Internet of Things Enabled Monitoring of Energymeters

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Abstract

In India electricity generated from the electric power plants is distributed for domestic as well as industrial usage. Domestic electricity usage is measured by electric energymeter which is installed in every house. Monthly electric bill is generated proportional to the energy consumed and unit cost of electricity fixed by the electricity board. The energy consumption is not monitored periodically and hence a limit is not set on the usage. This work is an attempt to eliminate the human intervention in meter reading in domestic electric meters by introducing an Internet of Things based electric energy monitoring system. This paper proposes a smart electrical energymeter developed using Arduino UNO controller, ACS 712 current sensor to sense the current and ESP 8266 Node MCU module to send the information over the internet. The system can capture amount of energy consumed, computes cost and displays the quantity and cost of electricity by sending information over the internet. The information can be viewed on mobile phone through Adafruit App /dashboard.

Keywords: *Energymeter, Internet of things, ACS 712 current sensor, Node MCU, Arduino Uno*

1.0 Introduction

Internet of things (IoT) is a system connecting mechanical and digital machines, computing devices with the help of the unique identifiers (UIDs) without the interaction of human-human or human-computer. This technology makes easier to track, real time cost of the electricity consumed. This proposed work uses devices such as Arduino board, ACS712 current sensor, Node MCU, 9-volt batteries and the connection jumper wires. According to the energy statistics by Central statistics office ministry of statistics and programme implementation government of India, the estimated electricity consumption increased from 5,01,977 GWh during 2007-08 to 10,66,268 GWh during 2016-17 [1]. So an attempt was made to make it simpler for the common man to get to know the real time cost of the electricity consumed.

Male et al [2] presented a simple low cost wireless GSM energy meter which saves human labour but it has limited access due to the network restrictions. Vijayaraj et al [3] showed automated billing system which used GSM and Ad-Hoc wireless routing protocol for generating the electric bill of all the homes connected. But, this method was not transparent as the end users were not the common men. Koay et al [4] developed bluetooth enabled energy meter which

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transmits the data of the energy consumed over the bluetooth. But, the system used short range bluetooth protocol. Imran et al [5] developed an IoT based electricity meter to display the units consumed and cost over the internet. The system used blinking LED signal interfaced with microcontroller through LDR sensor to give an interrupt when LED blinks. The reading of the energy meter was sent to ethernet shield module being fed through microcontroller, level shifter IC and RS-232 link. The system developed by this project was the device that works for limited distance.

Zahid Iqbal et al [6] proposed an automatic remote meter-reading system based on GSM. It is useful to obtain meter reading when desired so, meter readers don't need to visit each customer for the consumed energy data collection and to distribute the bill slips. Microcontroller was used to monitor and record the meter readings. In case of a customer defaulter, no need to send a person of utility to cut-off the customer connection. Utility can cut off and reconnect the customer connection by short message service (SMS). Furthermore, the customer can check the status of electricity (load) from anywhere. In this system, energy meter readings are being transferred by making use of GSM.

Ahin Shapir et al [7] presented smart energy meter connected with Electricity Board, household appliances and the user through IoT and mobile application. The system focused on making the smart energy meter to smartly connect with the household appliances through IoT and also to connect with the authorized persons through a mobile application to have a control over it. The idea of home automation was used to think of automation in automatic electricity meter.

The literature review showed that different techniques such as Global System for Mobiles (GSM), Bluetooth, ZigBee, Short Message System (SMS), Automatic Meter Reading (AMR) and the Automatic Polling Mechanism (APM) and Ethernet have been adopted to send the data such as quantity of the power consumed, total power utilized, current from the electric meter to the station or the user. Bluetooth based systems are limited to short range and SMS based systems are not effective because of network error and connectivity issue. Ethernet systems are limited to short distances. ZigBee based systems provide an idea of sending the data over the internet and home automation literatures give the idea of automation. There is a need for the system that can give information such as the amount of electric power consumed and proportional bill generated in real time to the common man. It has been found that sending the data of the electric meter using Internet is the best option to get the real time data. Internet can be used for longer range and there is very little error involved. Hence, the present project utilizes internet to send the data from the system to the end user.

