Automated Prepaid Electricity Meter using Arduino and GSM module

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Abstract

This paper proposed and demonstrated pre-paid 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 connects 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.

Keywords: *Energy meter, Global System for Mobile Communication (GSM), Arduino UNO, Liquid Crystal Display (LCD) and Relay.*

I. 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].

Then electronic meters were introduced with similar function with the electro-mechanical, 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 National 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.

II. EXISTING SYSTEM

Conventional Method

Conventional System "Energy meters displays kilowatt/hour by continuously measuring the instantaneous voltage (volts) and current (amperes) to give energy used in

joules"". [2] The primary type of electricity meter is the electromechanical induction meter and an electronic meter. In electromechanical induction meter, the total number of rotation of the aluminum disc is directly proportional to the power consumed. "Traditionally, the electricity meters are installed on consumer"s premises and the consumption information is collected by meter-readers on their fortnightly or monthly visits to the premises."[2].By seeing their electricity bill, then only the consumer knows how much amount of power they consumed and how much amount of rupees they have to pay.

Drawbacks

- Highly depends on meter reader.
- Human error cannot be avoided for the manual meter reading.
- Always there is no cross checking or recheck of human readers for energy utilization.
- High chance of stealing and bribery always high to misuse it especially during events.
- Wherever energy meter installed inside the house, which may lead to non-checking of reading due to lock.
- The consumer is not receiving updates of his regular usage of energy.
- The consumer may not receive his energy bill as per regular interval of the due date.

III. PROPOSED SYSTEM

In the proposed system we can able to recharge the electricity balance in advance. Even though digital meters are being replacing convectional electromechanical meters and provide much accurate readings, still the problem of deliberately making a false reading can exist. Despite this, the task of billing for the distribution grid. Also the consumer can deliberately consume more amount of power than required and still refrain from paying the bill and nothing can be done to serve the electric power supply. To eliminate all these problems, the most convenient method is making the whole system prepaid similar to a mobile phone recharge or a DTH recharge.

The power utility maintains a server and each consumer is provided an energy meter. The server and prepaid meters use GSM modem and GSM module respectively to communicate with each other using the GSM network. [3] The energy metering chip produces pulses proportional to the energy consumed using the outputs of current and potential transformers. The microcontroller calculates the energy consumption by counting the output pulses of the energy metering chip on an interrupt basis. The microcontroller uses AT command set to communicate with the GSM module (mobile phone).

IV. SYSTEM ARCHITECTURE

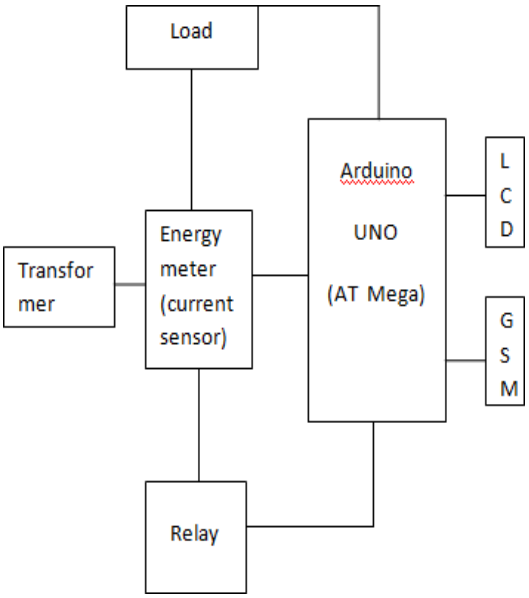

Fig.1

Block diagram of prepaid electricity energy meter

Basically like in a mobile phone recharging, the consumer pays an electricity balance in advance and gets some energy units in return of balance amount. From fig.1 the transformer transfers an electric energy to the load in between an energy meter is connected so the meter reads how much amount of energy is being consumed, when the power supply is in on condition that information is transferred to the arduino UNO and it is displayed on the LCD screen. The amount of energy left and amount of power consuming is countinuously displayed on display screen i.e. LCD.

Whenever the balance amount is low it sends an SMS through GSM i.e. low balance alert but the power supply will not be turned off. Whenever the balance amount is zero it sends an SMS to our mobile phone via GSM i.e. zero balance alert then the power supply is automatically turned off with the help of a relay switch.

