Automated Energy Meter Reading and Theft Detection

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***Abstract*— Energy crisis is one of the most important issues that the entire world is facing today. The feasible solution for the energy crisis problem needs optimal utilization of available energy. However, the state-of-the art energy metering systems suffer due to issues such as low battery backup, poor network connectivity and excessive memory consumption. To overcome these drawbacks, a novel automated energy metering framework is proposed in this paper, which makes use of Microcontroller based implementation for its operation. Specifically, Consumer can get the energy consumption statistics instantly on a LCD screen. Further, whenever any consumer attempts to tamper the energy meter, magnetic sensors get actuated and sends appropriate signals to the microcontroller, which in turn sends theft event messages to the management side for further processing. Experimental setup and results indicate the good performance of the proposed framework in terms of energy consumption display on LCD screen, which significantly help the customer to monitor their energy consumptions.**

Keywords*— *Programmable Interface Controller (PIC) microcontroller, GSM modem, electricity theft, automated meter reading.

I. INTRODUCTION

Energy crisis is one of the major problems that the world faces today. The best remedy for energy crisis problem is not only the increase in energy production, but also the effective use of available energy. By properly monitoring the energy consumption and avoiding energy wastage, energy crisis can be reduced to a greater extent. More specifically, currently in India there are almost 52 million electricity energy meters are interconnected and it is estimated to touch almost 2 billion by 2030 [1]. On the other hand, incorporation of mobile technology into electricity meter system is rapidly advancing, which can decrease the costs. But energy monitoring cannot be done efficiently, in the present scenario, because consumers are completely unaware of their energy consumption details. Precisely, consumers get an idea about their consumption precisely, only when the electricity bills are issued. More precisely in India, bills are issued only once in a month or two months. So the consumers are unaware about their energy consumption during this period of time. In this era of digitalization, no one wants to manually check for the energy consumption by referring to electricity bills of the previous months which is a tedious task. This complex procedure has to be repeated several times in a month to efficiently control the energy usage. Further, if the consumers can check the no. of units consumed regularly then it is beneficial for the consumer as well as management side to monitor the energy consumption. Based on these aspects, in order to overcome the drawbacks of the manual metering and billing systems, new automated energy metering systems are needed, which can continuously monitor the consumed meter readings. It can also help the management side to detect the tampering of electricity meter and electricity theft.

II. RELATED WORKS

In 2011, Landi et al. [2] proposed a system, which measures the main power system quantities and gives possibility to manage the whole power plant. Here, an integrated Web Server allows to collect the statistics of power consumptions and power quality. This system allows easy access to the information with the combination of a smart meter and data communication capability and thereby allow local as well as remote access to meter readings. But due to lack of battery backup and excessive memory consumption, this system fails to satisfy the customer level expectations. In
[3] an infrastructure called Smart Grid is proposed, in which the growing demand of energy, the capacity limitations of energy management are discussed. It is based on an energy meter with low-power microcontroller and the Power Line Communication standards. B.S. Koay et al. [4], introduced a system based on Bluetooth technology. At present, wireless digital energy meters are continuously replacing existing technology of electro-mechanical meters especially in China and India. In [4] the authors described that digital meter had already started replacing electromechanical meters in Singapore, where Bluetooth technology is chosen as a possible wireless solution to connectivity issue. Khalifa et al. in [7] surveyed four communication protocols available for automatic meter reading (AMR) device and one of them is PLC. Since the data travels through voltage signal, the voltage level carried is also considered. Although PLC provides low maintenance as well as good efficiency, yet it suffers from limited bandwidth and difficulty in supporting large scale networks

Further, integrating several communication protocols with PLC might overcome its drawbacks such as Wi-Fi, Micro- power Wireless, and Optical Fiber. [8], [9]. Recently in 2015, Iyer and Rao presented a

paper on IoT based meter reading and theft detection [5], in which the system design eliminates the human involvement in Electricity maintenance. However, in the above mentioned system if the customer misses to pay the bills on time or trying to tamper the meter then it automatically alerts the management side which can disconnect the power

