IOT BASED SMART ENERGY METER USING CLOUD

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ABSTRACT

The IoT-Based Smart Energy Meter Using Cloud project aims to develop an advanced energy meter system that facilitates real-time monitoring and control of energy consumption. The system integrates an ESP32 microcontroller, which manages energy readings and ensures seamless communication with cloud-based platforms. By leveraging IoT technology, the energy meter sends real-time usage data and tamper alerts to the cloud, enabling authorities to monitor energy consumption and detect unauthorized access to the meter cabinet.

The system includes an energy meter for continuous usage monitoring, a keypad for users to enter the desired recharge amount, an LCD for displaying current readings and entered amounts, a relay to disconnect power in case of nonpayment, and a tamper switch to detect illegal tampering. When energy consumption exceeds predefined thresholds, alerts are sent to the relevant authorities via the IoT platform. The microcontroller is programmed with an intelligent algorithm using Embedded C to ensure accurate readings and efficient energy management.

This smart energy meter system enhances transparency, reduces manual intervention, and provides tamper-proof operation, offering a robust and efficient solution for modern energy management.

1. INTRODUCTION

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1.1Introduction:

Monitoring and keeping tracking of your electricity consumption for verification is a tedious task today since you need to go to meter reading room and take down readings. Well, it is important to know if you are charged accordingly so the need is quite certain. Well, we automate the system by allowing users to monitor energy meter readings over the internet. Our proposed system uses energy meter with microcontroller system to monitor energy usage using a meter.

The meter is used to monitor units consumed and transmit the units as well as cost charged over the internet using wifi connection. This allows user to easily check the energy usage along with the cost charged online using a simple web application. Thus, the energy meter monitoring system allows user to effectively monitor electricity meter readings and check the billing online with ease. An embedded system is a combination of software and hardware to perform a dedicated task. Some of the main devices used in embedded products are Microprocessors and Microcontrollers. Microprocessors are commonly referred to as general purpose processors as they simply accept the inputs, process it and give the output. In contrast, a microcontroller not only accepts the data as inputs but also manipulates it, interfaces the data with various devices, controls the data and thus finally gives the result. The "IOT ENERGY METER MONITORING" using Arduino microcontroller is an exclusive project which is used to designing a completely automated for physically disabled persons.

The trend of the time has always been in favor of technology which has finally become cost effective as wel revenue collection did not yield satisfactory results. It is reported that the faultiest sub system in the metering and meter reading system. Traditional meter reading is done by the human operator, this require a more number of labor operator and long working hour to achieve the complete area data reading and billing. Due to increase in the development of residential building and commercial building the meter reading task increases which require more number of human operators. In order to achieve efficient meter reading, reduce billing error and operation cost, automatic meter reading system play an important role. In postpaid system, there is no control use of electricity from the consumer's side. There is a lot of wastage of power in the consumer's side due to lack of planning of electrical consumption in an efficient way.

The idea of designing the Prepaid Power Billing using "Energy Meter" is due to the basis that it would indirectly help to create a better understanding and awareness towards the value and the importance of electrical energy, energy saving, promoting of smart energy management as well as an innovation towards further improvement to proven existing system. The Adaptive meter is not only limited to automate the meter reading but also attributed with prepaid recharging ability and information of consumed data can be exchange between the grid and consumer. It was also due to the fact that in time to come, the cost of electrical energy generation continuously increase and the energy consumption may exceed its productions or generations. By realizing such idea, end users are provided with the proposed system to assist them in carefully planning and managing their electrical consumption. This is also helpful in saving the time of both electricity authority and consumer.

Consumers who use the IoT-based prepaid energy meter will monitor their real-time energy usage in the web database, as well as manage their whole device from the web database. To make it easier, the number of units required can also be charged in that database. As a result, the user can see how many units have been consumed and how many units remain. Once the given units have been consumed by the customer, the supply will be shut off and the consumer will receive a warning note indicating that all of the paid units have been consumed. In the event of non-payment or any other problem, the supplier retains complete leverage over the customer and can shut off the supply at any time. If the market for energy-efficient systems grows, effective control of device power and use becomes more critical, and it's a challenge that more engineers will have to solve. One approach is to use an analogue to digital converter (ADC) for both current and voltage, then multiply the result in a processor to get power. However, since both the current and the voltage will differ independently of one another, the communications delay and overhead in obtaining the current and voltage information causes time alignment errors in the power calculation.In developing countries, the idea of prepaid entering scheme is introduced [1]. This concept is based on Pay first use later one. From the consumers point of perception, the idea is attractive because there is no Fear of disconnection and reconnection for some reason.The amount remaining in themeter gradually decreases.

