Energy Theft Detection by Smart Energy Meter using WSN in Real Time

Mahima Singh[1], Asmita Kumari[2], Varun Goyal[3*], Parveen Kumar[4]
Deptt. of Electronics and Communication Engineering
Maharaja Surajmal Institute of Technology,
Janakpuri, Delhi, India

Abstract—**Electricity is one of the most important resources for humans and is commonly used for generating power by various utility companies. But recently these companies are facing huge amount of losses due to rampant theft of electricity. It is difficult for the utility companies to detect electricity theft. Annually, the world loses approx. US$89.3 billion due to this with India being on the highest. The proposed system in this paper uses a smart energy meter interfaced with controller to count and monitor the unit's usage and together with wireless sensor network, a procedure to detect any tampering done with the meter is deployed. The goal of proposing this system is to monitor the power consumption and detect theft. The Energy Meter used here deals with the measurement of power being consumed by a consumer and displays the information to the consumer and further identifies the status of the meter of any theft by using wire integrating technology.**

Keywords—Electricity Theft, Smart Energy Meter, Electricity theft, Wireless Sensor Network, Power measurement, Smart Grid, Real Time Monitoring

I. INTRODUCTION

Electricity is one of the most fundamental features of all matter. Electricity is used by majority of appliances for various purposes which include industrial, medical or personal use. Electricity is an essential component for overall development of a country. It is a vital source for quality of lifestyle of the public as well as industrial and agricultural development in the present society. A major part of the population depends on a stable and reliable power source on a daily basis. In this situation, it is therefore impossible to imagine a life without electricity. However, a high percentage of electricity income is lost due to unlawful theft and improper management of electricity. The purpose of this paper is to provide an implementation methodology for electricity theft detection which provides the status of the meter at remote location via wireless sensors. This proposal brings an implicit solution for the issues faced by electricity distribution companies such as energy theft and effective meter reading. It includes Smart Energy Meter based technology and wireless communication method to find out the electric theft and power usage done by the consumer. Moreover, collecting the meter readings for billing purposes from all consumers is a difficult and time consuming task which requires a great amount of human effort. In the proposed model, a Bluetooth based technology is used to transmit the meter reading and creates a detection alert automatically to the authorized energy provider via an alert status which eliminates the risk of false meter reading and power theft.

Conventional energy meter, wireless sensor network, Microcontroller and other simulation software merge together to form an automated power measurement system. With the advent of technology in various fields including the Wireless communication technology by the use of microcontrollers, there are many improvements in automating various industrial aspects for reducing manual efforts. The traditional manual meter reading was not an appropriate choice as it involves much human and material interference. Calculations involved in electricity consumption and noting down the electricity units may be full of errors. It is a hard task to handle and manage the power sources as per the growing needs and requirements. Paying a visit to each consumer and noting the reading becomes a cumbersome and time consuming task for the consumers as well as the companies. Moreover, the manual operator fails to detect a malpractice carried out by the consumer to reduce or alter the meter reading/power supply. The human error can be one way in which a false reading could be noted. The proposed system is considered to evaluate the meter reading and calculate the power consumed.

II. PROPOSED SYSTEM

The modeling is derived for a smart energy meter with the help of wireless sensor network. Smart energy meter operates by making a communication with wireless sensor network together with microcontroller to form an automated system. The smart meter sends data to the wireless sensor and it informs the utility company about the status of the meter. The smart energy monitor calculates the amount of energy which is used. It gives a detailed usage on the number of units consumed. Knowing more about how much energy things use, will help to choose the way we use them. This will bring an end to the meter readings noting and provide an accurate solution to the hassles caused by the traditional energy meters.

After switching on the power, the microcontroller and the Bluetooth module, the energy meter is connected to the load. Then the Bluetooth phone screen will display the current reading at regular intervals. Impulses are received from the energy meter to the controller. The Bluetooth screen also displays the status of the meter (OK/TEMPERED). Its showcases "OK" then the meter is working normally. If the message is "TEMPERED", it depicts that an attempt to energy theft has been made.
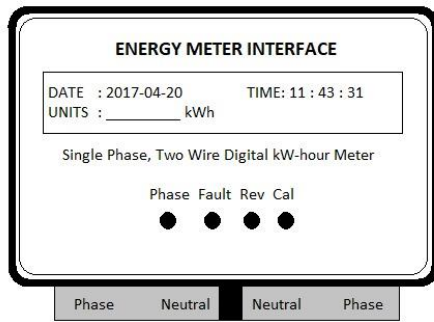
Fig -1: Interface of a generic energy meter

