RESEARCH ARTICLE

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Development of IoT Based Smart Solution for Real-Time Monitoring of Residential Energy Consumption with SMS Alert Notification Through IFTTT

Pankaj B Thote[1*], Afsar Khan[2], Mohammad Ashar[3], Akshay Deshmukh[4]

[1,*] Deptt. of Electrical Engineering, S.B Jain Institute of Technology & Research, Nagpur, India; e-mail: thote.pankaj@gmail.com

[2-4.] Deptt. of Electrical Engineering, S.B Jain Institute of Technology & Research, Nagpur, India.

ABSTRACT

Today's world witnessing the Internet of Things (IoT) based system as a very popular technique to access the data and information in real time for industrial, commercial and domestic applications. The developed system is a cost effective solution to monitor real time residential energy consumption through IoT and to provide an alert notification through an SMS on consumers mobile phone using IFTTT (If This Then That) platform. In this system the real time energy consumption information is sent to web server with the help of microcontroller and ESP8266 Wi-Fi module ATmega16. The microcontroller ATmega16 and ESP8266 Wi-Fi module are the notable and economical devices. There is no need of human engagement in the complete process which makes it an error free solution. The use of IFTTT platform for alert notification through SMS does not require extra hardware module like GSM.

Keywords: Energy meter, IoT, Opto-coupler, ESP 8266 Wi-Fi module, IFTTT, ATmega16 microcontroller.

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INTRODUCTION

In present scenario the power crisis is a major problem facing by the world. The control on wastage of residential power consumption may be one solution for this problem by developing a real time energy monitoring and control system. Though there is a rapid development in technology, human involvements in the work are being continued. The values from the older analog energy meter used during the old days are not accurate that causes error in electricity bill generation. This shortcoming had been taken care by the digital energy meter. In conventional metering and billing, someone from the Electricity Company is required to visit the settlements and take a photo of the meter for an energy reading.

In order for this procedure to be implemented, a minimum of an individual must be present in each of the relevant houses when the person coming from the electrical panel arrives. Therefore, consumers cannot deal with their private affairs in line with their needs, because it is not known when the person comes from the Electric panel. It also does not provide privacy as an unknown person enters our home for meter reading. Due to wireless

Corresponding Author : Pankaj B Thote, Deptt. of Electrical Engineering, S. B. Jain Institute of Technology, Management & Research, Nagpur, India; e-mail: thote.pankaj@gmail.com

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fidelity and the wireless communication environment the communication between wireless devices became more faster. In the present-day world mismanagement of electrical energy is a widespread problem. Development of an efficient energy monitoring system will help in overcoming this defect in the distribution of electricity. Hence, the authors have developed an IoT based smart solution for real-time monitoring of residential energy consumption with SMS alert notification via IFTTT to contribute in this regard. In the developed system real time energy consumption data is transferred to web server using ESP 8266 and ATmega16 microcontroller. The ESP8266 is an economical Wi-Fi module interfaced with microcontroller provides Wi-Fi connectivity. It is one of the leading platforms for IoT (Internet of Things). Since there is no human involvement in the whole process, there is no possibility of manual error.

In the last few years, due to advances in modern technology, computerized electricity billing and internet payments have become easier. However, the energy meter is still checked manually that requires a large workforce. Furthermore, incorrect valuation leads to a large loss of revenue. [1] Automated Meter Reading (AMR) technology combines automatic consumption assessment, analysis of the evaluated data for billing and payment. [2] An Automated Meter Reading (AMR) is achieved by assigning each energy meter an IP address that comes under the technology called internet of things (IoT). An Automatic Meter Reading (AMR) Using Radio Frequency (RF) Module was implemented in [3]. In [4], the authors have designed and implemented a system to track energy meter reading with the help of current transformer (CT) and a Wi-Fi module. The real-time energy monitoring system using IoT is developed with telegram messenger integration [5]. The ubidots cloud storage are being used for real time and continuous monitoring of data [6, 7].

THE SYSTEM DEVELOPMENT

In this section the block diagram and operation of the developed system is explained along with the components and hardware employed in the system development.

