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IoT Based Electric Meter Reading, Billing, Theft Detection and Control

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***Abstract*: In today's era, electricity is one of the basic and most essential necessity for any human to lead one's life. In conventional method, a meter reader who is authorized by the Electricity department visits the user's house and notes down the consumed energy units and calculates the amount for the number of units consumed by the consumer. In this method problems may arise due to errors caused by meter reader; it is also time consuming and requires human labour, the most common problem is if meter not maintained properly in a safer place the meter reading becomes invisible as the dust particles settle over it by time. Automation of billing system is the solution to this problem. It can be achieved by incorporating microcontroller with energy meter. A database at the server stores all the details and will be accessible to the officials and users on demand. User can access his daily electricity consumption by using an android application or a website. Data which is sent by the meter to the server is provided with network security. If the user fails to follow the rules and regulations of the electricity board then the server will automatically cut the power supply. Electricity theft is the main problem which needs to be eliminated. This project suggests a method for effective power theft detection. If there is any power tapping between the distribution post and the user's meter then power theft detection message will be sent to server. This system engages KEB office to assemble the bill and energy theft acknowledgement data normally without utilizing the man control. The data assembled at the customer premises are shared to KEB office through GSM. An LCD will exhibit the live readings at customer premises. The data is sent to the customer through SMS.**

***Keywords*: Arduino, Electric theft detection, GSM, LCD, LDR, Opto-coupler, Relay.**

1. Introduction

In the present billing system, the distribution companies are unable to keep track of the changing maximum 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 remedy for all these problems is to keep track of the consumers load on timely basis, which will be held to assure accurate billing, track maximum demand and to detect threshold value. These are all the features to be taken into account for designing an efficient energy billing system. The present project "IoT Based Electric meter reading, billing, Theft detection and control" addresses the problems faced by both the consumers and the distribution companies.

The project mainly deals with smart energy meter, which utilizes the features of embedded systems i.e. combination of hardware and software in order to implement desired functionality. The project discusses comparison of Arduino 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 of 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 webpage to the consumer on request. This system also can be used to disconnect the power supply of the house when needed.

Electricity theft is one of the major factors for the revenue losses in the country. In order to prevent power theft, this project has come with an effective method to avoid power theft which is based on comparing the energy transmitted from the provider and the energy consumed by the consumer

Ideally, the energy supplied from the provider should be equal to the amount of energy consumed by the user. But, due to few losses like copper losses, dielectric losses, skin effect, corona loss and etc., the total power supplied will not be received at the consumer end. Whereas, the energy loss due to these losses can be calculated. Still the significant marginal gap exists between the current supplied to the consumer consumed then it is said to be the current is being tapped somewhere in

middle of its journey.

2. Literature Survey

The paper [1] in 2018 has implemented an electric power theft detection and location tracking using IoT. The main aim is to reduce the power theft. These proposed system claims to detect power theft in real time, along with location of theft. The system will have an online database. The heart of this project is Arduino UNO controller. In this system the location of the theft is determined. The system can be further improved in future because of its high usage factor, we can detect the theft of power more precisely.

The paper [2] proposed electro-mechanical meter with motorized nature of the segments utilized in many regions ruin due to long usage. These meters were later substituted by digital energy meter having high precision and accuracy with LCD display. Evolution in this pathway include AMR using digital energy meter. There are diverse technologies being utilized for ARM using Bluetooth, GSM, GPRS, Zigbee, PLC, RFID and so on. design of such meters based on BT, GPRS may direct to network uncertainty; with GSM, instantaneous invoice might lead to loss of message. Although problems may arise due to errors caused by meter reader, it is also time consuming and requires human labor.

The paper [3] proposed a digital meter whose blinking LED signal is interfaced to microcontroller through LDR the blinking LED flashes 3200 times for 1 unit the LDR sensor gives an interrupt each time the meter LED flashes to the programmed microcontroller, microcontroller takes this reading and displays it on LED duly interfaced to the microcontroller. The reading of the energy meter is also sent to Ethernet shield module being fed from the microcontroller via level shifter IC and RS232.

The paper [6] has implemented monitoring and keeping tracking of electricity consumption. In this method we are using Arduino because it is energy efficient, it consumes less power. The advantages are efficient use of energy, less labor cost, they know exactly how much power is being utilized, no need to wait for the month end bill. Remote access of meter reading the propagated model is used to calculate the energy consumption and make the energy unit reading to be handy and also has been made to make a practical model of IoT based smart energy meter. It is used to calculate the energy consumption. The proposed system is designed in such a way to avoid the limitations of the existing system. It supports more flexibility, comfortability and security. It also reduces the wastage of energy and bring awareness.

