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IoT based Smart Home Energy Tracker and Saver

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Abstract

The knowledge about the amount of energy used every month or day at home is the initial step to reduce the energy usage. So, the proposed research focusses on developing a smart energy management system using the IoT to track the daily electricity usage and enhance the energy efficiency at home. The system employs network of sensors placed throughout the home to monitor energy usage in real-time. The information gathered is transmitted to the Blynk Cloud and visualized through the Blynk app. The chart displayed in the Blynk app enables the user to identify the excessive energy usage and reduce both consumption and the electricity bills. By integrating IoT technology and user-friendly control interfaces, this research aims to provide homeowners with actionable insights to minimize energy waste, reduce utility bills, and contribute to environmental conservation.

Keywords: Energy Tracker, Electricity Usage, ESP32 Microcontroller, Blynk, User Interface

1. Introduction

Conserving electricity and reducing its consumption, especially at home, has become essential nowadays to reduce the electricity bills, and the harmful environmental effects. Human negligence in the energy conservation today could lead to multiple problems in future, such as depletion of resources and hazardous impacts on both the environment and the planet. Therefore, limiting energy consumption positively impacts the environment.

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The proposed study aims to develop an IoT based energy tracker for houses to keep the homeowner informed about their energy usage. The system utilizes a network of sensors to collect data on daily electricity usage and transmits this information to the Blynk Cloud. The Blynk app then visualizes the data, helping users identify excessive usage and reduce consumption. Additionally, the system detects room occupancy and regulates the operation of essential electronic devices such as fans and lights.

The primary aim of the research is to reduce the electricity usage at home, which in turn lowers electricity bills, protect the environment, and improves overall health for people and the planet.

1.1 Objective

The proposed system focuses on developing a IoT based smart home energy tracker and saver to monitor the energy consumption in real-time and optimize the energy usage, and provide insights on the energy usage patterns and the details of the excessive usage.

2. Literature Review

A novel Smart Home Energy Management System (SHEMS) integrating IoT and big data analytics to optimize energy usage is suggested in the research, enabling real-time monitoring of appliances and environmental conditions, SHEMS provides personalized energy-saving recommendations to users [1]. The study in [2] explores applications in smart cities such as smart transportation, energy conservation, and environmental monitoring, highlighting their advantages and difficulties. It also discusses the basic ideas of IoT, such as sensor networks, data analytics, and cloud computing.

To improve energy consumption efficiency within smart grid systems, the research introduces an Internet of Things (IoT)-based Smart Energy Meter. The energy meter uses Internet of Things (IoT) technology to provide real-time monitoring and analysis of energy consumption, allowing customers to make informed decisions about their energy use. With the use of precise data and insights, the system aims to solve issues related to energy waste and inefficiency, benefitting both energy providers and their customers. The study shows how the IoT-based energy meter helps optimize energy use in smart grid systems by implementing smart metering functionalities, including remote monitoring and control [3].

Furthermore, the research study proposes the architecture of an IoT-based energy monitoring system for comprehensive monitoring and analysis of energy usage in various environments. The system facilitates real-time data collection from energy meters and sensors located throughout the environment. After gathering the data, it is processed and analyzed to provide insights into energy consumption trends, patterns, and inconsistencies. The study also explores the development of a user-friendly interface for gathering and visualizing energy consumption statistics, enabling users to make informed decisions about energy management [4]. Several useful suggestions and proposals for monitoring and reducing energy consumption have been discussed in previous research, such as a fail-safe home monitoring system with sensors and hybrid IoT and GSM technology [5], smart home automation using Wi-Fi technology for managing multiple home devices and energy usage [6], an energy management system developed using a sensor network to measure power consumption across an entire building under different loads [7], and Arduino and GSM-based smart energy meters for advanced metering and billing [8]. These IoT-based energy monitors evaluate energy usage and enable real-time remote monitoring and control of devices [9] using cloud computing for data storage and visualization of energy usage [10]. Additionally, systems designed to sense room occupancy and regulate the operation of electronic devices help domestic consumers reduce unnecessary power consumption [11]. As a result, home automation systems enable the control and management of electrical appliances without human intervention [12].