III. SYSTEM ARCHITECTURE

The system architecture of the proposed network is shown in the figure below. In this paper, a Bluetooth module is used to transmit and receive serial data across the network.
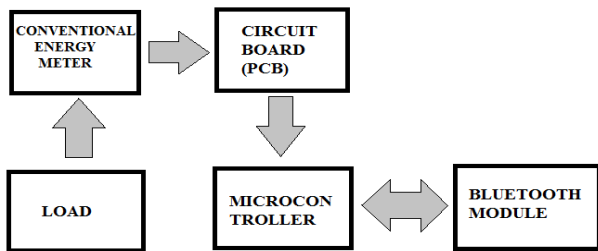

Fig -2: System architecture

There are two parts that were combined to make the system. Firstly, a SEM is made through the conventional energy meter with the help of processing board and wireless sensor network. The energy meter proposed here deals with computation of power by the consumer and storing it in its memory by receiving the signal pulse from the conventional energy meter. The data is stored temporarily to monitor the load and corresponding amount will be calculated and communicated to the wireless network.

A conducting wire on the circuit box of the energy meter is deployed with the seal, when the consumer makes an attempt to temper or open the meter box, the seal will be broken with the conducting wire which will break the connection and deliver a status update of the meter to the utility company.

A. ATMEG2560
The ATMEGA2560 is a microcontroller board with an operating voltage of 5V. Broadly used for creating and development of projects in the electronics field, the ATMEGA is programmed with Arduino software.

B. SMART ENERGY METER
Electromechanical meters are used traditionally which need manual power to note down the readings and calculate energy consumed after certain periods. It works on the counting of revolutions of the rotating wheel which is proportional to the power consumed.
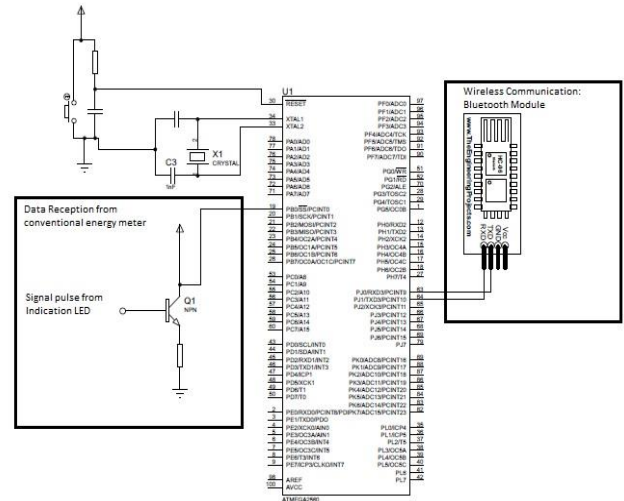

Fig -3: Smart Energy Meter using Bluetooth module and WSN

It induces errors and is not a hassle free journey. Therefore keeping in mind the need to automate such system, integration of the electromechanical meter with a microcontroller and wireless sensor network will make it intelligent and error free. The smart energy meter thus formed will give an accurate reading of the energy consumed at certain set intervals with a programmed microcontroller. The SEM also offers added features like transmission of the calculated power via wireless sensor networks. It analyses the received data and then predicts the electricity theft.

C. WIRELESS SENSOR NETWORKS
In this paper we have deployed wireless technology to monitor theft in Energy meter.
The proposed system uses a Bluetooth module for wireless sensing of the data. It is a Bluetooth Serial Port Protocol module which is specifically used for clear wireless serial connection framework. It supports two modes of operation, the Data mode is used for sending and receiving of data from other Bluetooth devices. AT command mode is used to change the device settings. The device can function in either of the two modes which can be controlled by the key pin. It operates with USART port and is very simple to connect.

Wireless Sensor Network via the Bluetooth Module provides a bridge between the real physical and virtual worlds. It allows the ability to observe the previously unobservable at a fine resolution over large spatiotemporal scales. They have a wide range of potential applications in industry, science, transportation, civil infrastructure and security.

The Bluetooth terminal app is intended to send serial information to the Bluetooth module once connected to the application.

IV. METHODOLOGY

In accordance with the power consumption of an appliance, the pulses will be generated. A single unit of Kilo watt Hour is consumed in 1 hour by an appliance. Assuming our meter generates 3200 pulses per KWH.

3200Pulses/KWH=0.0003125KWH/pulses

Hence, Power consumed by a pulse will be 0.3125W.

Power will be calculated by the multiplication of the number of pulses generated in one hour and the power consumed by each pulse.

The LED of the energy meter will glow bright for each pulse. Data through the LED will be taken to the microcontroller and further calculations are done through the pre-defined logic.

