CAM COURSE PROJECT FINAL REPORT

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IoT Based Electricity Energy Monitoring System Using ESP32

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Preface

This project, undertaken as part of the Computer Architecture and Microprocessor course under the esteemed guidance of Professor Nissan Kunju, explores the practical applications of microprocessors through the design and implementation of IoT Based Electricity Energy Monitoring System using ESP32.

Our primary motivation stemmed from a desire to gain a deeper understanding of microprocessors and their real-world capabilities. Throughout the project, we honed our skills in Arduino coding and hardware integration, all of which are crucial aspects of microprocessor-based systems.

The following report details the design, development, and implementation of our IoT Based Electricity Energy Monitoring System. We believe this project serves as a valuable example of how microprocessors can be utilized to create practical and user-friendly solution.

Motivation for choosing the project

Our drive to undertake this project stems from the necessity to curb excessive electricity consumption through the development of an IoT-based electricity monitoring system. By embarking on this endeavour, we aim to delve into the realm of microprocessors and their practical applications, thereby expanding our knowledge and expertise in this field.

Problem Statement

The crux of our project revolves around addressing the issue of mindless electricity consumption in homes and buildings.

- Environmental Impact: Excessive electricity usage contributes to the escalation of carbon footprint, intensifying environmental degradation and climate change.
- Economic Burden: Mindless electricity consumption places a financial strain on families, leading to higher utility bills and decreased disposable income.
- Global Energy Scarcity: The unrestrained consumption of electricity exacerbates the global energy scarcity crisis, underscoring the urgency for sustainable energy management solutions.

Solution

Our solution involves the development of an IoT-based energy monitoring system using Arduino Uno and Node MCU. This system will track voltage, current, power, and energy consumption in real-time and transmit data to users' mobile phones for timely alerts.

Benefits:

- Cost Savings: Efficient monitoring leads to reduced electricity bills.
- Energy Scarcity Reduction: Promoting responsible energy usage helps mitigate global energy scarcity.
- Lower Carbon Footprint: By reducing excessive electricity consumption, we contribute to environmental conservation efforts.

Available solution from Literature

SmartThings, Samsung’s global connected living platform, is thrilled to announce a groundbreaking collaboration with Eve Systems, transforming home energy management through advanced power monitoring and expanding the number of SmartThings compatible brands and products that support energy management. With Eve Energy, a Matter compatible smart plug and power meter, consumers will now be able to track energy consumption for everyday appliances and devices right through the SmartThings app, helping to reduce their carbon footprint and ultimately save money.

SmartThings users will have the ability to reduce power consumption by monitoring individual devices that are connected to Eve's smart plug, finally answering the question, "How much does that light actually cost me?" For instance, users can track an appliance such as a coffee machine to calculate its power usage and monthly cost. Armed with this insight, consumers can make more informed decisions to reduce utility bills by creating automation routines and setting timers to optimize energy usage via SmartThings.

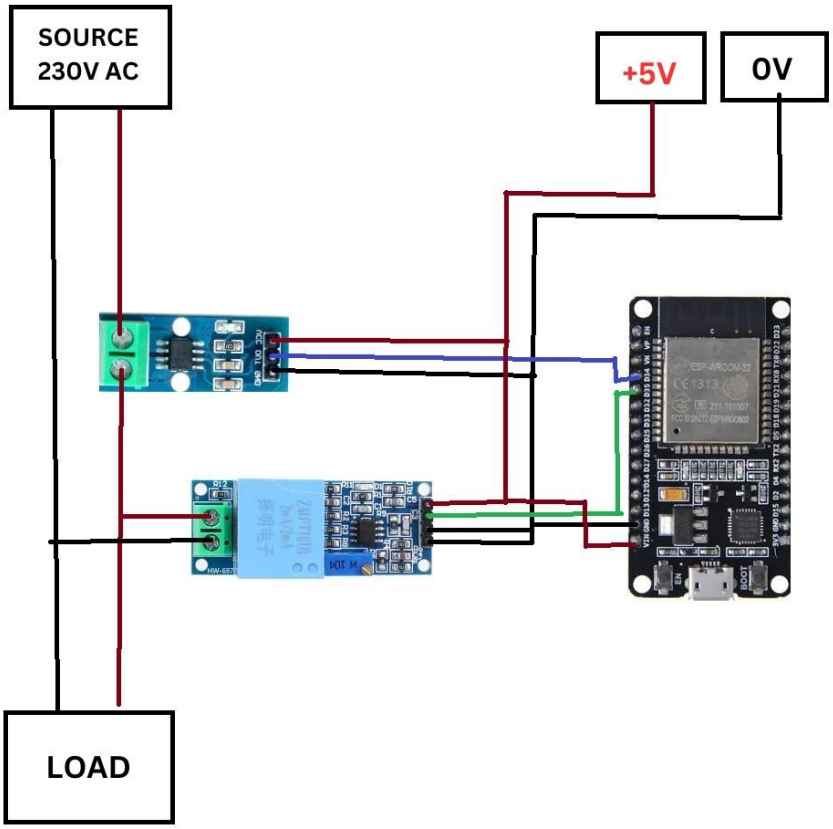
Building on the success of SmartThings Energy, this integration tracks the energy use of existing devices and appliances. Furthermore, users can integrate their non-Samsung appliances, fostering cross-platform compatibility and making energy savings accessible to a wider range of users. Eve Energy works with SmartThings through Matter, a new, unifying standard for smart home connectivity. Built on Thread, Eve Energy connects directly to compatible SmartThings hubs and therefore works right out of the box.

