IoT Based Cloud Enabled Smart Electricity Management System

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Abstract. In the age of digitalization, Internet based applications are gaining popularity at an exponential rate. Today, everyone wants to make their lives easier and devices smarter [1]. In the age of automation, most of the devices we interact with on a day-to-day basis for example: air conditioners, refrigerators, etc. are made increasingly intelligent to simplify our lives and make it comfortable [2]. Using the principles of IOT and AI, we can create home-automation devices such as automatic security devices and e-meters that make our homes smarter and more secure. Keeping a track of how much electricity is consumed per household becomes imperative seeing the rate at which global warming is increasing. Gone are the days where users had to go to meter reading room and take down readings [3]. By employing IOT concepts, we can simplify this tedious process and record the reading over cloud for easy accessibility. The major advantage of digitalizing the process is that the user has the facility to view his consumption remotely i.e. anywhere in the world. This also enables the user to keep a log of how many units of electricity a device is consuming and with how much amount the user is being charged fairly or not [4].

Keywords: Internet of Things, Energy Meter Billing, GSM, Cloud, Big data

1 Introduction

With the help of Internet of Things we can remotely get the objects to be controlled and sensed throughout the infrastructure that is already available and thereby we can create more opportunities to integrate physical world and systems based on digital world which provide us a direct integration [5]. As a result we get very efficient system which consist of improvisation thus we get better accuracy and economically benefited [6].
One of the most important commodity is electricity, that need to be saved and properly utilized in order to get maximum benefits of this energy and minimum consumption (in terms of cost). There is great impact of electricity in the lives of humans and these days consumption of electricity is drastically increasing. Because of the rapid increase of the consumers of electricity and nearly every day new equipment are introduced which uses electricity, it is becoming difficult day by day to fulfil the requirement of electricity consumption. This is the factor where IoT comes into picture [7]. Internet of Things is a faster and more develop technology that smartly look after the devices and controls or handles them over the internet.
The steps involved in the manual electricity unit monitoring and billing is quite a lengthy process in which human intervention is required and thus it delays many times [8]. Reason of delay is simple as it involves many steps like; first the human operator goes to every single consumer and generates the bill, which is time consuming and can be erroneous as it involves human.
So in order to overcome the above stated problem we come up with the IoT based solution as E-monitoring of Energy Meter Readings [9].

2 Objective

One of the main objective of this chapter through the project we have made is to simplify the tedious task of monitoring electric meters since the user no longer needs to go to meter reading room and take down readings [10]. In comparison to the older systems, the new system is smarter, user-friendly and bound to lesser failures. This provides reliability, accountability and accessibility (because of remote access) [11]. It also saves user's time and effort while empowering them with facility to be aware of what are they charged for by the electricity board [12].
In this chapter the objective is to monitor electric meter readings and record the units and IRMS using IOT concepts. The readings should be visualized using cloud-based application and stored over cloud using big data technology [13].

2.1 Scope

This technique can be extended in too many areas such as in home automation where we can integrate the construction of contemporary smart houses [14-18]. It assist in effective monitoring of electricity consumption.

Also this can be used in industries for restricting the production plants to any misuse of electricity and no electricity leakage or theft is present in the system. It can also prove helpful in monitoring which machines are consuming what amount of electricity which can prove beneficial to determine if a machine requires maintenance [19-23].

3 Methodology

The main steps are stated below (can be seen in figure 1):
First we learning about Arduino and basic working of electric meter. Then gathered the hardware components (Electric meter, transformer, Arduino Uno board, WIFI module, wires, bulb, bulb socket, LCD, resistors) [24-28].
Connections were made to connect all the components. Then the external power supply is provided and made the suitable transformer connections. After that writing is done according to the code and uploaded it on the Arduino and made connections to the Wi-Fi module. After this connections to the cloud service and visualization of the data and then testing of the cloud service and related connections to ensure proper functioning of system (can be seen in Figure 1) [28-32].

