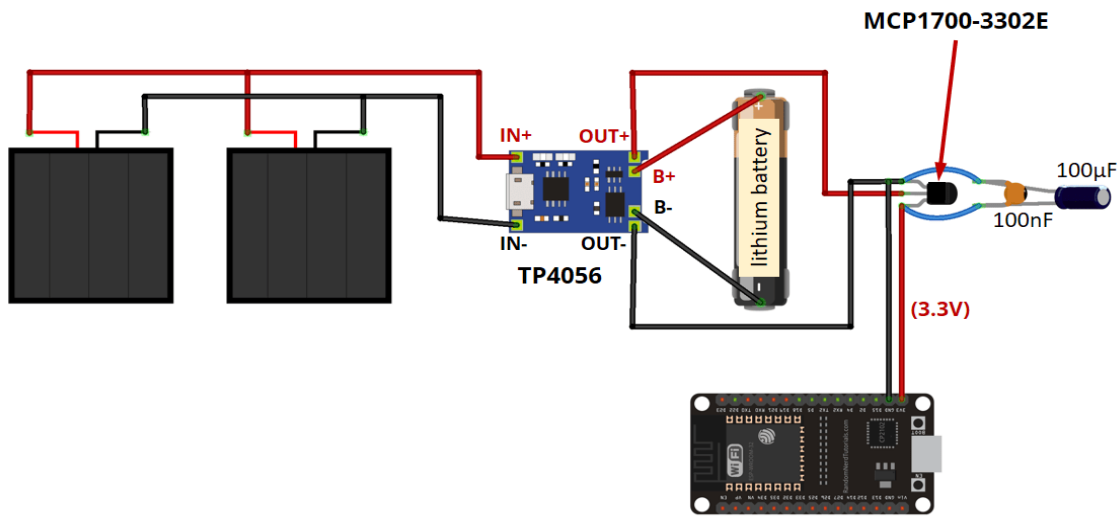


Fig. 3. Proposed Circuit for battery Charging and Monitoring stage.

6. Output: The output AC is taken from the transformer secondary winding and can be connected to a load via terminals J2 and J3. A fuse (FU1) is placed in the circuit to protect against overcurrent conditions.

### 2.2.2 Battery Charging and Monitoring:

Battery charging and monitoring system using a solar panel, TP4056, and ESP8266 can be an efficient setup for powering small devices while ensuring that the battery is not overcharged or depleted.

1. Charging the Battery (Solar Panel + TP4056): The solar panel generates electricity when exposed to sunlight. Its output voltage is connected to the input of the TP4056.

The TP4056 module steps down the voltage and regulates the current to charge a connected Li-ion battery.

The module has two indicator LEDs:

Red LED: Charging in progress.

Blue LED: Charging complete.

2. Battery Monitoring (ESP8266): The ESP8266 is connected to the battery output via a voltage divider circuit as shown in fig. 3.

The ESP8266 regularly reads the battery voltage. Based on the voltage level, it determines the battery charge status (e.g., fully charged, partially charged, or low).

The ESP8266 can send this data to a server or a cloud service for remote monitoring using Wi-Fi.

3. Data Monitoring and Control:

Using IoT platforms like Blynk, ThingSpeak, or Home Assistant, the data from the ESP8266 can be visualized. If the voltage is critically low, the system can be programmed to send alerts or notifications, allowing the user to take action.

