

LIVE ENERGY METER READING - CONTINUOUS MONITORING AND ANALYSIS USING THINGSPEAK

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Received: 29 March 2018, Revised and Accepted: 26 May 2018

ABSTRACT

The current energy meters do not provide any provision to monitor continuous reading about our electricity consumption. Even the provision for automatic billing system is inefficient. Recently developed automatic meter systems uses the GSM modem for transferring the data from the user to provider over particular time through SMS. It has several disadvantages that the cost of the SMS is comparatively high and does not provide continuous monitoring. However, the designed energy meter uses GPRS to transfer the data continuously. When compared to SMS facility, the cost of GPRS is low at continuous monitoring. There is no need for a person to visit every home at the end of the month for checking the unit consumption. In recent years, the numbers of smartphones and computer users have increased drastically. The users can view their current energy meter reading through the web link *thingspeak.com* and also pay their Electric bills through the internet. The users and providers can also monitor their energy meters online, and they are also given an option of paying the bill online. Using this system, the users will be aware of the electricity usage in his/her home. Even the provider can remotely cut the supply of the user who is not paying electricity bill in time by visiting their host page. Once the bill is paid the provider can resume the power supply. With some modifications, we can track the energy consumption of any industrial plants, offices, educational institutions, and corporates companies and hence this system may help them to save the power consumption to a greater extent.

Keywords:The numbers of smartphones and computer users have increased drastically.

INTRODUCTION

Internet services have become an inextricable part of daily life; it enables communication and the management of personal information from anywhere and at any time. Now the recent trend is that every hardware manufacturers were working to connect that hardware to the internet. Thereby they can include the several features such as continuous monitoring, remote accessing, and data analysis. At 2025 mostly 75% things in the world will be connected to the internet. Recently, there have been several issues of faulty energy meter. Till date, the readings are manually collected at the end of the month by a person from EB department by visiting every home. Furthermore, the user needs to pay the electric bills either through online or by visiting EB offices. We have designed an energy meter to ease the work of both users as well as EB officers.

The proposed system provides a graphical user interface for monitoring the energy meter through web portals. The user and the provider can monitor the energy consumption from anywhere through internet. The Automatic Meter Reading system consists of client-server architecture where the web browser is the client, and the server functions are shared between a web-server, a communication server, and a database server.

The reading is automatically sent to the server along with the service number of that particular meter. This information is used by the server to calculate the total consumption of electricity of the end user and generates the Electricity Bill automatically at the end of every month. All these information can be viewed through web portal connected to the internet. The important feature is, if the user does not pay his Electricity bill in time, the provider can disconnect the power supply from EB office. It's possible to reconnect the power once the bill is paid by the user.

EXISTING SYSTEMS AND SERVICE

Simple energy meter

A simple energy meter measures electricity consumption of an end-user. The most common type is a kilowatt hour (KWh) meter. When

used in electricity retailing, the utilities record the values measured by these meters to generate an invoice for the electricity. They may also record other variables including the time when the electricity was used. Modern electricity meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (joules, KWh ,etc.).

The meters fall into two basic categories:

1. Electromechanical and electronic.
2. Electromechanical meters.

Existing automatic reading systems (automatic meter systems [AMS])

Many systems built on various platforms have been proposed by different research groups all over the world for AMS. There are two types of AMS systems:

1. wire-based
2. Wireless.

One such system is uploading the data through SMS to the server. Only the total electricity consumption can be calculated in such systems. In advanced systems, the reading values can be monitored. However, it requires designing a separate device and setting up additional hardware which makes it costly to be implemented. Some communication mediums used are Zig-Bee, narrow B and RF, and power line communication. Each of the media has its own complexities and cost factor [1,2].

Disadvantages of existing AMRs

SMS is costlier and sometimes unreliable. Other advanced techniques are costlier to implement and are more complex. Furthermore, there is no protection from tampering of energy meters. In most cases, the errors in the system can be identified only at the end of the month.

