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IOT Based Controlled Smart Distribution Box

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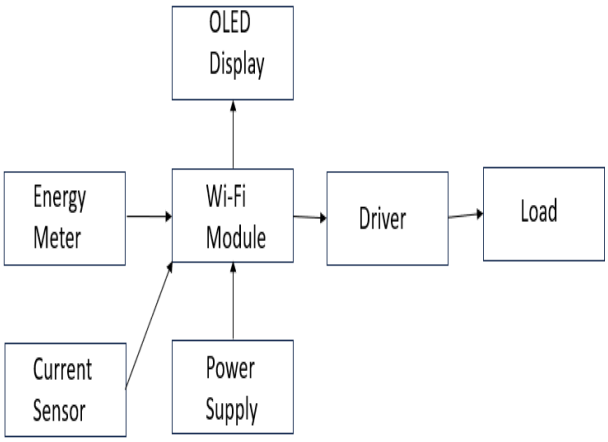
Abstract: ***This project introduces an IoT-controlled smart distribution box designed for enhanced energy management and convenience, boasting versatile features for both online and offline usage. Utilizing a NodeMCU microcontroller unit, the system integrates a 4-channel relay for load management via voice commands (Google Assistant, Amazon Alexa), manual switches, and programmable timers and schedules. An LCD 2004 display provides real-time feedback, while a PZEM004T sensor enables precise energy monitoring. Users can also set load limits, with notifications sent when thresholds are reached, further enhancing efficiency and safety. With these comprehensive capabilities, the system empowers users to optimize energy usage, promote sustainability, and simplify control of electrical appliances in residential and commercial settings.***
Keywords: IOT controller, Overload protection, Abnormal condition, Display monitoring in smart phone.

I. INTRODUCTION

In this project, we will implement a smart meter that will compute the power consumption and communicate with the control office over the internet. Also, it will have the capability to disable some of the loads based on the current electricity price and demand. The current electricity distribution and metering infrastructure faces significant challenges, including a lack of real-time data hindering efficient grid management and load forecasting for utility providers, costly and error-prone manual meter reading, limited remote monitoring and control capabilities, difficulties in implementing demand-side management programs, vulnerability to energy theft, inefficient outage management, and high operational costs. For consumers, this translates to a lack of transparency in energy consumption, potential for inaccurate billing, delayed outage information, limited control over energy usage, and difficulty in participating in demand response initiatives.

II. DESIGN AND IMPLEMENTATION

For college purposes, the IOT based controller and overload protection was built with more responsible activities. It is used in academic schedules most frequently in related ways. We followed these studies and developed a kit after studying research papers.



III. SETUP CONFIGURATION

1) Energy Meter

- Function: Measures the energy consumption (voltage, power, energy units).
- Configuration:
  - Interface with a microcontroller or Wi-Fi module via UART, SPI, or I2C.
  - Calibrate for accurate readings (e.g., set voltage/current scaling factors).
  - Ensure safety and isolation when interfacing with high-voltage systems.

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2) Current Sensor

- Function: Measures real-time current flowing to the load.
- Configuration:
  - Choose a suitable current sensor (e.g., ACS712 or Hall-effect sensor).
  - Connect sensor output to an ADC input on the Wi-Fi Module or microcontroller.
  - Calibrate sensor readings according to expected load current range.

3) Wi-Fi Module

- Function: Central controller and communication hub.
- Configuration:
  - Use modules like ESP8266 or ESP32.
  - Connect:
- Energy Meter via UART/I2C.
- Current Sensor via ADC.
- OLED Display via I2C/SPI.
- Driver via GPIO.
  - Connect to Wi-Fi network for cloud or app communication.
  - Program logic to read sensor data, display it, and control driver output.

4) OLED Display

- Function: Displays real-time data such as voltage, current, power, energy units.
- Configuration:
  - Use I2C (SCL, SDA) or SPI based OLED (e.g., 0.96” SSD1306).
  - Powered by 3.3V/5V depending on display specifications.
  - Update display data from Wi-Fi Module.

