A SMART ELECTRIC METER READING AND MONITORING SYSTEM USING EMBEDDED CONTROLLERS

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Abstract— **The rapidly changing technological development and pervasive usage of web enabled services, there is greater speculation among customers to look at reducing the manpower in electrical meter reading system. Few research efforts are made in the literature to automate the meter reading process, however the price of the system was not affordable to low power consumer. The reason is they used GSM based meter reading system. So there is a need of low cost smart electrical meter reading and monitoring system. Here a new smart electrical meter reading and monitoring system was proposed that reads and monitors the power reading and keep informing the power usage to the customers and electricity department through web associated interface. Live meter reading are read from the meter through arduino microcontroller and the Energy usage is monitored, analysed and stored in the Thingspeak server. Energy Usage and the Amount is displayed in a In Home Display installed in every home. Each Household is provided with a Login Id which can be accessed via a Smart Metering website(created especially for this purpose) , to acquire a knowledge on their Energy Consumption and think on Energy reduction measures if required. The Energy Usage and the Bill amount is periodically updated in the cloud. The officers at EB can retrieve the energy usage data and the amount of each users even as a spreadsheet for easy manipulation.**

Keywords—Smart Meter, Energy Usage, Rate, Website, Thingspeak Server, Cloud

I. INTRODUCTION

The traditional meter reading for electrical consumption is carried out by human operators by visiting the site in person. The man power and time required to accomplish the task increases linearly with the increase in area. Further human operator reading are prone to reading errors and sometimes the electrical meter in the house or building is placed in a location where it is not easily accessible. Also meter reading process affected by bad weather conditions. In addition to that additional cost associated with the meter reading process will be loaded over the consumers. With the increase in the development of residential housing and commercial building, accomplishing meter reading task with manual operator is a challenging task. This pushed the need to develop automated meter reading system. With the development in digital technology electromechanical meters are replaced by digital electronic meter. This offers greater convenience to implement Automated Meter Reading (AMR) system. The major challenges in AMR system are efficiency and reliability of retrieving meter reading. Various methods and technologies of AMR system are developed in [1] to [6] using RF module, Bluetooth. ZigBee and GSM, however they are expensive and requires complex interfacing structures. The proposed smart energy meter reading and monitoring system uses low cost microcontroller embedded with WiFi module reads the power continuously and update the values in the central data base through web associated interface.

II. LITERATURE SURVEY

Electric meters is the device that used for creating the billing charges, that billing charges are on a month basis & that is computed in terms of kilowatt hours (kWh).Automatic meter reading (AMR) it is the creation or new invention of automatic collect information of energy meter. After that the collected information is send to base station for other analysis. The main aim is not to reduce manpower its main aim is to collect data from different and difficult places which is not possible or difficult to collect from the premises or from any other places.

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A small light weight Web server designed on Raspberry pi board, which will make the system to work much faster and based on IoT technology the data will be uploaded to the Internet via Ethernet protocol, which is much faster communication protocol then Modbus.

Existing System used a complex approach in order to gather data and upload to webpage using MySQL database and external web server, Modbus, which are very heavy for the SBC type Board and also no front GUI system was designed for day to day monitoring.

System enables the Electricity Department to read the meter readings regularly without the person visiting each house. It sends meter reading to the consumer & Service provider through SMS using a GSM Modem. A RASPBERRY-Pi unit continuously monitors and records the Energy Meter readings in its permanent (non-volatile) memory location.Raspberry Pi board is used as the Central Unit of this Project. Energy measuring circuit is connected to Raspberry Pi Board. In this system a unique Id number is given for every energy meter. This ID number is interlinked to SIM card service number of the user & service provider. This system continuously monitors the energy consumption and sends weekly SMS to the service provider and the user. The meter reading is stored in database of Raspberry Pi board.

Electronic Meter Reading units are used for calculating electricity bill and this electricity bill sent to client residence by post.Client goes to electricity office for paying their bill. The mechanism of causing the electricity bills to client area terribly punishing and incommodious.AMR annihilate all the disadvantages of typical reading system.This system could be a subtle method that permits corporations to gather the meter reading while not going to positioning.AMR embrace varied technology for knowledge assortment like ZIGBEE technology,RF Methods,Power line communication and GSM networks.