Based on the insights gained through the literature review, the proposed study aims to develop a smart home energy tracker and saver using the IoT, sensors, and Blynk Cloud to minimize energy waste, reduce utility bills, and contribute to environmental conservation.

3. Proposed System

The Smart Home Energy Tracker and Saver system includes a comprehensive array of hardware components. The hardware backbone of the system consists of IoT sensors strategically deployed throughout the home, including smart plugs, energy meters, and temperature sensors. These sensors collect real-time data on energy consumption, appliance usage patterns, and environmental conditions. The gathered data is transmitted wirelessly to a central hub, typically ESP32 microcontroller, which then sends the data to the Blynk Cloud for storage and processing. The Blynk app retrieves and visualizes this data for the user, enabling

them to monitor energy usage and optimize consumption. The Table.1 below shows the hardware and the software components used.

Table 1. Components Used

S.No	Hardware Components	Software Components
1.	Microcontroller (ESP32)	Arduino IDE
2.	Ultrasonic Sensor (HC-SR04)	Blynk
3.	AC Current Sensor (SCT-013-000)	
4.	2-Channel Relay (SRD-05VDC-SL-C)	
5.	Power Supply (HLK-PM01)	

3.1 Block Diagram

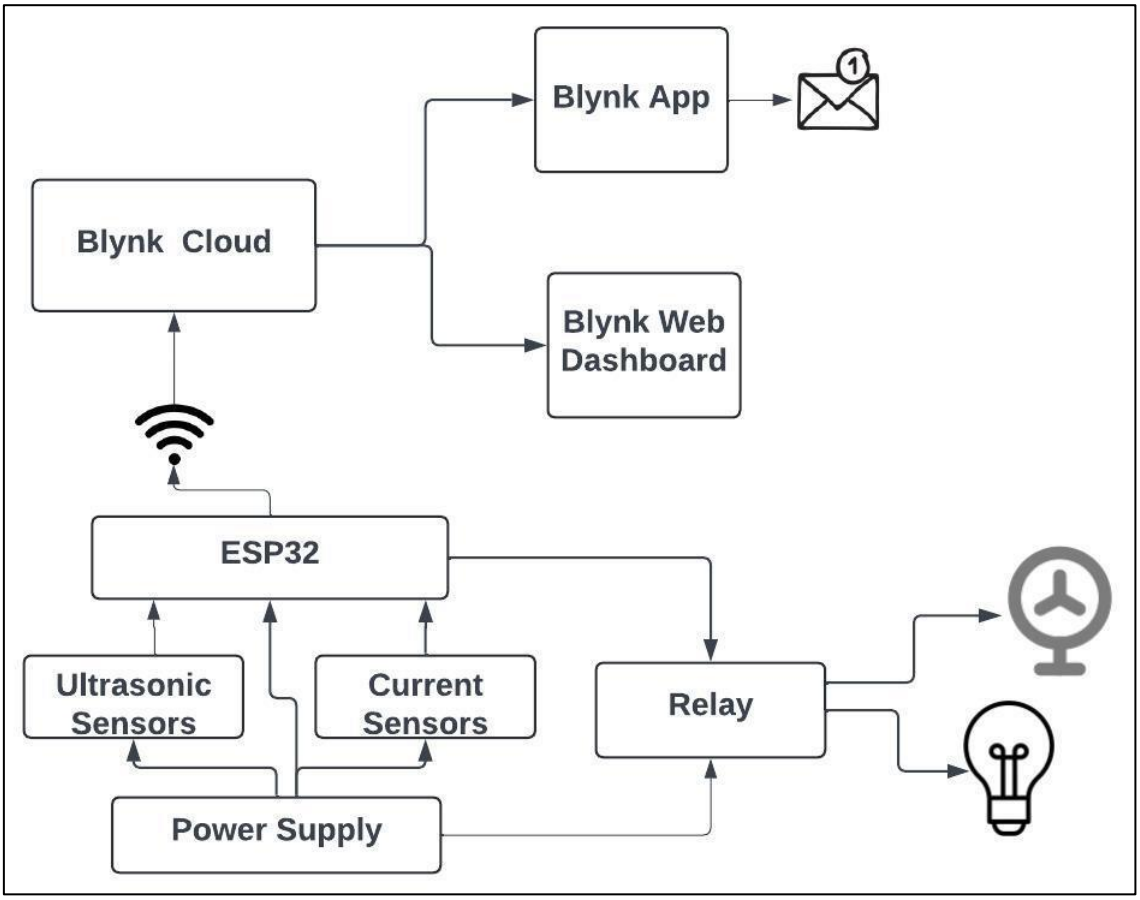


Figure 1. Block Diagram of Smart Home Energy Tracker

