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Smart Energy Meter using IOT

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Abstract: *In order to transform the monitoring of energy use, this study presents a Smart Energy Metre (SEM) system that is integrated with Internet of Things (IoT) technology. IoT-enabled sensors are used by the system to gather data on electricity use in real time. With the use of cloud-based analytics and seamless connectivity, the suggested solution gives consumers insight into their patterns of energy consumption. Predictive analytics, anomaly detection, and remote monitoring are important aspects that support well-informed decision-making for efficient resource management. In addition to improving energy efficiency, the deployment of an Internet of Things-based Smart Energy Metre also helps create a more robust and sustainable energy infrastructure.*

Keywords: Smart energy meter, IOT ,Energy consumption monitoring , Real time data collection ,Cloud based analytics ,Remote monitoring

I. INTRODUCTION

Recent years have seen a paradigm shift in how we monitor and use power due to the growing demand for energy combined with environmental concerns. The Internet of Things (IoT)-enabled smart energy metres have surfaced as a game-changing answer to these problems. The goal of this project is to investigate and put into practice a Smart Energy Meter system that makes use of Internet of Things technology, providing a clever and effective method of energy management.

Difficulties with traditional metres include manual readings and delayed billing. IoT-integrated smart energy metres provide remote management, data analytics, and real-time monitoring.

Devices are connected to the internet through the Internet of Things to exchange data. IoT allows real-time data transmission to a cloud-based server in our smart energy metre, enabling remote access and monitoring. The system consists of communication modules for data transfer, a microprocessor for processing, and sensors for measuring usage. A central hub for data processing, visualisation, and storage is a cloud-based server.

The metre sends data to the cloud in real-time to monitor power consumption. Through a smartphone app or web portal, users can view this data, get insights, and receive alerts for unusual consumption. It is imperative to tackle issues such as interoperability and data security.

AI integration for predictive analytics and machine learning for improved energy efficiency could be future breakthroughs. Finally, this short study examines how IoT-enabled Smart Energy Metres might advance energy-saving behaviours for a sustainable and effective future.

II. ALGORITHM

1. Initialization: Configure the 20x4 LCD display using the I2C module, the Voltage Sensor ZMPT101B, the Current Sensor SCT103, and the NodeMcu ESP-32.Set up the required libraries for reading sensor data, I2C communication, and ESP-32.
2. Voltage Measurement: Use the ZMPT101B voltage sensor to continuously check the voltage. An analogue voltage output proportionate to the line voltage will be produced by this sensor. Using the appropriate formula, convert the analogue voltage reading to the actual voltage value (in volts).For use in future computations, save the voltage value in a variable.

3. Current Measurement: Use the SCT103 current sensor to continuously check the current. An analogue voltage output proportionate to the current is produced by the SCT103.Using the appropriate formula, convert the analogue current reading to the actual current value (in amperes).
4. Power Calculation: Multiply the voltage and current values found in steps 2 and 3 to get the instantaneous power (in watts).Update the power value often.
5. Energy Calculation: To determine energy consumption, integrate the power values over time. This entails multiplying power by time intervals continuously. Continually update the energy value.
6. LCD display: Set up the 20 x 4 LCD screen to show current data. On the LCD screen, show the values for voltage, current, power, and energy consumption.
7. Communication: Configure the Wi-Fi feature of the NodeMcu ESP-32 to send data about energy consumption to a distant server or to show it on a web interface. Send data to a remote server by putting data transmission protocols like HTTP or MQTT into practise.
8. User Interface: Install a user interface on the NodeMcu ESP-32 so that users can view local data on energy consumption. Create an LCD screen menu or display format that allows for user interaction.
9. Accuracy and Calibration: If required, carry out calibration procedures to guarantee the precision of voltage and current readings. Provide information about calibration on the LCD screen.