III. PROBLEM IDENTIFICATION

With smart metering initiatives gaining increasing global popularity, the system seeks to challenge the increasingly entrenched view that providing householders with feedback about their energy usage, via an in-lcd-display, will lead them to substantially reduce their energy consumption. Specifically, draw on existing quantitative and qualitative evidence to outline key problems with feedback: (a) the limited evidence of efficacy, (b) the need for user engagement, and (c) the potential for unintended consequences. And thereby conclude nothing that, in their current form, existing in-lcd-displays may not induce the desired energy-reduction response anticipated by smart metering initiatives.

If a system provides High Data accuracy , it inturn increases the processing time[6].When the system becomes complex it requires High cost to be implemented and leads to data inaccuracy. As platforms were larger in size ,they were unsuitable for real time applications[9]. Some systems includes separate calculation, Transmission rate is low and leads to high data inaccuracy[10].In certain existing systems, Message were sent to the customers and requires manual work as the datas were not stored in the server [12].Existing Systems used a complex approach in order to collect data and upload to webpage using MySQL database and external web server, Modbus, which are very heavy for the SBC type Board and also no front GUI system was designed for day to day monitoring.

Instead, if the proposed system for smart metering effectively reduces energy consumption where there is a clear need to develop and test innovative new feedback devices that have been designed with user engagement in mind.

IV. PROPOSED METHODOLOGY

Smart energy meters can be used with home energy management systems such as Web-based tools that utility provides or devices that can be installed in the home. Smart meters can display the home energy use, helps find ways to save energy and money, and even allows to remotely adjust the thermostat or turn appliances off. The proposed system consists of both hardware and software.The proposed system incorporates Energy Meter, Arduino, Pulse Monitoring circuit and a LCD. And this system reads the energy meter readings and automatically updates the Units consumed by the customer periodically, so that the householders receives the feedback about their energy usage.

Figure 1 illustrates the Overall blockdiagram of the proposed system. The softwares required are Python IDLE, PHP ,HTML, C-Programming

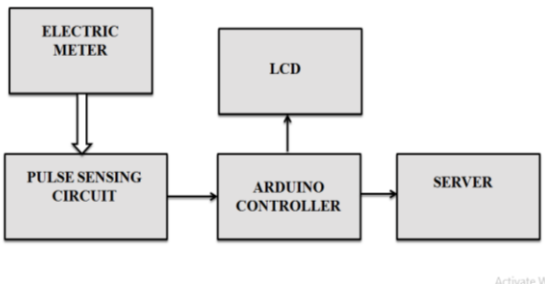


Figure 1 Overall Blockdiagram

A. Model Calculation

Before proceeding for the calculations, first note the pulse rate of energy meter. There are two pulse rates of energy meter first is 1600 imp/kwh and second is 3200 imp/kwh. The energy meter used is 3200 imp/kwh pulse rate energy meter. So first calculate the Pulses for 100watt, means how many times Pulse LED will blink in a minute, for the load of 100 watts.

Number of Pulses is given by the Equation 4.2,

Pulse= (Pulse_rate*watt*time)/ (1000*3600) ---- (4.2)

For 3200 imp/kwh electric meter.,
Pulses=3200*100*60/1000*3600
Pulses = ~5.33 pulse per minute

Power Factor is the estimation of electricity consumption per unit pulse.
Power factor is given by the Equation 4.3,

PF= watt/(hour*Pulse) -------- (4.3)

PF=100/60*5.33=0.3125 watt in a single pulse

Units consumed is given by the equation 4.4,
Units= PF*Total pulse/1000 -------- (4.4)
Total pulses in an hour is around 5.33*60=320
Units = 0.3125*320/1000
Units = 0.1 per hour
If a 100 watt bulb is lighting for a day then it will consume
Units =0.1*24=2.4 units

