



DESIGN AND IMPLEMENTATION OF INTELLIGENT INVERTER FOR SMART CITIES

¹Ms.S.Sneha,²I.Hema Bindu,³K.Varshitha Reddy,⁴M.Sai Parwathi

¹Assitant Professor,²Student 1,³Student 2, ⁴Student 3

¹Electrical and Electronical Engineering

¹Stanley College Of Engineering And Technology For Women,Abids,Hyderabad

Abstract : In today's technologically driven world, an uninterrupted power supply is essential for both Domestic and Industrial applications. Power outages can lead to significant disruptions, affecting daily activities and critical operations. This project aims to develop a Smart Inverter/UPS (Uninterruptible Power Supply) system that ensures a seamless transition from mains electricity to battery power during a power outage, thereby providing continuous power to essential devices. The system is designed to intelligently detect power failures and automatically switch to battery mode without any delay, preventing data loss and equipment damage in critical applications. Additionally, the inverter incorporates overload protection, short-circuit safety, and voltage regulation to ensure reliability and durability. This innovative inverter not only ensures uninterrupted power but also provides an intelligent, automated, and efficient energy management solution, making it a valuable addition to modern smart power systems.

IndexTerms - Uninterrupted power supply (UPS), Intelligent Inverter, Voltage Regulation, Energy management, smart power systems, Power Outage Protection, Intelligent Power System

I. INTRODUCTION

In today's rapidly evolving technological landscape, the demand for reliable and efficient power management systems has become more critical than ever. Power outages and voltage fluctuations can disrupt everyday activities, and impact productivity in both residential and commercial settings. Widespread use of Distributed Energy Resources (DERs) creates novel problems in grid operation and control [1]. In response to these challenges, intelligent inverters have emerged as a vital solution, offering seamless energy conversion, and automated switching capabilities [2]. Generally, an inverter capable of making effective and independent decisions based on local measurements and external data can be considered a smart inverter [3].

This project focuses on the design and implementation of an intelligent inverter system with automatic switching functionality. Unlike traditional inverters, which require manual intervention or offer limited control, this intelligent system is designed to automatically detect power failures and switch between the main grid and backup power sources, such as batteries without human intervention [4]. It aims to ensure uninterrupted power supply, improve energy efficiency, and protect connected devices through smart monitoring and control mechanisms. The system is built around a microcontroller (like Arduino) that continuously monitors the status of the power supply and controls relays for switching, ensuring fast and efficient transitions [5]. With added features like an LCD display for real-time status, battery voltage monitoring, and overload protection, this project offers a smart, reliable, and user-friendly solution for uninterrupted power.

This inverter system maintains pivotal role. In offices and workshops, it Keeps computers, servers, printers, and communication equipment running smoothly, prevents data loss during sudden power outages, Reduces downtime and boosts productivity [6]. In medical and health care centers it Supports uninterrupted operation of diagnostic equipment, lighting, and refrigeration for medicines Ensures safety of patients during critical procedures [7]. In banking and ATM centers inverter system Keeps ATMs, servers, and security systems operational 24/7, Helps avoid service disruption and maintains customer trust. In industries it Supports machinery, surveillance, and basic automation systems. Avoids machine resets or process interruptions caused by power loss [8]. In shops and retail, it maintains operation of billing systems, lighting, and security cameras. Prevents revenue loss due to downtime during peak business.

II. LITERATURE SURVEY

A Number of Researchers have looked into designing a inverter This study carried out by Smart Inverter/UPS system offers numerous benefits, including uninterrupted power supply, automatic switching, efficient battery management, and cost-effectiveness. It can be particularly useful in areas prone to frequent power outages or where a reliable backup power system is required. Throughout the project, we focused on ensuring efficient power conversion and management to prolong battery life and maintain system reliability. The system was thoroughly tested to confirm its ability to detect power outages and switch seamlessly between power sources.

Existing System

The conventional inverter/UPS with manual or basic automatic switching, a battery bank, a charger, and a static transfer or relay that switches load between mains and inverter. Often implemented with discrete analog sensing and simple relay logic.