The paper [9] In this system proposed the IoT technology is used to detect the theft of electricity. The power transferred and the power consumed is measured and the difference is used to detect the theft of power. Security is automated and hence economy of the country is saved. Alert can be generated through GSM even in the case of failure of internet. This system is used in distribution systems and also in AMR. As further implementation to the developed model we can assemble GPS module in order to identify exact location of power theft.

The paper [7] has implemented Arduino because it is energy efficient. 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 pain regularly. The propagated model is used to calculate the energy consumption, reduces the wastage of energy. Arduino is used in this method because it is energy efficient, it consumes less power and also deduct the manual intervention. The propagated model is used to calculate the energy consumption of the household and even make the energy unit reading to be handy, reduces wastage of energy and creates awareness.

3. System Design

The system designing of shrewd imperativeness meter is showed up in figure1. It involves Arduino uno, essentialness meter, opt coupler, exchange, LCD show and GSM module. The block diagram of the energy meter is shown in fig. 1.

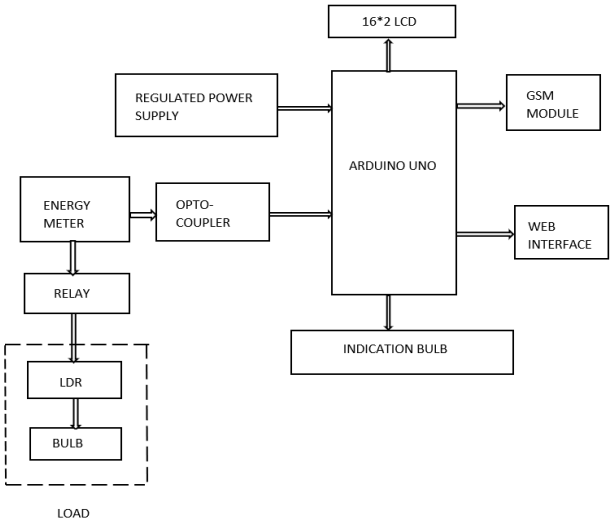

Fig. 1. Block diagram of the system design

As shown in the fig. 1, basically it has three Arduino microcontroller. In the section 1 microcontroller is connected the LSW, relay, LCD, ZigBee transmitter and receiver and buzzer. Once the broken live electrical wire is detected the relay sends a message to the microcontroller in the section 2, where it is received by the ZigBee receiver and it is displayed on the LCD screen and a SMS is sent using GSM module and the buzzer is ON. In the section 3, it has a GSM module and database with LCD and buzzer.

A. Arduino Uno

In the fig. 2, Arduino uno is an open source microcontroller, in our proposed project we are using it for programming the circuit. Its operating voltage is 5V, the input voltage can vary from 7-20V. it has 6 analog input pins and 14 digital I/O pins. Its clock speed is 16Mhz. The one we utilized is the Arduino Uno in light of ATmega328P. The equipment comprises of 14

digital pins, 6 analog pins, and programmable with the Arduino IDE. Arduino can be powered by USB cable connected to computer or by an external 9-volt battery.

Fig. 2. Arduino Uno

B. GSM

Fig. 3. GSM module

In the figure 3, We are using GSM 900A in our proposed project, it can be used for IoT and embedded applications. It is a 68 terminals device. Communication with this, is done through UART or RS232 interface. It is typically connected to +4V, can work up to 4.5V. we are using it for cellular communication to alert the predefined authorities about the broken live electrical wire from incident place to the nearest KPCTL, KEB, line man and to the electrical power substation and to nearby farms/residential areas. The main use of GSM in our proposed project is to inform the authority about the breakage of the live electrical wire, through the GSM module, once broken live electrical is detected, so that they will turn off the power supply and no harm or accident is caused to the people or animals.

This also provides the latitude and longitude so has to locate the address with ease.

C. Wi-Fi module (ESP8266)

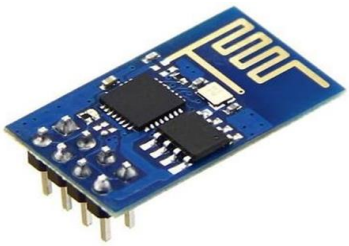

Fig. 4. Wi- Fi module

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces, it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

D. LCD

Fig. 5. LCD

A 16*2 LCD demonstrate contains two lines likewise, there are 16 characters for each line. Each character is appeared by 5x7 pixel lattice. This LCD includes two registers, specifically, Order and Data. The charge selects extras the charge bearings that are given to the LCD. A charge is a rule given to LCD to do a predefined errand like presenting it, clears its screen, sets the cursor position, controls show et cetera. The data enroll saves the data to be appeared on the LCD. LCDs are most commonly used in the embedded projects, it is easily available, low cost and programmer friendly. In our proposed project prototype, we are using LCD to display the amount of electricity consumed.