B. Connecting Energy Meter with Arduino

Firstly,the Analogue Electricity Energy Meter is opened and the Pulse LED or Cal LED's terminals (cathode and Anode) are found. Now two wires at both the terminals are taken out from the energy meter , soldered and then energy meter is closed. Figure 2 illustrates the connection between the Anode and Cathode of the energy meter to the Optocoupler .Secondly, a load is connected to the input of the energy meter and connect the anode terminal of LED(output terminals) at pin number 1 of Optocoupler(PC817) and cathode terminal to pin 2. Pin number four of optocouper should be connected to ground. A LED and a Pull-up resistor are connected at pin number 5 of optocoupler. And same terminal should go to the Arduino pin 8 too. The optocoupler is converts the 230V Spikes produced in the Anode and the Cathode terminals of the energy meter to 5V pulses. The Optocoupler is mainly used to provide Electrical isolation between the to devices(Energy meter operating at 230V and the Arduino operating at 5V). Figure 3 shows the Circuitry of the Opto Coupler(PC817).

Figure 2 Connecting the Anode and Cathode to the Optocoupler

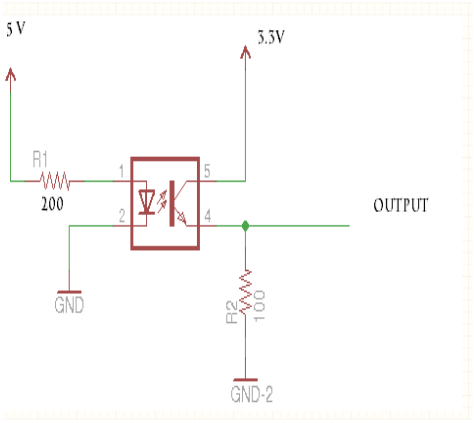


Figure 3 Circuitry of the Opto Coupler(PC817)

C. Arduino- LCD Interface

Interfacing an Arduino with an LCD display consists of two parts, wiring and programming.A typical LCD display consists of 16 pins that control various features of the screen. The Arduino can output voltages of either 5 V or 3.3 V, so the LCD can be powered by connecting VSS and VDD to the ground and 5 V pins on the arduino. It is possible to adjust the contrast of the screen by wiring a variable resistor to V0 located at pin 3 on the screen. Figure 4 shows the Arduino – LCD Interface.

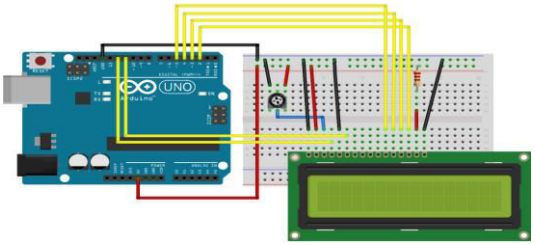


Figure 4 Arduino-LCD Interface

D. Website Creation and Server Updation

A user friendly website was created for Smart Metering to monitor, store and analyse the data from the energy meter. Each and every Household is given a Login Id so that they can easily get the Energy usage and the Bill Amount. In the EB office, each and every houses' unit consumed and their bill amount would be stored in the database for them to manipulate easily.

The Energy Usage and the rate is updated in the server via Pyserial (Python IDLE).A unique login ID is given to the users using a Thingspeak server. The data is updated in the Thingspeak Server using the Python IDLE.

V. RESULTS AND DISCUSSIONS

The Smart Energy Meter readings are monitored and displayed in the In home Display(LCD) which serves as a feedback for the Household to help in Energy

reduction. Figure 5 shows the Energy usage and Bill Amount Displayed in the In Home Displays(LCD). Figure 6 shows the Hardware setup of the Smart Energy Meter .