ΣPdelivered = ΣPconsumed + Loss (implies No Energy Theft)

ΣPdelivered $\neq$ ΣPconsumed + Loss (Energy Theft Occurs)

Where Pdelivered is the power sent to the consumer
and Pconsumed is the amount of power utilised by the consumer.

Power theft occurs due to the fraudulent actions of the consumers. The pin of the microcontroller is used to monitor the status of theft being tempered or OK. Hence, when an attempt to theft is made or any abnormal touching of the meter is done, the circuit breaks and the message of theft being done is sent to the concerned utilities via Bluetooth module.

V. IMPLEMENTATION AND RESULT

Case I. If there is no electricity theft between the Transmitter and Receiver end then the Meter status is shown as 'OK' shown in Fig-5.

Case II. If there is a theft of electricity between the Transmitter and Receiver then the person in charge of Substation end will automatically come to know about the meter being tempered and the theft of electricity in the system by getting an alert on their Android mobile phone as 'TEMPERED'. Fig-6 shows the hardware implementation of the proposed system.
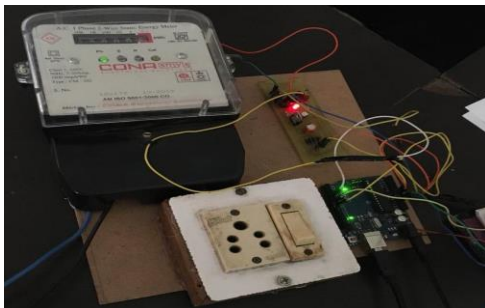

Fig- 4: Hardware Design

The meter detects the number of pulse consumed by the load and displays on the screen.

Fig-5: Status of the energy meter as 'OK'

The circuit will send the information about the status of the meter to the substation receiver which is the Bluetooth module.

Fig- 6: Status of the energy meter as 'TEMPERED"

When Power theft is detected then the warning message is displayed on the Bluetooth module.

VI. CONCLUSION

The proposed system will allow us to know the status of the smart energy meter and hence help in controlling electricity theft to large extent by deploying Conducting wire with the seal on the circuit box of the energy meter. This paper successfully depicts that the smart energy meter along with the wire integrating technology which will eventually help in monitoring power usage and detects power theft via wireless sensors in an efficient way.

REFERENCES

[1] Aakash Bansal, Varun Goyal, Real Time Electricity Monitoring using Smart Energy Meter in a Smart LAN based Network, International Journal of Electronics, Electrical and Computational System, IJEECS,ISSN 2348-117X, Volume 6, Issue 5, May 2017

[2] Md. Taslim Arefin, Mohammad Hanif Ali, A.K.M. Fazlul Haque, A Comparative Analysis of Short Range Wireless Protocols For Wireless Sensor Network, International Journal of Scientific & Engineering Research, Volume 8, Issue 4, April-2017.

[3] N. Mahalakshmi, E. Elavarasi, Design of Intelligent SMS Based Remote Metering System for AC Power Distribution to HT and EHT Consumers, International Journal of Computational Engineering Research, Vol. 2, Issue 3, pp. 901-911, Jun 2012.

[4] 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, Int'l Conf. on Electrical Engineering and Information & Communication Technology (ICEEICT),21-23 May 2015.

[5] Malka Tarannu, Durga Sharma,Dr Dharmendra Singh, Electricity Theft in India: Its Measure and Solution, International Journal of Advance Research, Ideas and Innovations in Technology, (Volume3,Issue5)

[6] Gower, A.H., Non-technical losses: how much are you losing?, Paper presented at the Fourth Annual South Africa Revenue Protection Association Conference, 2000.

[7] Jenita Ann Mathews,Jily Varghese, Jisha Raju, Lidiya Daley, Beena A.O, Intelligent Energy Meter With Power Theft Detection, India Technical Research Organisation

[8] Naveenkumar , Jagadeesh S K, Smart Energy Meter, International Journal of Technical Research and Applications,4, Issue 3 (May-June, 2016), PP. 126-129

[9] Pandurang G.Kate, Jitendra R.Rana, ZigBee Based Monitoring Theft Detection and Automatic Electricity Meter Reading, International Conference on Energy Systems and Applications (ICESA 2015), Nov, 2015

[10] Viredra Pandey, Simrat Singh Gill, "Wireless Electricity Theft Detection System using Zigbee Technology" IJRITCC,Volume 1,Isuue

[11] R.B Hiware, P.Bhaskar, Uttam Bombale, Nilesh Kumar, "Advance Low Cost Electricity Billing System using GSM" Hiware et al.,International Journal of Advanced Engineering Technology E-ISSN 0976-3945.