E. Opto-Coupler

Fig. 6. Internal structure of opto- coupler

Opto-coupler is an electronic component that transfers electrical signals between two isolated circuits. Opto-coupler also called Opto-isolator, photo coupler or optical isolator.

Often in circuits, especially low voltage or highly noise sensitive circuits, opto-coupler is used to isolate circuitry to prevent electrical collision chances or to exclude unwanted noises. In present commercial market, we can buy opto-coupler with 10 kV to 20 kV input to output withstand voltage capacity, with a specification of 25 kV/uS voltage transients.

This is the internal structure of the opto-coupler. On the left side pin 1 and pin 2 are exposed, it is a LED (Light Emitting Diode), the LED emit infrared light to the photosensitive transistor on the right side. The photo-transistor switches the output circuitry by its collector and emitter, same as typical BJT transistors. Intensity of the LED directly controls the photo-transistor. Since the LED can be controlled by a different circuitry and the photo transistor can control different circuitry so two independent circuits can be controlled by opto-coupler. Also, between the photo-transistor and the Infrared LED, the space is transparent and non-conductive material; it is electrically isolating two different circuits. The hollowed space between LED and photo-transistor can be made using Glass, air, or a transparent plastic, the electrical isolation is much higher, typically 10 kV or higher Hand-off.

A hand-off is an electrically worked switch. Exchanges are major parts in a bigger piece of sorts of electrical and electronic device. It is in addition used as a piece of vitality building. An over-trouble hand-off that uses a warming segment to distinguish over-loads. Electro-mechanical exchange is a quick device which is harsh to pulse and high-repeat check and surge voltage. It shows a solid lead in finished weight modes and has a worthy reset extent.

4. Implementation

The smart electricity meter using Wi-Fi module can be easily deciphered in to two parts. The first part being the physical part and the second one being the physical part - It consists of the Arduino board, ESP 8266 Wi-Fi module, 16*2 LCD display, indication bulb and power supply. Arduino Uno board Arduino is a microcontroller board and it is based on the AT mega 328P. It consists of 14 digital I/O pins and 6 analog input pins and a crystal oscillator of 16 MHz frequency, a power supply jack and a USB port to dump the code, ICSP header and a reset button. It can be powered with the power jack at the start and later can be powered with AC to DC adapter or with a battery.

ESP 8266 Wi-Fi module: The ESP 8266 Wi-Fi module is a low-cost component with which manufacturers are making wirelessly networkable microcontroller module. ESP 8266 Wi-Fi module is a system-on-a-chip with capabilities for 2.4GHz range. It employs a 32-bit RISC CPU running at 80 MHz's It is based on the TCP/IP (Transfer control protocol). It is the most important component in the system as it performs the IOT operation. It has 64 kb boot ROM, 64 kb instruction RAM, 96 kb data RAM. Wi-Fi unit performs IOT operation by sending energy meter data to webpage which can be accessed through IP address. The TX, RX pins are connected to the 7 and 8 pins of the Arduino microcontroller.

*16*2 LCD display:* LCD (Liquid crystal display) screen is an electronic display module and finds a wide range of applications. 16*2 display means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5*7-pixel matrix. The 11, 12, 13 and 14 pins of the display are used as data pins for Arduino interfacing. It is used to display the wattage.

Working of E-Meter: The meter which is utilized for estimating the vitality and uses by the electric board is known as the vitality meter. The vitality is the aggregate power expended and used by the heap at a specific interim of time. It is utilized as a part of residential and mechanical AC circuit for estimating the power utilization. The meter is more affordable and precise. Essential unit of energy is watts. One thousand watts is one kilowatt. In the event that we utilize one kilowatt in 60 minutes, it is considered as one unit of vitality devoured. These meters measure the prompt voltage and streams. This power is incorporated over a period which gives the vitality used over that day and age.

To enable the energy meter reading: A bulb which is considered as load is connected to the output pin of Arduino. Once the energy is supplies to the Arduino. The LDR is placed right below the bulb, as soon as the bulb glows the light intensity falls on LDR. LDR is connected to the input pin of Arduino. Once the light falls upon LDR. The LDR conducts and Arduino receives the signal from LDR. The internal Arduino counter begins and the same is reflected on LCD.

All the connections remain the same where an additional tapping is done by connecting the connecting leads to the output of Arduino and lighting the other bulb, this illumination of another bulb draws more current. The Arduino is programmed in such a way that if the current drawn is more than it is considered as theft and the theft detecting bulb will be on. Using the GSM sensor, the corresponding locality longitude and latitude information will be sent to corresponding energy supply board through SMS in the TELEGRAM application using Wi-Fi module.

