

# IMPROVED GSM-BASED SMART ENERGY METER WITH ARDUINO UNO

**Dr. P. Hemachandu,**

Professor, Dept of EEE Sasi Institute of Technology & Engineering, Tadepalligudem.

**B.Hemanth, L.Vamsi, Y.Lokesh, P.siva prasad, M.udaykumar, K.ajay babu**

Student members, Dept of EEE, Sasi Institute of Technology & Engineering, Tadepalligudem.

## ABSTRACT

This paper proposed and demonstrated Smart Energy Meter that the users will be able to monitor their current power consumptions (bill) anytime from anywhere by using their mobile phone via Short Message Services (SMS). It would be a huge beneficial for the customers if they can monitor their energy meter's power consumptions (bill) on a real-time basis. Arduino UNO, main controller, was the interface between energy meter and Global System for Mobile communication (GSM) module. GSM module connect the energy meter to users' mobile phone. Real Time Clock (RTC) DS1307 was used to get the real time to count and store the usage into the EEPROM. The program developed in C language with the Arduino syntax in the Arduino IDE. The proposed system demonstrated its capability to check the current usage (bill), notify when reaching the limit, reset the usage (bill) successfully, only via accessing GSM-based mobile phone.

## INTRODUCTION

Smart electrical energy meter technologies have been investigated and developed for approximately 10 years. Various technologies have been developed and used to measure the electrical consumptions. For the billing, the users will get the bill from the energy board after they generated and provided using the several methods. At the moment, most of the residences in Malaysia for example use the traditional electro - mechanical watt meters and the readings are not automated. The users will have to wait the bill of energy consumptions for every month to pay their energy bill. Normally, at the end of the month, a staff from the meter board billing will visit every house to read the meter reading and at the same time, give the bill to the users. An electricity meter or energy meter is a device that measures the amount of electric energy consumed to residence or business. There are two types of Domestic Ordinary Power Consumers meters single phase and three phases. The energy consumption is measured by all electrical services using kilowatt- hours meter with refer to kilowatt-hours (kWh) [1].

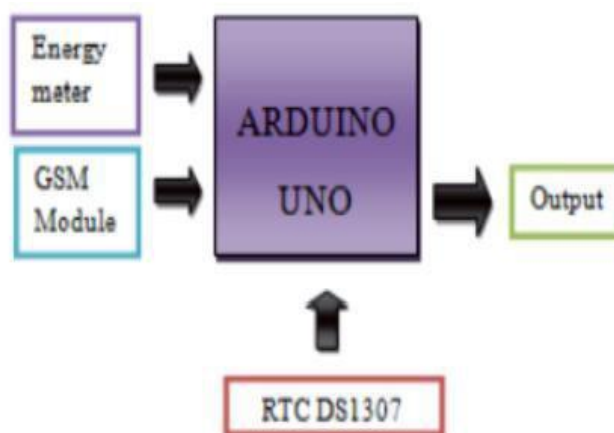


Figure 1: Block Diagram of the System

Then electronic meters was introduced with similar function with the electromechanical, but it replaces from analog to digital system. With this system users can note down the voltage, power reading unit, current and the time, date of the energy consumption. This system just gives some advantages over the previous meter reading. After the electronic ones, the meter reading developed with the Bluetooth based technology which is the wireless communication and also known as Automatic Meter Reading (AMR). This system is wireless and the personal computer could be used to record the power consumption of energy meter. The reading meter will be saved to the database and bill will be generated. The latest technology is using a Global System for Mobile Communication (GSM) based system. This system replace the Bluetooth technology and the data sent using Short Message Service (SMS) to the customer and the energy board [1]. In Malaysia, the energy provider is Tenaga Nasional Berhad (TNB). Mostly, TNB uses electronic meter as meter energy. Electronic meters are identifiable through the LCD display panels. Whilst electromechanical meters are still in use, TNB is gradually phasing them out through replacement programs. All TNB energy meters installed at the premises have been calibrated and tested in accordance with Malaysian Standards ISO/IEC 17025: 2005.

## **PROPOSED SYSTEM CONFIGURATION**

The System consists of hardware and software part. Figure 1, the hardware parts, shows the block diagram of energy meter project that the users can monitor their home current power consumptions anytime and anywhere. As for the software part, all the program located in Arduino UNO, using C language. Arduino UNO, as the main controller, connect energy meter, GSM module, and other sensors/peripherals so they can communicate each other. And Arduino UNO can only work after we uploaded the designed program into it. According to [2], Automatic Meter Reading system (AMR) continuously monitors the energy meter and sends data on request of the service provider through SMS. It saves huge human labor. The data received from an energy meter has been stored in database server, which was located at the electricity Board station through an SMS gateway for further processing by the energy provider. Automatic meter reading system helps the customer and energy service provider to access the accurate and updated data from the energy meter. AMR System can send energy consumption in hourly, monthly or on request. This data is sent to a central system for billing and troubleshooting. These data are stored into the database server for processing and recording. This technology mitigates labor cost, collection time, energy theft, avoids late payment. Adding to this it increases data security, improved customer service, reduced revenue losses. This system provides freedom for electricity companies to take action against lenient customers who have outstanding dues, otherwise companies can disconnect the power of customer [3]. The energy meter that chosen and suitable for this project is single phase meter from Smart Meter Technology Sdn. Bhd because it has a clear blinking LED indicator for 1Wh pulse and also have direct pulse output connection that compatible to the Arduino. To make sure the pulse taken accurately, the output pulse from LED blinking is more suitable. This meter use 240V AC current and count 1Wh per pulse. As prototype to count the pulse, the 2 units of lamps 100W and 25W was connected to this meter as shown in Figure 2.



