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Real-Time Energy Consumption Monitoring and Load Management Using IoT Technologies

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ABSTRACT

An energy meter monitoring and switching system is the project's goal. The suggested system interfaces Microcontroller, IOT modem, Relay, LCD, tamper switch, and energy meter. The microcontroller communicates energy readings to authorities via IOT server and LCD shows readings. The microcontroller runs an intelligent Embedded 'C' software. In the project, the IOT modem communicates between the house system and the electricity department, the energy meter continuously records usage, the LCD displays the current meter reading, and the relay disconnects power if the bill isn't paid. Today's excessive energy use has many downsides. Overuse of energy raises electricity bills, lowering household budgets and savings. The revolutionary IOT Remote Control and Monitoring System saves energy and improves user convenience. It remotely controls and monitors home appliances and devices using smart technology. Homeowners may remotely manage appliances, set energy-saving programs, and receive use warnings with energy meters and devices. Integration of energy meters raises awareness, encourages efficient consumption, and saves money.

Keywords: Set Energy, Consumption Motor, Auto Load Control IOT, LCD.

1. INTRODUCTION

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 Wi-Fi 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 ESP32 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 that technology which finally become cost effective as well as an elegant one. Indian power sector is facing serious problem of lean revenue collection as against energy supplied due to energy thefts and network losses. All the steps taken so far, regarding the improvement of the 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 requires amore 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 a greater 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 the meter 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 are 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 bill payment 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 ESP32 and other controllers, and the application of GSM and Wi-Fi modems to introduce

Smart 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 ESP32 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.

2. LITERATURE SURVEY

Birendrakumar 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 Wi-Fi 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.

3. EXISTING SYSTEM

- The existing system i.e. home automation refers to the use of smart technology and devices to control and manage various aspects of a home automatically or remotely.
- Through a centralized control system or mobile app, homeowners can monitor and control these devices, creating a more convenient and comfortable.
- A complete home automation can be achieved through the use of smart devices, sensors, and interconnected systems.

Drawback:

- It's hard to check energy usage daily without energy data.
- Without an energy meter, you won't have real-time information about how much electricity your device is consuming.
- This lack of awareness makes it difficult to track and manage energy usage effectively.

4. PROPOSED SYSTEM

In the proposed method, the consumer can manage their energy consumption by knowing their energy usage time to time. This method not only provides two-way communications between utility and consumer but also provides other functions that are if the consumer fails to pay the electricity bill the energy supply would be cut down from the utility side and once the bill is paid the energy supply is reconnected. Another huge advantage of this system is that it notifies the consumer & utility at the event of the meter tampering. By this information the consumer & utility can control the tampering are reduce energy crises. Another huge advantage of this system is that it notifies the consumer & utility at the event of the meter tampering. By this information the consumer & utility can control the tampering are reduce energy crises. Another huge advantage of this system is that it notifies the consumer & utility at the event of the meter tampering. By this information the consumer & utility can control the tampering are reduce energy crises