2.0 Experimental Details

2.1 Development of Working Model

The electric energy meter developed consists of Arduino Uno board, ACS 712 current sensor and Node MCU. The Arduino Uno has a microcontroller

ATMEGA 328P to process the data. The detailed method to program the Arduino using Arduino software (IDE) is explained in [8]. The current sensor works on the principle of Hall effect [9]. The node MCU is used for wireless communication with the smartphone or laptop to get real time data over the internet. The pin configuration for the Node MCU can be found in [10]. The processed data (Electric power wattage and cost of the electric power) sent over the internet can be visualised in Adafruit dashboard. The details to configure the dashboard can be found in [11]. The appliance used here is an incandescent electric bulb. The energy consumed by the incandescent bulb and cost of the electric power is to be found. The connections of the IoT based electric energy meter are shown in the Fig. 1 where, the current sensor ACS712 and Node MCU are connected to the Arduino Uno Microcontroller with the help of jumper cables. The current sensor is connected in series with the electric bulb

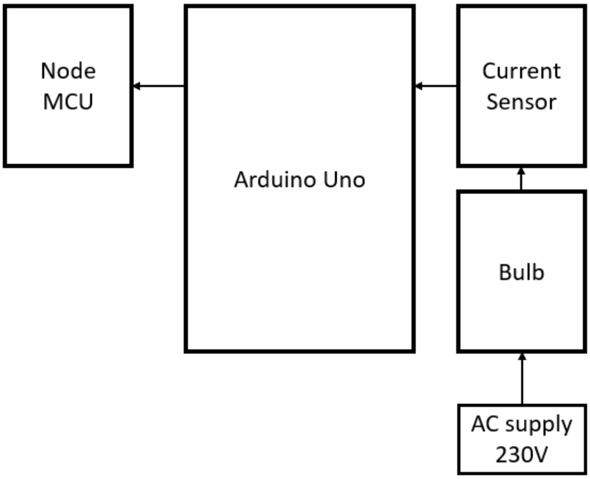

Fig. 1. Block diagram of experimental setup

2.2 Working of the model

The detailed model and working are shown in Fig. 2 respectively. When the power is supplied to the appliance (Incandescent bulb) coupled with the current sensor, the appliance gets switched on and it starts operating by consuming power. The current sensor senses the current supplied to the appliance. The sensed data is sent to the Arduino Uno microcontroller. The microcontroller processes the data and the processed data is fed to the Wi-Fi module (Node MCU). The micro controller is the main part which calculates the power based on the sensed data. The data sent through the Wi-Fi module can be viewed on the mobile screen through Adafruit Dashboard.

