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# Smart Energy Meter with IoT - Based Power Theft Detection and Usage Monitoring

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**Abstract**: *Objective: Replace traditional energy meters with an IoT-based smart meter for accurate, real-time power monitoring. Components: Uses current sensor (CT), voltage sensor, and microcontroller (ESP32) to measure electricity usage. Theft Detection: Detects tampering, bypassing, or unauthorized usage by analyzing abnormal power patterns. Remote Monitoring: Data is uploaded to cloud platforms (MQTT) for access via mobile/web apps. Benefits: Prevents revenue loss due theft. Improves billing accuracy. Helps users track and optimize energy consumption. Outcome: A cost-effective, automated and secure energy management system*

**Keywords**: ESP32, Arduinouno, Voltage Sensor, Current Sensor, Relay

## I. INTRODUCTION

This project focuses on the development of a Smart Energy Meter using IoT technologies to provide real-time monitoring of electricity consumption and detect power theft. The system integrates microcontrollers, sensors, and wireless communication modules to collect and transmit energy usage data to a cloud platform. The objective is to enable both consumers and electricity providers to monitor consumption trends remotely, receive alerts on unusual activity, and minimize losses due to unauthorized power usage. The solution aims to improve billing accuracy, enhance transparency, and reduce manual intervention. This approach supports the future vision of smart cities and grid automation.

## II. RELATED WORK

IoT-Based Energy Monitoring Systems Previous works have implemented IoT-based smart meters using microcontrollers like ESP8266 or ESP32 to monitor energy consumption in real-time. These systems typically utilize current and voltage sensors to compute power and energy, and transmit data to cloud platforms (e.g., Thingspeak, Firebase) for analysis. Such systems help users track consumption patterns and reduce wastage.

## III. SPECIFICATIONS

**ESP32:** The ESP32-WROOM-32 is a popular and widely used Wi-Fi and Bluetooth module developed by Espressif Systems. It is powered by a dual-core 32-bit Xtensa LX6 microprocessor running at up to 240 MHz, with 520 KB of SRAM and support for external flash memory (typically 4MB to 16MB). The module features integrated Wi-Fi (802.11 b/g/n) and Bluetooth v4.2 BR/EDR and BLE, making it ideal for a wide range of wireless communication applications. It provides a rich set of peripheral interfaces including SPI, I2C, UART, ADC, DAC, PWM, and touch sensors, along with 34 programmable GPIO pins. The module includes 12-bit SAR ADC (up to 18 channels) and 2 8-bit DACs, making it suitable for analog signal acquisition. Operating at 3.3V, the ESP32-WROOM-32 supports deep sleep mode with ultra-low power consumption (~10 µA), making it ideal for battery-powered IoT projects

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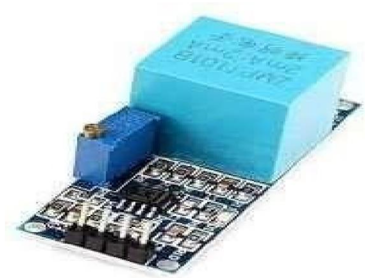
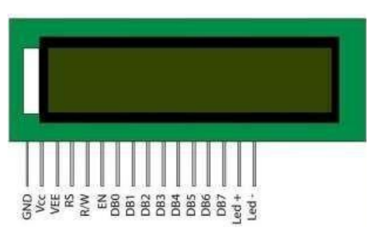
**ACS712 Current Sensor :** The ACS712 is a Hall-effect- based linear current sensor that is widely used for AC and DC current measurements. It can measure current up to
±5A, ±20A, or ±30A, depending on the variant used. The sensor outputs an analog voltage proportional to the current flowing through the input terminals, with a sensitivity of 185 mV/A (for the 5A version). Operating at 5V, the ACS712 provides galvanic isolation and offers excellent linearity and accuracy.