Source : https://news.samsung.com/us/smartthings-partners-with-eve-systems-to-revolutionize-home-energy-management/

Design Objective

- Real-Time Monitoring: Implement a system capable of real-time monitoring of voltage, current, power, and energy consumption in a home or building.
- Accuracy and Precision: Ensure accurate and precise measurement of energy parameters using calibrated sensors and reliable data processing algorithms.
- Wireless Connectivity: Enable wireless connectivity for remote access and data transmission, allowing users to monitor energy usage from anywhere with an internet connection.
- IoT Integration: Integrate the home energy monitoring system with IoT platforms such as ThingSpeak for data storage, visualization, and analysis.
- User-Friendly Interface: Design a user-friendly interface for accessing and visualizing energy consumption data, making it easy for users to interpret and analyze the information.
- Energy Efficiency Insights: Provide insights and recommendations for improving energy efficiency based on analyzed data, helping users optimize their energy usage and reduce costs.
- Customization and Scalability: Allow customization of monitoring parameters and scalability to accommodate different types of electrical loads and user preferences.
- Reliability and Stability: Ensure the system's reliability and stability for continuous monitoring and data transmission, with mechanisms in place for error handling and fault tolerance.
- Low-Cost Solution: Design an energy monitoring system that is cost-effective and accessible to a wide range of users, utilizing affordable components and open-source technologies where possible.

Simulation Based Result



The simulation for the above prototype has been performed in Proteus and the video for the same has been attached in the Google Drive link provided below:

https://drive.google.com/drive/folders/1DvgclbPXwMMDAv6jC27qVwEL66VLEWbU

Actual Implementation and Methodology

Actual Implementation:

Hardware Setup

- Connect the ZMPT101B voltage sensor and ACS712 current sensor to appropriate pins on the ESP32 development board.
- Ensure proper power supply to the ESP32 and sensors.
- Double-check all connections and ensure they are secure.

Firmware Development

- Write firmware code in Arduino IDE for ESP32.
- Include necessary libraries such as WiFi.h, ThingSpeak.h, and any libraries required for sensor interfacing.
- Implement functions to read voltage and current values from the sensors.
- Process sensor data to calculate instantaneous power and cumulative energy consumption.
- Configure WiFi connection to connect ESP32 to your local WiFi network.
- Integrate ThingSpeak API to send sensor data to the ThingSpeak cloud platform.

Integration with ThingSpeak

- Create a ThingSpeak account if you haven't already.
- Create a new channel on ThingSpeak to store sensor data.
- Configure fields on the ThingSpeak channel to match the data you'll be sending (voltage, current, power, energy).
- Obtain the Write API key for your ThingSpeak channel.

- Integrate the Write API key into your ESP32 firmware code to send sensor data to ThingSpeak.

Methodology:

Sensor Data Acquisition

- Read voltage and current values from the ZMPT101B voltage sensor and ACS712 current sensor connected to the ESP32.
- Ensure proper calibration of the sensors to obtain accurate measurements.

Data Processing

- Process the sensor data to calculate instantaneous power using the formula: `Power = Voltage * Current`.
- Calculate cumulative energy consumption over time by integrating power over time intervals.

WiFi Connectivity

- Configure the ESP32 to connect to your local WiFi network using WiFi.h library.
- Ensure stable WiFi connection for data transmission to the ThingSpeak platform.

Data Transmission to ThingSpeak

- Send sensor data (voltage, current, power, energy) to the configured ThingSpeak channel using the ThingSpeak.h library and Write API key.
- Implement error handling and retry mechanisms to ensure reliable data transmission.

Monitoring and Visualization

- Monitor the transmitted data on the ThingSpeak platform dashboard.
- Visualize sensor readings, power, and energy consumption trends using built-in ThingSpeak visualization tools.
- Set up alerts or notifications for abnormal or threshold-crossing values if required.