5. Comparison Between Conventional Energy Meter and Smart Energy Meter

Conventional electricity energy metering method: As we know in our country the electricity energy billing duration is either end of one month or end of two months. During the month electricity consumer cannot know how much power consumed, they can know at the end of one or two months when the bill is issued. The major drawback of this method is user cannot manage the power consumption. Another disadvantage of this system is theft caused by excess amount of power can be done easily and such practices are happening and increasing rapidly which is one of the major causes of power crises.

Smart electricity energy metering method: In this method we try to eliminate the drawback and limitations of existing electricity metering method. In this method there is a provision for the supplier that they can monitor the power consumed by consumer to find the exact location where theft occurred at the time when theft occurred and provides the information at the event meter tempering and power theft. Such information will be very useful to control the practices of power theft and reduce the power crises. Also, it is helpful if consumer fails to pay their electricity billed amount within the time period mentioned by the supplier, the supplier can be disconnected the power automatically from the distant end. This method is not only providing the facility to supplier end but also it is more helpful to consumer end also. As there is a provision for the consumer that they can see their power consumption time to time so they have an opportunity to manage the power consumption as they desire.

6. Advantages

No need to submit meter readings:

Smart meters automatically send out readings to your supplier so you don't have to worry about remembering to submit them.

You can closely track your usage and spend: The In-Home Display can show you exactly how much energy you're using as well as the associated cost. It encourages good energy habits and some homes are already showing energy savings of 5-20%. Great for budgeting.

Accurate bills-no more estimates: The smart meter sends your readings automatically so you will always be billed for what you use. If you have a standard (non-smart) meter and forget to submit a reading, your supplier will have to estimate how much energy you've used over the billing period. They estimate based on the typical amount of energy you have used in the past or how much they think you will use. Sometimes the supplier's estimates are inaccurate, especially if they don't have a lot of information about your usage. With a smart meter, not only will you avoid inaccurate shock bills but also you can also avoid building a large final bill at the end of your tariff.

Highlights faulty appliances: The In-Home Display shows how much energy you're using at any given time, allowing you to notice any sudden spikes which may be associated with a faulty appliance. By identifying these promptly, you can ensure it is dealt with quickly and safely.

Prepay friendly: If you have a prepayment meter you can also upgrade to a smart meter. With a smart prepay meter you easily track how much credit you have left on your meter and even top up from your smartphone or computer.

7. Future Scope

The project mainly aims at providing overall infrastructure of the energy meter presently used for the smart city concept. The main improvement for the future is going to make energy meter readings, tampering identification techniques, and connection and disconnection and also the pre information providing to the users all is going to happen on Wi-Fi internet. Where we are going to develop some Wi-Fi hotspots in each area through which all the energy meter gets connected and set 4 to 5 parameters which is also going to be monitored. And the overall improvement information will be provided to the energy meter i.e. KPTCL. Also, in future we can go with some standard apps or standard tools, where in which it makes work easy for KPTCL to take the meter readings faster. And connect and disconnect of every meter on the basis of – payment and non – payment that will be fast as compared to the present method.

8. Conclusion

Energy monitoring through the internet is easy. It gives the real power consumption as well as accurate reading. Also, it requires fewer labours and less time to monitor the energy. It can transmit the data to the utilities and also can receive information from utilities. After a specified time- duration electricity bill will be paid otherwise supply line will be disconnected through the internet. After a fixed time-validity for alert purpose buzzer will be ON. It is easy to know the two-month validity. By making this thing the energy will be monitored.

The project is mainly concentrated on IOT network. It shows the bill for the consumed units on the web server with time and date. shows tamper happened in energy meter which is displayed on We are doing automatic reading and also connection and disconnection of meters using WIFI module. Then meter reading has come faster. It is publicly available for the customers as well as for the KPTCL. Both the peoples will be using the information as per their requirements and they will be having freedom to check the bill, tampering, when the meter has been connected and disconnected before the due date. All the information will be displayed by using smart app. Finally concluding our project that we are successfully monitored the tampering i.e. seal tampering and we have read the meter bills which also be uploaded on the website using IoT concept.

An attempt has been made to make a practical model of 'IoT Based Electric meter reading, billing, theft detection and control.' The propagated model is used to calculate the energy consumption of the household, and even make the energy unit reading to be handy. Also helps in control of power theft which is a main issue in the present days. Hence it reduces the wastage of energy and bring awareness among all. Even it will deduct the manual intervention.

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