A short overview of IoT based energy metering system

Part II IoT smart energy meters

O scurtă trecere în revistă a sistemului de contorizare a energiei electrice dotat cu internet

Partea II Contoare inteligente de energie electrică dotate cu internet

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Abstract
Saving energy is high on the agenda for consumers and businesses, but with most of the electrical devices today, it's difficult to know how much energy we are actually using at any given point in time [1]. Electrical energy meter is a meter which helps the consumers to know their day to day power consumption to better control their usage and producers to manage production, One of the main method of communication between utilities and customers is Internet of Things (IoT), which is a mobile technology, available all over the world. IoT technology is also ideally suitable for data transfer over an always on-line connection between a central location and mobile devices. Therefore in this paper we will present a short review about smart energy meters based on Internet of Things (IoT) applications.
Key words *, electricity, smart energy meter, Internet of Things (IoT), arduino*

Rezumat.
O problemă foarte importantâ atât pentru producătorii de energie electrică cât şi pentru consumatori o constituie economisirea de energie electrică. Având însă în vedere gama foarte variată de dispzitive şi aparate electrice existente astăzi pe piaţă este foarte dificil să se cunoască câtă energie electrică se consumă de fapt la un moment dat [1], Contorul de energie electrică este un contor care îi ajută pe consumatori să-şi cunoască mai bine consumul zilnic de energie electrică pentru a controla mai bine utilizarea energiei elctrice, iar producătorii de energie electrică cu ajutorul contoarelor de energie electrică pot realize o gestonare mai eficientă a producţiei de energie Una dintre cele mai moderne şi importante metode de comunicare între furnizorii de energie electrică şi clienţii lor este Internetul tuturor lucrurilor sau internetul obiectelor (IoT de la expresia din limba engleză Interner of Things), care este o tehnologie mobilă, disponibilă în întreaga lume. Tehnologia IoT este, de asemenea, ideală pentru transferul de date printr-o conexiune întotdeauna on-line între o locaţie centrală şi dispozitive mobile. Prin urmare, în această lucrare vom prezenta o scurtă trecere în tevistă a contoarelor inteligente de energie electrică care sunt prevăzute cu internetul obiectelor,
Cuvinte cheie *electricitate, cpntoare inteligente de enerhie electricăm Internetul obiectelor , arduino*

1 Introduction

Electricity is an important invention without which life on Earth is impossible. So obviously there is a need for measuring the consumed electricity. It is accomplished by the energy meters.

In earlier times utility's distribution and communication was only unidirectional. They generate and distribute electricity to customers. Using the traditional energy meters consumption was recorded and the monthly estimated bill was calculated by man power going door to door to each customers house which is time wasting coasty and inaccurate. Unlike this situation in the case of intelligent electricity distribution networks the communication between utilities and customers is bidirectional. By the implementation of smart meters consumers electricity consumption is recorded in real time and with bill estimation data is sent to the utility with out any need of human interface [2]

With the great developments in the field of Internet and technologies, everything has become digital. Internet has become an important part of our lives. A new technology has entered into this picture known as Internet of Things (IoT). Internet of Things is a network comprises of many electronic devices and sensors which are connected together to exchange some information over the web. The devices based on IoT seem talking and sharing data with each other

Smart meter is one of the applications of IoT It records the consumption and sends the readings to the utility office on regular basis for monitoring and billing [3]

The smart meter should have the following functionalities [3 - 4]:

1. Quantitative measurement namely meter should have the capability to measure the quantity of the medium using various methods and topologies.
2. Control and calibration i.e. meter should be able to compensate the small variations in the system.
3. Communication: meaning meter send and receive data effectively and has the ability to receive upgrades from firmware.
4. Power management i.e. in the case when power source is not properly available meter should be able to perform its task.
5. Display so that customer should be able to see the meter readings so that he/she can control electricity consumption as well as it will be helpful in billing or payment.
6. Synchronization: between the meter and the utility provider's system.