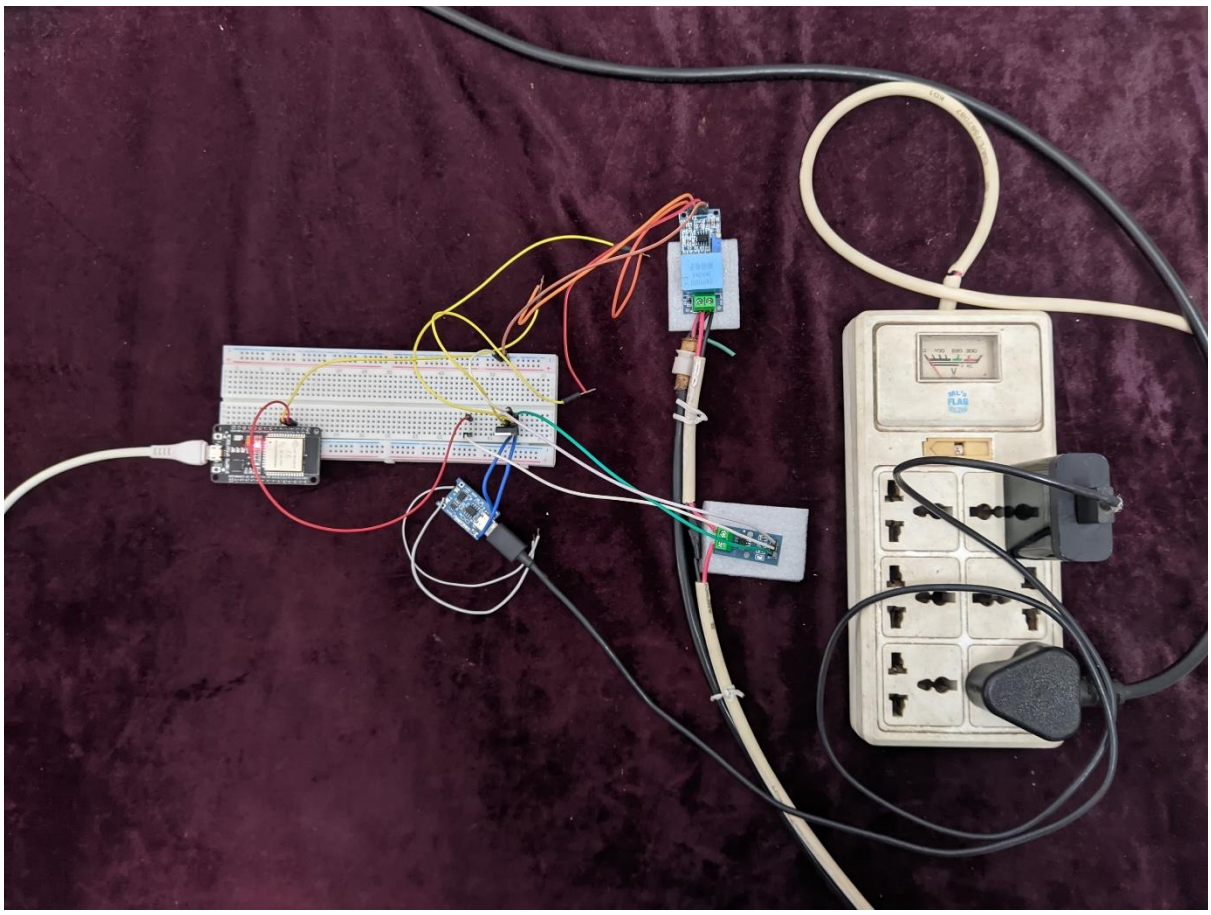
Testing and Optimization

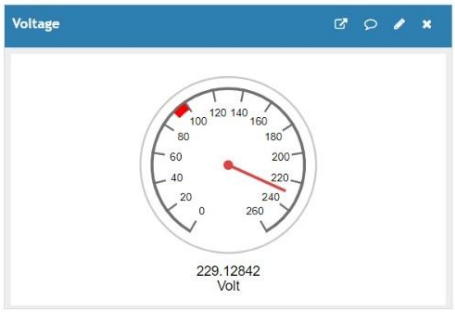
- Test the entire system for functionality, reliability, and accuracy.
- Optimize the firmware code, sensor calibration, and WiFi connectivity for better performance.
- Conduct real-world testing to validate the system's effectiveness in monitoring home energy consumption.

Budget

Components	Price (Rs)
ESP32	400/-
ZMPT101B Voltage sensor	150/-
ACS712-30A Current sensor	170/-
Connecting wires	50/-
Bread board	50/-
Total	820/-

Result




Voltage
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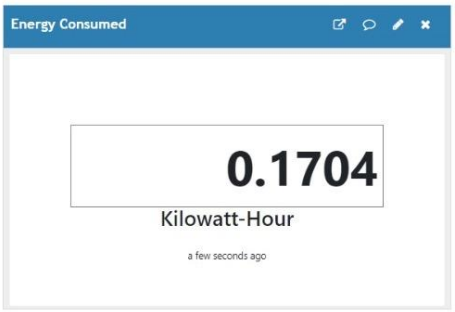
Volt


Current
2.58537
Ampere


Field 3 Chart
Power
Power [W]
500
250
11:15
11:20
11:25
Date
ThingSpeak.com


Energy Consumed
0.1704
Kilowatt-Hour
a few seconds ago

Conclusion

In conclusion, the adoption of an IoT-based electricity monitoring system presents a promising solution to combat excessive energy consumption in various settings such as homes and buildings. By tracking critical parameters like current, voltage, power, and energy, this system ensures users remain informed about their usage patterns in real-time, empowering them to make informed decisions. Through proactive monitoring and timely alerts, we can effectively address energy scarcity concerns and mitigate the escalating carbon footprint. This project serves as a testament to the potential of innovative technologies in fostering sustainable energy practices, paving the way for further advancements in this crucial field.