III. ARCHITECTURE

1. NodeMcu WiFi + Bluetooth ESP-32: - The central component of the system is the NodeMcu ESP-32, which offers Wi-Fi connectivity for data collection and transmission to a local server or the cloud. It also manages communication with other components and data processing.
2. ZMPT101B Voltage Sensor: The AC voltage of the power source is measured using the ZMPT101B voltage sensor. It guarantees precise and safe voltage measurement, which is essential for power consumption computation.
3. SCT103 Current Sensor:The AC current passing through the electrical circuit is measured using the SCT103 current sensor. It offers the information required to compute power consumption and can be measured by non-invasively clamping it around a live wire.
4. I2C Module with 20x4 LCD Display: - Real-time data on energy consumption is presented via the LCD display and an I2C module. Users can easily view local versions of voltage, current, power, and other pertinent data.
5. 100 ohm and 10k ohm resistors x 2:The project uses resistors for calibration and voltage division, among other things. While 10k ohm resistors are typically used for voltage division, the 100 ohm resistor can be used in conjunction with the current sensor to adjust the sensitivity.
6. Capacitor (63V, 10uF): - The capacitor ensures steady and precise voltage measurement by filtering noise from the power supply.

Project Functionality

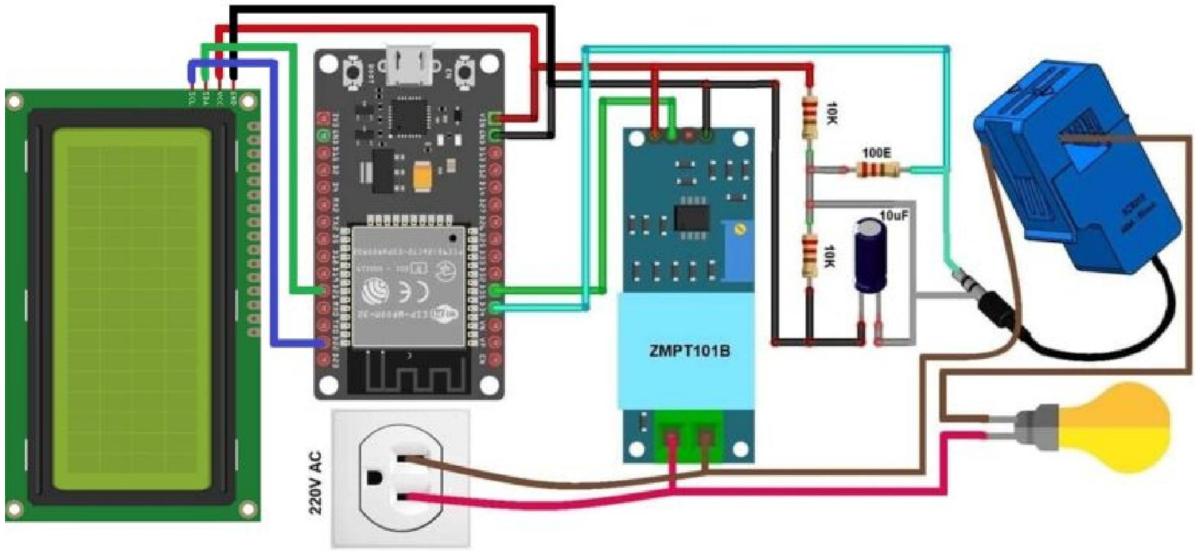
1. Real-time Data Measurement: The electrical supply provides real-time data to the voltage and current sensors.
2. Power Calculation: Using the formula P = V * I, the microcontroller processes the sensor data to determine power consumption.
3. Local Display: - Voltage, current, power, and possibly other data can be visualised locally on an LCD display, which offers an intuitive user interface.
4. Internet of Things Integration: - The NodeMcu ESP-32 uses Wi-Fi to transmit the gathered data to a distant server, giving users access to energy consumption data from any location with an internet connection.
5. Energy Monitoring: - By keeping an eye on their energy usage patterns, users can make well-informed decisions about how much energy to use.