In this system User must check the unit physically. There will not visible the battery status, no quality check of mains, and produce poor output waveforms.

Proposed System

The intelligent inverter introduces microcontroller-driven inverter/UPS that intelligent sensing of mains quality, manages battery charging status, executes fast and adaptive automatic transfer switching (ATS), prioritizes loads, and provides local and remote monitoring and control.

By integrating intelligence into the inverter system, the project aims to

- Eliminate downtime during power outages.
- Enhance energy efficiency by prioritizing power sources (e.g., battery).
- Reduce human effort in managing power switching.
- And provide a more reliable and user-friendly power management solution suitable for homes, offices, and small industries.

Block Diagram

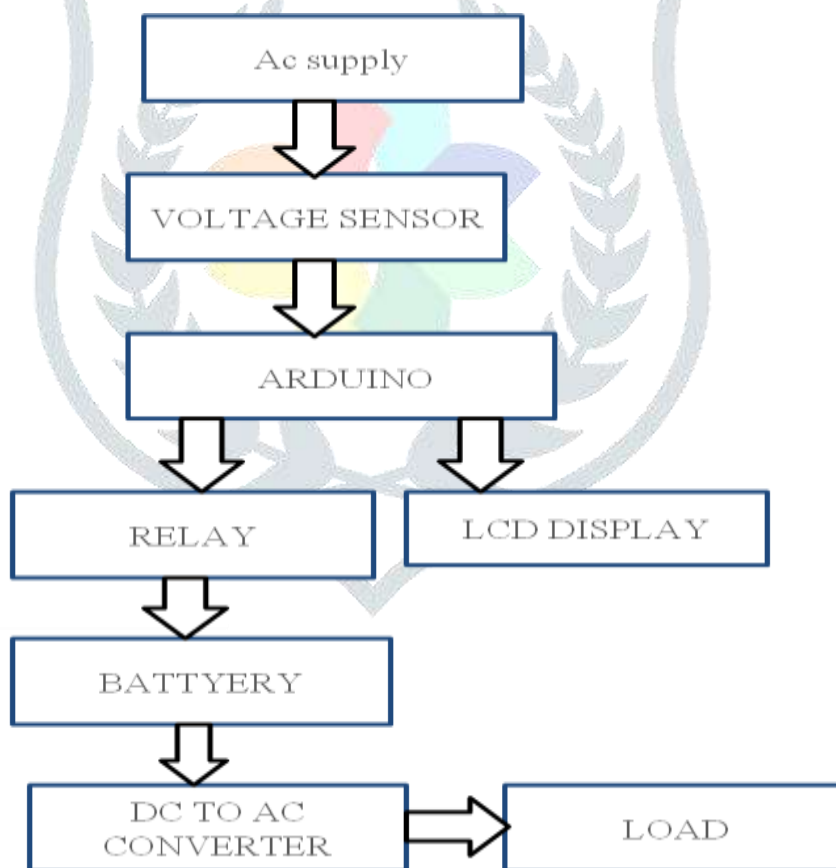


fig-1:Block Diagram

III. METHODOLOGY AND COMPONENTS

3.1 Inverter

The inverter is a key element of the system, responsible for converting the stored 12V DC from the battery into 230–240V AC required by household appliances. This conversion is carried out using high-speed switching devices such as mosfets, transistors, or IGBTs. In this design, 110A MOSFETs are used to handle high current during switching and rectification. These MOSFETs

interface with the transformer, enabling both AC-to-DC battery charging during grid availability and DC-to-AC conversion during backup operation. The inverter output is regulated to match the standard mains frequency and voltage.

3.2 Relay

The relay functions as an automatic transfer switch that protects the system and ensures continuous power delivery. During normal grid operation, the relay allows AC mains to supply the load while permitting the battery to charge. When the controller detects a power outage, the relay shifts the load to the inverter output within milliseconds. Once the grid supply returns, the relay restores the connection to the mains and safely disconnects the inverter to prevent backfeeding.