2 IoT Based Smart Energy Meters

IoT based smart power meter (see fig. 1) [3]. [5 -6].contains several parts, namely

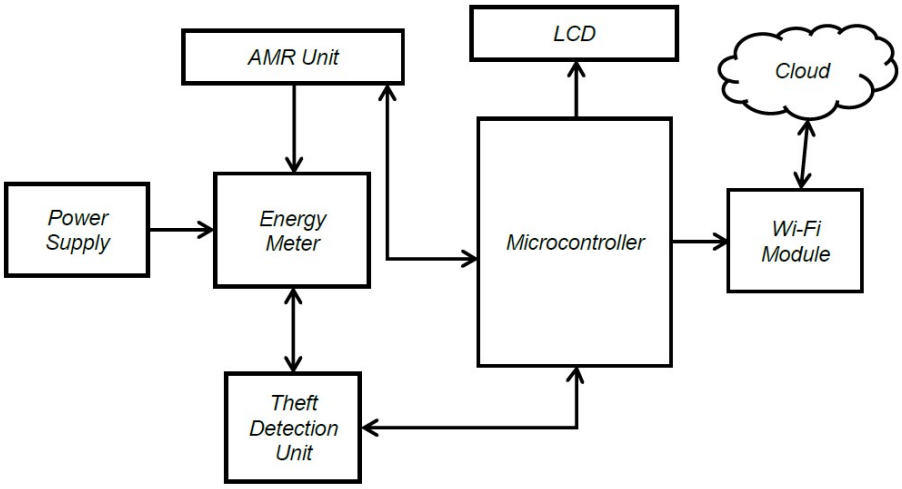

Fig. 1 Block diagram of IoT based energy meter [7]

1 *Main power supply*: The utility company's supply220V- 240V Ac (alternating current) which cannot be used directly.so we have to change it to DC (direct current) using a voltage transformer

2 *Energy Meter:* Energy meter used to measure the energy consumed by the customer is a digital meter because they are having high accuracy, with limited control and theft detection capability at nodes

3 *Electricity measurement circuit*: can be

a) *Hall element current sensor(IN4148 module)* In the measurement circuit, current is sensed based on the principle of Hall effect. [8-9]. According his principle, when a current carrying conductor is placed into a magnetic field, a voltage is generated across its edges perpendicular to the directions of both the current and the magnetic field. Let us not get too deep into the concept but, simply put we use a hall sensor to measure the magnetic field around a current carrying conductor. This measurement will be in terms of millivolts which we called as the hall-voltage. This measured hall-voltage is proportional to the current that was flowing through the conductor [10]. This sensor is chosen due to its low cost and easily interface with microcontroller. The current sensed from Hall effect sensor will be passed to the voltage sensor so as to be changed to direct current using the transformer in the voltage sensor

b) *CT current sensor* which is a type of instrumental transformer specially designed to transform alternating current in its secondary winding, and the amount of current produced is directly proportional to the current in the primary winding.

4 *Theft detection module* contain two CT current sensor, CT sensor 1 works as a main meter and CT sensor 2 works as a sub meter, both are connected to the Arduino using interfacing circuit. The interfacing circuit consists of burden resistor and voltage divider circuit for signal conditioning. During normal operation, the reading of CT sensor 1 should be equal to the reading of CT sensor 2. If the readings of both sensors are equal the message no theft will be displayed on LCD else it will displayed the theft is occur. If theft occurs the relay will operate and this can use for disconnecting the load [7]

5 *Transformers* is a static device which is used to power up or power down the electrical voltage without changing frequency. The transformation of electrical voltage is done with the help of mutual induction process. The frequency remains constant during the process [11]

6 *Microcontroller:* Measurement circuit is interfaced with the Arduino microcontroller - an open source microcontroller board based on the Microchip ATmega328P microcontroller.This microcontroller, which receives the measured data from sensor, using optocoupler (P817) to convert the pulses to electrical signals acting as clock pulses for the microcontrolle and send calculated data to Raspberry Pi. The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows. Arduino power measurement is an advanced method of determining power and this method is more advantageous than other software's such as MATLAB. Cross-platform. being also less in cost as compared to other controller. [10]. Arduino is energy efficient i.e. it consume less power, it is fastest and has two universal asynchronous receiver-transmitter (UARTS). The microcontroller is attached to our traditional energy meters that will scan the meter reading periodically [12]

7 *Relay* is an electrical device which is used to make or break contact. There are different types of relay such as Single Pole single Throw(SPST),Single Pole Double Throw(SPDT) and Double Pole Double Throw(DPDT).There are three contacts in the relay which are Normally Open(NO), Normally closed(NC) and No connection. It can be used for high power applications as well as low power applications. Relay controls the Arduino when the power in switched on and it is used to cutoff the power when overload detection and theft detection [11]

