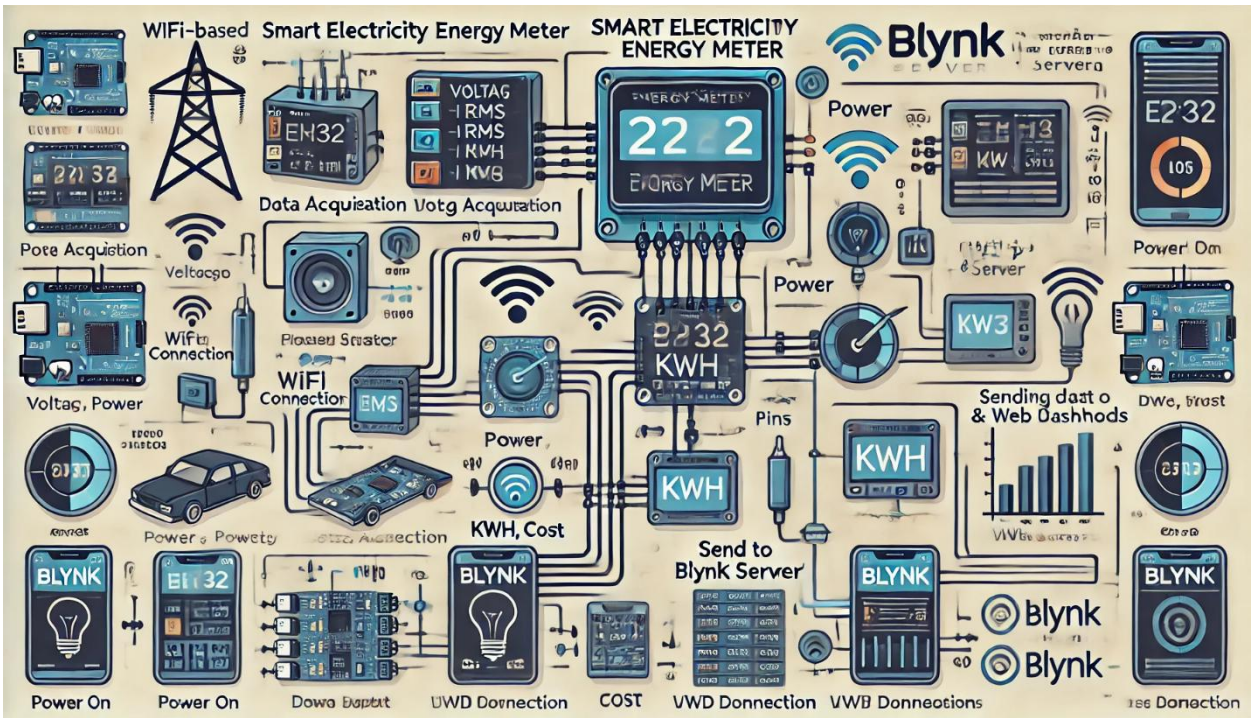


IoT-Based Electricity Energy Meter

- Istiak Ahammed

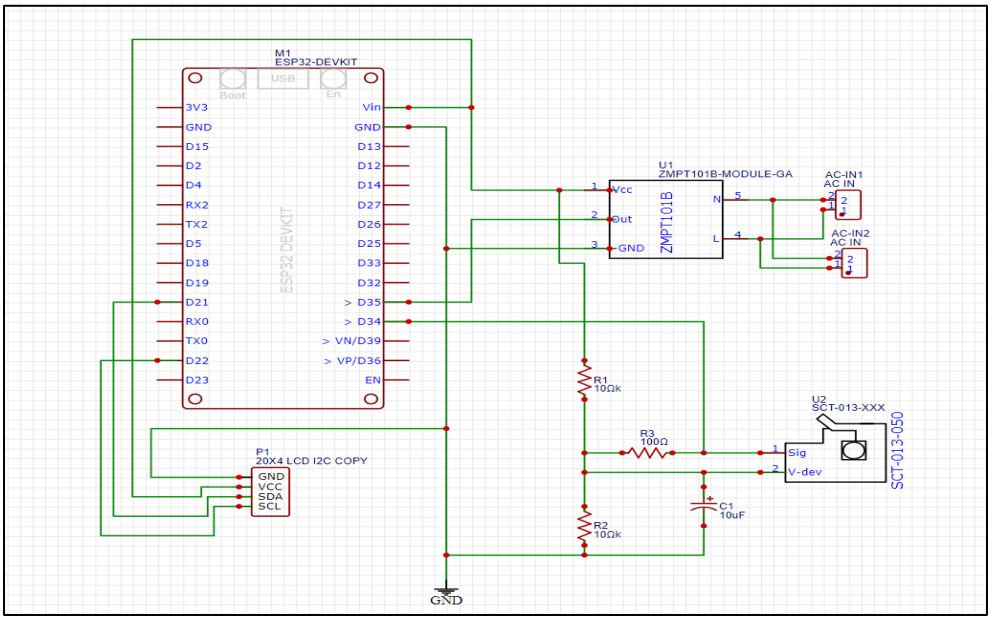
Project Details:

