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ABSTRACT:

This project aims to develop a smart energy meter leveraging the capabilities of the ESP32 microcontroller, Blynk dashboard, and various sensors. The system incorporates a current sensor and voltage sensor to measure real-time power consumption. A potentiometer is utilized for calibration purposes, ensuring accurate readings. The ESP32 facilitates the integration of these sensors, acting as the central processing unit.

It also introduces a smart energy meter employing ESP32, Blynk, SCT-013 current sensor, ZMPT101B voltage sensor, and a potentiometer. The ESP32 processes data from sensors, with a potentiometer allowing user calibration.

The Blynk dashboard serves as a user-friendly interface, allowing real-time monitoring and control of energy consumption. Users can access the dashboard remotely, enabling seamless management of their power usage. Additionally, an LCD display provides local feedback for convenience.

The combination of these components results in an efficient, IoT-enabled smart energy meter,empowering users to make informed decisions about energy usage and promoting sustainability. This project represents a step towards building smarter and more sustainable energy management systems.

The Blynk app provides a user-friendly interface for remote monitoring and real-time visualization of energy consumption. The project aims to enhance energy efficiency by offering users insights into power consumption patterns and enabling informed decision-making.

LIST OF FIGURES

TABLE OF CONTENTS:

		2.1	Block diagram	
		2.2	Flow chart	
		2.3	Project codes	
3	Implementation of the project			
		3.1	Software tools	
		3.2	Technologies to be used	
		3.3	Working of system	
		3.4	Process Flow Chart	
4	Results of the project			
		4.1	Project progress work done	
		4.2	Future scope	
		4.3	Limitations	
		4.4	Images	

CHAPTER-1

CONCEPTION OF PROJECT:

1.1 Introduction:

The smart energy meter project is designed to revolutionize energy monitoring and management through the integration of cutting-edge technologies. Leveraging the capabilities of the ESP32 microcontroller, Blynk platform, SCT-013 current sensor, ZMPT101B voltage sensor, and a potentiometer, this system aims to provide users with a comprehensive solution for understanding and optimizing their power consumption.By utilizing advanced sensor technologies, the project enables accurate measurement of both current and voltage. The inclusion of a potentiometer ensures user-friendly calibration, allowing customization according to specific requirements. The Blynk platform serves as a bridge for seamless remote monitoring, offering users real-time access to their energy consumption data via an intuitive mobile interface.

The significant importance of Smart Energy Meter:

- Energy Conservation:The smart energy meter aids in monitoring and optimizing power consumption, promoting energy conservation at both individual and societal levels.
- Cost Savings:By providing real-time insights into energy usage, the project empowers users to make informed decisions, potentially leading to significant cost savings on electricity bills.
- Data-Driven Decision-Making:Real-time data visualization enables users to identify patterns, allowing for data-driven decision-making to further optimize energy efficiency.
- Technology Innovation:The use of ESP32, Blynk, and sensor technologies showcases innovation in creating practical solutions for energy management, aligning with the advancements in IoT and smart devices.
- Remote Monitoring:The ability to remotely monitor energy consumption ensures convenience for users, allowing them to stay informed and take necessary actions even when away from their premises.
- Scalability and Adaptability:The modular nature of the project allows for scalability and adaptability, making it suitable for diverse applications and settings, from residential homes to commercial establishments.

1.2 Motivation

The motivation behind this project lies in the critical necessity for a more sustainable and efficient approach to energy consumption. With the increasing strain on energy resources and the escalating environmental impact of energy usage, there is a pressing need for innovative solutions that empower individuals to manage their energy footprint effectively. This project is motivated by the desire to create a user-friendly and technologically advanced smart energy meter, leveraging the capabilities of ESP32, Blynk, and sensor technologies. By providing

real-time insights into energy usage patterns and allowing user calibration, the project aims to raise awareness about individual energy consumption, enabling users to make informed decisions that not only lead to cost savings but also contribute to environmental conservation. The overarching goal is to foster a sense of responsibility towards sustainable living and to showcase the potential of technology in addressing the global challenge of energy management.