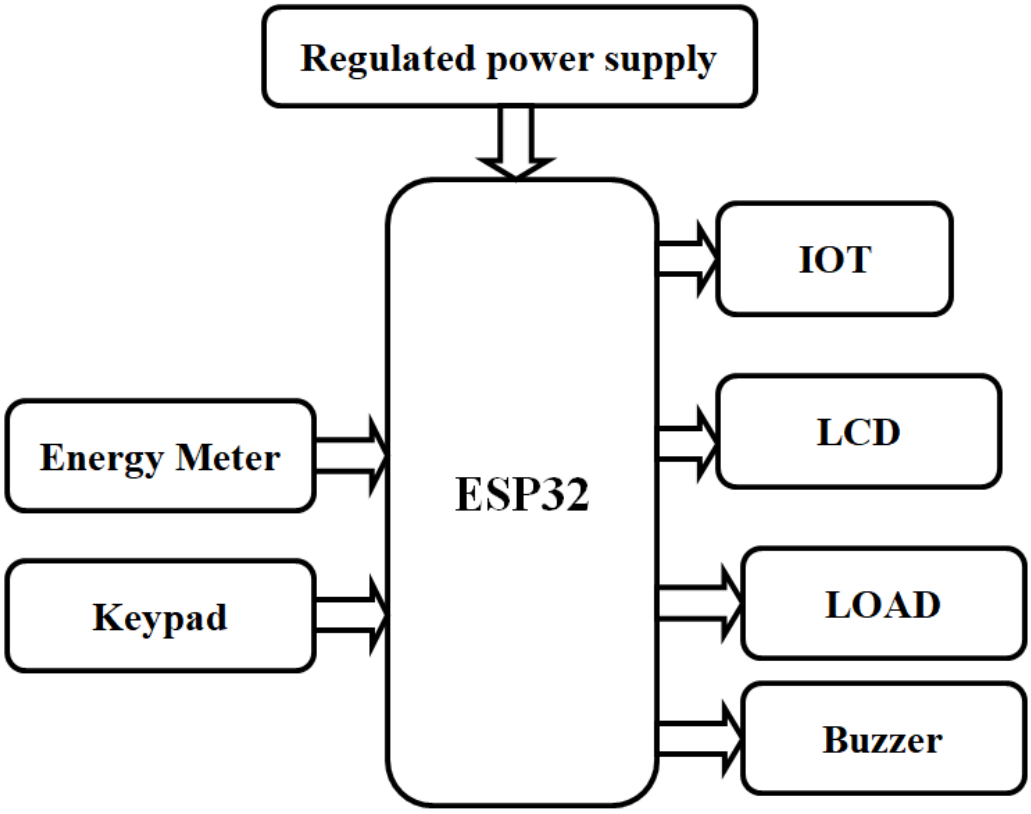

Figure.1: Block Diagram

When the various appliances of the household consume energy the energy meter reads the reading continuously and this consumed load can be seen on meter. We can see that the LED on meter continuously• blinks which counts the meter reading. Based on the blinking, the units are counted. Normally,• 3200 blinks is one unit. In our project we are trying to develop, a system• in which ESP32 Uno act as main controller, which continuously monitor energy meter. As per the blinking of LED on energy meter the• ESP32 will measure the unit consumption. The measured reading with the calculation of• the cost will be continuously displayed on web page that we have designed. Threshold value can be set on webpage with the• help of Wi-Fi, as per the consumer's requirement. When the consumers reading will be near about to the set threshold value it will send a notification value to the consumer. This threshold value notification will increase• the awareness amongst the consumer about the energy. When the consumer gets the notification, he can• visit the webpage and change the threshold value. If the consumer is not aware with the threshold• notification, then the meter will automatically get off. Then the consumer has to visit the webpage again and increment the threshold value. By the incrementation, the meter will automatically get ON. Finally, the overall monthly bill with cost will be• sent to customer as well as service provider in the form of text at first day of every month.

WORKING

The smart meter will monitor by using ESP32 microcontroller that is ATMEGA328. It maintains 8bit data size, operating range will be 3.3v to 5v. Wi-Fi module (ESP8266) works under six AT commands. Interfacing the Wi-Fi module, liquid crystal display, buzzer, and meter pulse by using C language on ESP32 ID1.6.9. LCD is 2line 16 characters, here providing 5v to activate and then it displays the IP address which needs to connect the Wi-Fi module to send the data to processor. The crystal oscillator is used to convert the digital current signals to alternate current signal which requires maintaining the entire module of energy monitoring system. Load takes 5v power from the power transformer. Energy meter will read the pulse to calculate the amount of consumed power. Here meter pulse will be counted for calculating how much power is consumed by the consumer. One example to calculate the amount for consumed power.

This is the pin diagram where all the hardware components are been connected components. this ESP32 microcontroller having 28 pins. In which 14 GPIO pins as digital pins and 6 GPIO pins. 16MHz crystal oscillator connected internally. The step-down transformer, Bridge rectifier capacitor with 1000f Resisters and led are connected in Regulated power supply which provide the 5v to the ESP32 and all input/output modules.

Logic Explanation:

1. Declaration Section:

- include the necessary libraries for Liquid Crystal, stdio.h, and Software Serial.
- set up the necessary pins for various components such as the motor, relay, and meters.

2. Setup Section:

- set up the Serial communication.
- set the pinMode for the components.
- initialize the LiquidCrystal display with a welcome message.

3. Loop Section (Main Logic):

- When the mtr pin goes LOW, it indicates energy usage. The code increments units and calculates the amount based on the energy usage.
- It displays the current units and amount on the LCD.
- It periodically reads the server control command (1 or 2) from the external server using the readserver() function.
- If the command is 1, it turns on the relay.
- If the command is 2, it turns off the relay.
- It counts and displays a loop counter and periodically sends usage data to the server.