The block diagram in Figure.1 depict an overview of the smart home energy tracker. The system consists of three primary layers: the hardware layer, microcontroller layer, and the Cloud and the user interface layer. The hardware layers include sensors and the actuators, such as the ultrasonic sensor (for occupancy detection), AC current sensor (for power consumption monitoring), and a 2-channel relay to controls appliances like the DC fan and electric bulb. These components are connected through jumper wires and powered by a transformer and power supply. The ESP32 serves as central unit in the microcontroller layer. It processes the data and communicates with the cloud platform over Wi-Fi, transmitting the real-time data for storage and analyses. The Blynk cloud and the web dashboard in the Cloud and the user interface layer enables the user to monitor and visualize the energy consumption as well as send notification to the users about the excessive usage.

3.2 Working

If the ultrasonic sensors detect the room occupancy, it sends signal to the ESP32, which then immediately triggers the 2-channel relay to turn on the electrical appliances, in this case the ESP32 instructs the relay to turn on or off the light bulb and the fan. When the energy consumption measured by the AC current sensors exceeds the predefined threshold, the ESP32 sends alerts to cloud and commands the relay to turn off the appliances. The real-time data on the energy usage and the device status are continuously transmitted to the Blynk Cloud over Wi-Fi by the ESP32. The data received by the Blynk Cloud is visualized on the web dashboard, allowing the user to monitor real-time energy consumption, view device status, consumption cost, receive notification and control the power usage. The flowchart below in Figure 2 shows the working of the smart home energy tracker.