1.3Literature survey

Sl.No	Research paper title	summary
1	“IoT BASED SMART ENERGY METER“ by Sanket Tule, Durvas Gade (2023):	Introducing IoT-based smart energy meter for automatic residential energy tracking. Sends consumption data to consumers and electricity supplier.Utilizes ESP32 microcontroller for data processing.Predefined program calculates total energy bill over a selected interval.Updates billing information on the user's smartphone.Implements Internet of Things (IoT) for network connectivity.
2	"IOT BASED SMART ENERGY METER USING ESP32" by Rinal Mistry,Shweta Gaur (2014): .	Monitor and record energy consumption of home appliances.Node MCU ESP32 and ZMPT101B voltage sensor.Data Transmission:Uses ESP32 Wifi module to send data to Blynk cloud storage. Enables real-time tracking of energy consumption. Verified for measuring power consumption by both AC and DC loads.
3	"ESP32 Based Electric Energy Consumption Meter " by Paul Stone Macheso and Doreen Thotho (2022):	Design and prototype low-cost IoT energy monitoring.Suitable for power billing, smart grid energy management, and home automation.ESP32 microcontroller. Non-invasive CT sensors and voltage sensor.Sends data to Blynk server over the internet.Accurately records voltage, current, active power, and cumulative power consumption
4	“ESP32 Based ELECTRIC ENERGY METER” by Ammar Othman,Nur Hafiza Zakaria:	Introduce wireless energy meter monitoring via Blynk app on smartphones.Battery backup.Optional overconsumption alerts.ESP32 micro-

		controller with Wi-Fi for IoT communication.AI application for smart meter evolution.Shift towards efficient energy management in smart cities. Prototype monitors daily energy via Blynk app.Blynk notifications promote electricity conservation.

1.4 Problem statement:

Manual meter reading processes lead to inefficiencies, billing inaccuracies, and a lack of real-time consumer insights in the current energy monitoring system.

1.5 Objectives:

- Implementing a system to automatically collect and transmit real-time data on electricity consumption to eliminate the need for manual readings.
- Enable users to monitor their energy usage remotely through a web or mobile interface, providing access to consumption patterns and historical data.
- Reduce operational costs by eliminating the need for physical meter reading visits and streamline the billing process.
- Ensure accurate measurement of both current and voltage using SCT-013 and ZMPT101B sensors, respectively, to provide users with precise information about their power usage.
- Encourage energy-saving practices by providing users with insights into their consumption patterns, helping them make informed decisions to reduce energy usage.
- To develop an intuitive and user-friendly interface for users to access and understand their energy consumption data easily.

1.6 Working:

The ESP32, paired with SCT-013 and ZMPT101B sensors, measures AC current and voltage, converting data to digital signals. Using the Blynk IoT platform, the ESP32 transmits processed data to the Blynk cloud for remote access. The Blynk mobile app provides users with an interface for real-time and historical energy consumption monitoring. This integration facilitates remote control of devices and ensures efficient smart energy monitoring with a focus on user convenience. The ESP32 and Blynk operates by integrating the ESP32 microcontroller with the energy meter and establishing a connection to the Blynk platform for remote monitoring and control. The ESP32, programmed through the Arduino IDE, interfaces with the energy meter to capture relevant data, such as power consumption or voltage levels. Blynk, a versatile IoT

platform, facilitates the creation of a user-friendly mobile app interface for monitoring and controlling the energy meter remotely. Users can visualize real-time data, set thresholds, and receive notifications through the Blynk app. The ESP32 continuously communicates with the Blynk server, ensuring up-to-date information is accessible on the mobile app. This project thus enhances energy management by providing users with convenient access to their energy consumption data and the ability to make informed decisions for efficient resource utilization.

1.7 Areas of application

The IoT-based smart energy meter using ESP32 and Blynk has diverse applications across various sectors.

1. Home Automation: Implementing the smart energy meter in homes allows residents to monitor and control energy usage, optimizing consumption and potentially reducing utility costs.
2. Industrial Monitoring: In industrial settings, the system can be deployed to monitor energy consumption in real-time, aiding in identifying inefficiencies and optimizing machinery usage.
3. Smart Buildings: This technology contributes to the development of smart buildings, enabling facility managers to track energy usage, implement energy-saving measures, and enhance overall building efficiency.
4. Renewable Energy Systems: Integrating the smart energy meter with renewable energy sources allows users to monitor the performance of solar panels or wind turbines and assess the impact on overall energy consumption.
5. Commercial Spaces: Businesses can utilize this system to monitor and manage energy consumption, promoting sustainability practices and potentially reducing operational costs.
6. Utilities and Grid Management: Implementing smart meters at a larger scale helps utility companies in efficiently managing energy distribution, identifying faults, and improving overall grid reliability.
7. Remote Monitoring: The ability to remotely monitor energy consumption makes this system suitable for applications in remote locations, where accessing real-time data is crucial for decision-making.

