

SMART ENERGY METER USING TELEGRAM BOT

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Abstract: The Smart Energy Meter is an IoT-based system that tracks and controls electricity use in real time. This project features a Wi-Fi enabled microcontroller (ESP32) to measure electrical parameters like voltage, current, power, and energy consumption. The collected data is sent to the mobile app Blynk, allowing users to check their electricity usage from anywhere. A notification system uses Telegram Bot to inform the user when power consumption goes over a set limit. A relay module is included to automatically cut off the power supply, helping to prevent overload or excessive energy use. This system enables users to manage electricity consumption effectively and cut down on energy waste. The proposed system is low-cost, easy to use, and suitable for homes and small industrial settings. It promotes better energy management through IoT technology.

INTRODUCTION

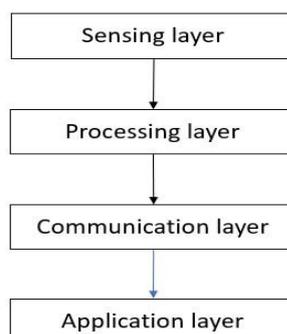
Electricity is one of the major resources used in homes, industries, and commercial centers. As the demand for electrical energy is increasing, it is necessary to monitor and control the electrical power consumed in homes, industries, and commercial centers. The traditional energy meter used to measure the electrical power consumed in homes, industries, and commercial centers can only measure the total electrical power consumed, but it cannot display the real-time electrical power consumed. This leads to electrical power wastage.

In order to overcome the above-mentioned problems, a Smart Energy Meter using Internet of Things (IoT) technology is proposed in this paper. In the proposed system, a Wi-Fi enabled microcontroller (ESP32) is used to measure the electrical parameters such as voltage, current, power, and energy consumed in homes, industries, and commercial centers. The electrical parameters measured by the proposed system are displayed in real-time using a mobile application called Blynk.

In addition, the proposed system has a notification system that sends a notification to the user through Telegram Bot when the power consumption exceeds the set limit. The proposed system has a relay module that automatically disconnects the power supply when there is an overload or excessive use of power. The proposed smart energy meter offers a cost-effective, efficient, and convenient solution for the management of energy consumption.

The proposed smart energy meter system is efficient, cost-effective, and user-friendly, which helps the user understand and manage their energy consumption. This kind of system is highly useful in homes, hostels, and small industries, where controlling and monitoring the consumption of electricity is a must.

LAYERED ARCHITECTURE OF SMART ENERGY METER



1. Sensing Layer

The role of the sensing layer is to sense the electrical parameters from the load or power supply line. This is achieved by a voltage sensor and current sensor module integrated with the electrical system. Voltage Sensor calculates the reading of the line voltage by either a voltage divider sensor or an isolation sensor. Current Sensor senses the value in the form of a current transformer, calculates the load current without making any physical contact with the powers supply wires. These sensors produce analog output reading based on proportion to voltage and current that the load or device consumed.

2. Processing Layer

The processing layer is equipped with a microcontroller, the microcontroller used is ESP32.

Key functions include:

- Analog-to-Digital Convertor (ADC)
- RMS Voltage and Current
- Energy Consumption (kWh)

3. Communication Layer

The communication layer allows transfer of data to remote areas using IoT connectivity. The microcontroller unit adopts Wi-Fi technology transmit processed data to the cloud server. APIs are utilized in the communication layer to ensure efficient and secured data transfer. Data packets carry voltage, current, power, and energy values. This layer makes remote meter reading unnecessary because continuous monitoring is made possible.

4. Cloud and Application Layer

The cloud layer stores and analysis the received energy data.

Key components:

- Cloud database for historical data storage
- Data analytics engine for usage trend analysis
- Visualization dashboard accessible via mobile or web applications

5. Overall System Operation

1. Real-time measurement of electrical properties is done using voltage and current sensors.
2. The microcontroller is able to process raw signals as well as calculate the related energy.
3. The calculated data is then wireless connected to the cloud server.
4. Users are able to access data in real time as well as historical data through the mobile or web interface.
5. Alerts or analytics functionality helps optimize energy usage.