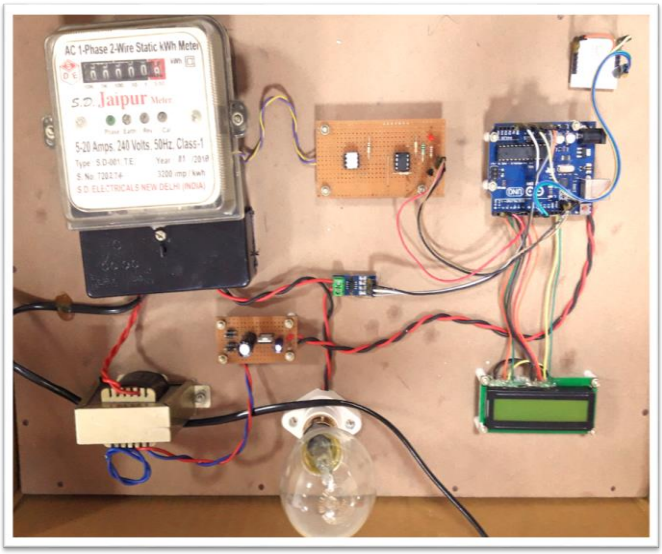

Fig. 1. Design of E-monitoring of Energy Meter Readings Using IOT principles

Thus, this chapter consist the part of project which focuses on the development of IoT (internet of things) based energy meter monitoring system to record the readings that are displayed for units consumed in I_{rms} on the LCD unit and over the cloud application. Using the readings that are clearly visualized, a user can monitor the electricity consumption of the household and that of individual devices. Thereby, the user can estimate the overall cost and prepare his/her monthly budget (in figure 2) [38-40].

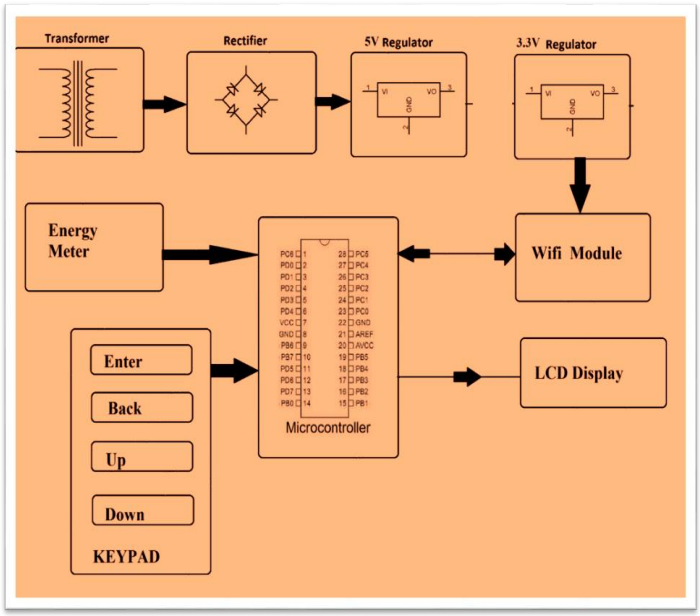

Fig. 2. Prototype of E-monitoring of Energy Meter Readings Using IOT principles

The power fluctuations are monitored using current sensors which are fed to the microcontroller and who sends the data to the cloud application. This allows user to easily check the energy usage along with the cost charged remotely using a simple web application [33]. Thus the energy meter monitoring system allows user to effectively monitor electricity meter readings and check the billing online with ease [34].
The whole system has four major components: controller, WIFI module, cloud and electric meter. Controller part plays a major role in the system. Through this part, all the information is collected and sent to the cloud and displayed on the LCD screen. WIFI module provides WIFI connectivity to the system and performs IOT operation in accordance with the Arduino controller [35].
Once the data is sent to the cloud (thingSpeak), the application displays all the readings in a visualized form (graphs) for easy viewing. Initially, DC power supply is used to give voltage to the circuit. Amplifier circuit and isolation circuits are connected with relays and load [36].
The load (bulb) and relays in this circuit represent the devices that need energy or electricity to operate and are used at homes. The electric meter is connected to a transformer (to step up/step down) and a current sensor. The sensor senses the current pulses and sends the reading to the controller (Arduino Uno) which processes it and displays it on LCD and cloud [37].
Instantaneous values of units and I_{RMS} are recorded and can be seen on the LCD every few milliseconds. The units are calculated using the formula given below (1)

$$\text{Unit} = \text{Pulse} / 2*0.01 \qquad (1)$$

3.1 Platform Used

Technology Used
Local area network
Wifi

Hardware Used
Arduino Uno
It is used as a micro-controller to control the current, wifi module and also to get the meter readings and display on the LCD (in figure 3).

