Home Automation with Solar Base Hybrid Inverter

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***Abstract*— In the burgeoning era of smart technology, the integration of renewable energy sources and home automation systems has garnered significant attention for its potential to enhance energy efficiency and user convenience. This paper presents the design and implementation of a cutting-edge Home Automation System with a Solar-Based Hybrid Inverter, leveraging the powerful capabilities of the Portenta C33 controller. The system seamlessly transitions between solar and grid power sources, optimizing energy utilization while ensuring uninterrupted operation. Equipped with a myriad of sensors including LPG, temperature, humidity, and ultrasonic, coupled with intelligent actuators such as relays and motors, the system offers comprehensive environmental monitoring and control. Integration with the Blynk platform facilitates remote access and control, empowering users with real-time insights and management of their home environment. Through meticulous hardware selection, circuit design, and software development, this project embodies innovation and sustainability, paving the way for smarter, greener homes in the IoT landscape. The research showcases the practical implementation of renewable energy integration in home automation, highlighting its effectiveness in optimizing energy usage and enhancingenvironmental monitoring capabilities.**

Keywords—Portenta C-33,Blynk App, Cloud Computing, Home automation, Solar panel, Ultrasonic sensor, MQ sensor, DHT-11.

I. INTRODUCTION

In the realm of smart home technology, integrating renewable energy sources like solar power with traditional grid electricity has become increasingly imperative. This project introduces a sophisticated smart home system designed to seamlessly switch between these power sources, ensuring uninterrupted power supply while optimizing the utilization of solar energy.[1] This capability is crucial for maintaining consistent electricity even during solar availability fluctuations or grid outages, thereby enhancing reliability and sustainability. Traditional home automation systems often neglect renewable energy integration, posing limitations in sustainability and resilience during power disruptionsMoreover, existing systems may lack comprehensive environmental monitoring and intuitive user interfaces. [2]

Addressing these gaps is pivotal to advancing the efficiency and resilience of smart home solutions. The motivation behind this project stems from the need to enhance energy efficiency, convenience, and safety in smart homes through robust integration of renewable energy sources. [3] By leveraging solar power alongside grid electricity, our system aims to reduce dependency on non-renewable energy and mitigate the impact of power outages on household operations. The primary objectives of this study include: Designing and implementing a smart home system capable of seamless transition betweensolar and grid power. Integrating advanced sensors such as ultrasonic and LPG sensors for enhanced safety and operationalefficiency. [4] Developing an intuitive control interface for remote monitoring and management of home environmental conditions. Evaluating the system's performance in terms of energy efficiency, reliability, and user satisfaction. This paper contributes a novel approach to smart home automation by: Demonstrating the feasibility of integrating renewable energy sources for enhanced sustainability. [5] Enhancing environmental monitoring capabilities through advanced sensor integration. Providing insights into the design considerations and performance evaluation of the implemented system. In this project, we're introducing a smart home setup that blends solar power with traditional grid electricity. [6] We've devised a smart system that seamlessly switches between these power sources, guaranteeing a steady power supply while optimizing the use of solar energy whenever it's accessible. This automatic changeover feature ensures uninterrupted power, even during fluctuations in solar availability or grid outages. We've integrated an ultrasonic sensor capable of precision distance [2] Addressing these gaps is pivotal to advancing the efficiency and resilience of smart home solutions. The motivation behind this project stems from the need to enhance energy efficiency, convenience, and safety in smart homes through robust integration of renewable energy sources. measurements, adding versatility to the system's functionality. This sensor serves myriad purposes throughout the household, providing accurate distance data for enhanced operational efficiency and convenience. [7] As technology continues to advance, there is a growing demand for smart home solutions that promote energy efficiency, convenience, and safety.