CHAPTER – 2

2.1 BLOCK DIAGRAM:

It uses ESP32 microcontroller as its central processing unit. The ESP32 establishes a Wi-Fi connection, facilitated by the Blynk library, enabling communication with the Blynk cloud platform. Energy measurements, which calculates voltage, current, power, and accumulated kWh. Real-time data is not only processed but also visually presented on an LCD display. This display serves as an interface for providing immediate information to users, showcasing details such as voltage, current, and power consumption. Meanwhile, the Blynk mobile app connects to the ESP32 over Wi-Fi, providing users with an intuitive platform for monitoring and controlling the energy meter. Through the app, users can access real-time data and exercise control over the energy monitoring system, making it a comprehensive and user-friendly solution for smart energy management.

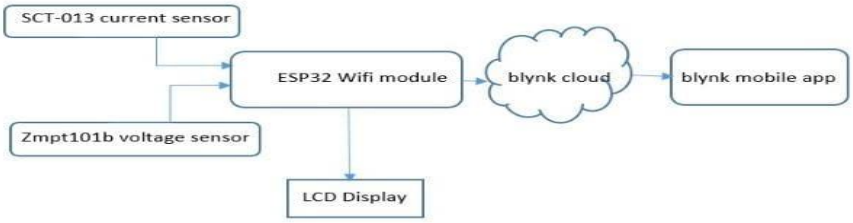

Fig1.Block diagram

Circuit Diagram:

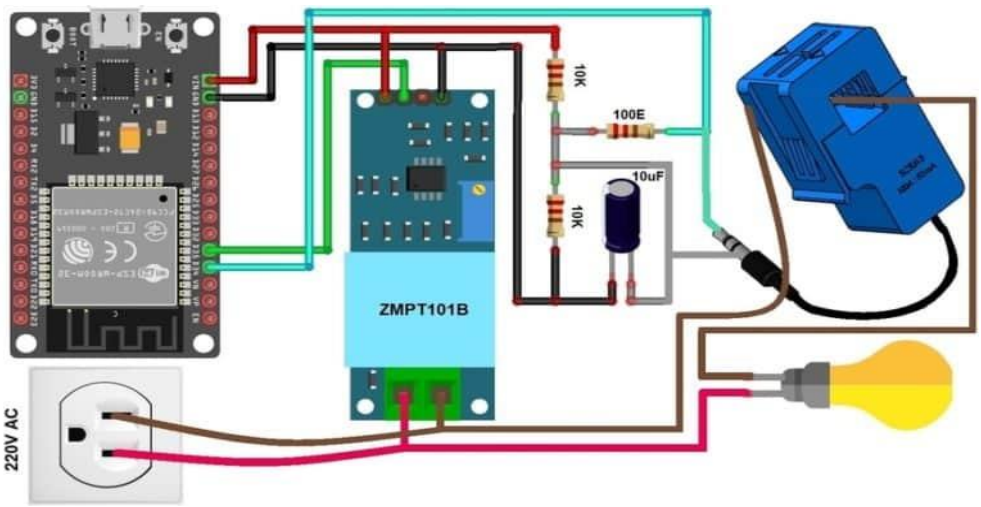

Fig2.Circuit diagram

2.2 FLOW CHART:

CHAPTER:

3.1 Software Tools:

In this smart energy meter project, the following software tools are utilized

- Arduino IDE:Used for writing, compiling, and uploading code to the ESP32.
- ESP32 Board Support Package:Installed in Arduino IDE to enable development for the ESP32 platform.
- Blynk Library:Integrated into the Arduino code to facilitate communication between the ESP32 and the Blynk app.
- Blynk App: Installed on a mobile device to create a graphical user interface (GUI) for monitoring and controlling the smart energy meter.

Fig4.Blynk app

3.2 Technologies to be used:

Smart energy meter involves integrating the ESP32 microcontroller, current/voltage sensors, and the Blynk IoT platform. The technologies used include:

- ESP32 Microcontroller: A powerful and versatile microcontroller with built-in Wi-Fi and Bluetooth capabilities, ideal for IoT projects.
- Current/Voltage Sensors: Devices like CT (Current Transformer) and VT (Voltage Transformer) sensors to measure the energy consumption accurately.
- Blynk IoT Platform: Blynk is a popular platform for building IoT applications. It provides a mobile app (iOS/Android) to control and monitor devices remotely.