5) Power Supply

- Function: Powers all electronic components.
- Configuration:
  - Use a regulated power supply (e.g., 5V or 3.3V depending on module specs).
  - Convert AC mains to DC using SMPS or adapter.
  - Provide stable voltage to:
- Wi-Fi Module
- OLED Display
- Driver Circuit

6) Driver

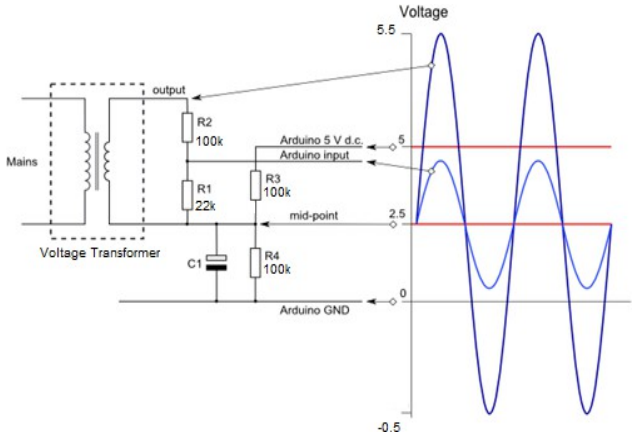
- Function: Controls the operation of the load (e.g., relay, MOSFET, SSR).
- Configuration:
  - Controlled by GPIO pin from Wi-Fi Module.
  - Choose driver based on load rating.
  - Use opto-isolation for safety when switching high power loads.

7) Load

- Function: Electrical appliance or system being controlled and monitored.
- Configuration:
  - Connected to the output of the driver circuit.
  - Should match the capacity of the driver and power supply.

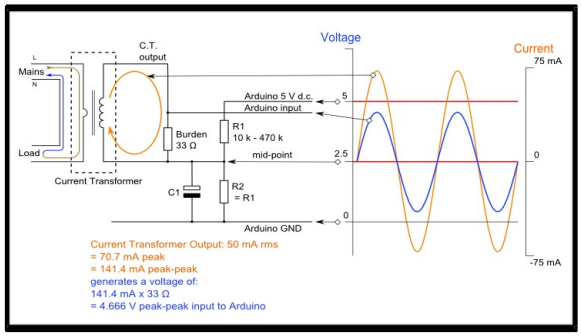
Voltage Reading: voltage readings is the first step in building a basic power meter. However, some of the power meters that we came across, during the research stage, did not advice to use voltage readings, instead, they only preset a specific voltage level that will be constant throughout the whole process of calculation.

Voltage measurement circuit:



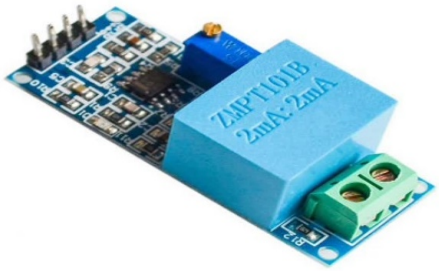
Current reading : current signal using a voltage source created by voltage divider connected across the Arduino's power supply because Arduino only accept positive values.Also, Arduino can only deal with voltage so a small resistor was added so that when the secondary current of the transformer pass through its voltage will be produced and measured.

Current measurement circuit:



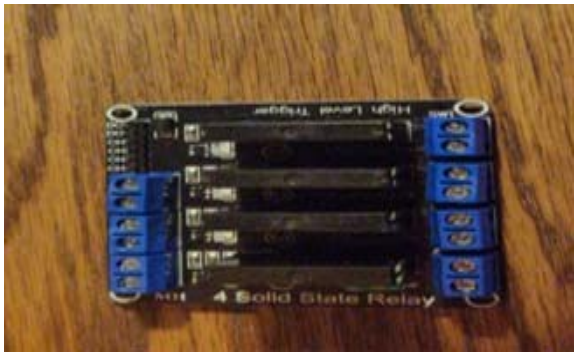
IV. COMPONENTS USED

1) Power factor module :



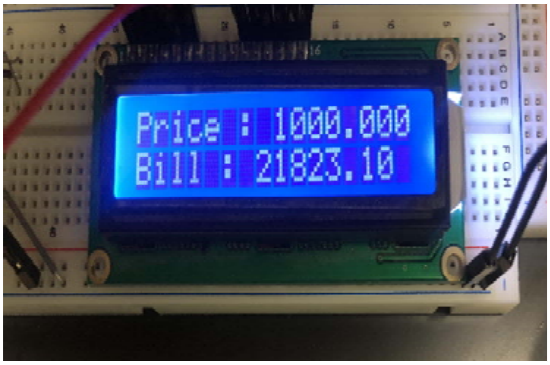
A power factor module in a smart distribution box smart meter is a crucial component responsible for measuring the relationship between the real power (kW) used by the load and the apparent power (kVA) being drawn from the grid.