However, traditional home automation systems often lack integration with renewable energy sources, limiting their sustainability and resilience to power outages. Furthermore, existing solutions may not offer comprehensive environmental monitoring capabilities or seamless integration with user-friendly control interfaces. The Portenta C33 offers sufficient processing power to handle complex algorithms and real-time data processing required for environmental monitoring, sensor fusion, and intelligent actuation. The automatic changeover mechanism ensures uninterrupted power supply to the home, even during fluctuations in solar availability or grid outages. This enhances the resilience of the system and ensures continuous operation of critical appliances and devices. Introduction: Provides an overview of the importance of integrating renewable energy sources in smart home systems, outlines the objectives, and introduces the proposed system architecture. Related Work: Discusses existing research and developments in smart home technology, highlighting methods, results, advantages, and limitations of relevant papers published from 2021 to 2023, following IEEE guidelines. System Design and Implementation: Details the design considerations, components used, and the integration of renewable energy sources and sensors within the smart home system. Performance Evaluation: Presents the methodology used to evaluate the system's performance in terms of energy efficiency, reliability, and user satisfaction. Results and Discussion: Analyzes the findings from the performance evaluation, discussing the system's effectiveness in achieving its objectives. Conclusion: Summarizes the key contributions of the paper, highlights the significance of the findings, and proposes future research directions.

II. Block Diagram

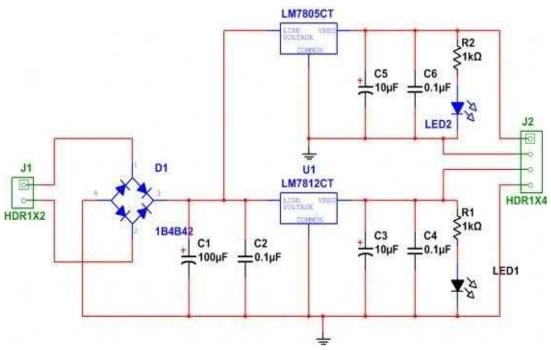

Figure 1. Power supply.

In this project, there are two main methods for supplying the system: the solar panel and the 230V AC system. A 230V power supply is fed into the step-down transformer with a rating of 12V. This output can then be connected to a bridge rectifier, which includes a rectifier, filter, and voltage regulator. The rectifier converts AC into pulsating DC, and the filter provides a pure DC signal by blocking ripples. The DC voltage is regulated to 5V and supplied to the microcontroller from these rectifiers, as shown in the figure. The snubber helps protect connected devices from voltage spikes or transients that may occur in the system. It regulates and dissipates excess voltage, safeguarding components from potential damage. During periods of high sunlight or low load demand, the excess electricity generated by the solar panel is used to charge the battery. The battery stores this energy for later use when sunlight is limited or during peak demand periods. When the solar panel's output is insufficient to meet the load demand or during peak demand periods, the stored energy in the battery is discharged.

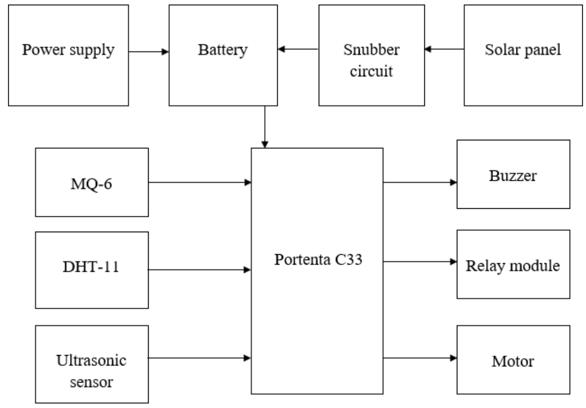

Figure.2. Block diagram of Home Automation with Solar Base Hybrid Inverter

In Fig. 1.1, the Portenta C33 serves as the main microcontroller for connecting cloud and mobile data. A buzzer is connected to pin D0, and a relay module is linked to pins D1, D2, D3, and D4. The DHT-11 sensor is connected to pin D5, while the MQ-6 sensor is connected to pin D6. Additionally, the ultrasonic sensor is connected to pins D7 and D8. The solar panel is connected to the snubber circuit, which is further connected to pin A0, enabling the reading of solar voltage.

Specification

Portenta C33

Arduino series of high-performance industry rated boards. As shown in figure. 1.2 pinout of Portenta C33. It can manage Wi-Fi and Bluetooth connectivity. It can handle up to 65 Mbps transfer rate. It operates on 5v dc supply. 8-bit parallel camera interface. It has 10-PWM outputs pins and 7-GPIO and 8-ADC inputs with separate VREF.