IV. MODULES USED

1. Energy Metre Module: Standard or intelligent energy metres that track and measure energy usage.Gives precise current and voltage readings.
2. NodeMCU ESP32 Microcontroller/Processor Module: Functionality: Communicates with various sensors and the energy metre. Reads sensor data, such as voltage and current and manages communication with the Blynk app and processes data.
3. Blynk-based Connectivity Module: Utilises the Blynk platform to enable Internet of Things connectivity. Allows the NodeMCU ESP32 and the Blynk app to communicate with each other.Permits control and monitoring in real time through the Blynk mobile app.
4. Sensors Module: Capabilities: Consists of voltage, current, and possibly temperature sensors and keeps an eye on electrical parameters to ensure precise readings.
5. Blynk App Module: Functionality: Offers an easy-to-use interface for keeping track of energy usage and enables consumers to see data in real time on their smartphones. Also facilitates communication and control of the smart energy meter.

V. PROPOSED SYSTEM

We have tried to utilize NodeMCU ESP32 as the central controller interfacing with current and voltage sensors to monitor energy consumption. The NodeMCU connects to the Blynk cloud platform via Wi-Fi, enabling real-time transmission of data. Users interact with the system through the Blynk mobile app, gaining access to real-time and historical energy consumption data, as well as the ability to receive alerts for abnormal conditions. The system offers benefits such as remote monitoring, historical analysis, energy optimization insights, and timely alerts, providing users with a comprehensive tool for efficient energy management. Security measures, sensor calibration, and customization of the Blynk app interface are integral considerations for ensuring the system's reliability and user satisfaction.
This is the basic pin diagramto demonstrate the whole circuit.



VI. IMPLEMENTATION

6.1 Hardware Implementation

1.Assemble the Hardware:

Connect the NodeMCU ESP32 to the energy meter and sensors (current, voltage, and temperature) based on their specifications. Ensure proper power supply to the NodeMCU.

2.Sensor Calibration:

Calibrate the sensors to ensure accurate readings. Follow the sensor datasheets and adjust the calibration parameters in the code accordingly.

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6.2 Software Implementation:

- Set Up Blynk Account: Create an account on the Blynk platform (https://blynk.io/). Create a new project on the Blynk app and obtain the authentication token for communication with the NodeMCU.
- Install Blynk Library:Install the Blynk library in the Arduino IDE or PlatformIO.Use the Blynk library to establish a connection between the NodeMCU and the Blynk app.
- Write NodeMCU ESP32 Code:Write Arduino code for the NodeMCU ESP32. This code should include:Initialization of sensors ,Wi-Fi connection setup ,Blynk connection setup using the obtained authentication token, Reading sensor data and sending it to the Blynk app.
- Blynk App Configuration:Customize the Blynk app interface by adding widgets (e.g., Value Display, Gauge) to display energy consumption readings.Configure the app to receive and display data from the NodeMCU.
- Real-time Monitoring:Flash the NodeMCU ESP32 with the written code.Open the Blynk app on your smartphone, and the NodeMCU should start sending real-time data to the app.

VII. ADVANTAGES

1. Real-Time Monitoring and Informed Decision-Making: With IoT-enabled smart energy meters, users gain instant access to real-time data on their energy consumption. This empowers them to make informed decisions promptly, optimizing usage based on immediate insights.

2. Remote Accessibility for Convenience: The IoT connectivity allows users to remotely monitor and control their energy consumption through internet-connected devices. This level of accessibility enhances convenience and flexibility in managing energy usage, especially when users are away from their premises.

3. Cost Savings through Efficient Management: Smart energy meters facilitate precise tracking of energy consumption patterns, aiding in the identification of inefficiencies. This, in turn, helps users implement targeted strategies to reduce overall energy costs through more efficient usage.