2) Relay :



Auxiliary Circuit Switching Provides flexibility in the internal architecture and control logic of the smart meter without the need for power-hungry continuously energized relays

3) LCD Display :



The LCD display is a crucial component in a smart energy meter, serving as the primary interface for users and providing essential information about electricity consumption and meter status.

4) Current transformer split coil :

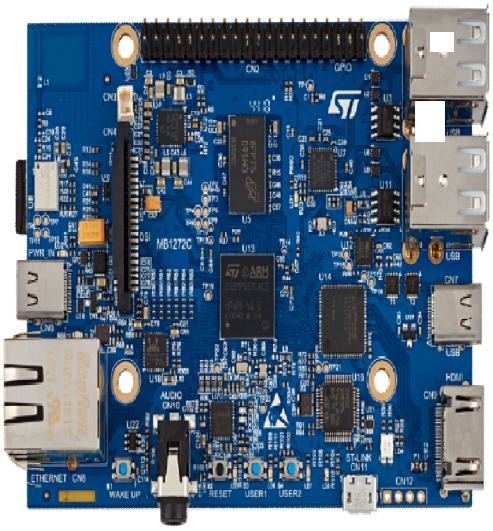
A split-core current transformer (CT) is a type of current transformer where the magnetic core can be opened and closed, allowing it to be installed around a live conductor without disconnecting it.This feature offers several advantages when used in smart energy meters.

5) Miniature Circuit Breaker :

Sr.No	Component Name	Range
1	Power Factor Module	0 (lagging or leading) to 1 (unity).
2	SPDT Relay	DC: Commonly 5V, 12V, or 24V DC AC: Commonly 24V AC
3	LCD (Liquid Crystal Display)	LCD's are alphanumeric 16x2, 20x4 characters.
4	Current Transformer Split Core	Commonly use CTs with ranges like 5A to 100A for Residentials.

Smart Miniature Circuit Breakers (MCBs) in a smart distribution box are upgraded safety devices. They sense electrical data (current, voltage) and communicate it to a central brain. This allows for remote control, energy monitoring, automation, and proactive fault detection, making your electrical system safer and smarter.

6) STM32MB1 microcontroller :



The STM32MP1's dual cores (Cortex-A7 for smart features, Cortex-M4 for real-time control) make it perfect for smart electrical panels, enabling intelligent monitoring, remote control, and robust security.

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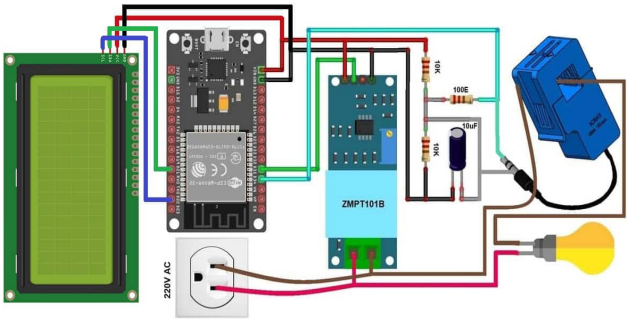
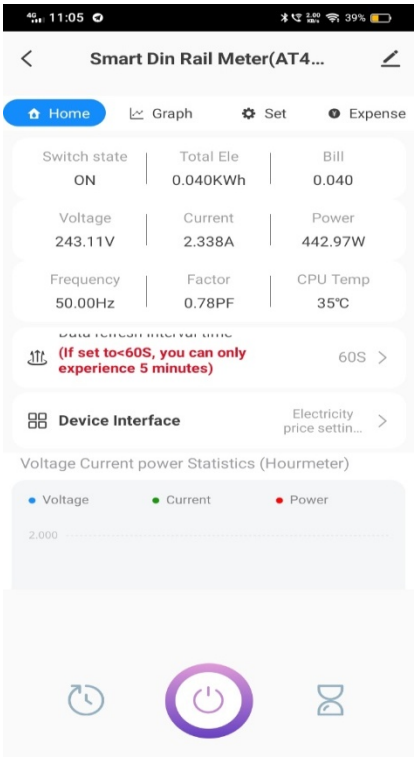
V. COMPONENT SPECIFICATION CHART

Circuit Diagram of Smart Distribution Box :



VI. EXPERIMENTAL SETUP AND IMPLEMENTATION

Display reading on mobile app:



This reading display on smart life mobile app.