[12] Jayaprakash J.,Iot based Energy Meter,IJARTET, Vol.5, Issue 6,June 2018

[13] Win Adiyansyah Indra, Fatimah Bt Morad, Norfadzlia Binti Mohd Yusof, Siti Asma Che Aziz GSM-Based Smart Energy Meter with Arduino Uno, International Journal of Applied Engineering Research ISSN Volume 13, pp. 3948-3953, November 6 2018.

[14] Pandurang G. Kate, Jitendra R. Rana, ZigBee Based Monitoring Theft Detection and Automatic Electricity Meter Reading, 2015 International Conference on Energy Systems and Applications, November 2015.

[15] D. N. Nikovski, Z. Wang, T. Muso, Smart Meter Data Analysis and Power Theft Detection in Machine Learning and Data Mining and Pattern Recognition, Springer Journal for Computations 2013.

[16] Md Mejbaul Haque, Md. Kamal Hossain, Md. Rafiqul Islam Shiekh, Microcontroller Based Single Phase Digital Prepai Energy Meter for Improved Metering and Billing System, International Journal of ower Electronics and Drive Systems, Vol. 1, No. 2, December 2011.

[17] Z. Xiao, Y. Xiao, D.H. Du, Non-repudiation in Neighborhood Area Networks for Smart Grid, IEEE Communication Magazine, Vol. 51, No. 1, pp/ 18-26, 2013.

[18] B. Loeff, Deputizing Data: Using AMI for Revenue Protection, Utility Automation and Engineering 2008.

[19] J. Nagi, K. Yap, S. Tiong, S. Ahmed, Detection of Abnormalities and Electricity Theft using Genetic Support Vector Machines, IEEE TENCON Region 10 Conference, pp. 1-6, 2008.

[20] A. Molina-Markham, P. Shenoy, D. Irwin, Private Memoirs of a Smart Meter, Proceedings of the Second ACM Workshop on Embedded Sensing Systems for Energy Efficiency in Building, pp. 61-66, 2010.

[21] Stephen McLaughlin, Brett Holbert, Ahmed Fawaz, SamanZonouz, A Multi-Sensor Energy Theft Detection Framework for Advanced Metering Infrastructure, IEEE Journal on Selected Area in Communications, Vol. 31, No. 7, July 2013.

[22] Rong Jiang, Rongxing Lu, Jun Luo, Energy Theft Detection Issues for Advanced Metering Infrastructures in Smart GridTsinghua Science and Technology, Vol. 19, No. 2, April 2016.

[23] G. L. Prashanthi and K. V. Prasad, Wireless Power meter and Intimation System using GSM and Zigbee Networks, Journalof Electronics and Communication Engineering, Vol. 9, Issue 6, Ver. 1, Nov 2014

[24] Alvaro A C'ardenas, Saurabh Amin Galin Schwartz, Roy Dong, A Game Theory Model for Electricity Theft Detection andPrivacy-Aware Control in AMI Systems, Fiftieth Annual Allerton Conference, October 2012.

[25] W. A. Doorduin, T. Mouton, Feasibility Study of Electricity Theft Detection using Mobile Remote Check Meters, IEEEAFRICON 2004, October 2004.

[26] Sergio Salinas, Ming Li, Pan Li, Privacy-Preserving Energy Theft Detection in Smart Grid: A P2P Computing Approach, IEEE Journal on Selected Areas in Communications/Supplements, Vol. 31, No. 9, September 2003.

[27] Saurabh Amin, Galina A. Schwartz, Game-Theoretic Models of Electricity Theft Detection in Smart Utility Networks,IEEE Control Systems Magazine, February 2015.

[28] S. McLaughlin, P. McDaniel, Energy Theft in the Advanced Metering Infrastructure, Proceedings of International Conference on Critical Information Infrastructure Security, Springer-Verlag, pp. 176-187, 2010.

BIOGRAPHIES

Mahima Singh

Mahima Singh is a final year B.Tech student in Electronics and Communications Engineering at Maharaja Surajmal Institute of Technology affiliated to Guru Gobind Singh Indraprastha University, Delhi.

Asmita Kumari

Asmita Kumari is a Final year B.Tech student in Electronics and Communications Engineering at Maharaja Surajmal Institute of Technology affiliated to Guru Gobind Singh Indraprastha University, Delhi.

Varun Goyal

Varun Goyal is an Embedded System Designer at Emtech Foundation and Founding Member of Institution of Science, Engineering and Research(ISER), India

Parveen Kumar

PARVEEN KUMAR is an Assistant Professor at Maharaja Surajmal Institute of Technology affiliated to Guru Gobind Singh Indraprastha University, Delhi.