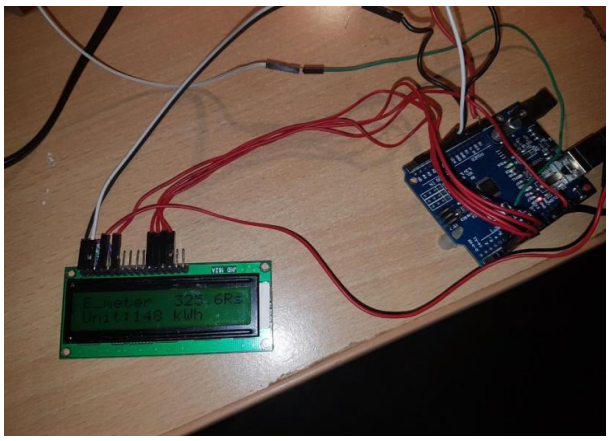


Figure 5 Energy usage and Bill Amount Displayed in the In Home Displays (LCD)

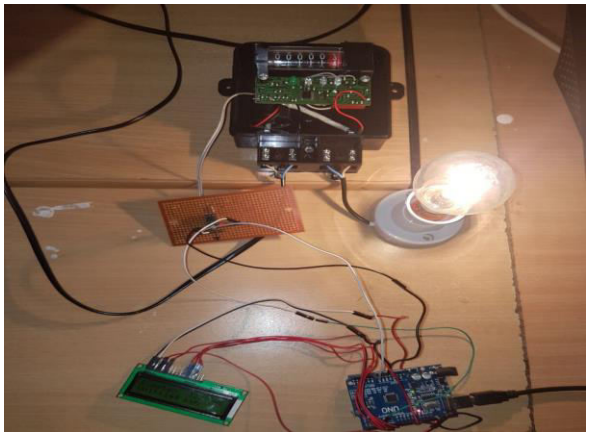


Figure 6 Smart Energy Meter Hardware Setup

Figure 7 shows the Interface between Arduino and Python IDLE. The Energy Usage and the rate is updated in the server via Pyserial (Python IDLE).A unique login ID is given to the users using a Thingspeak server. The data is updated in the Thingspeak Server using the Python IDLE.

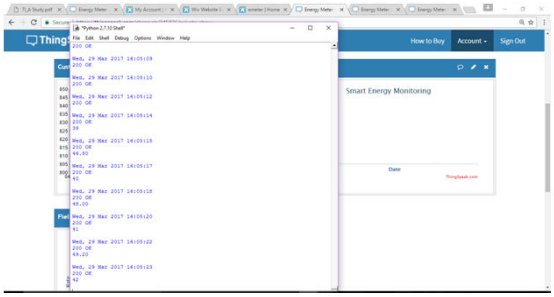


Figure 7 Interface between Arduino and Python IDLE

A user friendly website was created for Smart Metering to monitor, store and analyse the data from the energy meter. Each and every Household is given a Login Id so that they can easily get the Energy usage and the Bill Amount. In the EB office, each and every houses' unit consumed and their bill amount would be stored in the database for them to manipulate easily. Figure 8 and 9 and 10 shows the Welcome Page ,Characteristics and provisions of the Smart Metering Website.