TECHNICAL AND IMPLEMENTATIONS OF SMART ENERGY METER:

The design of the smart energy metering system was conducted using the ESP32 microcontroller with the inclusion of voltage and current sensors for the measurement of electrical parameters. The data was processed using the ESP32 to determine the voltage, current, power, power factor, and energy consumptions. The processed information was transmitted to the Blynk cloud platform using Wi-Fi connectivity. At the same time, a Telegram Bot was developed using the Telegram Bot API with the inclusion of secure authentication using the access token. Customizable commands were developed to receive real-time data, status, and energy consumptions using Telegram. To provide solutions for smart energy meters, the system continually extracts and transmits data to our customers and provides a seamless communication experience for customers who want to have their questions answered instantly and efficiently. By using cloud-based technology, we are able to eliminate any variability in the data acquisition and communication processes associated with smart energy metering, providing the most costeffective and effective solutions. The system employs Telegram as a communication medium between the customers and the system. A Telegram bot has been built into the system, which allows the customer to receive instant messages from the system, thus enhancing customer satisfaction and generating customer loyalty through immediate gratification. It uses Telegram's Bot API to provide instant messaging and an authentication token has been integrated into the ESP32 firmware, which will allow secure data transfer. Predefined commands have been added to the system; this allows the customer to query the real-time values of voltage, current, power, total energy, and system status via the bot. Upon receipt of these commands, the ESP32 will send back the requested information via a Telegram message. The continuous command-driven automation of the system will allow the customer to have real-time access to their system without delay, providing the customer with peace of mind. This design will create a low-cost, scalable, and effective smart energy metering experience.

TELEGRAM BOT CREATION

Telegram is a messaging application and web service offering an open and secure bot application programming interface (API), creating telegram bot using Bot Father appropriate for notification/ monitoring energy consumption information. In the smart energy metering system, a Telegram bot is created for distant access to the energy usage information as well as immediate notification to the user. The bot is developed using the Telegram BotFather service are showed in (fig 1.1 & 1.2) provide by telegram application, that service provides a unique authorization token for a secure communication link between the ESP32 controller board and Telegram application/webpage. The authorization token is integrated into the ESP32 by the embedded c program to provide a communication between the ESP32 board and the Telegram Bot API in the HTTPS request. Finally, the bot enables the user to control the smart energy meter by utilizing the predefined commands.



Fig1.1 Features of bot

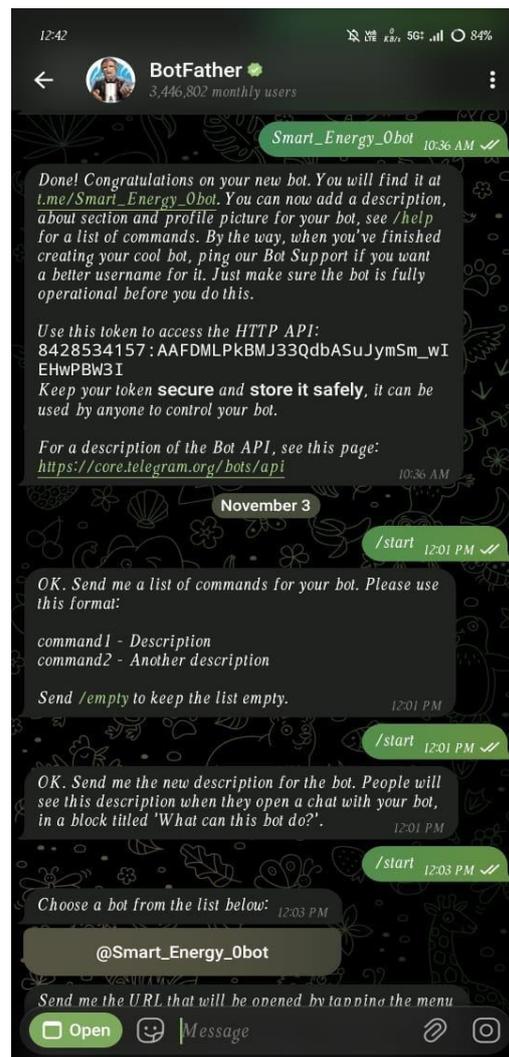


Fig1.2 User name for bot

Inclusion of Telegram services upgrades the usability of the system as it enables instant notification services, alerts for irregular consumption, as well as monitoring services at the customer's request. The use of Telegram services as an interface is much cheaper compared to traditional monitoring services.