System Block Diagram

The block diagram of the developed is shown in Figure 1 which includes the following mentioned parts:

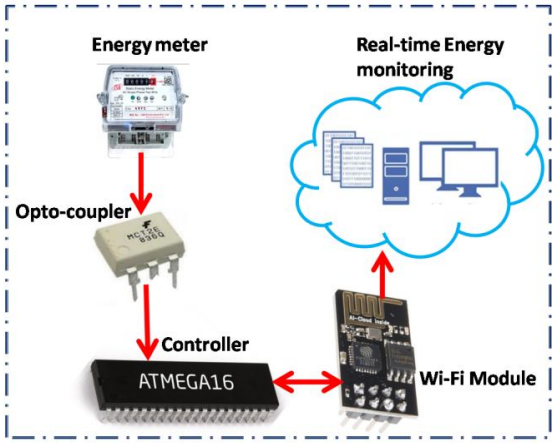

Figure1: Building Blocks of The Proposed System

Hardware at Customer Residential : It consists of customer's existing energy meter, opto-coupler (MCT2E) and the developed IoT board consisting of microcontroller ATmega16 and ESP8266 Wi-Fi module as main component. The opto-coupler is connected with blinking LED of energy meter to count the unit consumption. Whenever the energy LED blinks the microcontroller gets interrupted by opto-coupler (MCT2E) and start calculating the energy consumption. With the help of internet connectivity through Wi-Fi the communication between microcontroller and ESP8266 is established and the information regarding energy usage is transmitted to the Thingspeak web server.

User Interface: The Thingspeak web server and Thingspeak-IoT Smartphone application along with IFTTT web server is used to monitor and send the message alert about the energy consumption. There are lots of developed systems for sending SMS alert, which require extra hardware like GSM module. The developed system uses IFTTT (If This Then That) web server. IFTTT (If This Then That) provides services in which the user can program a response to the events. The IFTTT service provides an SMS alert on mobile phones without any extra hardware like GSM module. Figure 2 shows the IFTTT interface.

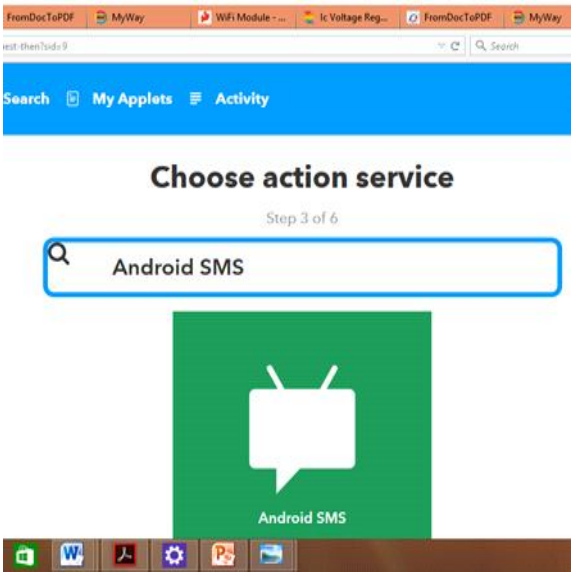

Figure 2: IFTTT an online messaging service

The System Work Flow

The system work flow process is explained in this section.

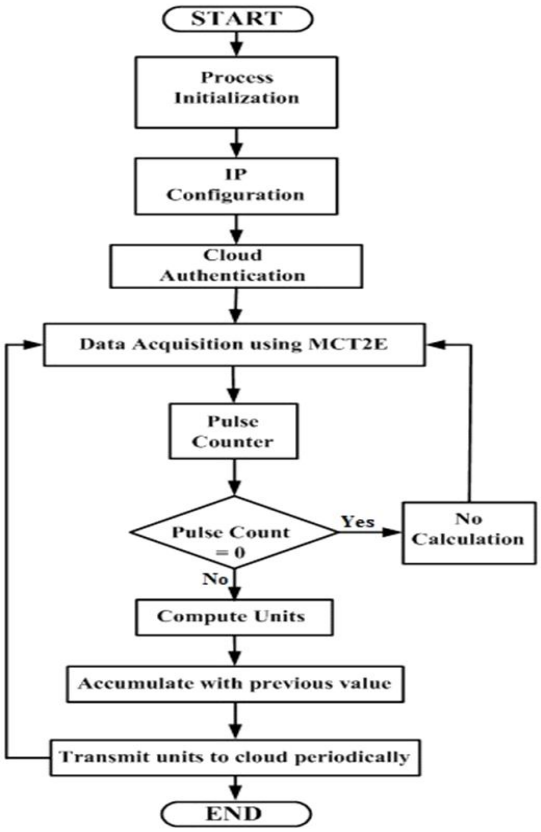

Figure 3: System work flow chart

The system work flow chart is shown in figure 3. Once the developed IoT board is powered, the process gets initialized. It then connects to Wi-Fi with the configured SSID and password. Upon successful configuration and authentication the data acquisition process begins. The blinking of the LED on the energy meter is converted into a voltage signal by means of an optical sensor MCT2E. The output of the opto-coupler sensor is connected to the interrupt pin of microcontroller. Whenever there is power consumption, the LED gives a flicker that is felt with an opto-coupler and generates a voltage signal to interrupt the microcontroller. After being interrupted by an opto-coupler, the microcontroller calculates power consumption by performing interrupt service routine (ISR). The calculated units are grouped with the previous unit in the cloud and the process is then repeated.