**ZMPT101B VOLTAGE SENSOR :** The ZMPT101B is a high-precision voltage sensor module designed for AC voltage measurement. It is based on a high-accuracy voltage transformer and includes signal conditioning circuitry for safe interfacing with microcontrollers. The module can measure AC voltage in the range of 0 to 250V and outputs a scaled analog voltage signal proportional to the input.



**LCD DSPLAYS**: There are many display devices used by the hobbyists. LCD displays are one of the most sophisticated display devices used by them. Once you learn how to interface it, it will be the easiest and very reliable output device used by you. More, for micro controller based project, not every time any debugger can be used. So LCD displays can be used to test the outputs. Obviously, for last possibility, you need to know how to use this stuff pretty well. Hitachi has set up a mile stone by its LCD controller IC. one of the IC s based upon the architecture introduced by Hitachi.



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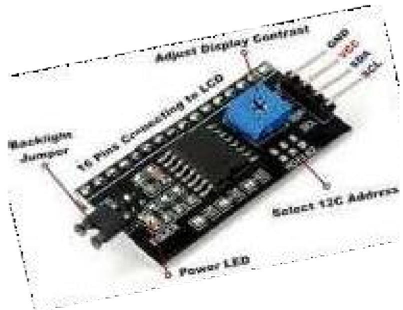
**I2C 16x2 LCD DISPLAY :** The I2C 16x2 LCD display is a widely used alphanumeric display that can show two lines of 16 characters each. It is based on the HD44780 LCD controller and includes an I2C (Inter-Integrated Circuit) interface module, which significantly reduces the number of required connections to just four pins: VCC, GND, SDA, and SCL. The I2C interface uses a serial communication protocol, making it ideal for microcontrollers with limited GPIO pins, such as the ESP32 or Arduino.




**SIM800L GSM MODULE:** The SIM800L is a compact and cost-effective GSM/GPRS module designed for wireless communication in embedded systems. It supports quad-band GSM (850/900/1800/1900 MHz), allowing it to operate globally for making calls, sending SMS, and accessing basic GPRS data services. The module communicates with microcontrollers via UART (serial communication) and supports AT commands for configuration and control. It operates at a voltage of 3.4V to 4.4V (typically 4V) and requires a stable power supply capable of delivering up to 2A peak current during transmission

**RELAY MODULE(5V):**A Relay Module is an electrically operated switch used to control high-voltage devices like fans, lights, or appliances using a low-voltage microcontroller signal. The standard 5V single-channel relay module includes an electromagnetic relay rated for 10A at 250V AC or 10A at 30V DC.