4. Server Functions:

- Upload() function sends energy consumption data to the server using an HTTP GET request.
- Readserver() function reads server control commands (1 or 2) and returns the command.

5. Wi-Fi Initialization Function:

- The wifiinit() function attempts to connect to a Wi-Fi network using provided credentials. It sends AT commands to set up the Wi-Fi mode, join the network, and establish a connection.

6. Analog-to-Digital Conversions:

- Converts() and convertl() functions convert and display integers on the Serial and Liquid Crystal displays, respectively.

5. RESULTS

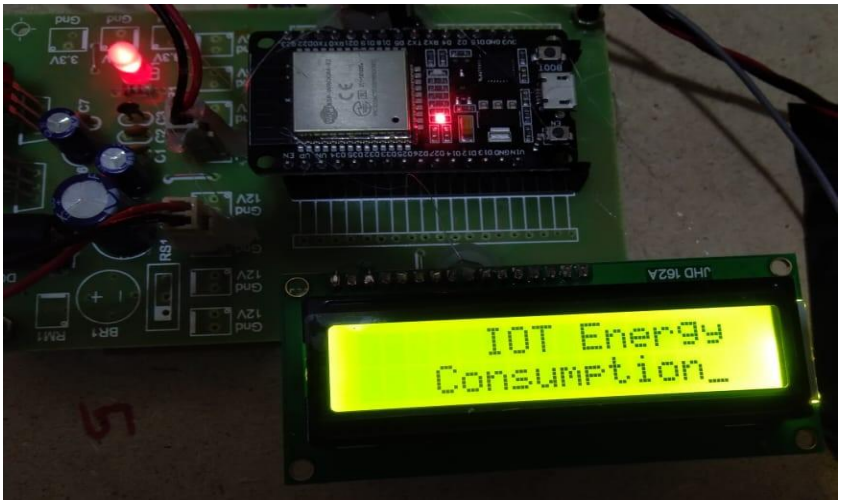

Figure 2. lcd display of energy consumption meter

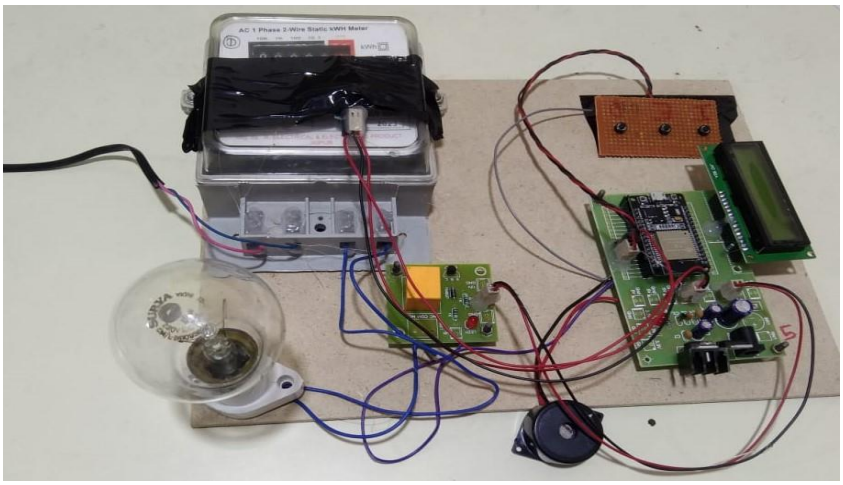

Figure 3. IOT based energy consumption meter

6. CONCLUSION

The project designed and implemented IOT smart prepaid energy meter using Arduino, esp8266 IOT module, LCD, Buzzer, Relay and Load. The proposed IOT based energy meter is easy to install and beneficial for both energy Provider and Customer. This reduces revenue cost and reduces the human errors and problems like over running of the meter etc. This leads to reduction of outstanding dues. This device improves usage level and energy monitoring. The proposed system continuously monitors the meter reading and shut down the power supply remotely whenever the recharged units become zero. It avoids the human intervention, provides efficient meter reading, avoid the billing error and reduce the maintenance cost. Here energy

consumption is calculated by counting calibration pulses from energy meter. In this system, electricity controlled prepaid energy monitoring bill payment system electricity controlled prepaid energy monitoring bill payment system is designed to continuously monitor the meter reading to be handy and transfer the data to a central server which can be accessed from anywhere on the remote place at any time by android app. Disconnection of electric service from remote place is done through our designed android application.

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