Development Board/ Hardware Setup

The developed IoT board is shown in Figure 4. It consists of Microcontroller ATmega16 and ESP8266 Wi-Fi modules as key components. The board is configured and turned on with a 5 V adapter. The opto-couper sensor (MCT2E) is then powered from the ATmega16 Microcontroller. The opto-coupler (MCT2E) is connected to the blinking LED of energy meter converts the blinking into voltage signal and this signal is then given to the interrupt pin of Microcontroller ATmega16. The components used in the development board are discussed below. By analyzing the output of the system, the consumer's base, average and peak usage can be found. With the help of the real-time data available, the peak consumption time can also be determined.

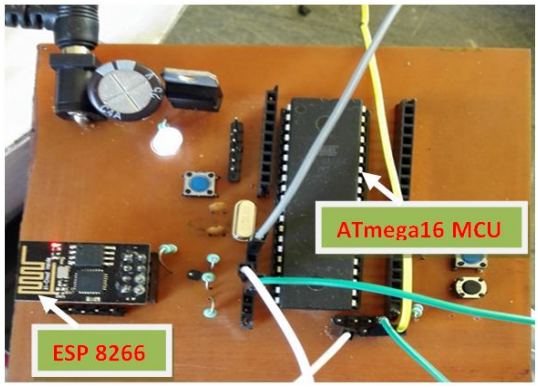

Figure 4: Developed IoT Board

Optical Sensor (Opto-coupler) : The optocoupler is an important component in electrical and electronics based systems and here it is MCT2E used in the developed system that is a hugely popular optocoupler available. The MCT2E optocoupler has an infrared light emitting diode (IRLED) that optically controls a phototransistor. The forward voltage of the diode is typically 1.25 V at 20 mA of forward current. It is packaged in a 6-pin DIP package. The Figure 5 is the optocoupler MCT2E.

Figure 5: Opto-coupler IC MCT2E

Controller ATmega16 MCU : The ATmega16 is an 8-bit high performance, low power microcontroller from the Atmel's Mega AVR family. It is a 40 pin Dual Inline Package (DIP) advanced Reduced Instruction Set Computing (RISC) architecture which supports 131 powerful instructions. It has up to 16 million instructions per second (16 MIPS) throughput at 16 MHz. The ATmega16 microcontroller has a 16 KB programmable non-volatile storage, static RAM of 1 KB and EEPROM of 512 Bytes.

The Wi-Fi Module ESP 8266 : The Wi-Fi module ESP8266 is an economical microchip, with a full TCP/IP stack and microcontroller capabilities. The microcontroller can connect to Wi-Fi networks and facilitate TCP / IP connection using ESP8266. The features of ESP 8266 is shown in Table.1

Table-1: Features of ESP 8266

Sr. No.	*Features*
1.	It has a 32-bit low power CPU with 80MHz frequency
2.	It has 64 KB instruction RAM and 96 KB data RAM
3.	Integrated RF parts and WPA 2 authentication, IEEE 802.11 b/g/n WiFi
4.	4 MB of Flash memory
5.	Cost is below INR 300

RESULTS AND DISCUSSION

A small modification in the already installed energy meters at the residential can change the existing meters into smart meters. The LED blinks 3200 times for 1 unit which is to be counted for energy meter reading. To calculate the blinks, the opto-coupler MCT2E is interfaced with controller (ATmega16) and it is programmed accordingly. By obtaining the blinking count the energy consumed is calculated in units. ATmega16 is programmed in BASCOM AVR. The obtained data is sent to Thingspeak web server with the help of ESP8266 Wi-Fi module and ATmega16 microcontroller. The energy consumption data is continuously transmitted to web application, so that it will always be available 24/7, 365 days. Human involvement is not required.

The novelty of the developed system is that it is very cost effective solution and use of IFTTT provides a feature of energy consumption notification through SMS on consumer's mobile phone without any extra hardware like GSM.