PROPOSED SYSTEM

Since GPRS is cost-effective compared to SMS, monitoring of energy meters is made possible at lower cost. Daily consumption reports are generated which can be monitored through web portal (thingspeak.com) and MatLab applications. Furthermore, users can pay their Electric bills on their computer or mobiles or offline mode.

Users can monitor and pay their bills online and offline. The system is more reliable and accurate readings are collected from energy meters. Live readings of the energy meter can be viewed through the computer. Furthermore, the readings can be viewed online from any part of the world. The human intensive work is avoided, and all the values are maintained in the central server. The communication medium is secure. If an error occurs in the system, the value in the central server will not be updated. Once the value updated crosses the threshold time, the server can determine that something is wrong in the system and can report the engineers in EB. Thus, identification of error becomes easier. Since the values are stored in the central database, the reports are made accessible from anywhere in the world. Furthermore, the server is online 24×7. If the user does not pay his Electricity bill in time, the provider can disconnect the power supply from EB office. It's possible to reconnect the power once the bill is paid by the user. These things are possible and accessible only by the EB officers alone from any part of the world [3,4].

Advantages of the proposed system

The users can be aware of their electricity consumption. The human work of collecting readings by visiting every home at the end of every

month can be avoided by generating Electricity bills automatically. Supply can be disconnected when the bill is not paid in time and connected when the bill is paid.

SYSTEM DESIGN

The designed energy meter includes digital energy meter, Arduino microcontroller, 16×2 liquid crystal display (LCD) display, Wi-Fi shield, Wi-Fi connectivity, relay switches, thingspeak.com web portal. The system can be divided into four parts: The project is mainly divided into four modules:

- Recording section
- Transmitting section
- Indication section
- Switching section.

Recording section

Digital energy meter

The conventional mechanical energy meter is based on the phenomenon of "magnetic induction." It has a rotating aluminum wheel called Ferri wheel and many toothed wheels. Based on the flow of current, the Ferri wheel rotates which make rotation of other wheels. This will be converted into corresponding measurements in the display section. Since many mechanical parts are involved, mechanical defects and breakdown are common. Moreover, chances of manipulation and current theft will be higher. Electronic energy meter (EEM) is based on digital microtechnology and uses no moving parts. Hence, the EEM is known as "static energy meter" in EEM the accurate functioning is controlled by a specially designed IC called application specified integrated circuit (ASIC). ASIC is constructed only for specific applications using embedded system technology. Similar ASICs are now used in washing machines, air conditioners, automobiles, and digital cameras, etc. In addition to ASIC, analog circuits, voltage transformer, and current transformer are also present in EEM to "sample" current and voltage.



