ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

IoT Based Electricity Energy Meter Reading, Theft Detection and Disconnection using PLC modem and Power optimization

Darshan Iyer N[1], Dr. K A Radhakrishna Rao[2]

M.Tech student, Dept. of ECE, PES College of Engineering, Mandya, Karnataka, India[1]

Professor, Dept. of ECE, PES College of Engineering, Mandya, Karnataka, India[2]

ABSTRACT: This paper describes PIC18F46k22 Microcontroller based design and implementation of energy meter using IoT concept. The proposed system design eliminates the human involvement in Electricity maintenance. The Buyer needs to pay for the usage of electricity on schedule, in case that he couldn't pay, the electricity transmission can be turned off autonomously from the distant server. The user can monitor the energy consumption in units from a web page by providing device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering occurs in energy meter and it will send theft detect information through PLC modem and theft detected will be displayed on the terminal window of the company side. Wi-Fi unit performs the IoT operation by sending energy meter data to web page which can be accessed through IP address.

The Hardware interface circuit consists of PIC18F46k22 Microcontroller, MAX232, LCD display, theft detection unit, Triac switch circuit, DB18B20 temperature sensor, PIR sensor, PLC modem, and ESP8266 Wi-Fi module. Wi-Fi unit performs the IoT operation by sending energy meter data to web page which can be accessed through IP address.

KEYWORDS:PIC18F46k22, PIC18F2520, ESP8266 Wi-Fi module, PLC modem.

I.INTRODUCTION

In the Internet of Things (IoT) model, many of the living and non-living things that encompass us will be on the internet in one form or another. Driven by the popularity of gadgets empowered by wire-less technological innovation such as Wireless Bluetooth, Radio Frequency Identification, Wireless-Fidelity, embedded sensor, IoT has moved out from its beginning stage and it is actually on the edge of changing the present fixed inter-net into a well featured upcoming Internet. Currently there are almost nine billion inter-connected gadgets and it is estimated to touch almost fifty billion gadgets by 2020.

Today the world is facing such an environment that offers challenges. Energy crisis is the main problem faced by our society. A relevant system to control and monitor the power usage is one of the solutions for this problem. One approach through which today's energy crisis can be addressed is through the reduction of power usage in households.

The consumers are increasing rapidly and also burden on electricity offering divisions is sharply increasing.The consumers must be facilitated by giving them an ideal solution: - i.e. the concept of IoT (Internet of Things) meters and on the other hand service provider end canalso be informed about electricity thefts using theft detection unit and PLC modem.

By keeping above factors, the concept of IoT meters thrived consisting of 4 units: Microcontroller unit, Theft detection unit, PLC unit and Wi-Fi unit. The paper describes PIC18F46k22 Microcontroller based design and implementation of energy meter using IoT and PLC concept. The user can monitor the energy consumption in units from a web page by providing device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering occurs in energy meter and it will send theft detect information through PLC modem and theft detected will be displayed on the terminal window on the service provider end.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Today's Demand actually requires accessing the device characteristics remotely in a reliable way. One of the possible way to accomplish the task is to connect a device (energy meter) to internet by providing IP address to it.

In this project we are using three Microcontrollers, two on the consumer side for theft detection and IoT, one on the company side for PLC modem communication.