This project aims to create an IoT-based smart electricity meter using an ESP32 microcontroller, the EmonLib library, and the Blynk platform. The goal is to provide users with real-time and remote access to their electricity consumption data (voltage, current, power, and kWh) via a mobile app or web interface. This allows for better energy management, cost savings through informed usage, and the potential for integration with smart home systems. The project will also include data storage, analysis, and alerts for excessive consumption. Ultimately, it seeks to promote energy efficiency and sustainability.

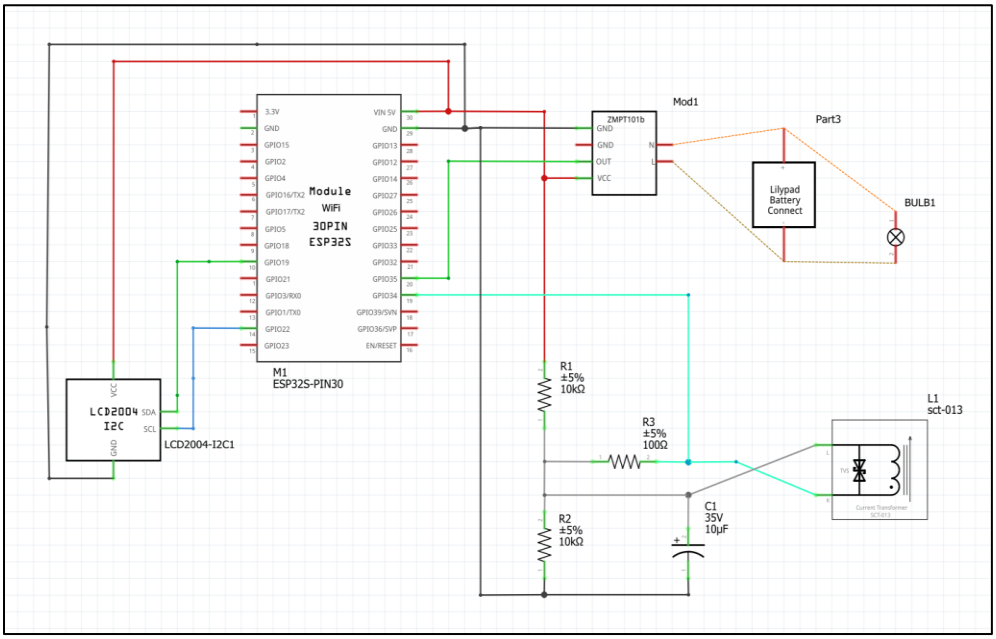
Technical Design: Module Level

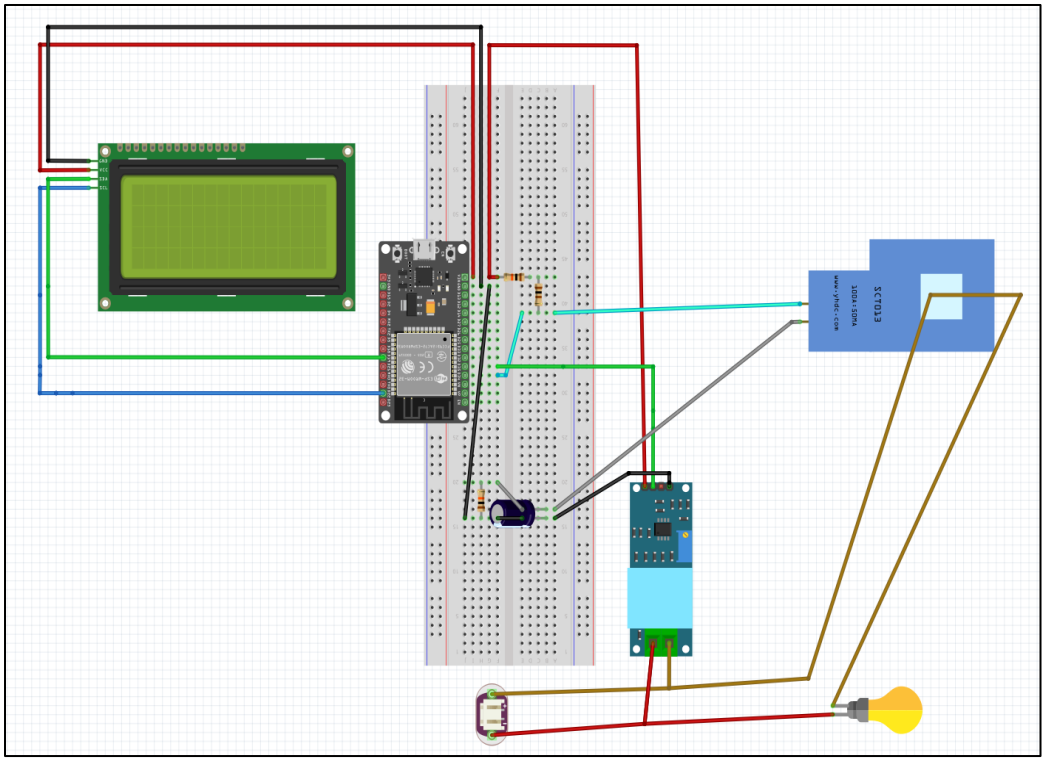
CIRCUIT DIAGRAM

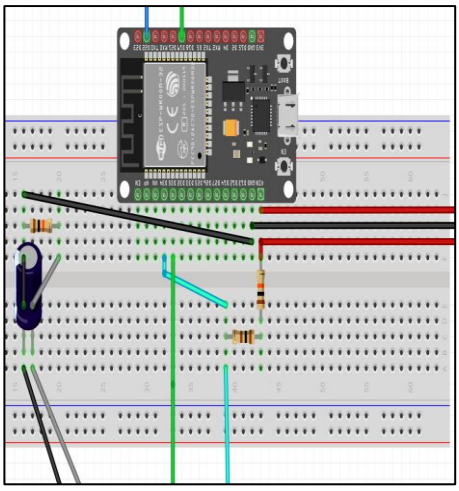
EasyEDA:

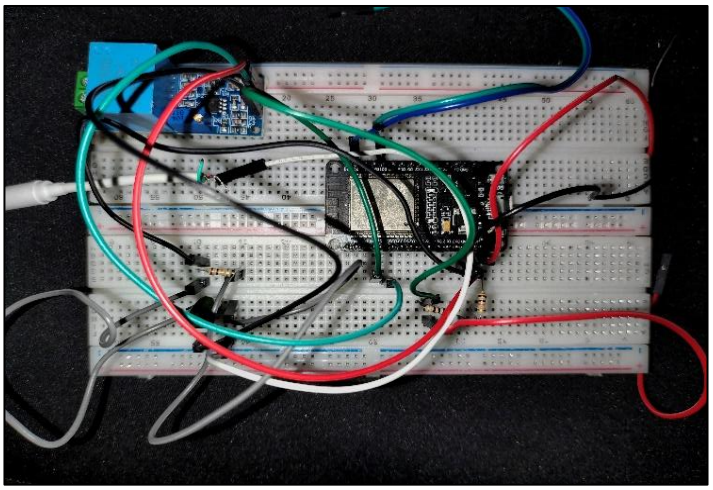


Fritzing :









Design Alternative (PCB Implementation)

Instead of using a breadboard for the circuit implementation, an alternative design approach is to create a custom Printed Circuit Board (PCB) for the project. This alternative offers several advantages over the breadboard implementation, including increased reliability, compactness, and ease of production.