Fig. 1: Digital energy meter

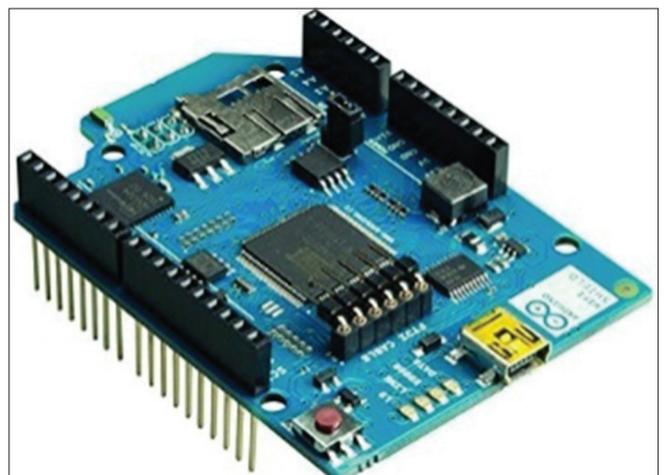


Fig. 3: Wi-Fi shield



Fig. 2: Arduino microcontroller

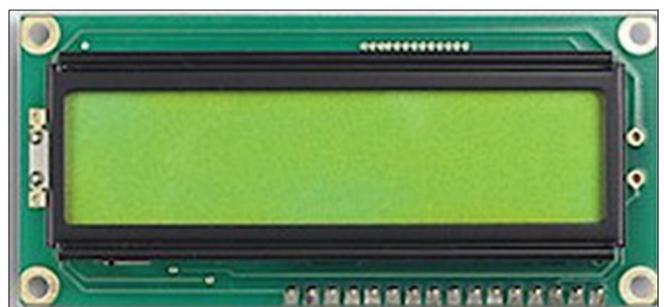


Fig. 4: 16×2 liquid crystal display

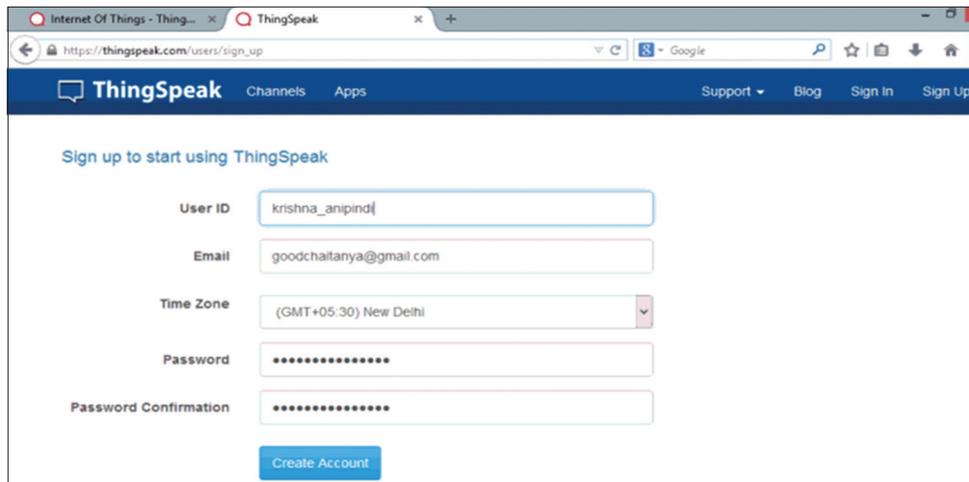


Fig. 5: Sign up window in ThingSpeak

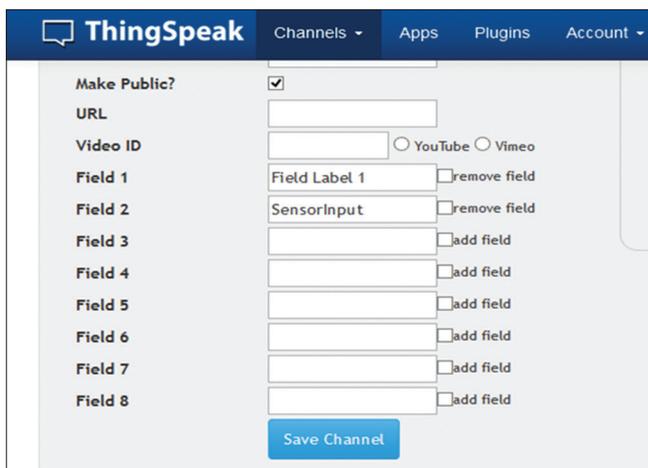


Fig. 6: Final page in ThingSpeak

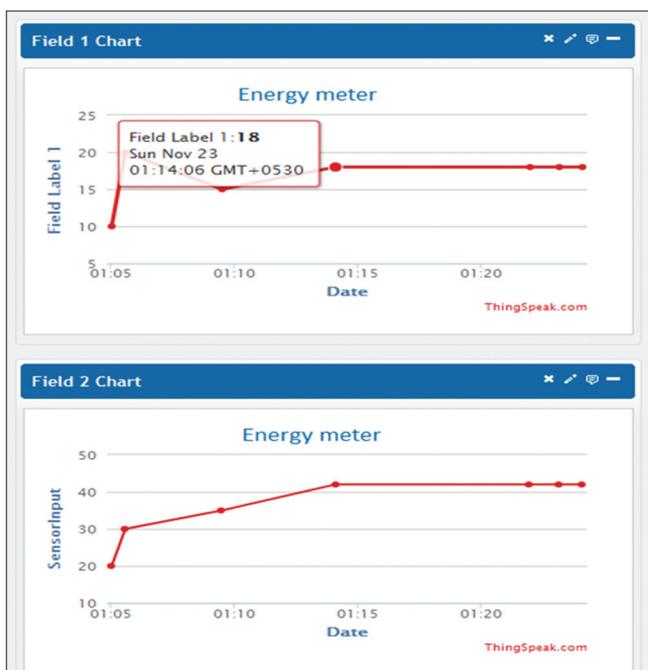


Fig. 7: Field view of ThingSpeak

The “input data” (voltage) are compared with a programmed “reference data” (voltage) and finally a “voltage rate” will be given to the output. This output is then converted into “digital data” by the analog to digital converters (ADC unit) present in the ASIC. The digital data are then converted into an “average value.” Average value/mean value is the measuring unit of power. The output of ASIC is available as “pulses” indicated by the light emitting diode (LED) placed on the front panel of EEM. These pulses are equal to average kilowatt-hour (kWh/unit). Different ASIC with various kWh is used in different makes of EEMs. However, usually 800–3600 pulses/kWh generating ASICs are used in EEMs. The output of ASIC is sufficient to drive a stepper motor to give display through the rotation of digits embossed wheels. The output pulses are indicated through LED. The ASIC is manufactured by analog device company. ADE 7757 IC is generally used in many countries to make EEMs. ADE 7555/7755 ASIC maintains the international standard CLASS I IEC 687/1036 [5,6].

Arduino microcontroller

The Uno is a microcontroller board that uses ATmega328P processor. It has 14 digital input/output pins (of which six can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; by simply connecting it to a computer with a USB cable or powering it with an AC-to-DC adapter or battery we can start working with it. Since our proposal should end up considering economy, we have chosen a low-cost microcontroller with necessary features such as I/O interfacing facility, ADC, PWM output, and serial communication option.

Transmitting section

Wi-Fi shield

Wi-Fi shield is used to establish the internet connectivity to the microcontroller. Once the connection is established it is possible to send and retrieve data from and to the microcontroller. The Arduino Wi-Fi shield allows an Arduino board to connect to the internet using the 802.11 wireless specifications.

Features

- Connection via: 802.11 b/g networks
- Encryption types: Wired equivalent privacy and Wi-Fi protected access 2 personal
- Onboard micro SD slot
- FTDI-style connection for serial debugging of Wi-Fi shield