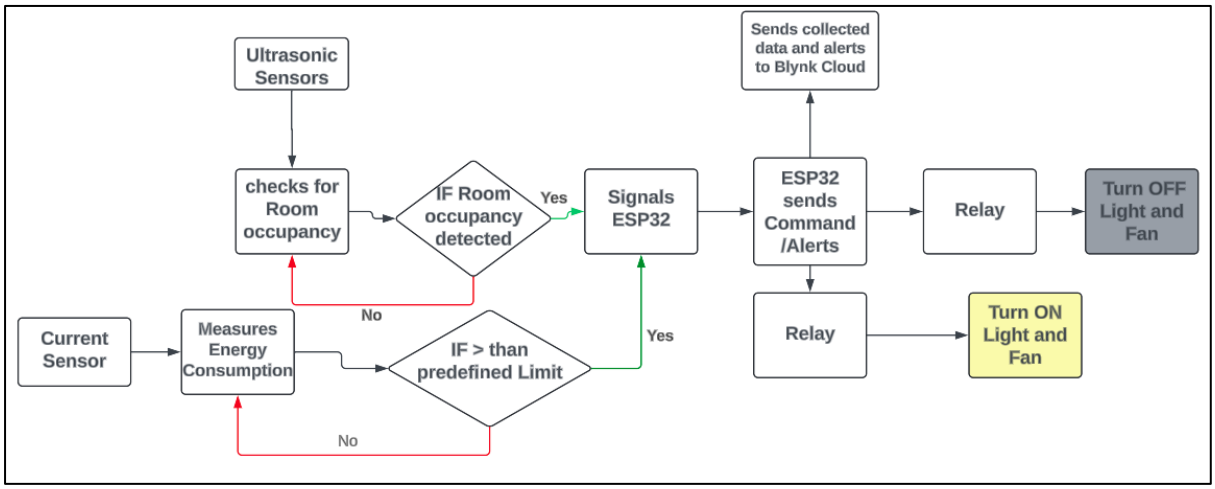
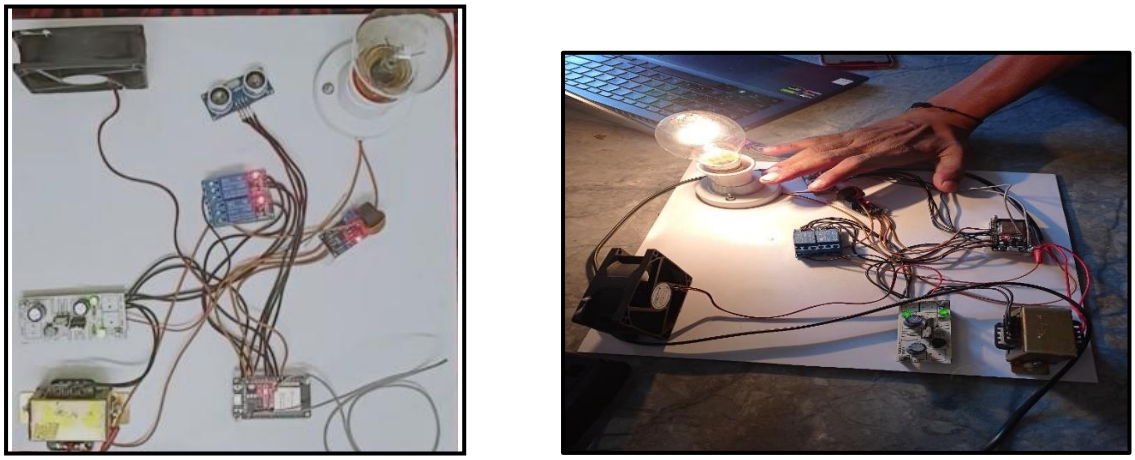


Figure 2. Workflow of Smart Home Energy Tracker

4. Results

The ESP32 is programmed using the Arduino language (C++), to collect the data from the sensors, control the appliances operations, and transmit it to Blynk Cloud. The code is uploaded to the microcontroller through Arduino IDE. Alerts from the ESP32 are transmitted to the Blynk Cloud, and the Blynk app is configured to send notification to the user if excess usage is detected. The Blynk web dashboard visualizes the data received.



(a) **(b)**

Figure 3 (a), (b). Hardware Design of Smart Home Energy Tracker

Figure 3 (a) depicts the prototype of the proposed system, which contains various components such as ultrasonic sensor, AC current sensor, transformer, power supply board, 2-channel relay, DC fan, bulb, and ESP32. The working of the smart home tracker is shown in the Figure 3(b) above. When the ultrasonic sensor detects an object or hand in this case, it signals the ESP32, which then sends commands to the relay to turn on the light and fan.