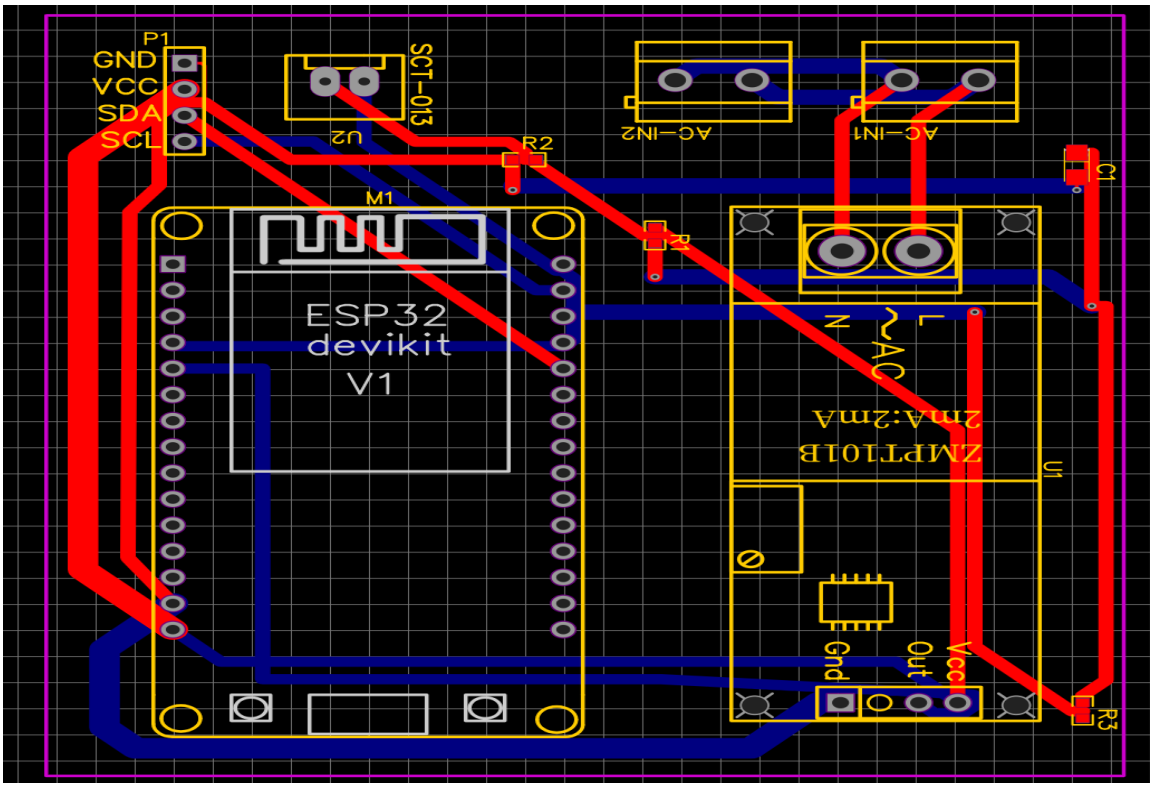


Fig: Schematic Design in EasyEDA

A custom-designed PCB allows for a more professional and streamlined appearance, making it suitable for commercial production and deployment.