In the present billing system, the EB are unable to keep track of the demand of consumers. The consumer is facing problems like receiving due bills for bills that have already been paid as well as poor reliability of electricity supply and quality even if bills are paid regularly. The solutions for all these problems is to keep track of the consumers for accurate billing, monitoring, controlling and theft detection. These are all the features to be taken into account for designing an efficient energy billing system. This paper Implementation of IOT based electricity controlled prepaid energy monitoring billpayment system addresses the problems faced by both the consumers and the Electricity Board. It mainly deals with energy meter, which utilizes the features of embedded systems i.e. combination of hardware and software in order to implement desired functionality. The paper discusses comparison of Arduino and other controllers, and the application of GSM and Wi-Fi modems to introduceSmart concept.

With the use of GSM modem the consumer as well as service provider will get the used energy reading with the respective amount, Consumers will even get notification in the form text through GSM when they are about to reach their threshold value, that they have set. Also, with the help of Wi-Fi modem the consumer can monitor his consumed reading and can set the threshold value through webpage. This system enables the electricity department to read the meter readings monthly without a person visiting each house. This can be achieved by the use of Arduino unit that continuously monitor and records the energy meter reading in its permanent (non- volatile) memory location. This system continuously records the reading and the live meter reading can be displayed on Android Application to the consumer on request. This system also can be used to connect and disconnect the power supply of the house when needed.

3. LITERATURE SURVEY

Birendra kumar Sahani.al [1] are made a practical model of IoT Based Smart Energy Meter. The proposed model is used to calculate the energy consumption of the household, and even make the energy unit reading to be handy. It reduces the wastage of energy and bring awareness among all.

Mayur Rawte.al [2] are developed a system to solve many problems such as over usage of electricity, large amount of manpower transparency of usage and wastage of money and resources etc. This technology allows verified customers to check status of electricity usage by using Device identification number and password in real time. This can be done from web application using Internet.

Nazmat Toyin.al [3] are designed the system to resort to a local server and database, upon resumption of internet connection, all information is synchronized with the web server. The billing is handled locally by the web server and has not been interfaced with any online payment platform agencies.

Mst. Shahnaj Parvin.al [4] are explained the framework and how it will be beneficial in detecting an unauthorized use of electricity. The relative advantages of the proposed system over conventional systems have also been outlined in the paper.

Azfar Tufail.al [5] provide some enhancement in the conventional Metering system by smart metering. The term Smart Meter is an advanced energy meter that measures consumption of electrical energy providing additional information compared to a conventional energy meter.

Omijeh.al [6], introduced a tamper detect feature for a GSM solution for prepaid energy meter, however this work didn't provide an interactive interface for real-monitoring, access control as well as a robust database.

Mahfuzet al (2020) proposed the power monitoring of the consumed energy is one of the main concepts. Once the power is monitored it is sent to the consumer through SMS and a feedback control is taken from the SMS to the microcontroller for the relay control. Mishra, J. K et al (2018) presented old meter is made as new smart meter that has an Electronic Meter Automation

Device that sends the output data to the webpage and smart app for the real-time monitor of the power consumed. And the feedback control is connected in between webpage and microcontroller for the control of Electronic Meter.Ali Zaidi et al (2008) [7], presented in his work the proposed system consists of the digital billing and power consumption on lcd display. Gautam A. Raiker et al presented the paper the load is monitored in the web database through the IOT. And the energy management in a demand side is clearly mentioned what are the necessary things needs to be followed. On switching of the on load or off load is made simple.

In 2010, using multi-appliance power disaggregation technology implementers implemented the linear detection algorithm to determine which appliances are active in their power contributions. Problems are robust to errors in this database. [8] In 2011, using cloud computing technology found the solution for efficiency calculation of individual equipment. [9] In 2012, using three feedback system, monitored the energy in residential Real-Time. It is critical to the continuing engagement and use of the device to save energy. Residences to determine the feedback provided by real-time energy monitors results in lower residential consumption rates during the 30 days after installation. [10] In 2013, using GREEN technology is the smallest Zigbee-compatible node in existence. This technology will possible in every place sensing of a different data types, from energy metering to environmental monitoring. [11] 1n 2014, GSM technology implemented automatic power will be reading. [12] In 2016.

Using wifi technology application can develop for Apple and BlackBerry 10 OS, thus providing multiple platform users support [13] In 2017, using IOT technology An IoT device was created for measuring the voltage, current, power and energy of a three-phase four-line power line in a laboratory building [14] Through a brief review of the published literature and previously done work, we can say that the researches have done a severe work on the plc power line communication and Internet of Things (IoT). It is concluded from the ken study of their work that in today`s world PLC & IoT based meter could improve the overall efficiency of the existing or present system and could help in examining the unnecessary losses of power in different areas. Recent advancements in smart energy metering have leveraged cutting-edge technologies to enhance efficiency, security, and sustainability in power management.