V. HARDWARE IMPLEMENTATION

POWER SUPPLY

Fig.2 DC power supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. Typically, it converts one type of electrical power to another, but it may also convert a different form of energy such as solar, mechanical, or chemical - into electrical energy

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ARDUINO UNO

Fig.3 Arduino UNO

Arduino is standard term for a software company, project, and user community that designs and produce computer open-source hardware, open-source software, and microcontroller based kits for produce digital devices and interactive objects that can sense and monitor the physical devices. The board‟s features are serial communication interfaces, including universal serial bus (USB) on some designs, for loading programs from personal computers. For programming the microcontrollers, the Arduino project generates an integrated development environment (IDE) based on a programming language named processing, which also assist the languages C and C++.

A microcontroller is an integrated circuit that contains processor core, memory and programmable input and output peripherals. It also known as small computer that designed for embedded applications. On the other hand, the microcontroller incorporates all the features that founds in microprocessor. However, it has also added features to make a complete microcomputer system on its own. The microcontroller has built-in ROM, RAM parallel I/O, serial I/O, counters and clock circuit [4]. The project use Arduino UNO for the microcontroller, The host processor for the arduino UNO is the Atmel Atmega328. The „328‟ is the 28 bit microcontroller. The architecture is based on Reduced Instruction Set Computer concept which allows the processor to complete 20 million instructions per seconds operating at 20MHz contains three main memory sections SRAM, EEPROM and byte-addressable EEPROM for data storage [5].

ENERGY METER

Fig.4 energy meter

An **electricity meter**, **electric meter**, **electrical meter**, or **energy meter** is an electrical measuring device, which is used to record Electrical Energy Consumed over a specified period of time in terms of units. One unit equals one kWh (killo-Watt-hour) or 1000 Watt-hours. Energy meters are installed by electricity board at entry point of every electrical consumer (domestic as well as industrial / commercial). The energy meter has the aluminium disc whose rotation determines the power consumption of the load. Due to the interaction of eddy current and magnetic field it exerts a force on the magnetic disk. So disk starts roatating and energy is displayed.

GSM MODULE

Fig.5 GSM module

The SIM800A Quad-Band GSM/GPRS Module with RS232 Interface is a complete Quad-band GSM/GPRS solution in an LGA(Land grid array) type which can be embedded in the customer applications. SIM800A support Quad-band 850/900/1800/1900 MHz, it can transmit Voice, SMS and data information with low power consumption. To make efficient use of frequency bands GSM networks uses combination of FDMA and TDMA[6].

Featuring and Embedded AT, it allows total cost savings and fast time-to-market for customer applications. The SIM800A modem has a SIM800A GSM chip and RS232 interface while enables easy connection with the computer or laptop using the USB to the Serial connector or to the micro-controller using the RS232 to TTL converter. Once a serial connection is open through the computer or your micro-controller you can start sending the AT commands. When you send AT commands for example "AT\r" you should receive back a reply from the SIM800A modem saying "OK" or other response depending on the command sent.

RELAY

Fig.6 Relay

Relay is an electrically operated switch and that can able to open and close the circuit. If the relay is turned ON then the circuit is in closed condition then electricity is generated. If the relay is turned OFF then circuit is in open condition therefore the electricity will not generated in open loop condition then automatically power is turned OFF.

LCD

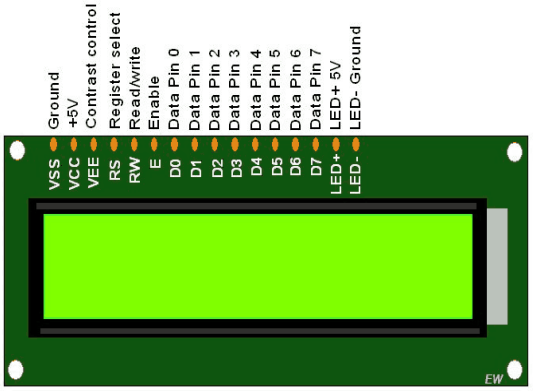

Fig.7 16x2 LCD

The system also added liquid crystal display (LCD), the display unit that used in this project is a 16 X 2 alphanumeric LCD which consist of 16 character and 2 line. It can act as the output display to show the bill, unit and GSM status on the meter.

VI. SOFTWARE REQUIREMENT

In prepaid electricity energy meter we are using ardunio UNO software. Their we write a code in Embedded C language which very easy to write and very easy to understand the program. From the below flow chart we can clearly understand the operation of prepaid electricity energy meter. Once when we recharge the electricity, the process gets start and the amount of energy is displayed on screen i.e. LCD. By consuming the energy the power and the balance amount will gradually reduces based on the consumption.