Table.: PCB Design

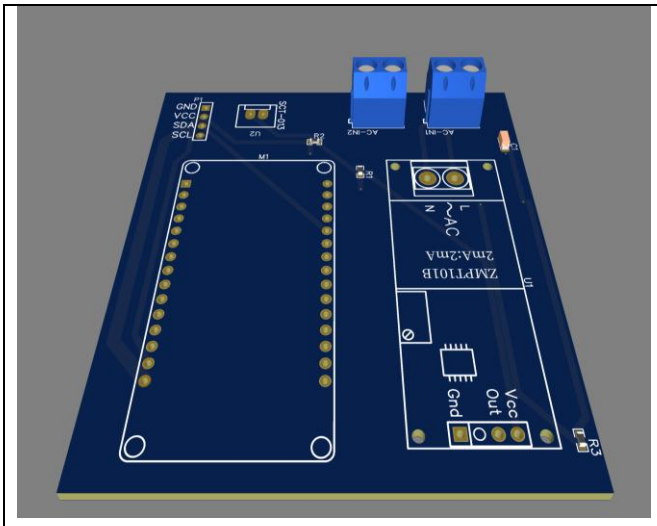


Fig: PCB Design in EasyEDA

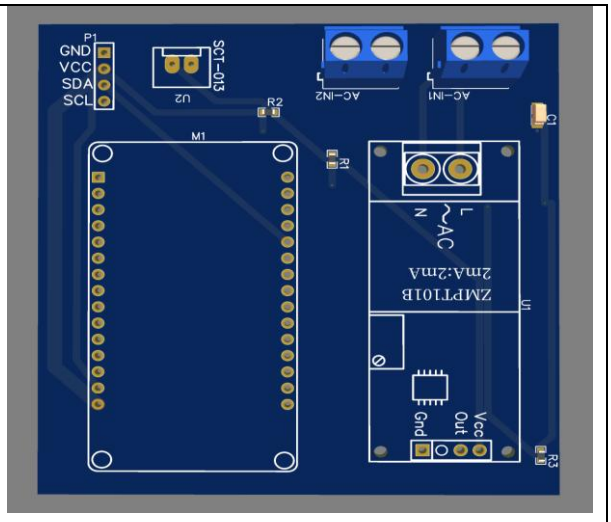


Fig: Top View

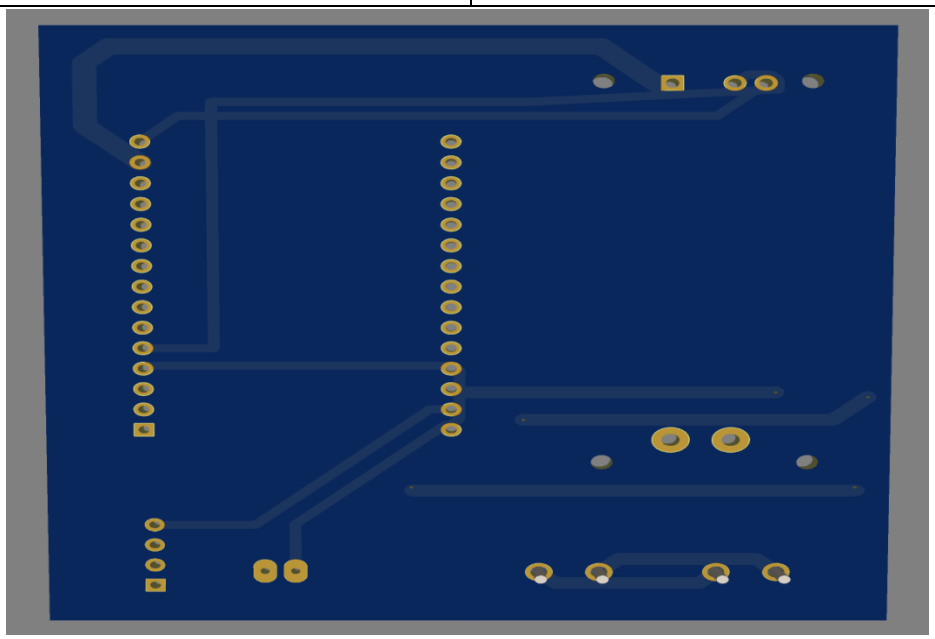
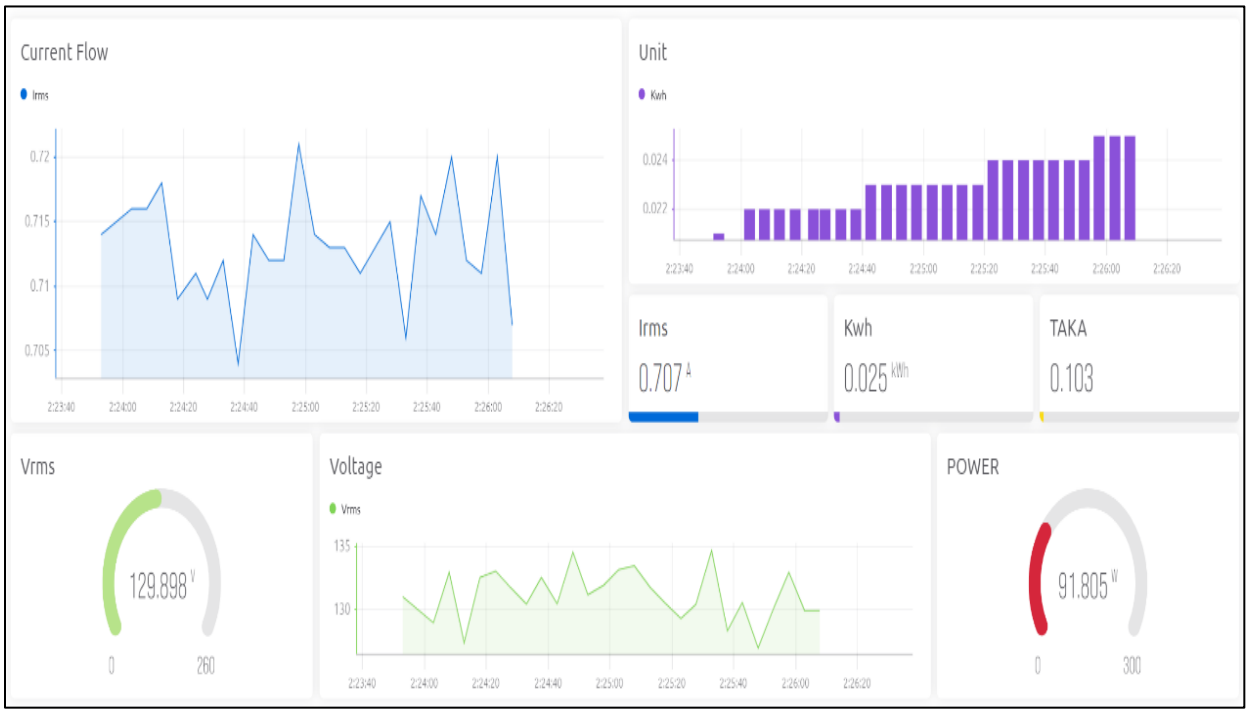