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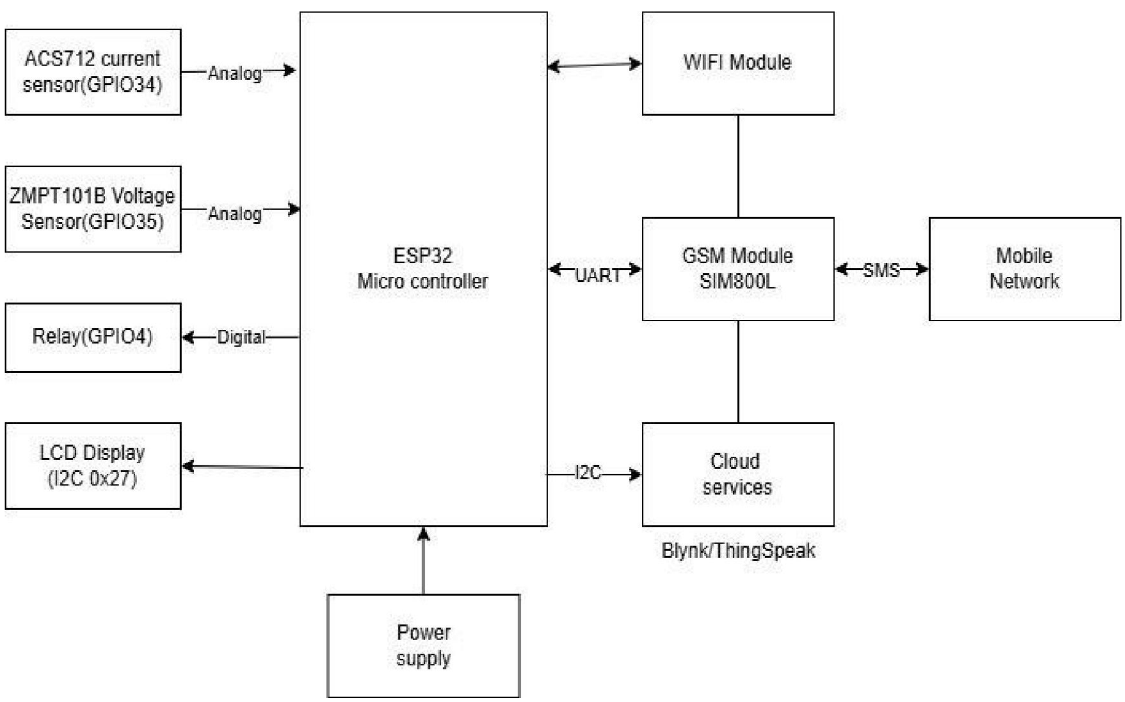
**ARDUINO UNO :**The Arduino UNO is a widely used open-source microcontroller board based on the ATmega328P microcontroller. It operates at a clock speed of 16 MHz and features 2 KB of SRAM, 32 KB of flash memory, and 1 KB of EEPROM. The board provides 14 digital I/O pins (6 of which can be used as PWM outputs) and 6 analog input pins, making it suitable for a variety of sensor and actuator connections. It operates at 5V and can be powered via USB or an external power supply (7–12V recommended)

**BLOCK DIAGRAM**




## IV. WORKING

The working principle of the smart energy meter with theft detection and usage monitoring involves continuously measuring the voltage and current using the ZMPT101B voltage sensor and the ACS712 current sensor. These values are used to calculate real-time power and energy consumption. The system monitors for irregularities such as sudden drops or unexpected changes in power usage that may indicate electricity theft, like bypassing the meter or unauthorized tapping. If such anomalies are detected, the system can automatically disconnect the power supply using a relay module. It also sends alerts via a GSM module to notify the user or utility provider. Additionally, a 16x2 I2C LCD displays real-time data such as voltage, current, power, and energy usage, providing local monitoring and control.

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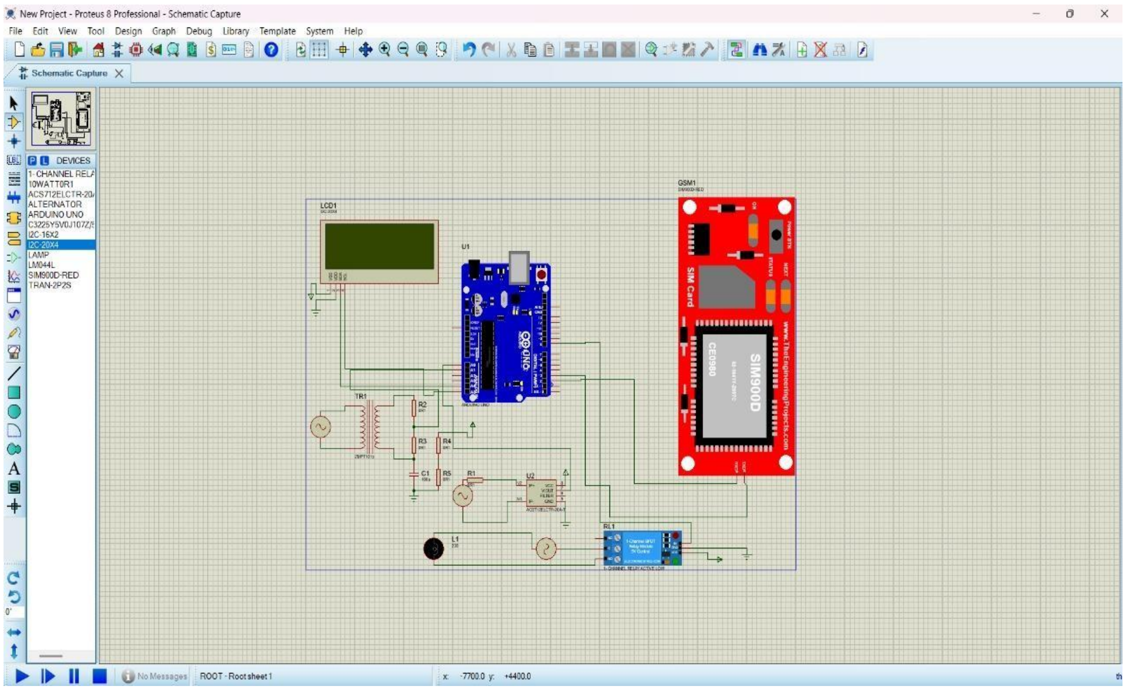
## V. SIMULATION