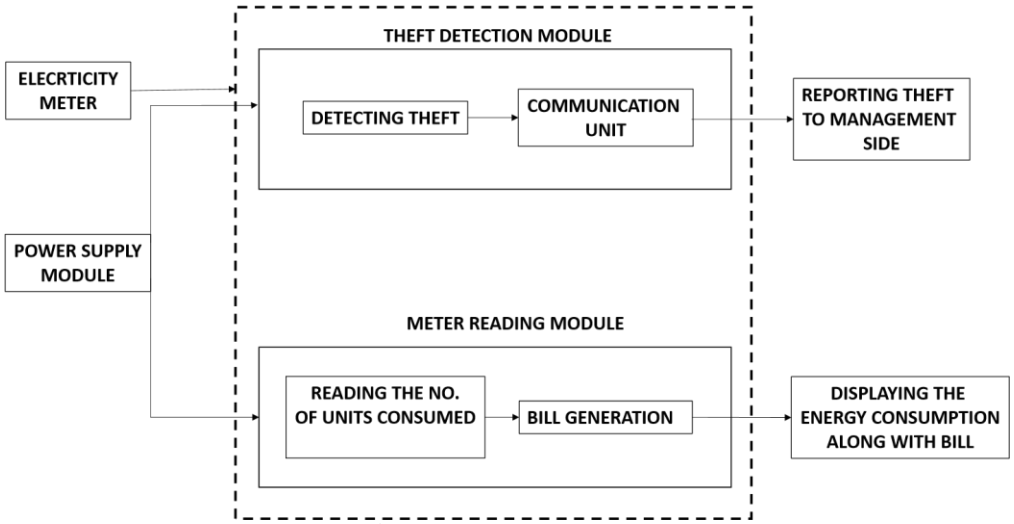

Figure 1: Block Diagram of Proposed Automated Energy Meter Reading Framework

supply from an autonomous server. This system fails due to need for continuous internet connection and poor internet connectivity problems in remote localities.

To outline, in the existing literature, less focus is given towards the major issues of automated electricity meter reading, such as battery backup, excessive memory consumption and poor network connectivity. To overcome these drawbacks, this paper proposes a new automated energy metering system which makes use of GSM technology and Microcontrollers for its operation.

III. PROPOSED FRAMEWORK

Usage of electromechanical energy meters leads to inaccuracy while taking readings and allows energy theft. In order to overcome these problems, a new automated energy meter is proposed which automatically shows the energy consumption in units and can also detect thefts. The Proposed system given in Figure 1. Consists of four modules, namely power supply module, meter reading module, theft detection module and electricity energy meter respectively.

The functionalities of each of the modules of the proposed system are explained as follows:

I. Power Supply Module:

With an end goal of consistently supplying a constant voltage, this unit basically drives the other components of the system and the microcontroller. It consists of a 12V Step down transformer, bridge rectifier, filter capacitors and regulators. Initially a 230V, 50 Hz load is fed into the system which needs to be regulated to 5V and 12V respectively. Then current is passed through a 12V step down transformer. The step down transformer reduces 230V current to 12V 50Hz. AC. The output of the transformer is connected to a bridge rectifier. The rectifier consists four IN4007 diodes, which is mainly used to convert the AC to pulsating DC. The output current coming from the rectifier comprises of some ripples (noise).The yield of rectifier is directed into the capacitor filter in order to isolate the ripples. The outcome of this will be a varying current and needs to be regulated. For this purpose the varying current is nourished into 7812 IC and 7805 IC which gives a constant 12V and 5 V direct current.

II. Meter Reading Module:

This unit is mainly used to read the number of units consumed by the consumer and display it on a LCD screen. Input of the meter reading unit is connected to microcontroller and the output to energy meter. Here opto-interrupter is parallely connected to the LED in the energy meter which indicates consumption of one unit. When a power unit is consumed the opto-interrupter generates a signal and sends it to the microcontroller. The microcontroller is programmed to keep a track of units consumed and the same information is displayed on LCD screen.

III. Theft Detection Module:

The prime function of this module is to detect the tampering of electricity meter, disconnect the power supply and send a message of power theft to the management side. Whenever any consumer tries to tamper the meter, the theft detection unit identifies it with the help of magnetic sensors. Then a signal generated by the sensors is sent to the microcontroller as well as relay circuit. Relay circuit is used to disconnect the power supply. Then the microcontroller sends a power theft message to the management side via the communication unit comprising of a RS232 interface and GSM modem. In this way the power theft is detected and alerted to the management side.