Fig: Back View

Data Analysis

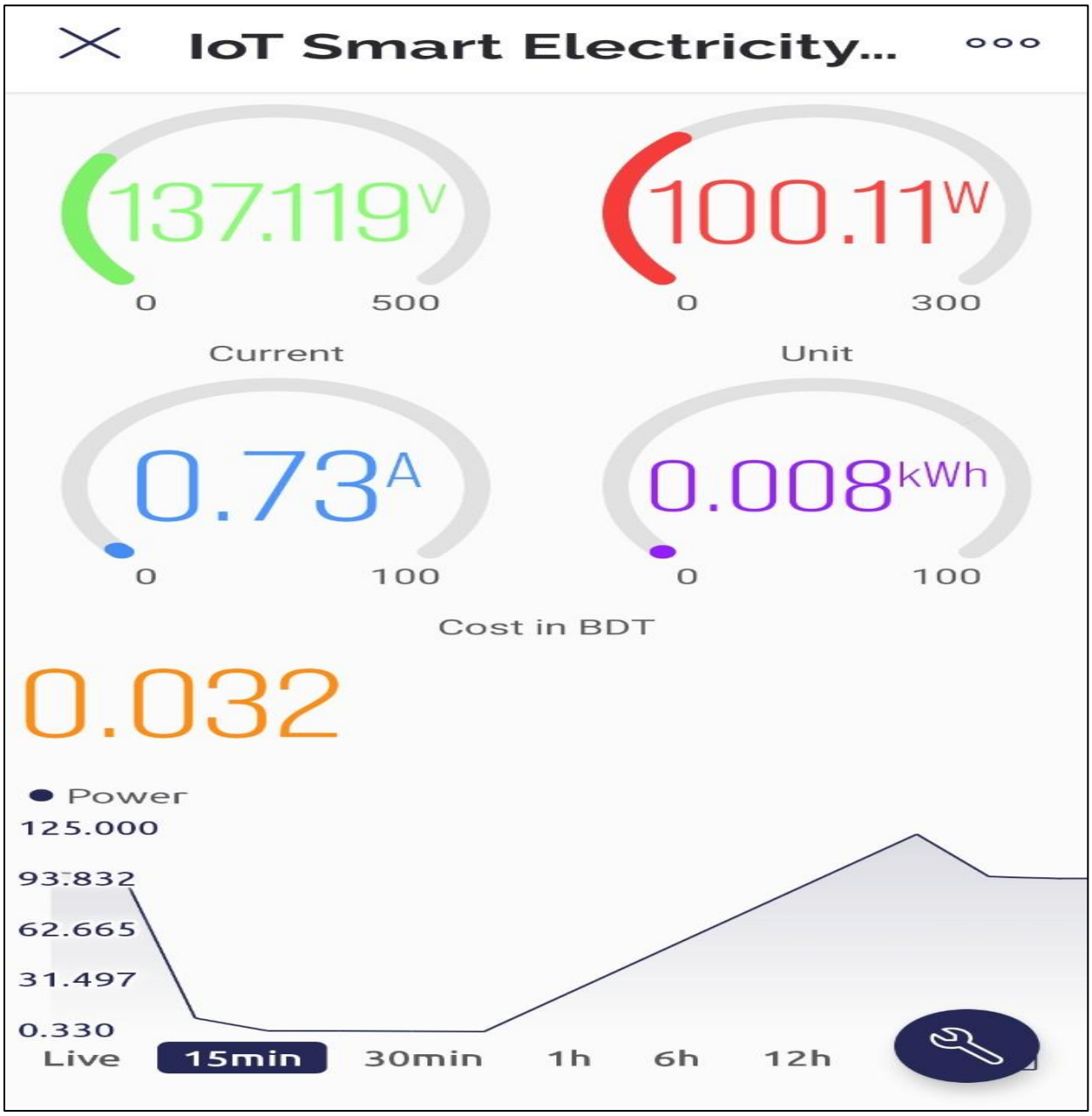
Blynk Web Dashboard

The Blynk web dashboard provides an intuitive platform for real-time and historical analysis of energy consumption data. Users can create customizable visualizations with widgets like graphs, charts, and gauges to monitor voltage, current, power, kWh, and costs. Historical data can be analyzed using filtering and aggregation tools to identify trends, anomalies, and patterns over specific periods. The dashboard supports data export in formats such as CSV or JSON for further analysis and integration with other tools. Users can design custom dashboards to focus on daily usage, monthly trends, or cost analysis. With real-time monitoring and extensive widget customization options, the web dashboard empowers users to optimize energy efficiency and make data-driven decisions effectively.



Blynk Mobile Dashboard