John D. et al. [15] developed a cloud-based smart metering system integrating AI to predict energy consumption patterns, allowing users to optimize their power usage. Ravi Kumar et al. [16] implemented blockchain-based smart meters to ensure secure and tamper-proof energy data, improving billing transparency and reducing power theft. Chen Wei et al. [17] proposed a hybrid energy metering system combining IoT and Machine Learning to detect anomalies in electricity consumption, improving fault detection and power monitoring accuracy.

Ahmed Hassan et al. [18] introduced a real-time power quality monitoring system using IoT sensors and edge computing to alert consumers about voltage fluctuations and prevent electrical hazards. Patel K. et al. [19] designed a demand-side energy management system that integrates with smart grids to balance power distribution during peak hours. Singh R. et al. [20] proposed a prepaid smart metering system where users can recharge electricity credits via a mobile app, reducing billing disputes and improving resource management. Alok Sharma et al. [21] developed an AI-powered predictive maintenance system for smart meters, enabling early fault detection and preventive maintenance. Rajesh Kumar et al. [22] designed an IoT-based home automation system that integrates smart meters with household appliances, automating power usage based on real-time consumption data. Mehta P. et al. [23] introduced a solar-powered IoT smart meter for remote areas, promoting sustainable energy use and reducing reliance on fossil fuels. Liu Chang et al. [24] implemented an AI-driven load forecasting model using IoT smart meters to predict future power demand, aiding utility companies in optimizing energy distribution. These advancements highlight the growing role of AI, IoT, blockchain, and renewable energy in transforming traditional energy metering systems into more efficient, transparent, and sustainable solutions.

4. PROPOSED SYSTEM

The proposed system enhances the existing energy monitoring framework by integrating additional functionalities such as a keypad and an auto/web mode for improved user interaction and remote accessibility. The Arduino-based system remains at the core, processing real-time energy consumption data received from the energy meter while displaying it on an LCD screen. A regulated power supply ensures stable performance, while an IoT module enables remote monitoring and control of the energy usage. The inclusion of a keypad allows users to manually input commands, while the auto/web mode provides the flexibility of automated energy management through a web interface. Additionally, a buzzer is incorporated to alert users about critical power consumption levels or system errors. The system also controls electrical loads efficiently based on predefined conditions, enhancing automation and energy optimization. By integrating these advanced features, the proposed model improves user convenience, real-time monitoring, and efficient energy management while paving the way for smarter electricity usage.The proposed system aims to develop a smart IoT-based LED notice board using the ESP32 microcontroller, enabling real-time wireless communication for displaying messages remotely. This system integrates Wi-Fi connectivity, allowing users to update notices via an IoT app, eliminating the need for physical intervention. Additionally, environmental parameters such as temperature and humidity are monitored using dedicated sensors, and real-time clock (RTC) functionality ensures accurate time-based scheduling of messages. This approach enhances efficiency, accessibility, and automation in information dissemination, making it ideal for educational institutions, offices.

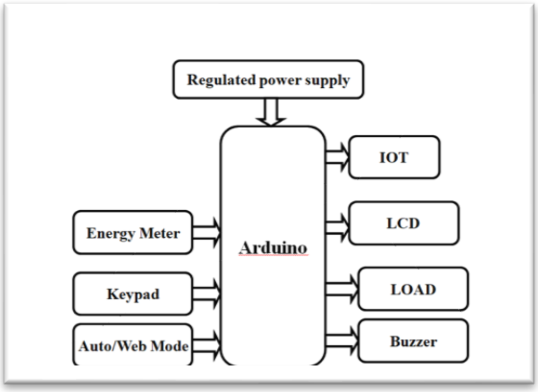

Fig 1:Block Diagram

The block diagram represents the architecture of the proposed system, illustrating how different components interact with the ESP32 controller. The power supply unit (RPS) provides stable voltage to the system. The ESP32 serves as the core processing unit, receiving input from an IoT application via Wi-Fi for remote message updates. Environmental data is collected through temperature and humidity sensors, while RTC ensures time-based operations. The processed information is displayed on an LED notice board, providing real-time updates. This structure design enhances the functionality, automation, and accessibility of the notice board system.