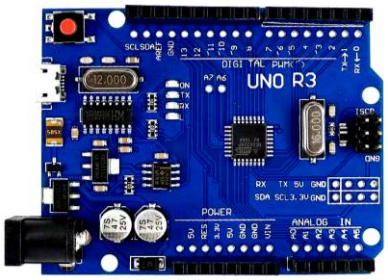

Fig. 3. Arduino board

Jumper Cables
Jumper cables are used to make the connection with all electronic devices. There are three types of jumper wires (in figure 4)
1. Male to male (M-M)
2. Male to female (M-F)
3. Female to Female (F-F)

Fig. 4. Jumper wire

LCD panel:
Liquid crystal display is used to displays the data (cost in rupees and Units of electricity used) to the user (in figure 5).

Fig. 5. LCD display

Features: It is 8X2 LCD Display
Its brightness can be increased or decreased by potentiometer. It has 16 pins. Its contrast and ratio ranges from contrast ratios range from 450:1 to 600:1. Its response rate is fast. It can also be used in portrait mode by adjusting the features.

Electric Meter
Electric meter is used to get the readings of electricity (in figure 6).

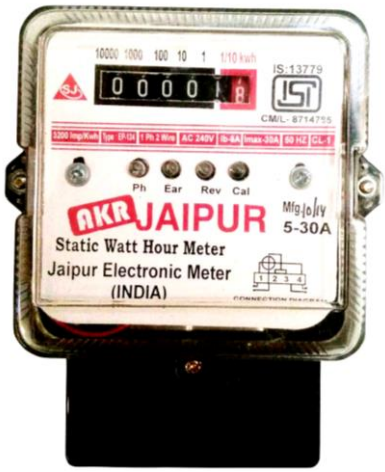

Fig. 6. Electric meter

ESP8266 WiFi Module
ESP8266 WiFi Module is used to do the connectivity with cloud (in figure 7).

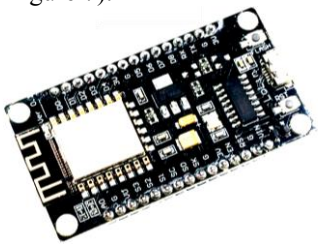

Fig. 7. WiFi Module

Transformer: Step down transformer is used because the 220V need to be step down to 5V in order to supply it to Arduino (in figure 8).

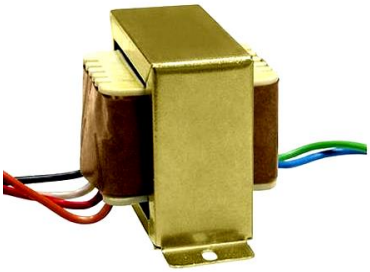

Fig. 8. Step down transformer

40V Bulb: 40V bulb is used to give load to the meter so that readings come in units and we can calculate cost according to the electricity consumption (in figure 8).

Fig. 9. Bulb

Resistors: They are used to reduce the current-flow and to divide the voltage can be seen in figure 10.

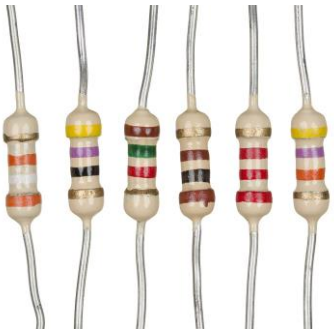

Fig.. Resistor

Bread board: Breadboard is used to construct the circuit (in figure 11).

Fig. 11. Connecting boards

Software Used
Arduino IDE: Used to program arduino

Tools/Application used
ThingsSpeak API: It is used for visualization of data [40]

Platform Used
ThingsSpeak: It is used to get cloud services

Operating System
Linux: The entire system is tested on Linux (Ubuntu 16.04).

4 Discussion and Results

An E-electric meter was implemented and all the basic functionalities of a standard electric meter was included in the system (figure 12).

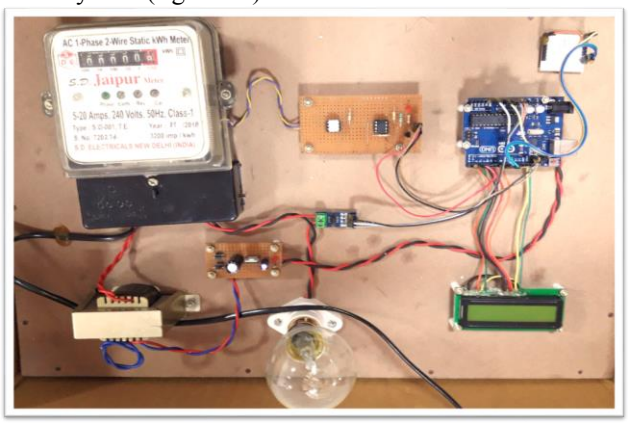

Fig. 12. E-Monitoring

The system was successfully connected to Wi-Fi when bulb is turned on (figure 13).