- Mini-USB for updating the Wi-Fi shield firmware
- Open source firmware making it possible to add new protocols directly on the shield.

Indicating section

Local indication

The energy consumption is locally indicated using LCD screen is an electronic display module. A16 ×2 LCD means it can display 16 characters per line and there are two such lines. This LCD has two registers, namely Command and Data. A command is an instruction given to LCD to do a predefined task such as initializing it, clearing its screen, setting the cursor position, and controlling display. The data register stores the data to be displayed on the LCD. The data are the ASCII value of the character to be displayed on the LCD. Here, it is used to display the unit consumption details from the energy meter.



Fig. 8: Simple relay used in the proposed model

Remote indication

Thingspeak.com

The internet of things (IoT) is a system of “connected things.” The things generally comprise an embedded operating system and an ability to communicate with the internet or with the adjacent things. One of the key essentials of a generic IoT system that bridges the various “things” is an IoT service. An interesting implication from the “things” comprising the IoT systems is that the things by themselves cannot do anything. At a bare minimum, they should have a capability to connect to other “things.” However, the real power of IoT is harnessed when the things connect to a “service” either directly or through other “things.” In such systems, the service plays the role of an invisible manager by providing capabilities ranging from simple data collection and monitoring to complex data analytics.

One such IoT application platform that offers a wide variety of analysis, monitoring, and counter-action capabilities is “thingspeak.” ThingSpeak is a platform providing various services exclusively targeted for building IoT applications. It offers the capabilities of real-time data collection, visualizing the collected data in the form of charts, ability to create plugins and apps for collaborating with web services, social network, and other APIs. The core element of ThingSpeak is a “ThingSpeak Channel.” A channel stores the data that we send to ThingSpeak and comprises eight fields for storing data of any type - these can be used to store the data from a sensor or an embedded device.³ location fields - Can be used to store the latitude, longitude, and the elevation. These are very useful for tracking a moving device. 1 status field - A short message to describe the data stored in the channel. To use ThingSpeak, we need to sign up and create a channel.