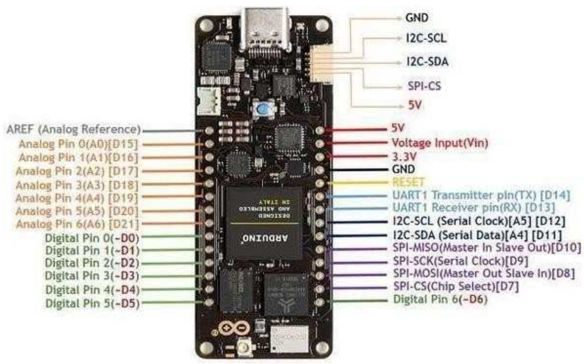

Figure.3. Portenta C33

Ultrasonic sensors

Ultrasonic sensors are trigger the signal and received the data. In general, it sends out high-frequency sound waves that bounce off objects and come back. where the ultrasonic transmitter transmits the ultrasonic wave, which travels through the air until it reaches an object or person, then the wave is reflected back and received by the ultrasonic receiver. As shown in figure. 1.3. ultrasonic sensor how to wave reflect. It has four terminal VCC, GND, Echo and Trig pins. It operated on 5V dc. Echo and Trigger pin are connected to the Controller to send the feedback of sensor.

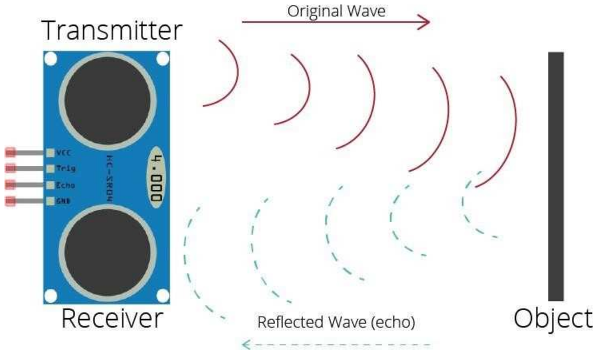

Figure. 4. Ultrasonic sensor how to wave reflect.

DHT-11

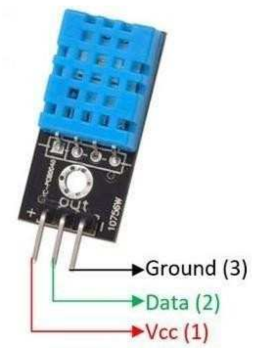

Figure.5. DHT-11

The DHT-11 is a sensor that helps measure temperature and humidity in the air. It operated on 5v dc. It has three terminal VCC, GND and data pin. As shown in figure.1.4. The sensor accuracy is ± 2%. A Sensor is measuring real time and send to the cloud.

Relay Module

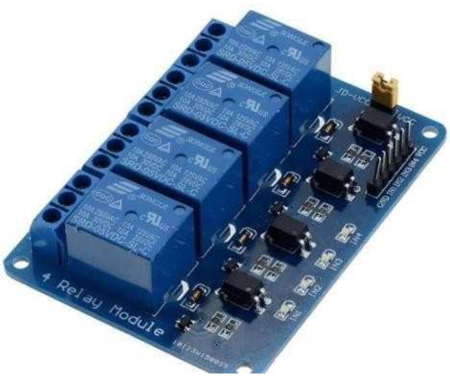

Figure.6. Relay module

This board has four separate channels, which means it can control four different things at once. Each channel has a special switch called a relay that can turn things on and off. These relays are powered by a 5-volt signal, which is safe for most electronics. When you turn on a channel, the LED lightsup, showing you that the relay is working. In our project, we're using a 12-volt four-channel relay module to control LEDs. Each channel is connected to a different thing: a fan, a light bulb, a power socket, and an extra device. So, with this board, we can turn each of these things on or off whenever we want, all from our microcontroller. Figure is shown below. 1.5. An SPD type relay I'm using in our project.

MQ-6

The main function of the gas sensor is to detect or measure the amount of gas such as LPG in an area. It operates on 5V dc. The sensor analog and digital output voltage is 0 to 5v DC. It has four terminals like VCC, GND, A0 and D0. We digital and analog data can read.

Figure.7. MQ-6 sensor

Buzzer

A buzzer can used for alerting. For example, alarm, alerting the when temperature rises it will be beeping and alerting. It operates on 5v dc. It has two positive terminal and negative.