Figure 2: Energy meter with loads of 2 lamps

In figure 2 shows the box covered the circuit, only Energy meter and LCD can be seen from the outside. The material for the box is plastic PVC with A4 size and cover with stickers wallpaper. The socket was implementing as a switch between load and the energy meter. So that, 2 lamp can be used as the load. Each lamp can give load for 100W for 1 hours. The LCD display had been place at the top side of the meter while beside the LCD, the LED indicator will blink when counting 1 pulse. The sensor was placed close to the LED at the Energy Meter to catch the blinking when 1 pulse. This prototype might be different to the real product in the future. It must be well arranged without the socket close to the Energy meter and the box should be built with the proper material such as wood or perspex transparent. As for GSM, It is the second generation digital cellular system. Digital transmission was used rather than analog transmission in order to improve transmission quality, system capacity, and coverage area. GSM works on three frequencies 900 MHz, 1800 MHz and 1900 MHz. To make efficient use of frequency bands GSM networks uses combination of FDMA (frequency division multiple access) and TDMA (time division multiple access) [4]. GSM operators have set up roaming agreement with foreign operator which help users to travel abroad and use their cell phones. GSM module was used for receiving SMS from users mobile phone that automatically enable the controller to take further action like switching ON and OFF electrical applications such as fan, air - conditioner, light and other [5]. The system was integrated with microcontroller and GSM network interface using arduino or other microcontroller and software was utilized to accomplish the integration. In this project, GSM module SIM900 is chosen to use. The SIM900 is a complete Quadband GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industrystandard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. [6] define that, GSM module which contain of SIM card and subscription with mobile operator will operate like a mobile phone. The GSM module must be connected to Arduino with TX and RX to pin 2 and 3 respectively. When switch 'ON' the module, the blue LED will be 'ON' and after push the Button Key the red LED will be blinking. That shows the GSM in good condition, but we cannot define the line connected or not until we program the Arduino to test the GSM module. There are other technologies beside GSM that can act as interface between the energy meters to the users, so that the users can monitor the current usage of their power consumptions. Technologies like Bluetooth and ZigBee are the some of the them. ZigBee is a radio frequency (RF) communications standard based on IEEE 802.15.4. ZigBee is a new wireless communication technology, representing a wireless sensor network which is highly reliable, secure, low data rate, low power consumption, low cost and fast reaction. The Zigbee coordinator is responsible for creating and maintaining the network. All communication between devices propogates through the coordinator to the destination device. The wireless nature of ZigBee helps overcome the intrusive installation problem with the existing systems identified earlier. The ZigBee standard theoretically provides 250kbps data rate, and as 40kbps can meet the requirements

of most control systems, it is sufficient for controlling the system. The low installation and running cost offered by ZigBee helps tackle the expensive and complex architecture problems with existing systems, as identified earlier [7]. According to [8], Zigbee enables broad-based deployment of wireless networks with low-cost, low-power solutions. It provides the ability to run for years on inexpensive batteries for a host of monitoring and control applications. Smart energy/smart grid, AMR (Automatic Meter Reading), lighting controls, building automation systems, tank monitoring, HVAC control, medical devices and fleet applications are just some of the many spaces where zigbee technology is making significant advancements. But the limitation of ZigBee against GSM is the coverage or distance area. Unlike ZigBee that has distance limitation up to hundred metres, we can find or get GSM signal in almost everywhere. This is the main consideration why we use GSM instead of ZigBee technology. So that the users can monitor their home power consumption from anywhere as long as they have cellular (GSM) signal in their mobile phones. Different frequencies have different characteristics, low frequency tend to have better penetration of particular materials compare to high ones, with the assumption of using same power. Experiment conducted in [9] showed the microwave capability of penetrating material of water to measure moisture content.

## CONCLUSION

This article proposed new approach of energy meter monitoring system by using Arduino UNO as microcontroller and GSM module as interface with the users in the purpose of the flexibility of the customers to monitor their current bill or power consumptions usage from anywhere with their mobile phones. The results showed that the system works successfully. Future research is controlling the energy meter, meaning instead of just monitoring the meter, usage, power consumption, controlling them will be one step further, so that the users can even control their bill, usage, power consumptions by themselves remotely from their mobile phones.

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