Once we have a channel, we can send the data, allow ThingSpeak to process it and also retrieve the same. Let us start exploring ThingSpeak by signing up and setting up a channel. Open <https://thingspeak.com/> and click on the “Get Started Now” button on the center of the page, and we will be redirected to the sign-up page.

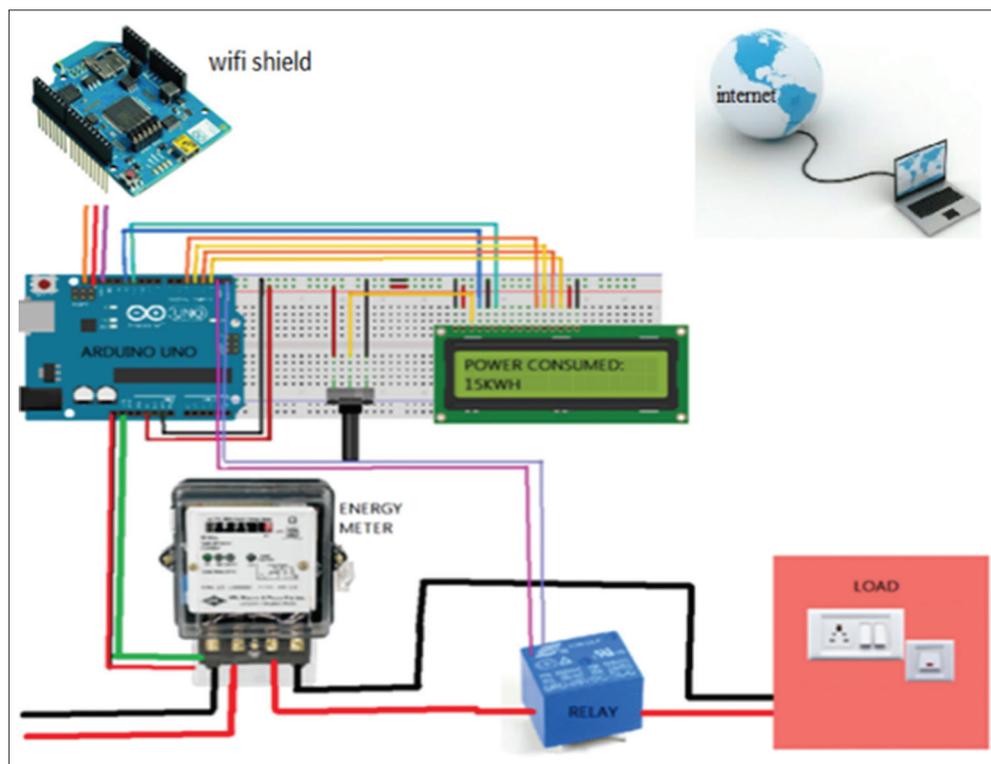


Fig. 9: Proposed model

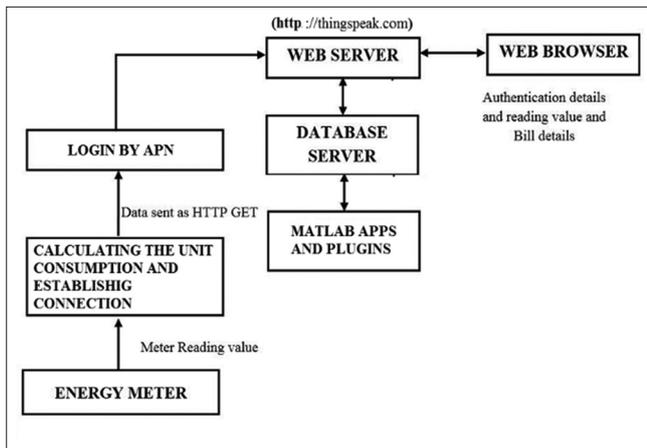


Fig. 10: Working flow of the circuit



Fig. 11: App window to turn on/off the relay

Fill out the required details and click on the "create account" button. Now we could see a page with a confirmation that the account was successfully created. The confirmation message disappears after a few seconds, and the final page should look as in the below screen: Go ahead and click on "new channel" to see a page as shown below: Here one can change the name to fit one's need and can add an explanation matching to the channel.