The Blynk mobile app offers a convenient platform for real-time monitoring and data analysis of energy consumption. Users can track live data, such as voltage, current, power, kWh, and costs, through interactive widgets like graphs, gauges, and value displays. Historical data visualization helps identify trends and patterns, while customizable notifications alert users to high energy consumption or unusual fluctuations. The app also enables data export for further analysis and supports remote control and automation of appliances based on energy usage thresholds, enhancing energy efficiency and convenience.



LCD Display

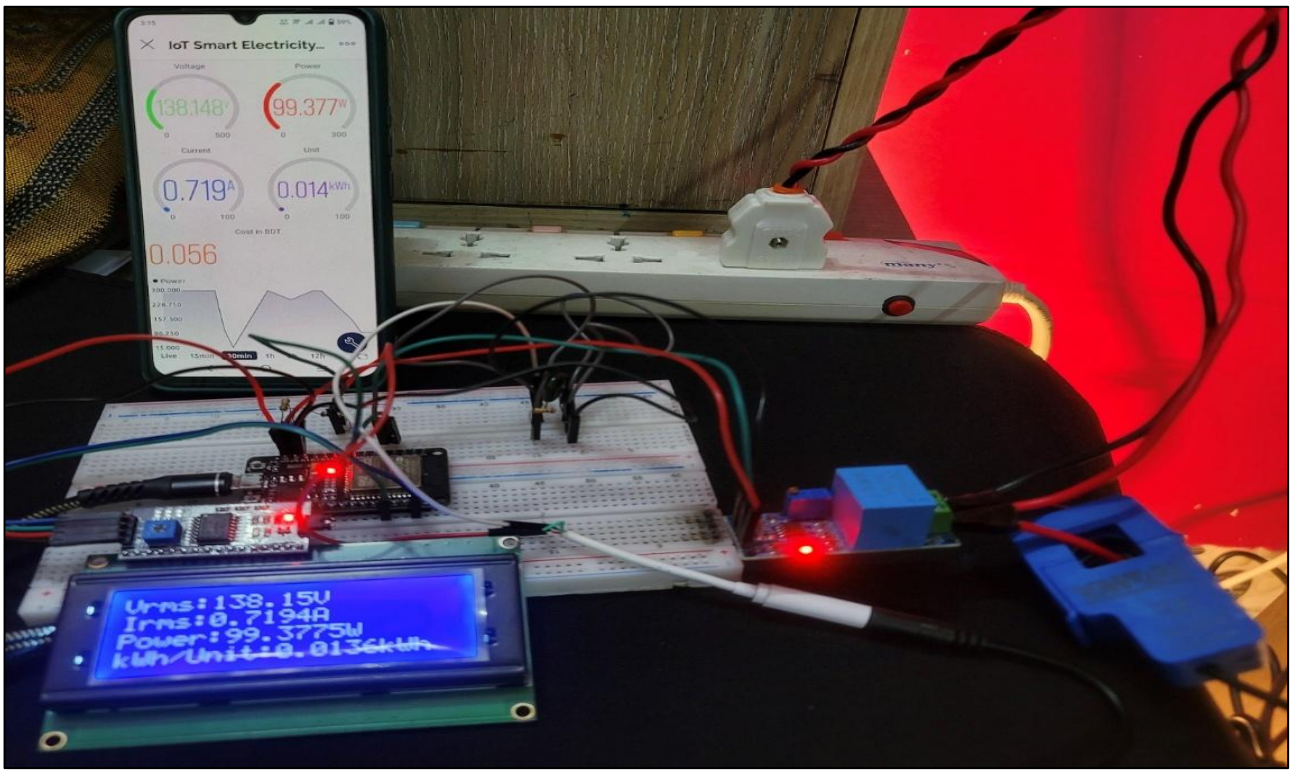
The 20x4 LCD provides a straightforward interface for real-time energy data, including voltage, current, power, cumulative kWh, and total costs. It formats and organizes the information for clarity, with options for unit conversion to improve user understanding. Threshold alerts notify users directly of excessive energy consumption on the display, enabling immediate action. While less advanced than the Blynk dashboard, the LCD delivers essential insights into energy usage in a simple and accessible manner.