IV. EXPERIMENTAL SETUP AND RESULTS

Figure 2. depicts the experimental setup of different

components of the system and their respective connections. Figure 3. shows the snapshot of the proposed framework. The automated metering system consists on components such as PIC microcontroller, RS232 interface, GSM modem, magnetic sensors, LCD display, meter reading unit, theft detection unit,

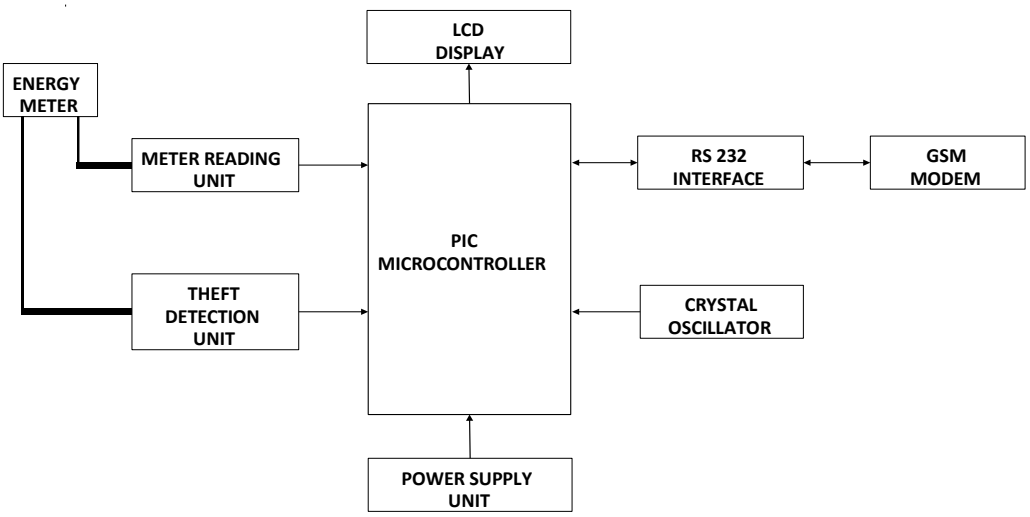

Figure 2: Experimental Setup

power supply unit and an energy meter respectively. The live readings from the energy meters are collected by meter reading unit and nourished into microcontroller. The energy consumption in no. of units can be viewed through an LCD display which is connected to microcontroller. LCD display shows the readings of the energy meters and theft status. The LCD display is driven by a lithium ion battery. Crystal oscillator is used to provide electrical signals of precise frequency to the microcontroller by utilizing the vibrating crystal's mechanical resonance. Whenever any consumer tries to tamper the meter the dimensionality of the magnetic sensors changes. Then a signal is generated and sent to the microcontroller indicating theft of energy meter. Microcontroller sends appropriate message to GSM modem via RS232 interface. RS232 interface is used to convert signals shared between a microcontroller and a modem.

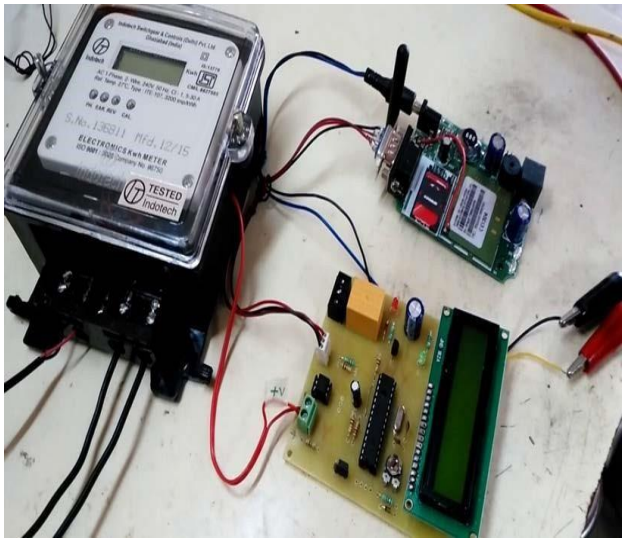

Figure 3: Snapshot of Experimental Setup of Proposed Framework

After receiving the message from microcontroller, GSM modem transmits a theft message to management side. Along with sending a message to the management side, the theft detection unit disconnects the load using a relay circuit

Figure 4.shows the snapshot of proposed framework, in which no. of units consumed by the consumer on LCD display as well as the amount calculated depending upon how much units are consumed. For every unit consumed, amount of bill is calculated. The amount is calculated as follows,

*Amount of bill (A) = No. of units consumed (n) * price per unit*

After calculating the amount, it will be displayed on the LCD screen. This mechanism helps the consumer to efficiently monitor electricity consumption.