We can add any other useful description into the metadata field. In the same page, one should see the fields for latitude, longitude, and elevation. Let us consider the significance of the various fields and the tabs: Latitude, longitude, and elevation - These fields correspond to the location of a "thing" and are especially significant for moving things. If the channel is made public, anyone can view the channel's data feed and the corresponding charts. If this checkbox is not checked, the channel is private, which means for every read or write operation; the user has to pass a corresponding API key. URL - This can be the URL of your blog or website and if specified, will appear on the public view of the channel. Video ID - This is the ID corresponding to your YouTube or Video ID. If specified, the video appears on the public view of the channel. Fields 1-8 - These are the fields which correspond to the data sent by a sensor or a "thing."

A field has to be added before it can be used to store data. By default, Field 1 is added. In case try posting to fields that have not been added, your request will still be successful, but will not be able to see the field in the charts and the corresponding data. Once click the "add field" box, a default label name appears in the text box corresponding to each field and the "add field" text changes to "remove field." We can edit the field text that appears by default when a field is added to make more sense.

For example, in the below screen, I have modified the text for Field 2 to "Sensor Input." To remove a field which is added, just check on the "remove field" box. Once we click this, the text "remove field" changes back to "add field," and the corresponding field text is cleared. Once we have edited the fields, click on "Save Channel" button. One should now see a page like the below in which the "Private View" tab is defaulted: The Private View shows a chart corresponding to each of the fields that we have added. Now click on the "Public View" tab.

The write API key is used for sending data to the channel, and the read API key(s) is used to read the channel data. When we create a channel, by default, a write API key is generated. We generate read API keys by clicking the "Generate New Read API Key" button under this tab. We can also add a note supportive to each of the read API keys. Furthermore, in case your channel is private, others can only view the channel's feed and charts using a Read API key. Please share the Read API keys with people who are approved and authorized to view your channel [7-9].

Switching section

Relays

If the user does not pay his Electricity bill in time, the provider can disconnect the power supply from the EB office and reconnect the power once the bill is paid by the user. It is possible through the relay. A relay is an electrically operated switch. It is mainly used to isolate/control higher voltage circuits with lower voltage. The "controller" and "controlled" circuits are electrically isolated from each other. Since relays are switches, the terminology applied to switches is also applied to relays; a relay switches with one or more poles, each of whose contacts can be thrown by energizing the coil.

- Normally-open (NO): The circuit is disconnected, i.e., open when the relay is inactive.
- Normally-closed (NC): The circuit is connected, i.e., closed when the relay is inactive.

PROPOSED MODEL

Fig. 9 shows the model of the proposed system.

ARCHITECTURE FLOW DIAGRAM

RELAY DISCONNECTION

The image below shows the application window to turn on/turn off the relay on bill payment/failure to pay the bill in time by the officers, which directly affects the EB line of individual houses.

CONCLUSION

Live electric meter reading and billing system are successfully implemented using existing EEMs where Wi-Fi is used as the communication medium to get the values of the meter. It greatly reduces the manual work of the EB officer every month to go and notice down the individual house readings. The earlier versions have used SMS facility as the communication medium; however, the recent implementation uses Wi-Fi which reduces the cost of communication and enables frequent updates of the readings. The proposed system avoids electricity theft to a large extent and also makes the energy meter damage proof. This system also helps the users to be aware of their energy consumption. EB server uses PHP scripts to get the values from the energy meter and stores this information in the database. This information is available to authorized users of the system through open source IoT website thingspeak.com. It is also helpful in usage analysis using the applications of MatLab. It provides continuous monitoring; it may be useful for the study purpose of energy consumption for both the users as well the service providers over the internet.

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