Figure.8. Buzzer

Solar panel

Solar panels, comprised of photovoltaic cells, function as semiconductor devices absorbing sunlight. When sunlight bombarded on cells, it energizes electrons, starts the flow of an electric current. This process directly generates electricity from sunlight, providing a sustainable and renewable energy source. The electricity generated by the solar panel is in the form of DC electricity. This can used to store in batteries for later use.It can generate up to 5 watts of power. It operates at a voltage of 6 volts.

Figure.9. Solar panel

A. Software

- MQTT is a lightweight messaging protocol designed for small bandwidth, low-power devices or applications with intermittent connectivity. It works on a publish-subscribe model, where devices publish messages to topics, and other devices subscribe to those topics to receive messages. State the units for each quantity that you use in an equation. In simple terms, MQTT enables communication between your IoT devices, while Blynk provides a user-friendly interface to control and monitor those devices from your smartphone.

Publishing: A device sends a message (payload) to a specific topic.

Subscribing: Another device listens (subscribes) to that topic to receive messages.

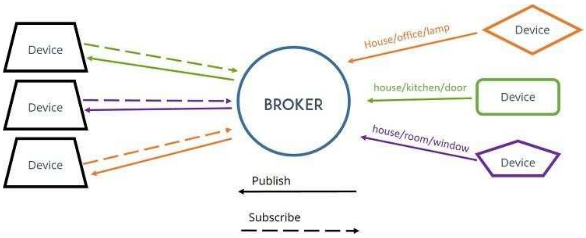

Figure.10. MQTT Broker

An MQTT broker is a server or middleware that acts as an intermediary between MQTT clients. It receives messages published by clients and delivers them to the appropriate subscribers. The broker also stores messages for clients that are offline, ensuring message delivery when they reconnect. As in above figure. 1.7 explain

- Message Routing: When a client publishes a message to a specific topic, the broker receives the message and routes it to all subscribed clients interested in that topic.
- Topic-Based Subscription: Clients can subscribe to specific topics of interest. The broker keeps track of subscriptions and forwards messages accordingly.
- Persistence: The broker may optionally store messages in a persistent database to ensure reliable message delivery,even if clients are offline.
- Authentication and Authorization: MQTT brokers often support authentication and authorization mechanisms to secure communication between clients. This ensures that only authorized clients can publish or subscribe to specific topics.

B. Solar Panel Calculation

In a home automation system, solar panels serve as a sustainable power source, reducing reliance on the grid and lowering electricity bills. In this project, we have chosen 5- watt load. Let's assume you choose 12 volts DC as the input voltage. Since the load is only 5 watts, you need to decide the output voltage based on the load requirements. According to load, we have chosen 5w 6v solar panel. A 12V, 5Ah batteryis selected, which equates to 60 watt-hours of energy storage. The charge time for the battery is calculated as 15 hours, considering a lead-acid battery with 50% efficiency.

- Battery 12v, 5Ah is 60watt.
- Solar panel current = 2A
- 12v, 5Ah is 60watt for 5watt solar panel
- Charge time = 60Ah ÷ 2A = 30 hours
- Charge time for lead acid batteries = 30 hrs × 50% = 15 hours

- Load Calculation = 220V * 0.0217A
  = 5W
- Battery Storage = Total Load * Backup Time
  = 5W * 12 hrs.
  = 60W
- Battery Capacity = Required Battery Storage / Battery Storage
  = 60W / 60W
  = 1 Batteries
- Solar Panel Capacity = 6 * Battery Capacity
  = 6 * 10Ah
  = 60 Watt

Table 1 Solar Table reading:

Sr. No.	Time	Voltage (Volt)
1	8 AM	8.17
2	9 AM	9.58
3	10 AM	10
4	12:30 PM	10.2
5	1:30 PM	9.78
6	3 PM	9.95
7	4 PM	9.62
8	5 PM	8.38
9	6 PM	-

The table 1 is provided contains data on solar readings taken at different times throughout the day. 50 W/m² (in watts per square meter, W/m²) daily solar readings.

So,

Total power generated per day (in watts) = Solar reading (W/m²) * Area (m²)

Let's assume the voltage output of your solar panels is 12 volts (V). To convert the total power generated per day to voltage.