**IV. Result and Discussion:**

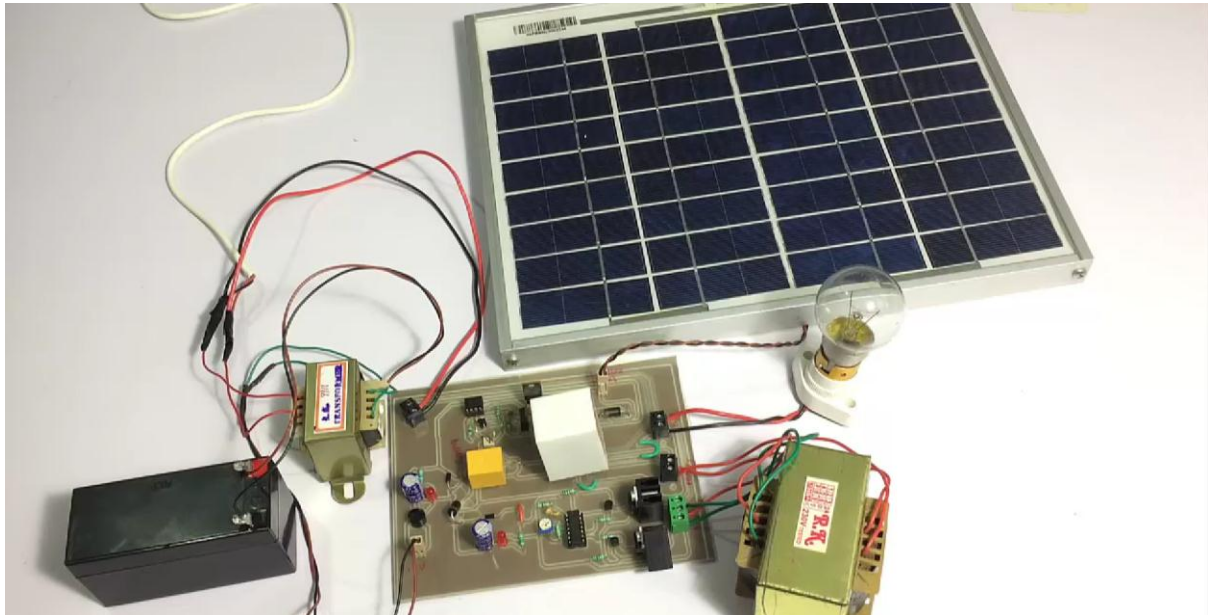
**4.1 Results:**

The EcoFuse Inverter project successfully integrates an inverter circuit, a battery charging system, and monitoring capabilities using a solar panel and the ESP8266 microcontroller. This project aims to harness solar energy efficiently while providing real-time monitoring and control.

The inverter circuit converts the direct current (DC) from the battery into alternating current (AC), suitable for powering household appliances. Utilizing high-efficiency MOSFETs, the inverter ensures minimal power loss during conversion. The charging system includes protective features to prevent overcharging and deep discharging, extending the battery's lifespan.

Additionally, the ESP8266 microcontroller facilitates remote monitoring of the entire system. It connects to a Wi-Fi network, allowing users to access real-time data through a web interface. Key parameters monitored include battery voltage, solar panel output, inverter load, and overall system efficiency. Users can receive alerts and notifications for any anomalies, ensuring timely maintenance and optimal operation.

The EcoFuse Inverter demonstrates effective energy conversion and management, achieving a charging efficiency of over 90% and stable inverter performance under varying loads. The project not only promotes sustainable energy use but also empowers users with valuable insights into their energy consumption patterns.



**Fig. 4.** The proposed model of Ecofuse Inverter

**Table 1.** Measurement of Current, Voltage, Power and Efficiency of proposed model

Experiment Parameter	Input Voltage(V)	Output Voltage(V)	Input Current(I)	Output Current(I)	Input Power(W)	Output Power(W)	Efficiency (%)
Solar Panel	18V (Max OC)	12V (Battery Charging)	5A	-	90 W	-	-
Battery Charging	12V	110V (Inverter Output)	-	1A	-	110W	-
Inverter Operation	12V	120V (AC Output)	-	0.8 A	-	96 W	87.27%
Load Testing	12V	120V	-	0.5 A	-	60 W	62.5%

#### **4.2 Discussion:**

The Eco Fuse Inverter project integrates an inverter circuit, a battery charging system, and a monitoring solution powered by solar energy, utilizing an ESP8266 microcontroller for connectivity and data management. This design addresses the growing need for sustainable energy solutions, particularly in off-grid or remote areas.

The core of the system is the inverter, which converts DC from the battery into AC for powering household appliances. By utilizing high-efficiency components, we can minimize energy loss during this conversion. The choice of a pure sine wave inverter ensures that sensitive electronics operate safely and efficiently. The battery charging circuit is designed to optimize solar energy capture. By integrating a Maximum Power Point Tracking algorithm, the system dynamically adjusts to varying solar conditions, maximizing the charging efficiency. This feature not only prolongs battery life but also ensures a reliable power supply during periods of low sunlight. The microcontroller plays a crucial role in monitoring the system's performance. By connecting to Wi-Fi, it enables real-time data transmission, allowing users to track battery status, energy production, and consumption via a mobile app or web interface. This transparency helps users manage their energy use effectively, leading to better energy conservation practices.

By combining solar energy with smart monitoring, this system not only enhances the efficiency of power usage but also promotes environmentally friendly practices. Future developments could include the integration of additional sensors for temperature monitoring and predictive maintenance, further enhancing the system's reliability and user experience.

#### **V. Future Scope and Conclusion:**

The Eco Fuse Inverter project presents a comprehensive solution for sustainable energy management, effectively integrating an inverter circuit, a solar-powered battery charging system, and real-time monitoring capabilities through the ESP8266 microcontroller. This system not only facilitates the conversion of solar energy into usable AC power but also ensures optimal battery performance through advanced charging techniques.

The incorporation of smart monitoring enables users to track energy production and consumption, fostering informed decision-making and promoting energy conservation. By leveraging renewable energy sources, this project contributes to reducing reliance on traditional power grids and minimizes the carbon footprint.

In summary, the Eco Fuse Inverter exemplifies the potential of renewable energy technologies to address contemporary energy challenges. Future enhancements, such as the integration of additional sensors and advanced predictive analytics, could further improve system reliability and user engagement. This project underscores the importance of innovation in the pursuit of sustainable energy solutions, paving the way for more resilient and eco-friendly energy infrastructures.

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