The increasing demand for electrical energy has created a need for efficient and intelligent energy monitoring systems. Conventional energy meters lack real-time monitoring and remote accessibility. This project presents an IoT-based smart energy meter using an ESP32 microcontroller integrated with voltage and current sensors to measure electrical parameters such as voltage, current, power, and energy consumption. The measured data are transmitted wirelessly via Wi-Fi and visualized using the Blynk IoT platform for real-time monitoring. Additionally, a Telegram bot is integrated to provide instant notifications and command-based access to energy usage information. The proposed system is low-cost, reliable, and user-friendly, making it suitable for residential and small commercial applications while promoting efficient energy utilization.

TELEGRAM INTEGRATION

The flowchart below shows the sequence of operations of the Telegram bot integrated with the smart energy meter system. The process starts with installing the Telegram application on the smartphone of the user. Following this, the user looks for and opens the BotFather service to create a new Telegram bot and then name it uniquely. If creation is successful, BotFather issues an authentication token.

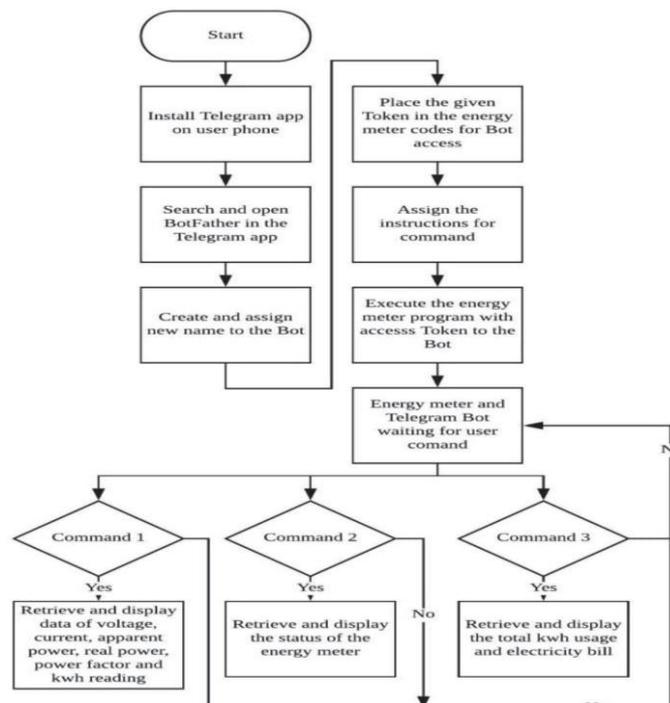


Fig. 2 Flowchart of the program code

This token is integrated with the ESP32-based energy meter firmware in order to have secure communication between the energy meter and the Telegram Bot API. Then, after setting up the token, predefined instructions and commands are set up for the bot. After that, the program of the energy meter starts running with enabling access to the bot. The smart energy meter and the Telegram bot keep the system in running mode and waits for the commands through the user. Once the command is received, the system verifies the command type. In case of Command 1, it retrieves the electrical parameters like voltage, current, apparent power, real power, power factor, and energy consumption in kWh. If Command 2 is received, then the operation status of energy meter is returned. In case of selection of Command 3, system calculates and shows the total energy consumption along with the estimated electricity bill. It goes back, after the execution of the requested operation is performed by the system in a continuous real-time interaction and monitoring.

HARDWARE IMPLEMENTATION:

All the hardware components and specification, process are explained below and represented in the fig 3.

CURRENT SENSOR (CT):

The conductor carrying the load current is passed through the opening of the CT, where the magnetic field produced by the current induces a proportional secondary current in the transformer winding. In this sensor, the rated specification of 100A/50mA indicates that when a primary current of 100 A flows through the conductor, a secondary current of 50 mA is generated at the output. This low-level current signal is then supplied to an energy metering module, such as the PZEM004T, where it is converted into usable electrical parameters like current, power, and energy consumption.