3.3 Working of System:

This smart energy meter project employs an ESP32 microcontroller along with ZMPT101B voltage sensor, SCT013 current sensor, and a potentiometer for simulation. The ESP32 is programmed to continuously read data from these sensors in a loop. The ZMPT101B provides voltage readings, while the SCT013 calculates current. The combined voltage and current measurements enable the calculation of power, simulating energy consumption with a potentiometer. The Blynk platform facilitates remote monitoring by connecting the ESP32 to the Blynk app. Through Blynk's virtual pins, the ESP32 updates real-time data on the app, allowing users to monitor voltage, current, and power values. The project is a practical implementation of IoT, offering a user-friendly interface for monitoring and managing energy-related parameters remotely. Users can customize the Blynk app widgets to visualize the data as per their preferences, enhancing the overall user experience in monitoring and controlling the smart energy meter.

CHAPTER – 4

4.1 Project Progress Work Done

- Hardware Setup
- Programming ESP32
- Blynk Integration
- Energy Data Collection
- Blynk App Configuration
- Real-time Monitoring
- Power Management
- Data Logging
- User Notifications
- Testing and Optimization

4.2 Future Scope:

As technology evolves and user needs change, the future scope of this project can adapt and expand to meet new challenges and opportunities in the field of smart energy management.

- **Multi-Device Integration:**Expand the system to monitor multiple devices and energy sources within a home or industrial setting.
- **Energy Analytics and Reporting:**Implement advanced analytics to generate insights, trends, and reports on energy consumption, helping users make informed decisions.
- **Automation and Control:**Integrate the system with smart home automation to control energy-consuming devices based on real-time monitoring and user preferences.
- **Machine Learning for Predictive Analysis:**Utilize machine learning algorithms to predict future energy consumption patterns, optimizing energy usage and reducing costs.
- **Battery Storage Monitoring:**Include features to monitor and manage energy storage systems like batteries, providing insights into backup power and optimizing charging/discharging cycles.
- **Mobile Alerts and Notifications:**Implement a notification system to alert users about abnormal energy consumption, potential faults, or required maintenance.
- **Security and Privacy Enhancements:**Strengthen security protocols to ensure the confidentiality and integrity of the data transmitted and stored.
- **Global Connectivity:**Develop the capability to access and monitor the system remotely from anywhere globally, ensuring a seamless user experience.
- **User-Friendly Interfaces:**Continuously improve the Blynk app interface for a more intuitive and user-friendly experience.

4.3 Limitations

- **Accuracy of Sensors:**The accuracy of the ZMPT101B and SCT-013 sensors may not be sufficient for highly precise energy measurements. Calibration and understanding the limitations of these sensors are crucial.
- **Calibration Complexity:**Calibrating the sensors might be a complex task, especially when dealing with different loads and environmental conditions. Achieving accurate readings across a wide range of loads can be challenging.
- **Power Factor Accuracy:**Calculating power consumption may not be entirely accurate without considering power factor, which may require additional hardware and complexity.
- **Limited Resolution:**The ESP32's analog-to-digital converter (ADC) has a limited resolution, affecting the precision of the sensor readings.
- **Real-time Communication Dependence:T**he project heavily relies on real-time communication with the Blynk app. Any network issues or delays may impact the responsiveness of the system.
- **Limited Historical Data:**Storing and visualizing historical data may require additional hardware or cloud services, which could add complexity to the project.

- **Power Consumption:**ESP32, being a powerful microcontroller, consumes a considerable amount of power. If the goal is to create an energy-efficient system, power consumption should be considered.

4.4 Images:

CONCLUSION

In conclusion, the development of a smart energy meter using ZMPT101B, SCT-013, a potentiometer, and Blynk with ESP32 represents a valuable exploration into the realms of IoT, sensor integration, and energy monitoring. This project underscores the significance of practical calibration techniques for sensors, acknowledging their inherent limitations. The incorporation of Blynk and ESP32 for real-time data communication provides a tangible experience in the realm of remote monitoring and control. Despite challenges in accuracy and calibration complexity, the project serves as an effective learning platform, fostering insights into the intricacies of creating IoT-based systems for monitoring and optimizing energy consumption. Moreover, the project's scalability and potential for further enhancements pave the way for future iterations, encouraging ongoing exploration and refinement in the domain of smart home automation and energy efficiency.