Voltage (V) = Power (W) / Current (A)

Average voltage = (Sum of all voltage readings) / (Number of readings)

Sum of voltage readings = 8.17 + 9.58 + 10 + 10.2 + 9.78 + 9.95 + 9.62 + 8.38 = 75.68 volts

Number of readings = 8

Average voltage = 75.68 volts / 8 = 9.46 volts

So, the total power generated per day is approximately 50 watts, and the corresponding voltage is approximately 9.46 volts.

III. FLOW PROCESS

A. Flow Chart

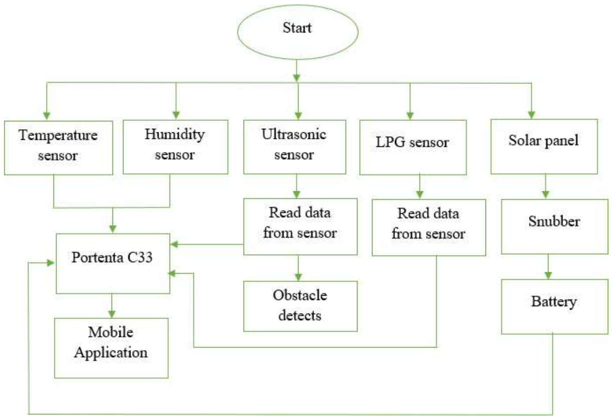

Figure.11. Flow chart

- Initiates the system.
- Solar Power Available: Checks if solar power is available.
  - i. If yes, switches to solar power and proceeds to monitor the environment.
  - ii. Activates necessary actuators based on sensor readings (LPG, temperature, humidity, ultrasonic).
  - iii. Sends data to the Blynk platform for remote access and control.
- Grid Power Available: Checks if grid power is available.
  - i. If yes, switches to grid power and proceeds tomonitor the environment.
  - ii. Activates necessary actuators based on sensorreadings (LPG, temperature, humidity, ultrasonic).
  - iii. Sends data to the Blynk platform for remote access and control.
- End: Concludes the system operation.

B. Algorithm

- Initialize the system.
- Continuously monitor power source availability.
- If solar power is available, switch to solar power mode.
- Monitor environment using sensors.
- Activate actuators based on sensor readings.
- Send data to the Blynk platform.
- If grid power is available, switch to grid power mode.
- Monitor environment using sensors.
- Activate actuators based on sensor readings.
- Send data to the Blynk platform.
- Repeat steps 2-4 indefinitely.
- End the system operation.

IV. RESULT AND DISCUSSION

In this project, there are two primary methods to supply power to the system: solar panels and a 230V AC system. A 230V power supply is fed to a step-down transformer rated at 12V. This output is then directed to a bridge rectifier, which converts AC to pulsating DC, followed by a filter that smoothsout the DC signal by reducing ripples. The regulated DC voltage of 5V is then supplied to the microcontroller, ensuring stable operation as depicted in the figure. A snubber is employed to protect connected devices from voltage spikes or transients that may occur in the system, thus safeguarding components from potential damage. During periods of high sunlight or low load demand, surplus electricity generated by the solar panel is used to charge the battery. This stored energy is later discharged when solar output is insufficient or during peak demand, ensuring a continuous and reliable power supply to the connected devices.

Figure.12. Mobile app switches

In Figure 12, two switches are displayed, each managing different loads through a mobile app interface provided by the Blynk app. Activating switch 1 triggers the designated load, and pressing the off button deactivates it, showcasing seamless control over electrical devices. The operation, swift and responsive, completes within a second, contingent upon a robust internet connection for uninterrupted functionality. This setup offers a convenient and efficient means to remotely manage and control various loads, enhancing user convenience and accessibility in home automation systems.

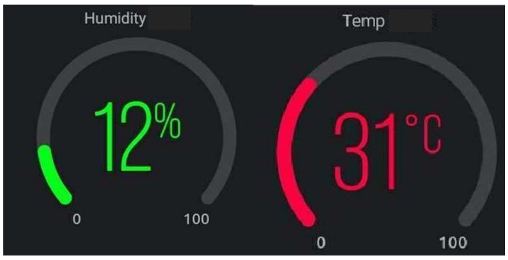

Figure. 13: Humidity and Temperature (Blynk App Screen)

When the temperature rises to 40 degrees Celsius, the system activates the fan and simultaneously sends a notification to the user's mobile device. Additionally, a buzzer emits a distinct 'beep beep' sound to provide an audible alert. Furthermore, the system continuously monitors both temperature and humidity levels, enabling users to conveniently track environmental conditions in real-time via their mobile devices. Figure 13 illustrates the Humidity and Temperature (Blynk App Screen).