Whenever the power is greater than 30 rupees then it allows to display how much amount of balance is left. Whenever the power is less than 30 rupees then it sends an SMS via GSM i.e. low balance alert and again displays the balance left. During this process the power may not be changed it is in ON position only.

Whenever the power is less than 2 rupees then SMS will be sent to the users mobile phone i.e. zero balance alert then the power is turned OFF. If the power is greater than 2 rupees then amount left is displayed on the LCD screen power will not be turned OFF. Again when we recharge the process will be restarted. By seeing the below flow chart we can clearly understand the operation of prepaid

electricity energy meter.

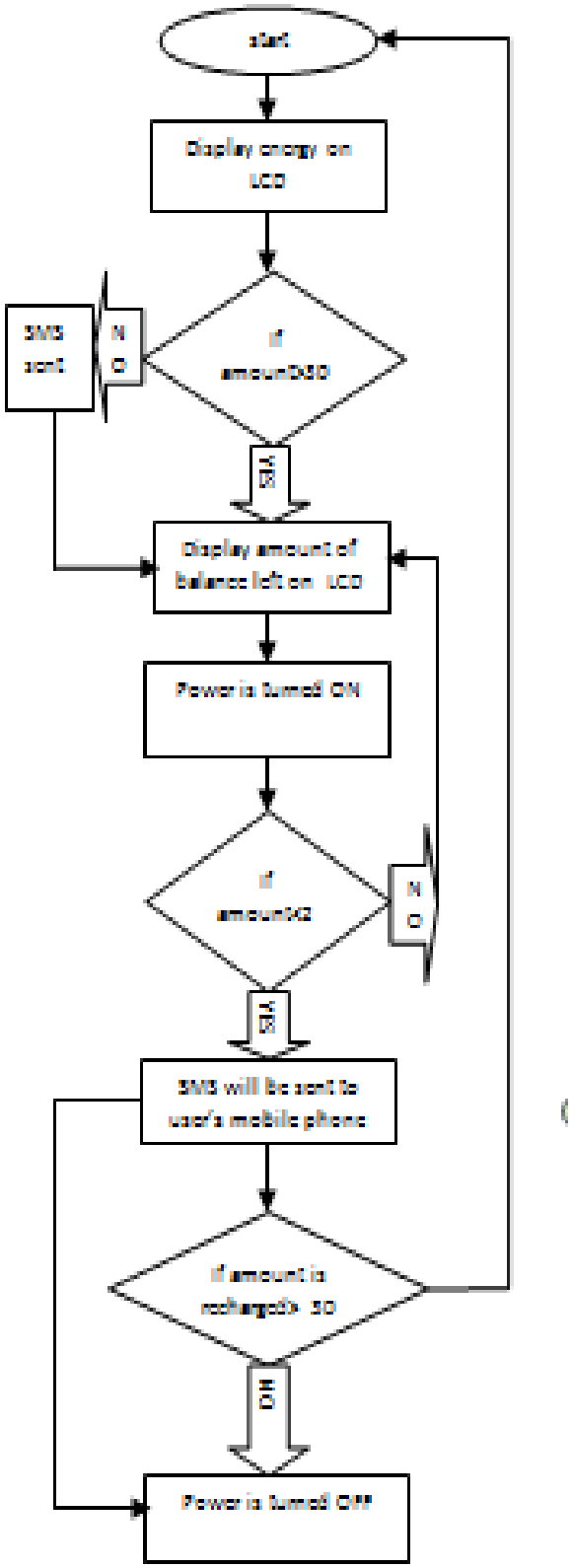

Fig.8 represents flowchart of prepaid electricity energy meter

VII. EXPERIMENTAL RESULTS

This prepaid electricity is combined with two parts and they are circuit for interfacing energy meter to arduino and interface from GSM module to Arduino. Circuit operation was in good condition with the right sequence of program that uploaded into microcontroller. Arduino with microcontroller ATmega238 was used to count the input, calculate the bill and store it into EEPROM.

The value of unit and bill price was display at the LCD display as set in the microcontroller. At the program, the number of mobile phone user was set to receive a message when it is recharged or when it reaches to low balance or zero balance. In GSM network, the network plan SIM card was used to transmit message to mobile phone. To combine this two part system, the GSM module Tx and Rx was connected to pin 2 and 3 respectively to Arduino and ground pin is connected between the modules.