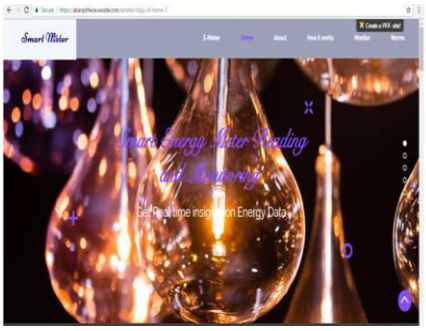


Figure 8 Welcome page of Smart Metering Website

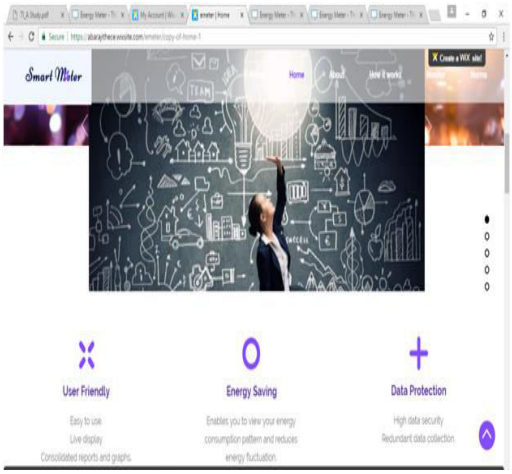


Figure 9 Characteristics of Smart Metering Website

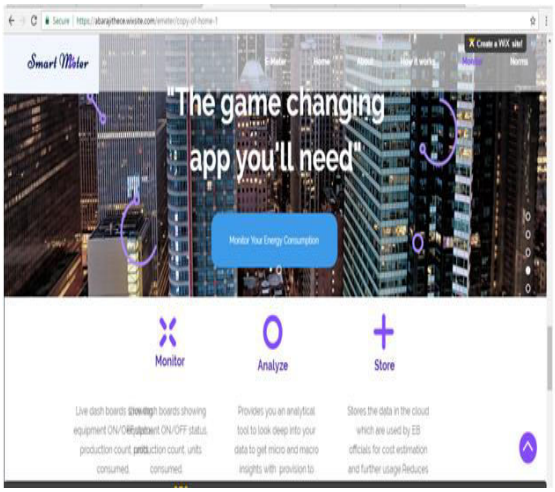
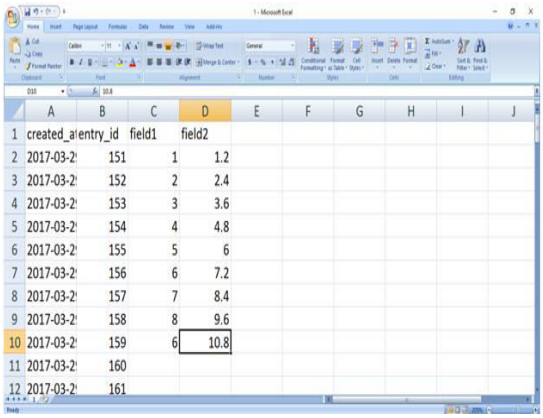


Figure 10 Provisions of Smart Metering Website

Figure 11 Analysis Curves in the Thingspeak Server

Figure 11 shows the Analysis Curves obtained in the Thingspeak Server and Figure 12 and 13 shows the User Database and EB Database retrieved as a Spreadsheet.



	A	B	C	D	E	F	G	H	I	J
1	created_at	entry_id	field1	field2						
2	2017-03-2	151	1	1.2						
3	2017-03-2	152	2	2.4						
4	2017-03-2	153	3	3.6						
5	2017-03-2	154	4	4.8						
6	2017-03-2	155	5	6						
7	2017-03-2	156	6	7.2						
8	2017-03-2	157	7	8.4						
9	2017-03-2	158	8	9.6						
10	2017-03-2	159	6	10.8						
11	2017-03-2	160								
12	2017-03-2	161								

Figure 12 User Database retrieved as a Spreadsheet

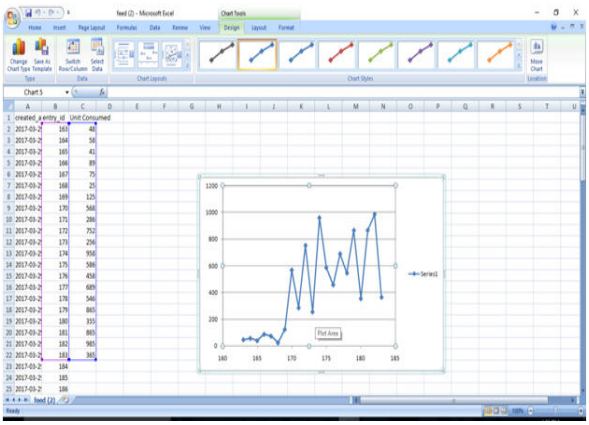


Figure 13 EB Database retrieved as a Spreadsheet

VI. CONCLUSION AND FUTURE WORK

A Smart Energy Meter to monitor, analyze and store the Energy Usage was designed using Arduino. The proposed design becomes highly efficient as it updates the Energy usage details periodically in the Thingspeak server. The Thingspeak server was accessed using a Unique Id by each and every user. The interface between Arduino and the server was established via python IDLE environment. The user would be able to view and analyze their energy usage details easily by various analysis plots. The proposed system effectively reduced the Human Intervention and turned into one of the best advancements in the technology. The Key problems persisting in the Energy Saving Environment such as the limited evidence of efficacy, the need for user engagement and the potential for unintended consequences have been addressed.