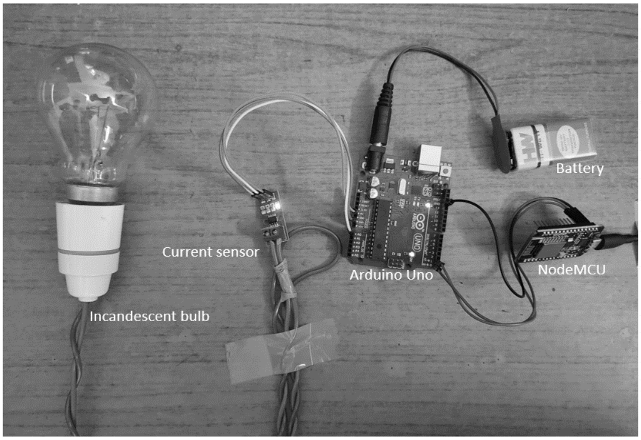

Fig. 2. Working model

3.0 Experimental Results

Experiment was conducted using a 60 W incandescent bulb. Since the electric bulb consumes very less power, a bill equal to ₹ 8 will be generated if the bulb glows for 16.67 hours. In other words a bill of ₹1 will be generated if the bulb runs for 2.08 hours. So, a scaling factor of 2.08 x 60 = 125 is used for simplification. For the data considered, 8 ₹ x 125 = 1000 ₹ is used for calculating the bill and this bill (₹. 1000) will be shown on the Adafruit dashboard if the bulb glows for 16.67 hours. This scaling factor is included in the program burnt on to the Aurdino board. For calculating the actual bill, the bill shown on the Adafruit dashboard should be divided by the 125 to eliminate the scaling factor.

The scaling factor is mainly used to conveniently check for the consistency of the measurement within short time duration rather than conducting the experiment for very long hours. No need of using any scaling factor for the electric power since the dashboard is showing the actual power consumed in Watt hour

The Adafruit dashboard on appears on the computer screen. The same dashboard can be accessible on the phone screen using the Adafruit android app. It displays the cumulative electric power consumed in Watt hour and bill in Rupees. These data were calculated as per the program and sent over the internet to Adafruit dashboard using Node MCU. The electric power can also be monitored in real time and at a particular time interval using the Android app.

As per Adafruit Dashboard the bill amount is ₹.14. This bill was generated by considering the scaling factor. So to get the actual bill, the scaling factor is to be eliminated as follows:

Actual bill $= \frac{14}{125}$ = 0.112 ₹ → 0.112 x 100 Paisa

Hence actual bill rate = 11.2 Paisa, actual cumulative electric power consumed is 14.36 W-h

<u>Cross check</u>

From Figure 4 the power consumed is 14.36 W-h (Actual). Tariff for 1 kW - h = 8 ₹. The bill that should be given from the experiment is $\frac{8 \text{ x } 14.36}{1000}$ = 0.1148 ₹ = 0.1148 x 100 Paisa = 11.48 Paisa

Similar observations were taken from the adafruit dashboard and tabulated as shown in Table 1, which shows the generated bill in ₹. Cumulative time in seconds and the cumulative power consumed in W - h as per Adafruit dashboard

Table 1. Results Showing Bill in ₹ and Power in W – h

Bill in ₹.	Time	Power in W –h
1	1 min 11 sec	1.12
2	2 min 12 sec	2.07
3	3 min 12 sec	3.03
4	4 min 22 sec	4.12
5	5 min 24 sec	5.09

From the Table 1, the bill shown in the Adafruit for 5 min and 22 sec is 5 ₹. Actual bill after 5 min 24 sec by eliminating the scaling factor is,

Actual bill = $\frac{5}{125}$ = 0.04 ₹ = 0.04 x 100 Paisa, Hence Actual bill = 4 paisa

Actual cumulative electric power consumed is 5.09 Watt hour

<u>Cross check</u>

From the Table 1, the power consumed after 5 min 24 sec = 5.09 W – h (Actual).

Tariff for 1 kW - h = 8 ₹, The bill that should be given from the experiment is $\frac{8 \text{ x } 5.09}{1000}$ = 0.0407 ₹ = 0.0407 x 100 Paisa = 4.07 Paisa. Therefore the system arrangement and the experimentation appears to be proper.

4.0 Conclusions

The system was successful in sensing the quantity of electric power consumed, sending the data such as quantity of power consumed and generated bill amount over the internet and displaying them on the phone screen. The data were displayed in real time and hence, continuous monitoring of electric power consumption is possible. Since IoT is used in the system, human intervention in electric meter reading can be completely eliminated. Also, as IoT based systems communicate through internet, power consumption can be monitored continuously anywhere in the world. This is a main advantage compared to the conventional domestic electric energy meters. With some hardware and software modifications, the demonstrated system can be developed into a device to replace the present domestic electric energy meter to monitor the electric energy in real time.

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