V. CONCLUSION

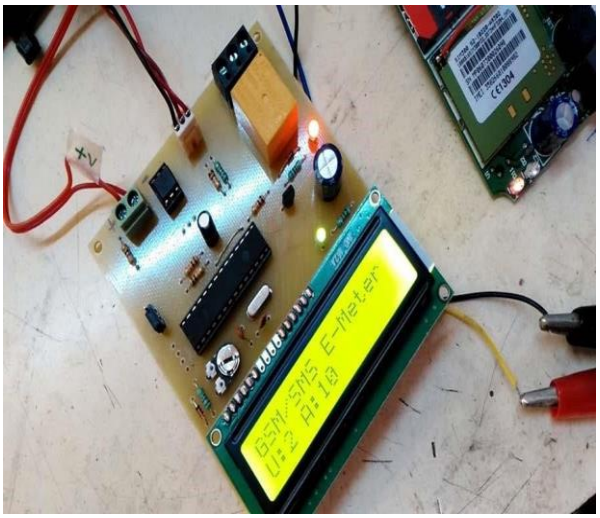

Figure 4: Snapshot of Result of Proposed Framework

In this era of energy crisis period, methodologies which help in effectively controlling energy utilization

and avoiding energy wastage are very important. In this paper, PIC- microcontroller based design and implementation of automated energy meter reading system is presented. In this system the energy consumption is available instantly to consumer by means of LCD displays, which helps the consumer to know about the energy utilization and hence can monitor it effectively. Further, whenever a theft occurs load to the energy meter gets disconnected and the management side is alerted by a SMS. The objectives accomplished in this system are ease of accessing energy consumption at consumer end, theft detection is alerted at management end and disconnection of load whenever theft occurs. In future, we can further incorporate a system that alerts the consumer when the energy utilization crosses a specific threshold.

REFERENCES

[1] N. Langhammer and R. Kays, Performance Evaluation of Wireless Home Automation Networks in Indoor Scenarios, IEEE Transactions on Smart Grid, vol. 3, no. 4, pages 2252-2261 ,

[2] Landi, C., D. di Ing Dell ,Merola, P and Ianniello, G, ”ARM-based energy management system using smart meter and Web server”, in proceedings of IEEE Instrumentation and Measurement Technology Conference Binjiang, pages 1 - 5, 2011.

[3] Garrab, A. Bouallegue, A. and Ben Abdallah, ”A new AMR approach for energy saving in Smart Grids using Smart Meter and partial Power Line Communication”, in proceedings of IEEE First International Conference on Renewable Energies and Vehicular Technology (REVET), pages 263 - 269, 2012

[4] B. S. Koay, S. S. Cheah, Y. H. Sng, P. H. Chong, P. Shum, Y. C. Tong,
X. Y. Wang, Y. X. Zuo and H. W. Kuek, ”Design and implementation of Bluetooth energy meter”, IEEE Proceedings of the 4th International Joint Conference of the ICICS, vol. 3, issue 7, pages 1474-1477,2003.

[5] Darshan Iyer and Dr. K.A. Radhakrishna Rao,” IoT Based Electricity Energy Meter Reading, Theft Detection and Disconnection using PLC modem and Power optimization” , in proceedings of International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol 4 ,issue 7, pages 6482,6483, 2015.

[6] K. Li, J. Liu, C. Yue and M. Zhang, ”Remote power management and meter-reading system based on ARM microprocessor”, IEEE Precision Electromagnetic Measurements Digest CPEM, vol 8, issue 12, pages 216-217, 2008

[7] Khalifa T, Naik K and Nayak A. , ”A survey of communication protocols for automatic meter reading applications”, IEEE Communications Surveys & Tutorials, vol. 3, issue 3 pages 168-82 , 2012.

[8] Qingyang L, Dapeng L and Jian W, Ning D. , ”Construction of Electric Energy Data Acquiring Network Integrating Several Communication Methods”, in proceedings of fourth international conference on multimedia information networking and security, pages 121-124,2012.

[9] Rafiei M and Eftekhari S M. ”A practical smart metering using combination of power-line communication (PLC) and WiFi protocols ”, in proceedings of 17th conference on electrical power distribution networks, pages 1-5, 2012.