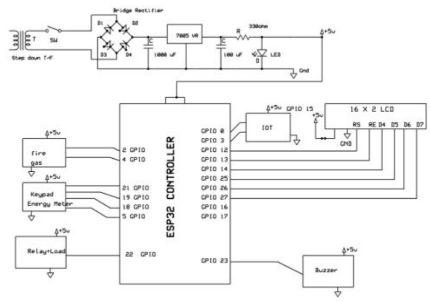

Fig2: Schematic Diagram

The circuit diagram represents an IoT-based LED notice board system using the ESP32 microcontroller. The system is powered by a step-down transformer, which converts AC voltage to a lower DC voltage, regulated by a 7805 voltage regulator to provide a stable 5V supply. A bridge rectifier (D1-D4) and capacitor filters are used to smoothen the DC output. The ESP32 microcontroller acts as the central processing unit, interfacing with different components to control and display information on the LED boards.

Pin Configuration:

- **Power Supply (RPS):** Converts AC voltage to regulated 5V DC.
- **DHT11 (Temperature Sensor):** Connected to GPIO 2 and GPIO 4 for temperature data.
- **IoT Module:** Connected to GPIO 16 and GPIO 17 for internet-based communication.
- **LED Board 1:** Connected to GPIO 26 for displaying messages.
- **LED Board 2:** Connected to GPIO 27, receiving data from LED Board 1 for extended display.
- **ESP32 GPIOs:** GPIO 0, GPIO 3, GPIO 12, GPIO 13, GPIO 14, GPIO 25

5. RESULTS

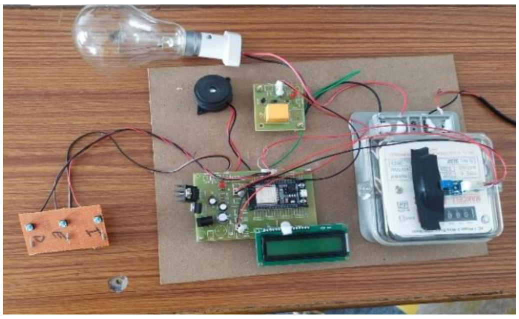

Fig 4.1 Experimental Setup

Fig 4.2 Project Name in LCD Display

Fig 4.3 Output Result 1

- After 5seconds delay it shows us Units(U), Amount(A) and SetUnits(S) columns in LCD Display to preset the number of units.

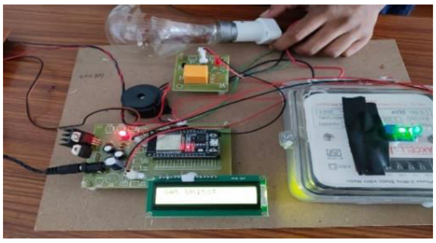

Fig 4.4 Output Result 2

- When we press the Enter Button in keyboard , It asks the user to SetUnits.

- When we SetUnits for example: S:5**,** Then the relay load will be ONand The units and amount are counted and displayed in the LCD Display.

Fig 4.5 Output Result 3

- The user sets set_units = 5 but consumes more than 5 units.
- The LCD should display updated Units and Amount.
- The buzzer should beep when units == set_units - 1.
- When units >set_units, the relay will turn OFF to cut power supply.
- The system should still try sending data to the server.

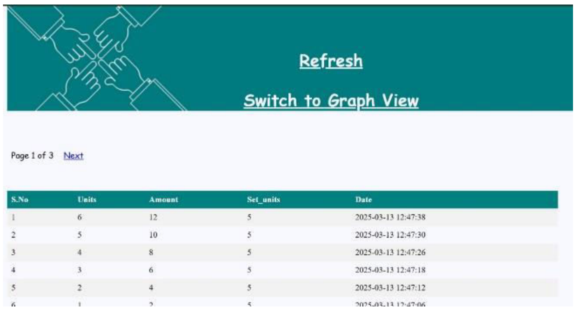

Fig 4.6 Web server Result

- The Data is updated and stored in the web server

6. CONCLUSION

This project is a microcontroller-based automation system using the ESP32 controller to integrate multiple sensors and output devices for monitoring and control applications. The system receives power through a regulated 5V supply derived from a step-down transformer and a bridge rectifier circuit, ensuring stable operation. Various sensors, including fire and gas detection modules, are interfaced with the ESP32 to provide real-time environmental monitoring. A keypad and energy meter are included for user interaction and power measurement, enhancing system functionality. Output components such as a relay module control external loads, while a buzzer provides alert notifications for critical events. A 16x2 LCD display ensures real-time data visualization, and an IoT module allows remote monitoring and control. The system effectively combines hardware and software to create a versatile, efficient, and scalable automation solution, suitable for applications in safety monitoring, energy management, and smart home automation.

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