3.3 Battery

A 12V lithium-ion battery is used as the energy storage unit, providing backup power when the mains supply fails. Lithium-ion cells were selected due to their higher efficiency, compact size, and longer service life compared to traditional lead-acid batteries. The charging module regulates the charging current, prevents overcharging, monitors temperature, and safeguards the battery from over-voltage or overheating. This ensures reliable and safe operation of the power backup system.

3.4 Voltage Sensor

The voltage sensor is employed to measure and track the input and output voltage levels. It operates using a voltage divider network, where resistors scale down higher voltages to a range that can be safely interpreted by the microcontroller. Depending on its type, the sensor may provide an analog signal, digital output, or waveform representation of the measured voltage. This data is crucial for decision-making, allowing the controller to switch between power sources at the correct time.

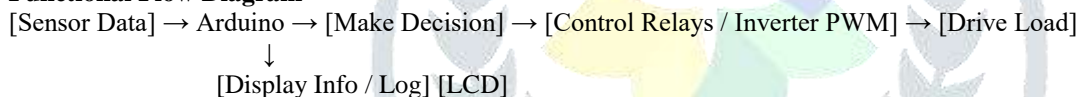
3.5 Arduino UNO

The Arduino UNO, built around the ATmega328P microcontroller, serves as the central processing unit of the system. It includes digital I/O pins, analog inputs, PWM outputs, and a 16 MHz oscillator for stable operation.

Roles of Arduino in the project:

- Controls the relay to toggle between grid and inverter supply
- Generates PWM signals to drive the MOSFETs in the inverter stage
- Reads voltage sensor data and determines when to switch power modes
- Sends real-time system information to the display unit

Functional Flow Diagram



3.6 LCD display

A 16x2 alphanumeric LCD is used to present system parameters such as voltage levels, battery state, and operating mode. Each character is rendered using a 5x7 dot matrix. The command register handles instructions like clearing the screen or setting cursor position, while the data register receives ASCII codes for characters to be shown. This display helps users monitor the system status in real time.

IV. RESULTS AND DISCUSSION

Normal Operation (Mains Power Available)

The mains 240V AC is stepped down by the transformer and converted to 12V DC by the rectifier circuit. The 12V DC charges the battery and powers the connected AC devices through the relay. The relay continuously monitors the mains power supply. It displays mains ON on the display.

Power Outage (Mains Power Not Available)

The system constantly checks the voltage drop and main failure. When it detects no mains supply, the microcontroller activates the inverter circuit. The 12V DC from the battery is converted back to 240V AC by the inverter. The connected AC devices, such as the 0.5W bulb, continue to receive power from the battery. Displays inverter ON or battery mode.

Restoration of Mains Power

When mains power is restored, the relay switches back to mains power. The system resumes charging the battery while continuing to power the AC devices from the mains supply. Microcontroller detects main power restoration. Automatically switches back the load to mains. hence by turning off the inverter, thus saving battery.