4. Automatic Meter Reading (AMR) for Operational Efficiency: The integration of AMR eliminates the need for manual meter readings, reducing human errors and operational costs associated with traditional methods. This automation streamlines the billing process and improves accuracy.

5. Integration with Renewable Energy and Sustainability: Smart energy meters seamlessly integrate with renewable energy sources, allowing users to monitor both consumption and generation. This supports sustainability efforts by promoting the efficient use of renewable energy and contributing to a reduction in carbon footprints.

VIII. DISADVANTAGES

1. Privacy Concerns: The continuous monitoring of energy consumption raises privacy concerns as it involves collecting and transmitting detailed usage patterns. Users may worry about the potential misuse or unauthorized access to this sensitive information.

2. Security Risks: IoT devices, including smart energy meters, may be susceptible to cybersecurity threats. Unauthorized access to the metering system could lead to data breaches or malicious manipulation of energy consumption data.

3. Initial Implementation Costs: The deployment of IoT-enabled smart meters can incur significant initial costs. This may include expenses related to device procurement, installation, and system integration, posing a financial challenge for some users.

4. Technological Dependency and Maintenance: Smart energy meters rely heavily on technology and connectivity. Technical glitches, network outages, or software failures could disrupt the functionality, requiring prompt and possibly costly maintenance.

5. Limited User Understanding and Engagement: Despite providing detailed data, users may struggle to interpret and act upon the information effectively. Limited user understanding or engagement could hinder the realization of potential energy savings and efficiency improvements.

IX. FUTURE SCOPE

1. Advanced Data Analytics: Continued advancements in data analytics will enable utilities and consumers to gain more insights from the data collected by smart energy meters. Predictive analytics can help anticipate energy consumption patterns, identify areas for efficiency improvements, and optimize energy distribution.

2. Integration with Smart Grids: Smart energy meters can play a central role in the development of smart grids. These grids enable bidirectional communication between utilities and consumers, facilitating better load management, quicker response to outages, and integration of renewable energy sources.

3. IoT and Connectivity: The Internet of Things (IoT) can enhance the capabilities of smart energy meters by enabling seamless connectivity between various devices and systems. This connectivity can lead to more automated and responsive energy management solutions.

4. Blockchain for Transactions: Blockchain technology might be integrated into smart energy meter systems to enhance security and transparency in energy transactions. This could be particularly useful for managing peer-to-peer energy trading or ensuring the integrity of energy data.

5. Demand Response Programs: Smart meters can enable more effective demand response programs where consumers adjust their energy consumption based on real-time pricing or grid conditions. This can lead to more efficient energy use and reduced peak demand.

X. CONCLUSION

In conclusion, the implementation of Smart Energy Meters using the Internet of Things (IoT) technology represents a significant advancement in the realm of energy management and sustainability. These devices offer a multitude of benefits, ranging from real-time monitoring and data analytics to enhanced efficiency and cost savings. By leveraging IoT, Smart Energy Meters enable two-way communication between consumers and utility providers, fostering a more dynamic and responsive energy ecosystem.

The ability to collect and analyze granular data empowers both consumers and utilities to make informed decisions about energy consumption, promoting energy conservation and reducing overall wastage. Additionally, the remote monitoring capabilities of Smart Energy Meters contribute to quicker issue detection and resolution, leading to improved system reliability.

Furthermore, the integration of IoT facilitates the development of smart grids, allowing for better load balancing, demand response, and the incorporation of renewable energy sources. This paves the way for a more sustainable and resilient energy infrastructure that aligns with global efforts to combat climate change.

While the adoption of Smart Energy Meters brings forth numerous advantages, it is essential to address potential concerns such as data privacy and cybersecurity to ensure the secure and responsible deployment of these technologies.

In conclusion, the synergy between IoT and Smart Energy Meters holds great promise in revolutionizing how we generate, distribute, and consume energy, contributing to a more sustainable and intelligent energy landscape.

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