Tools used: proteus 8

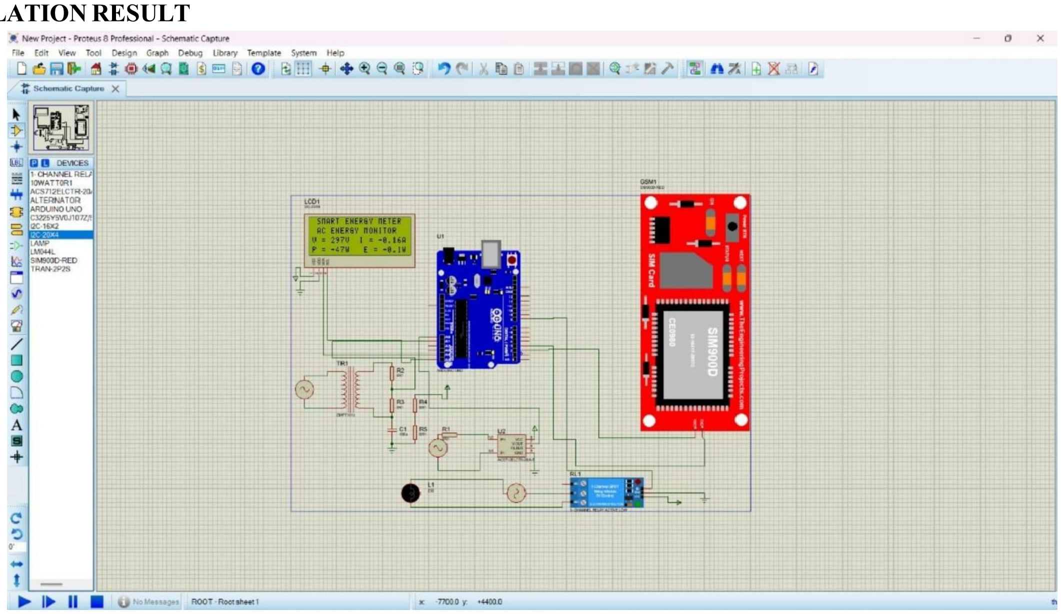
Platform used : Windows XP 32bit

System configuration : core i3 (1.7GHZ)