In Indian scenario, Smart metering is a mandatory requirement which has not yet been replaced by any automated system. This Smart Energy Monitoring system can be combined along with the Gas Usage details so that Households would have updates on gas Usage too. Both the Energy Usage and the gas Usage could be displayed in the In Home Displays making it more efficient.

VII. REFERENCES

[1] Embedded Automobile Engine Locking System, Using GSM Technology, Jayanta Kumar Pany1 & R. N.DasChoudhury2 International Journal of Instrumentation, Control and Automation (IJICA) ISSN : 2231-1890 Volume-1, Issue-2, 2011.

[2] X. P. Liu, W. Gueaieb, S. C. Mukhopadhyay, W. Warwick, and Z. Yin, ―Guest editorial introduction to the focused section on wireless mechatronics,‖ IEEE /ASME Trans. Mechatronics, vol. 17, no. 3, pp. 397–403, Jun. 2012

[3] PIC Microcontroller and Embedded Systems, Mazidi, Muhammad Ali; Mckinaly, Rolin D; Causey, Page no 99-112.

[4] www.allaboutcircuits.com.

[5] Microcontrollers Architecture, Programming, Interfacing and System Design, Raj kamal, (2011), Page no 34-52[10] PCB Designe Tutorial. Page no 17-25, David.L.Jones (2004)

[6] GSM based Automated Embedded System for Monitoring and Controlling of Substation, Amit Sachan, M.Tech.Thesis, Page no 7-9 June 2012.

[7] A. Kansal, J. Hsu, S. Zahedi, and M. Srivastava, ―Power management in energy harvesting sensor networks,‖ ACM Transactions on Embedded Computing Systems, Vol. 6, No. 4, Article 32, September, 2007.

[8] C. Moser, L. Thiele, D. Brunelli, and L. Benini, ―Adaptive power management for environmentally powered systems,‖IEEE Transactions on Computers, Vol. 59, No. 4, pp. 478– 491, 2010.

[9] D. Zhu, H. Aydin, and J.-J. Chen, ―Optimistic reliability aware energy management for real-time tasks with probabilistic execution times,‖ Proc. 29th IEEE Real-Time Systems Symp. (RTSS), pp.313– 322, 2008.

[10] D. Zhu and H. Aydin, ―Reliability-aware energy management for periodic real-time tasks,‖ IEEE Trans. on Computers,Vol. 58, No. 10, pp. 1382– 1397, 2009.

[11] R. Iyer and L. Kleinrock, ―QoS control for sensor networks,‖ IEEE International Conference on Communications, vol. 1,pp. 517– 521, May, 2003.

[12] A. Koubaa, R. Severino, M. Alves, and E. Tovar, ―Improving quality-of-service in wireless sensor networks by mitigating―hidden-node collisions,‖ ‖ IEEE Trans. Ind. Informat., vol.5, no.3, pp.1444– 1452, Mar. 2008.

[13] K. T. Phan, R. Fan, H. Jiang, S. A. Vorobyov, and C. Tellambura, ―Network lifetime maximization with node admission in wireless multimedia sensor network,‖ IEEE Trans. Veh. Technol., vol. 58, no. 7, pp.3640– 3646, Sept. 2009.

[14] A. Fallahi and E.Hossain, ―A dynamic programming approach for QoS-aware power management in wireless video sensor networks,‖ IEEE Trans.Veh. Technol., vol. 58, no. 2, pp.843– 854, Feb. 2009.

[15] Yujun Bao and Xiaoyan Jiang, "Design of electric Energy Meter for long-distance data information transfers which based upon GPRS", ISA 2009. International Workshop on Intelligent Systems and Applications,2009.

[16] W.L. Sunshine, (no date). Pros and cons of smart meters [On Iin e]. Available:http://energy .about.comlod/metering/a/Pros -AndConsOf-Smart-Meters.htm