Feasibility Study

MATHEMATICAL TERMS

1. ***Vrms (Voltage RMS):***
   - It is calculated using the formula: $\mathbf{Vrms} = \frac{\sqrt{V1^2 + V2^2 + V3^2 + \ldots + Vn^2}}{n}$ where ***V1, V2, V3, ..., Vn*** are the instantaneous voltage samples, and ***n*** is the number of samples.
2. ***Irms (Current RMS):***
   - It is calculated using the formula: $\mathbf{Irms} = \frac{\sqrt{I1^2 + I2^2 + I3^2 + \ldots + In^2}}{n}$ where ***I1, I2, I3, ..., In*** are the instantaneous current samples, and ***n*** is the number of samples.
3. ***Power:***
   - It is calculated using the formula: **Power = Vrms * Irms** where **Vrms** is the voltage RMS and **Irms** is the current RMS.
4. ***kWh (Kilowatt-hours):***
   - The formula for calculating kWh is: $\mathbf{kWh} = \frac{\Sigma(Pi * \Delta t)}{(1000 * 3600)}$ where **Pi** is the power at each time interval **Δt**, and the summation is performed over the entire time. The division by (1000 * 3600) converts the energy from watt-seconds to kilowatt-hours.
5. ***Unit:***
   - The formula for calculating the unit is: **Unit = kWh / TotalNumberOfKWh**
6. ***Total Cost:***
   - The total cost represents the monetary cost of energy consumption.
   - It is calculated by multiplying the energy consumption (kWh) by the cost per unit.
   - The formula for calculating the total cost is: **Total Cost = kWh * CostPerUnit**

Final project



REFERENCES

1. IoT Based Electricity Energy Meter using ESP32 & Blynk: https://how2electronics.com/iot-based-electricity-energy-meter-using-esp32-blynk/
2. IoT Based Electricity Energy Meter using ESP12 and Arduino: https://circuitdigest.com/microcontroller-projects/iot-electricity-energy-meter-using-esp12-arduino
3. IoT based Smart Energy Meter using ESP32 & Google Sheet or Google Spreadsheet: https://www.electroniclinic.com/iot-based-smart-energy-meter-using-esp32-google-sheet-or-google-spreadsheet/
4. IoT Smart Electricity Energy Meter with ESP32 & Blynk 2.0: https://how2electronics.com/iot-smart-electricity-energy-meter-with-esp32-blynk-2-0/
5. IoT AC Energy Meter with ESP32 & HMI Display: https://how2electronics.com/iot-ac-energy-meter-with-esp32-hmi-display/
6. IoT Based Smart Electricity Energy Meter: https://www.prateeks.in/2021/12/iot-based-smart-electricity-energy-meter.html
7. Iot Smart Energy Meter: https://www.instructables.com/Iot-Smart-Energy-Meter/
8. Iot based electricity energy meter using esp12 and arduino at sln technologies: https://www.slideshare.net/slideshow/io-t-based-electricity-energy-meter-using-esp12-and-arduino-at-sln-technologies/106599158