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VII.RESULTS

The system is capable of computing power and energy consumption. It can calculate the electricity bill based on consumption and pricing.The system includes a display (LCD) to show information like power, energy, price, and the bill.The project encountered challenges that affected the final implementation, such as issues with the Wi-Fi module and the inability to fully test the load control features

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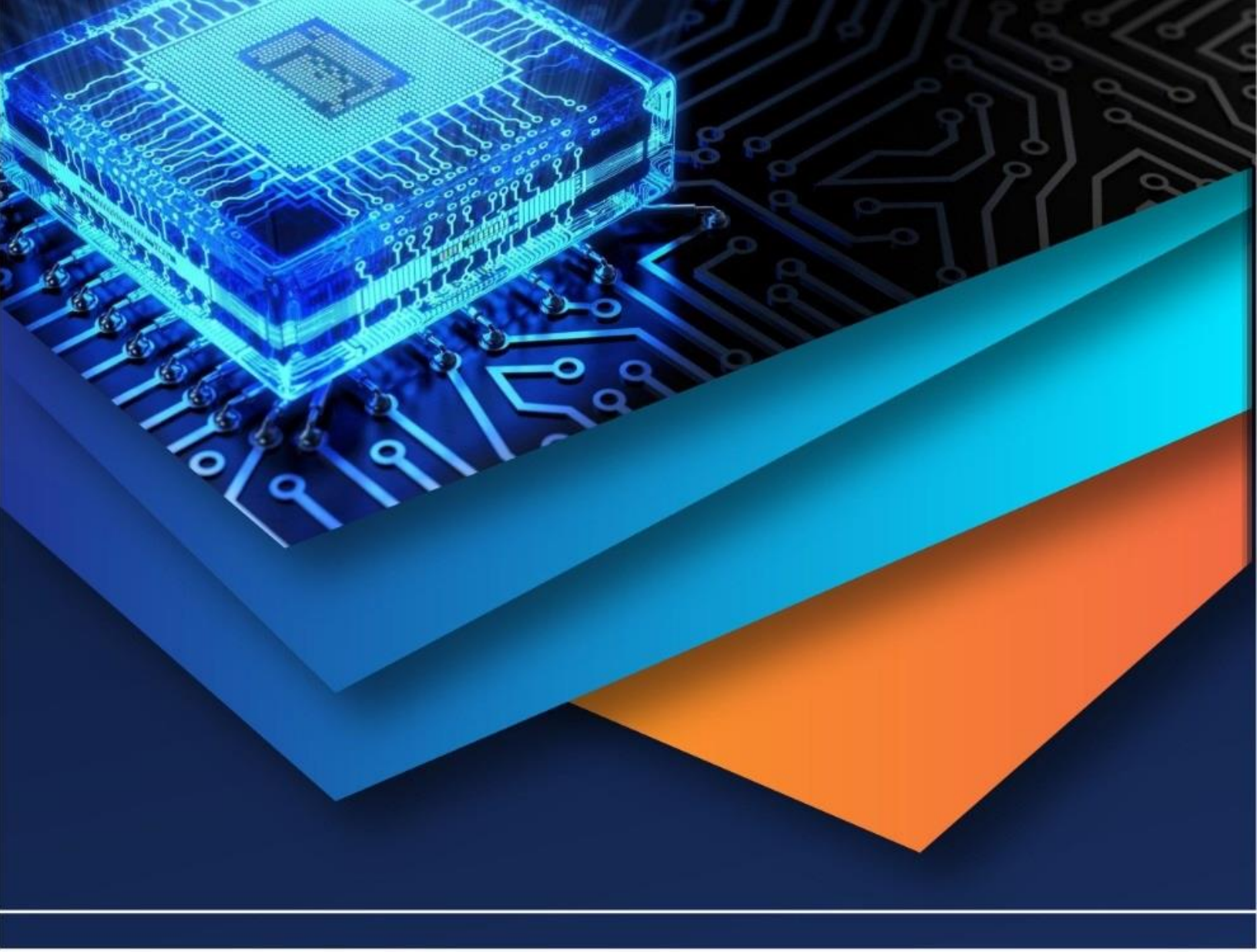

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