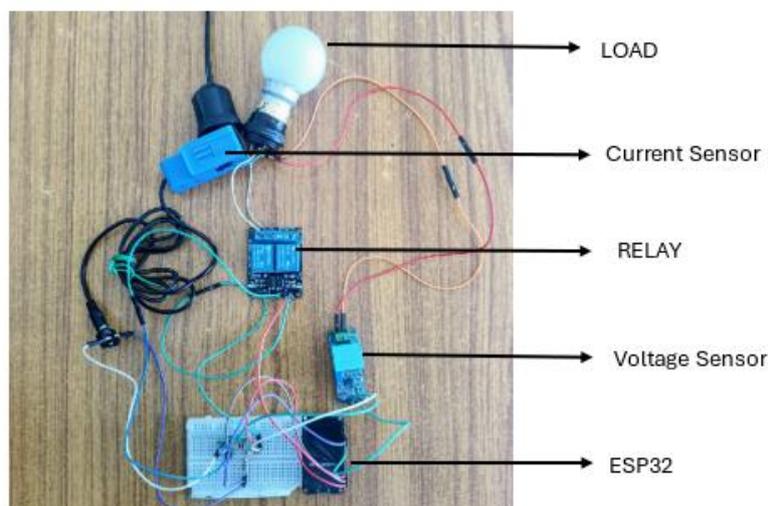


Fig. 3 components

VOLTAGE SENSOR:

The ZMPT101B AC Voltage Sensor is a module that can be used to safely detect high-voltage AC mains by a microcontroller. It uses a precision transformer to detect the voltage, thereby offering a safe interface from high voltages to low voltages, thereby safeguarding your circuit from dangerous spikes. It steps down high voltages to a lower-level signal so that you can adjust this signal using a built-in potentiometer to suit the requirements of a circuit like Arduino to detect real-time voltages.

ESP32 Developer Board:

The ESP32 is an advanced microcontroller with a dual-core processor and in-built Wi-Fi and Bluetooth connectivity. This makes it ideal for real-time data acquisition and wireless communication. The ESP32 receives electric parameter data of voltage, current, power, and energy from the energy metering sensor module. It processes this parameter data and formats it for display and transmission. The ESP32 uses its in-built Wi-Fi connectivity feature and transmits processed energy consumption data from the microcontroller to a cloud-based online monitoring system known as Blynk.

RELAY MODULE:

A relay module is an electrically operated switch for turning electrical devices and circuits on and off. The module uses a low-voltage control signal from microcontrollers like Arduino Uno and ESP32 to control high-voltage and high-current devices. The relay module comprises a relay, driver circuit, and protection diode. Once the control signal is applied to the

module, the relay turns ON/OFF the devices. The relay module is used in smart home devices, smart energy meters, and other IoT devices.

LOAD:

Load is anyone of electrical device or equipment that consumes electrical energy for the power supply, such as tungsten lamp (for demo), in industrial level like blowers, fans, coolers, pumps etc.

RESULTS

The Smart Energy Meter project was successfully tested and implemented. As expected, it successfully read real-time voltage, current, and cost. The data was successfully sent to a Telegram bot, which always responded immediately to the required user query /voltage, /current, /cost, /all, /status, etc. Throughout the execution, the readings remained stable and showed successful connectivity with the internet. In summary, the project worked well, providing accuracy in data reading and efficient connectivity for smart energy management purposes. The pictorial represent of notification is attached in fig 4.



Fig.4 Telegram notification

The developed smart energy meter functioned perfectly for the real-time observation of electric measurements such as voltage, current, power, power factor, and energy consumption. The ESP32 chip enabled the transmission of the readings to the Blynk IoT cloud at a scheduled interval, reflecting the readings on the mobile application with satisfactory precision. There was immediate response from the Telegram bot to any commands, reflecting real-time readings of energy, the status of the energy meter, as well as the total consumption of energy measured in kWh. Hence the over all figure representation in fig 5.