8 *Communication unit design*, can be:

a) *Wi-Fi module* [2] In order to create wireless communication between the device and customers WIFI module (ESP8266) or in other words Wireless Fidelity module is used since its low cost standalone wireless transceiver that can be used for end-point IoT developments. Wi-Fi module acts as heart for IoT. Through Wi-Fi the consumer can set changes in threshold value, he can ON and OFF the energy meter. Time to time the readings of units and cost are displayed on webpage. Consumer can accesses the Arduino board and meter with help of Wi-Fi ESP8266WIFImodule uses TCP/UDP communication protocol in order to communicate the microcontrollers data with client or server. The power calculated by the Arduino including time stamp will be transmitted to cloud server using this Wi-Fi module

b) *GSM/GPRS Module (SIM800C)* [12-13]**:** can accept any GSM network act as SIM card and just like a mobile phone with its own unique phone number. This module will enable the remote access through the internet, SMS and call facility Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications.

GSM is the Global System for Mobile Communication is a digital network that is widely used by the people in the world. The GSM uses the TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access) variations. The mobile devices will be connected using hardware and identifies through the Subscriber Identity Module (SIM). Through these connections the mobile phones can accessed.

9 *IoT Module* Internet of Things (IoT) is the main method of communication between the energy meter and the web server. IoT, being mobile technology, is available all over the world. In IoT everything is configured with internet protocol addresses [14] and it can monitor controlled and access remotely in accordance with web technology.

The main advantage of this technology is that devices are connected smartly with the help of sensors and transducers and these are again connected to (Local area Network) LAN, (Wide Area Network) WAN, via Ethernet or Wi-Fi connectivity [15]

In the IoT part is used an open data platform called Smart Living Make and ThingSpeak which Send Realtime data to the cloud for storage, analyze and visualize the data. Users can also control the meter using mobile application

Thing Speak is an open source platform for Internet of Things (IoT) application and Access Point Index (API) which stores and retrieves data from things by the HTTP and MQTT protocol [16]

10 *LCD Display* Liquid Crystal Display or 16X2 LCD module which comes with 4-bit data and 3-bit control pins is connected with microcontroller to show the consumed units and cost. At the end of each month the data containing the consumed units and cost is shared using internet shield web interfaced data are received and stored in a database at the premises of service. The LCD Contrast can be varied with the potentiometer provided on board [10], [17].

3 Conclusions and future enhancement

Benefits of IoT smart energy meter over traditional electromechanical meters are the following [3], [19]:

1. Smart meters are less error prone. Accurate readings are obtained by the customers and utility providers.
2. Readings can be sent remotely over the web to the utility providers. Employees need not to be physically present at the site.
3. Tampering of these meters can be easily detected by the authorities.
4. Smart meters when programmed with home appliances can be used to control the electricity consumption
5. Intelligent energy meter is easy to install and beneficial for both energy provider and consumer plus its cost effective and energy efficient. [2]
6. One of the main advantages of the smart meter installation is the link to a reduction in carbon emissions [19].

Limitations of smart energy meter are the following [20]:

1. Security to protect the privacy of the personal data collected should be good.
2. There can be an additional fee for the installation of the new meter.
3. The Internet is not available in remote areas.
4. The IOT is a diverse and complex network.

After loading and recording the load consumption of the residents, the data can be accessed and exported by the utility in various formats for further analysis such as:

- residential based load/demand forecasting
- customer behavior analysis (load profiling)
- bad data (electric theft) detection
- demand response program

The development of IoT based smart energy meter demonstrates the concept and implementation of new power metering system (see Part III of this paper) which is a flexible system, has low operating costs and less man power is required. This system is well suited for smart cities [10]

This IoT based energy meter use to access meter reading and bill amount by the use of web server and help consumer to avoid unwanted use of electricity as well as to detect any kind of theft of electricity [18]

Following are the future scope in order to save electric power and to detect theft [18]:-

- there can be a system where Automatic Switching of electric equipments by the use of IoT is applied.
- to make a system where user can receive SMS, if one crosses threshold of electricity usage.
- to make a IoT system where user can monitor energy consumption and pay electricity bill online
- user receives SMS when theft detected at consumer end.
- application of IoT based theft detection buzzer with Energy Meter

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