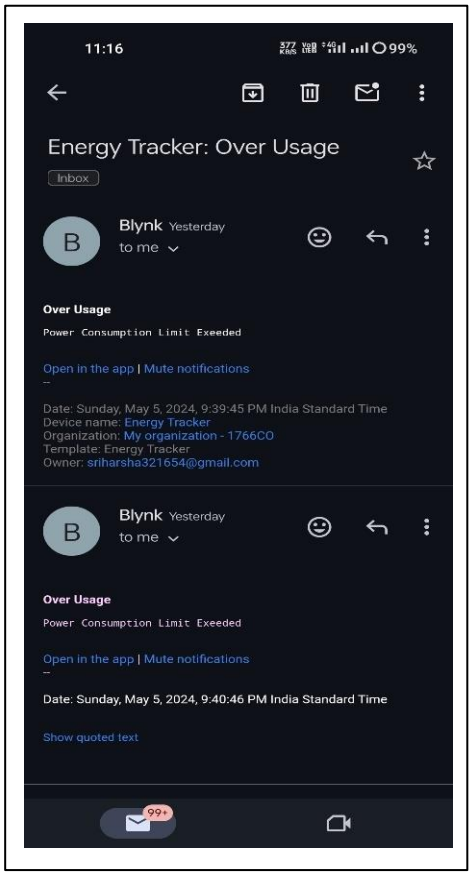


Figure 4. Alert Message

The Figure 4 shows the email alert send by the Blynk app to the user on detecting excess usage based on the predefined usage limits. The Figure 5 shows the visualization of the energy consumed in terms of the units, watts, and amps consumed as well as the overall power consumption rate.

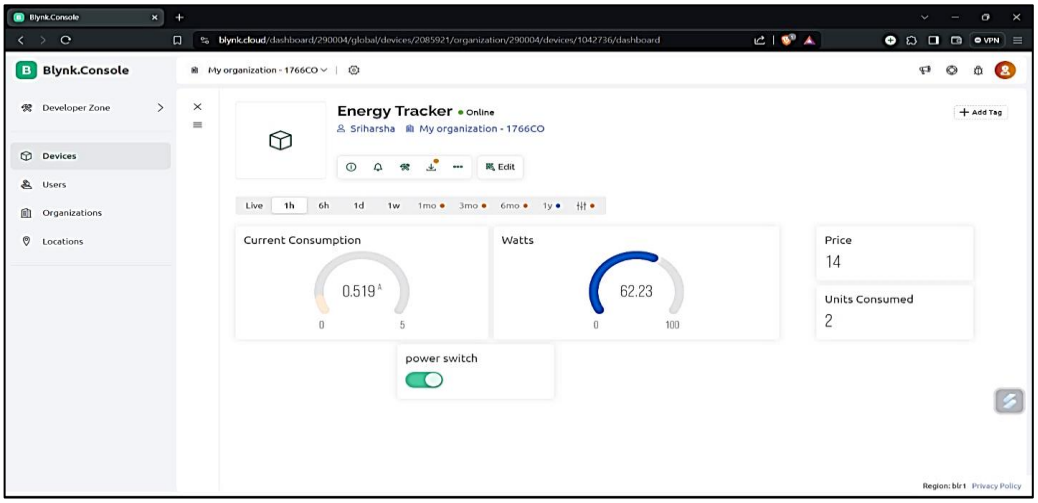


Figure 5. Blynk Web Dashboard

The proposed system offers a comprehensive solution for smart home energy management by integrating advanced hardware components, such as energy monitoring sensors and microcontrollers, with the Blynk app for tracking, analysing, and managing energy consumption within the home. The primary goal of the proposed system is to enable users to take control of their energy usage through actionable insights and smart automation. By using user-friendly interfaces accessible through the web dashboard and mobile app, homeowners can easily monitor their energy consumption patterns, identify areas of excessive use, and implement strategies to reduce waste and optimize usage.

5. Conclusion

In conclusion, the Smart Home Energy Tracker and Saver presents a transformative solution for residential energy management by using IoT to empower homeowners with actionable insights. By providing real-time monitoring, and user-friendly control interfaces, the system enables users to optimize energy consumption, reduce wastage, and lower utility bills. Ultimately, the Smart Home Energy Tracker and Saver not only enhances convenience and affordability but also promotes sustainable practices, contributing to environmental conservation and a greener future for residential living. Furthermore, the future development of the proposed work will focus on the successful completion of the research and its implementation at homes. Additionally, the integration of machine learning models to analyze collected data and forecast energy consumption will provide users with even more personalized recommendations.

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