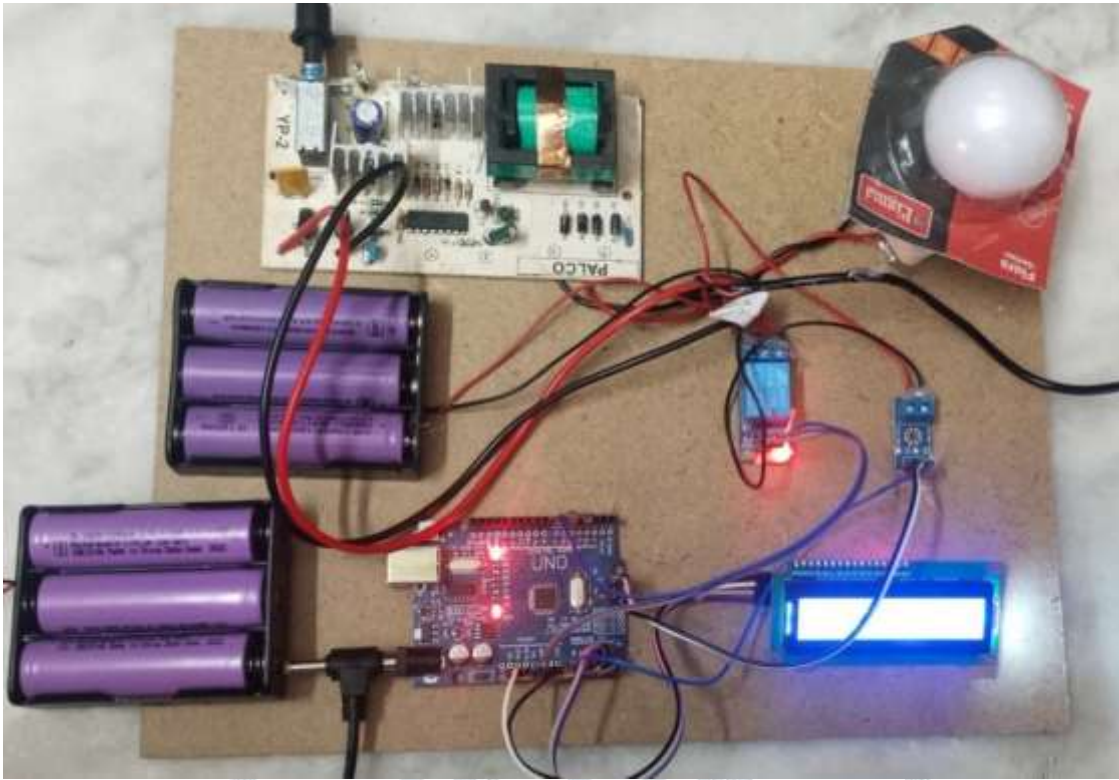


fig-2: Intelligent inverter with automatic switching



fig-3: Indication of power from mains



fig-4: Indication of power from battery source

V. CONCLUSION

Intelligent Inverter with Automatic Switching represents a significant improvement over traditional inverter systems by providing uninterrupted power supply through real-time monitoring and automatic changeover between mains and backup power. This system reduces the need for manual intervention, enhances convenience, and ensures better protection for connected devices. By integrating automation, it also improves energy efficiency and battery management. While it is ideal for homes, small offices, and educational projects, scalability and reliability need to be carefully addressed for large-scale or commercial applications. Overall, it is a smart, efficient, and practical solution for modern power backup needs.

The Smart Inverter/UPS system represents a significant advancement in providing reliable, efficient, and sustainable power solutions. By addressing current limitations and focusing on future developments, this technology can play a pivotal role in ensuring continuous power supply in an increasingly digital and interconnected world. The ongoing evolution of this system promises to deliver even greater benefits, driving innovation and enhancing quality of life across various domains.

VI. REFERENCES

- [1] A. Garg, M. Jalali, V. Kekatos, and N. Gatsis, "Kernel-Based Learning for Smart Inverter Control," in *2018 IEEE Global Conference on Signal and Information Processing (GlobalSIP), Anaheim*.
- [2] J. Abolarinwa and P. Gana, "Design and Development of Inverter with AVR using Switch Mode Square Wave Switching Scheme," *Assumption University Journal*, vol. 13, no. 4, pp. 249-257, April 2010
- [3] Ofualagba, G. and Igbino, C. (2017). Implementation of a Microcontroller Based 5 KVA Automatic Voltage Stabilizer. *International Journal of Latest Research in Engineering and Technology*, 01-08
- [4] Annie C. (2016). Design and Implementation of a 5 kVA Inverter. *Journal of Electrical and Electronics Engineering*,
- [5] A. M. Howlader, S. Sadoyama, L. R. Roose, and Y. Chen, "Active Power Control to Mitigate Voltage and Frequency Deviations for the Smart Grid Using Smart PV Inverters," *Applied Energy*,

[6]O. Ceylan, S. Paudyal, and I. Pisica, “Nodal Sensitivity-Based Smart Inverter Control for Voltage Regulation in Distribution Feeder,”

[7] H. V. Padullaparti, N. Ganta, and S. Santoso, “Voltage Regulation at Grid Edge: Tuning of PV Smart Inverter Control,”

[8]J. Hrouda, M. Čerňan and K. Procházka, “A New Method of Smart Control of Single-Phase Photovoltaic Inverters at Low Voltage for Voltage Control and Reactive Power Management,”