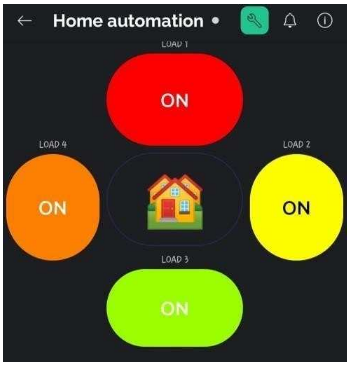

Figure.14. Home Automation controlling app

The ultrasonic sensor is employed to detect objects within a range of 50cm to 60cm. If an object is detected within this range, the system triggers an alerting buzzer to notify users, sending a notification through the Blynk app indicating that someone is entering the monitored area. Additionally, a gauge displayed on the mobile app provides real-time information about the distance of the detected object from the sensor, offering users immediate feedback on the proximity of the detected object. In Figure 16, a gas sensor detects surrounding gas levels. When the gas concentration remains below 150 units, the system displays this information on a gauge within the mobile app, reassuring users of the absence of any leakage. However, if the gas concentration exceeds 150 units, as depicted in the figure, the system initiates two actions: first, it sends a notification to alert users of the elevated gas levels, and second, it triggers a control action to address the situation and ensure safety measures are implemented promptly.

Figure.15. Ultrasonic sensor Gauge

Figure.16. Gas sensor Gauge

System Requirements: The system operates with the following hardware components: Portenta C33 microcontroller, ultrasonic sensor, gas sensor, DHT-11 temperature and humidity sensor, and associated actuators(fan, buzzer, relay module). It requires a stable power supply from either solar panels or a 230V AC system, managed by a step-down transformer, bridge rectifier, and voltage regulator to ensure reliable operation.

Software Requirements: The software architecture includes integration with the Blynk app for remote monitoring and control. It employs algorithms for real-time sensor data processing, threshold detection for gas levels, and temperature monitoring. The system's software is designed to operate seamlessly with Android and iOS platforms for user interface interaction and notifications.

CONCLUSION

The integration of renewable energy sources with advanced home automation systems, facilitated by cutting- edge technology such as the Portenta C33 controller, represents a significant leap forward in the pursuit of energy- efficient, convenient, and safe living environments. Our Home Automation System, featuring a Solar-Based Hybrid Inverter, not only ensures seamless power transitions between solar and grid sources but also optimizes energy use, contributing to reduced electricity costs and a lower environmental impact. Equipped with a comprehensive array of sensors, including LPG, temperature, humidity, and ultrasonic sensors, the system provides robust environmental monitoring and control, enhancing household safety and comfort. The automatic door system, activated by ultrasonic sensing, exemplifies thesystem's innovative approach to home automation, while continuous monitoring of critical parameters ensures a healthier living space. Remote access via the Blynk platform empowers users with real-time management capabilities from anywhere, adding to the system's convenience and functionality. By harnessing approximately 50 watts of solar energy daily, our system not only delivers immediate costsavings but also fosters long-term sustainability. Emphasizing solar energy utilization, we advance towards a greener future, highlighting our commitment to both technological innovation and environmental stewardship. This holistic approach underscores the transformative potential of integrating renewable energy with smart home technologies, setting a newstandard for modern, sustainable living.

However, current research faces limitations in scalability and affordability, particularly in widespread adoption across diverse economic and geographic contexts. Future advancements should focus on enhancing system scalability, reducing initial setup costs, and integrating more sophisticated AI-driven analytics for predictive maintenance and energy optimization. Additionally, expanding the system's compatibility with emerging renewable energy technologies and smart grid initiatives will further strengthen its role in sustainable urban development. By addressing these challenges, future iterations of this technology promise to revolutionize home automation, making energy-efficient and eco-friendly living accessible to a broader population while paving the way towards a more sustainable future.

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