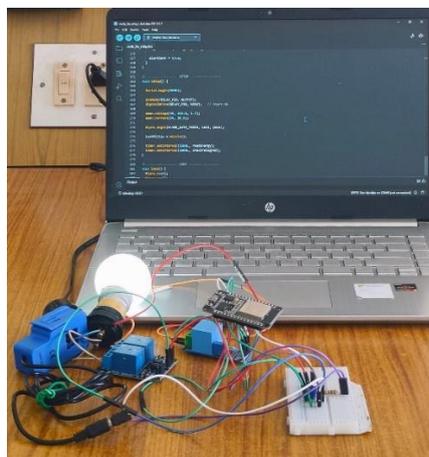


Fig.5 Overall setup

CONCLUSION

Smart Energy Meter project offers a solution for the control and monitoring of electrical energy usage through the application of IoT technology. In the proposed system, electrical parameters such as voltage, current, power, and total electrical energy consumed by the device are measured and transmitted through a Wi-Fi enabled microcontroller. These values are displayed in real time through the application of the Blynk app, making it easier for users to monitor the electrical energy consumed by the device.

In the proposed system, a notification feature has also been added, which sends a notification through the application of the Telegram bot if the electrical energy consumed by the device exceeds the predetermined limit. In addition, a relay module has also been added, which disconnects the power supply if the electrical energy consumed by the device exceeds the predetermined limit, helping prevent wastage of electrical energy and damage to the electrical device.

Overall, the developed system is cost-effective, reliable, and simple to implement. It can provide an efficient way to monitor energy usage in real-time, access energy usage remotely, and control power automatically. The proposed smart energy meter can be implemented in homes, hostels, and small industries to enhance energy usage and encourage the efficient usage of electricity.

REFERANCES

- [1]. Ajinkya Valanjoo, Priyesh Chiplunkar, Sheryl Bellary, Sheetal Dixit, Soham Jadiye, Sarthak Bansod (2024), AI-Based Smart Home Energy Meter, International Research Journal of Engineering and Technology (IRJET), (Volume: 11 Issue: 04).
- [2]. Md. Masudur Rahman; Noor-E-Jannat; Mohd. Ohidul Islam; Md. SerazusSalakin, Arduino® and GSM Based Smart Energy Meter for Advanced Metering and Billing System, Pabna University of Science & Technology, 2nd Int'l Conf. on Electrical Engineering and Information & Communication Technology (ICEEICT) 2015.
- [3]. Chongjin Xie, Fiber Nonlinearities in Coherent Optial Communication Systems, 10th International Conference on Optical Communications and Networks (ICOCN 2011).
- [4]. Patel H. K., D. Shah, M. Sheth, S. Trivedi, S.Bakliwal, I. Shah, R. Shrotriya, "Microcontroller and GSM
- [5]. Based Digital Prepaid Energy Meter", International Journal of Electronics, Computer and Communications Technologies (IJECCCT), Vol. 4, Issue 1, pp 32-37, Oct.2013,ISSN(P): 21803536,ISSN(O):2180-3706, Malaysia.
- [6]. Shreyash Gawande, R. M. Gharat (2023), Smart Energy Meter using IoT, International Journal of A dvanced Research in Science, Communication and Technology (IJARSCT), DOI: 10.48175/IJARSCT13502.
- [7]. Noor Nateq Alfaisaly, Suhad Qasim Naeem, Eman K. Jassim, Adnan Ali Abdullah, Study on Smart
- [8]. Designed Power Monitoring System Using IoT Devices, International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 23218169 Volume: 11 Issue: 10, October 2023.
- [9]. M Senthamil Selvan, Dr R Ramesh, H Ragadeepa, T
- [10]. Sivabalan, Iot enabled Smart Energy meter for energy management, 2023 International Conference in Advances in Power, Signal, and Information Technology.
- [11]. Kasireddy, Idamakanti, and Kasi Ramakrishnareddy Ch." An efficient selective harmonic based full bridge DC-DC converter for LED lighting applications." 2019 National Power Electronics Conference (NPEC). IEEE, 2019.