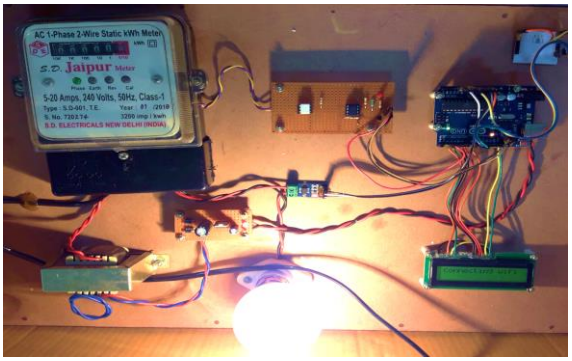

Fig. 13. E-Monitoring when lite is on it is connecting with WiFi

The units of electricity consumed was successfully calculated and recorded (figure 14).

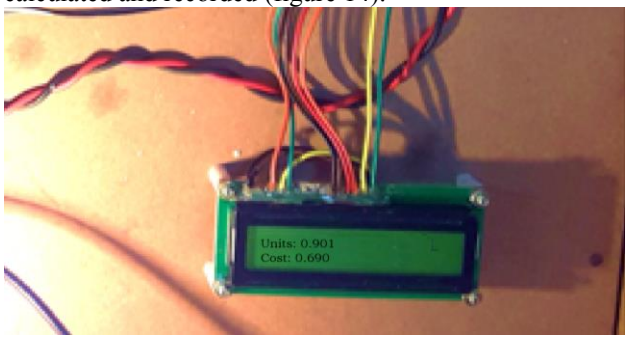

Fig. 14. E-Monitoring calculating the units of electricity consumed and cost accordingly

The new system was faster and more accurate than existing systems. The current pulses were successfully sensed and send to the cloud for further calculations.

The new system was more efficient that existing systems (shown in table-1).

Table 1. Electricity consumption in percentage.

Time	Manual-Monitoring (consumption)	E-Monitoring (consumption)
Morning	82%	79%
Afternoon	76%	70.1%
Evening	78%	77.1%
Night	81%	78%

Analysis has been done through the ThingSpeak cloud as shown in following readings (in figure 15, 16).

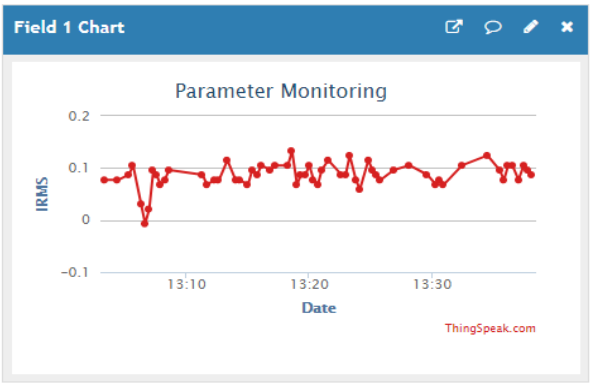

Fig. 15. Calculating IRMS

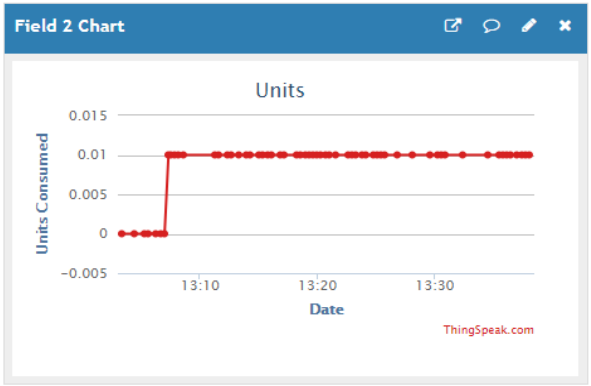

Fig. 16. Calculating the units of electricity consumed and cost accordingly on to the cloud

When data is uploaded on to the cloud then one can predict it through remote locations as the data is present remotely [40-42].

5 Conclusion

In this project, we implemented the basic functionalities of an electric meter in a smarter and more efficient manner. We made an attempt to simplify the process of electric meter reading collection and analysis thereby, making it efficient instead of the tedious traditional approach. Also, it was observed that the new system was more accurate and faster than the existing systems. By simple application of IOT principles, current sensor and microcontrollers, we have streamlined the process and move the process to a cloud-based application. This not only provides remote accessibility but, also accountability and reliability.

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