Result : POSITIVE




**SIMULATION RESULT**



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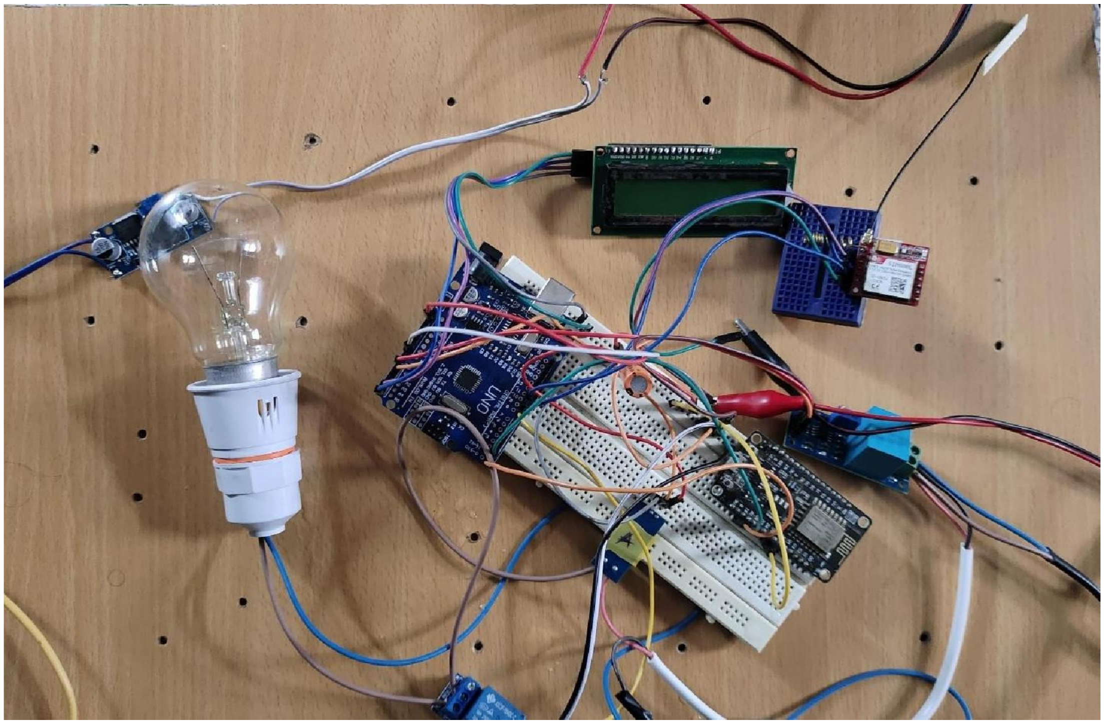
**PROJECT IMPLIMENTAION**



## VI. CONCLUSION

The proposed system effectively demonstrates a smart energy meter capable of real-time monitoring and power theft detection using IoT technologies. It provides a reliable and cost-efficient solution for energy consumption tracking and unauthorized usage detection. The integration of components like ESP32, voltage and current sensors, GSM, and relay modules enables automated operation and remote access via cloud platforms. This system not only improves billing accuracy and transparency but also supports future advancements toward smart grids and energy-efficient infrastructures.

## VII. ACKNOWLEDGMENT

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## REFERENCES

**[1].** Agarwal, R., & Sinha, A. (2019). Wireless Smart Energy Meter with Theft Detection Using IoT. Journal of Engineering Research and Applications, 9(7), 34–39.

**[2].** Shinde, S., & Pawar, V. (2020). Review on Smart Energy Meter for Energy Theft Detection Using IoT. International Research Journal of Engineering and Technology (IRJET), 7(5), 2478–2482.

**[3].** Hassan, R., Mishra, M., & Verma, P. (2021). IoT-Based Smart Grid with Power Theft Detection Using Machine Learning Techniques. International Journal of Advanced Science and Technology, 30(5), 51– 60.

**[4].** Jaiswal, R., & Patil, V. (2020). Smart Energy Meter with Load Control and Theft Detection Using IoT. International Journal of Science and Research (IJSR), 9(6), 925–929.

**[5].** Zhou, K., Fu, C., & Yang, S. (2016). Big Data Driven Smart Energy Management: From Big Data to Big Insights. Renewable and Sustainable Energy Reviews, 56, 215–225.