The arduino A0 pin is connected to the energy meter and 13 pin is connected to the relay 5v power supply. LED+ pin is connected the 2 pin of arduino LED- is connected to the GND pin of the arduino. D7, D6, D5 pins of the LCD are connected to the 3, 4, 5 pins of the arduino for data transmission.

Fig.9 represents prepaid electricity energy meter before power su

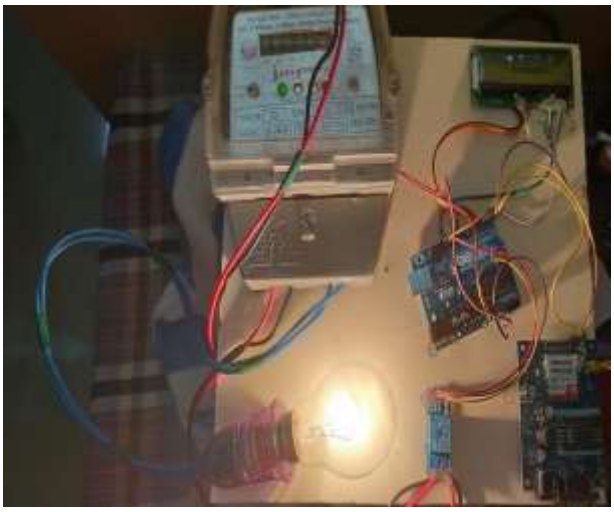

Fig.10 represents prepaid electricity energy meter after power supply

VIII. CONCLUSION AND FUTURE SCOPE

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.

REFERENCES

[1] Ashna, K. & George, S.N., "GSM based automatic energy meter reading system with instant billing", *Proceedings - IEEE International Multi Conference on Automation, Computing, Control, Communication and Compressed Sensing*, iMac4s, 2013, pp.65–71.

[2] Md. Masudur Rahman; Noor-E-Jannat; Mohd. Ohidul Islam; Md. Serazus Salakin, "Arduino and GSM Based Smart Energy Meter for Advanced Metering and Billing System" 2nd Int'l Conf. on Electrical Engineering and Information & Communication Technology (ICEEICT) Jahangimagar University, Dhaka-I 342, Bangladesh, 21-23 May 2015

[3] Nabil Mohammad ; Anomadarshi Barua ; Muhammad Abdullah Arafat 2013 International Conference on Power, Energy and Control (ICPEC)Year: 2013 | Conference Paper | Publisher: IEEE

[4] Pandya, V. & Shukla, D., "GSM Modem Based Data Acquisition System", *International Journal of Computational Engineering Research*, Vol. 2, No. 5, 2012, pp.1662–1667.

[5] Shahidi, S., Gaffar, M.A. & Salim, K.M., "Design and implementation of digital energy meter with data sending capability using GSM network", *Proceedings of 2013 2nd International Conference on Advances in Electrical Engineering, ICAEE*, 2013, pp.203– 206.

[6] Ghaderi, M and Boutaba, "Call Admission Control in Mobile Cellular Networks : A Comprehensive Survey", *Wireless Communications and Mobile Computing*, Vol. 6, No.1, 2006, pp 69-93

[7] De Capua, C. et al., "A smart energy meter for power grids", *Conference Record - IEEE Instrumentation and Measurement Technology Conference*, 2014, pp.878–883

[8] Dhananjayan, R. & Shanthi, E., "Smart Energy Meter with Instant Billing and Payment", 2014, pp.1397–1403.

[9] Jonnala, P. & Ieee, M., "Wireless Solution for Polyhouse Cultivation Using Embedded System", 2014, pp.21–25.

[10] Khan, J., "Handover management in GSM cellular system", *International Journal of Computer Applications*, Vol. 8, No. 12, 2010, pp.14–24.

[11] Kumar Sehgal, V. et al, "Electronic energy meter with instant billing", *Proceedings – UK Sim 4th European Modelling Symposium on Computer Modelling and Simulation, EMS*, 2010, pp.27–31.

[12] Lawan, S.M.E.A., "An Overview of Energy Sector and Wind Power Potential in Malaysia", *British Journal of Applied Science & Technology*, Vol. 4, No. 7, 2014, pp.1042–1059.

[13] Win Adiyansyah, Indra & Nurulhalim, Hassim, "Real-Time Microwave Moisture Measurement Of Nickel Ore In Conveyor Application", *Jurnal Teknologi,* Volume 78 No 6, June 2016, pp.111-115.

[14] Sheikh, J., https://www.academia.edu, [Online], Available:https://www.academia.edu/6839735/Android_Based_Electronic_Fare_Meter_System [24/05/2015].