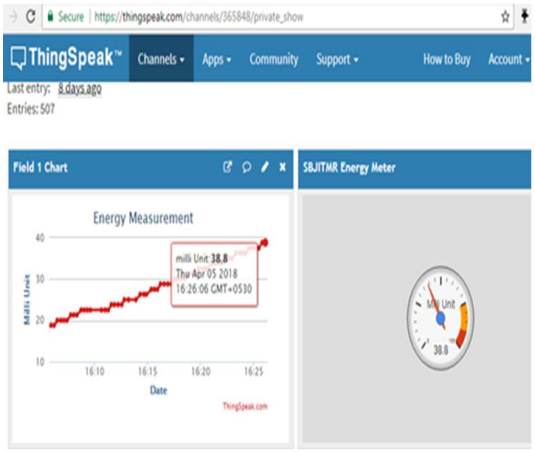

Figure 6: Energy consumption reading at different instant on ThingSpeak website

The Figure 6 shows Energy consumption reading at different instant on ThingSpeak Website.

Figure 7 shows Energy consumption reading at different instant on Smartphone using ThingSpeak Application.

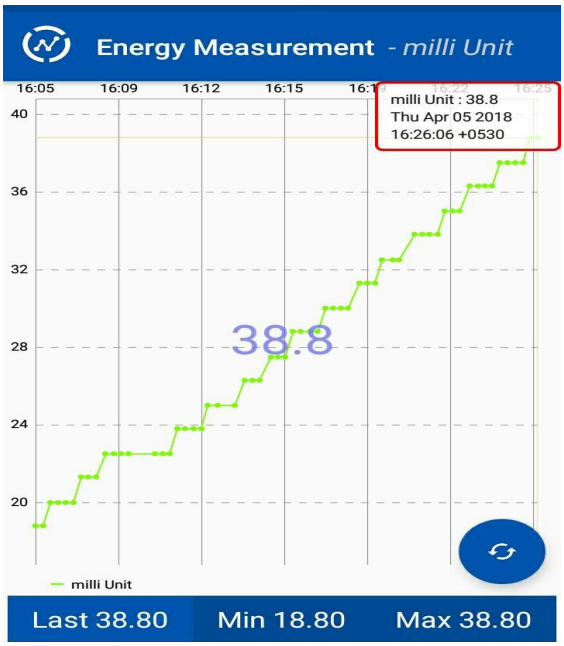

Figure 7: Energy measurement at different instant on mobile application

The Figure 8 shows Notification of slab of exceeded electricity tariff through SMS via IFTTT.

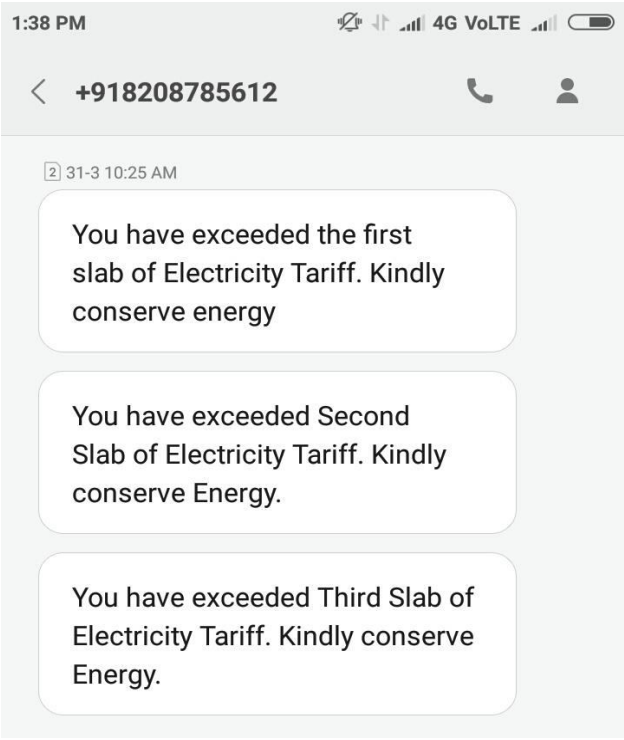

Figure 8: Notification of slab of exceeded electricity tariff through SMS via IFTTT

CONCLUSION

The developed system uses new IoT technology for real-time residential energy monitoring. This system provides real-time and ubiquitous monitoring of energy consumption. The following main points are drawn from this work:

1. Most developed systems use a GSM module for SMS alerting, which requires extra hardware and more cost. The developed system uses IFTTT (If This Then That) a free web server for SMS alert on mobile, which does not require additional hardware.
2. It reduces the demand of the workforce in evaluating energy measurements and also the errors caused by them.
3. It provides the cost effective light weight solution for real-time energy consumption monitoring with interactive and user-friendly platform to the customers.

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