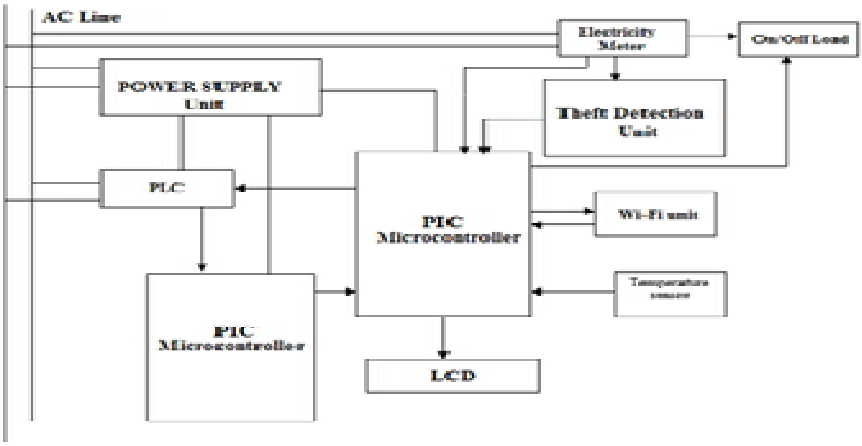

Fig. 1. Proposed IoT based electricity energy meter (consumer end)

The project mainly focuses on theft detection, power optimisation and providing the relevant energy consumption information to user. Here the user can monitor the energy consumption units from a web page by providing device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering and theft detection occurs in energy meter through PLC modem and theft detected will be displayed on the terminal window.

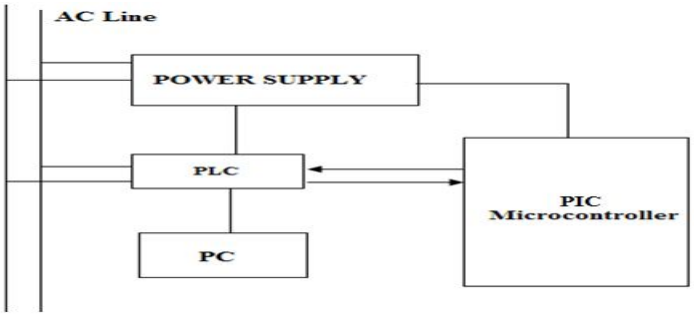

Fig. 2. Proposed PLC communication (service provider end).

The block diagram of the Proposed IoT based electricity energy meter (consumer end) consist of power line communication modem, theft detection and Wi-Fi unit. Power supply section deliveries power to all the components which requires Power. The µc unit takes the information from the electricity meter and additionally carries out the appropriate control procedures and sends the required information like number of units through Wi-Fi module. LCD module is used to get visual information like no. of units, temperature and Wi-Fi configuration.

On the service provider end, PLC acts as modem and sends necessary commands during theft detection and also if consumer fails to pay the billed amount in time, the disconnection and reconnection can be done by sending their respective commands to the controller.

II. RELATED WORK

From thorough review of related work and published literature, we have observed that many researchers have done rigorous work on power line communication (PLC)and IoT. It is observed from the careful study of reported work that

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

in the real world, PLC and IoT based meter can improve the efficiency of power system and can help to analyse the unnecessary loss of power in different areas.The paper by Landi C, Merola P, Ianniello G on ARM-based energy management system using smart meter and Web server gave us the basic idea for IoT based energy meter and also the paper by Poonam Borle, Ankitha Saswadhar, Deepali Hiwarkar, Rupali S Kali on Automatic Meter Reading for Electricity gave us idea for PLC communication.

A. Existing method

The present system only provides feedback to the customer at the end of the month that how much power is consumed in the form of bill. The consumer has no way to track their energy usage on a more immediate basis. The consumers are growing exponentially fast and load on power providing divisions is rapidly rising. In the existing system meter tampering can be done easily and it's one of the major drawback for an energy crisis.

B. Proposed method

In the proposed system, consumer can do power management by knowing energy usage time to time. The Customer needs to pay the bill on schedule, if couldn't, the electric power connectivity can be turned off autonomously from the distant host.

III. SYSTEM IMPLEMENTATION

The proposed IoT based Energy meter and theft detection using PLC is implemented at two ends, one on the consumer end for IoT operation and other on the service provider end for observing energy thefts.

A. Consumer End implementation

In this project we are using three 8-bit Microcontrollers. PIC18F46K22 and PIC18F2520 on the consumer end for theft detection, PLC communication and IoT operation. PIC18F46K22 on the service provider end for PLC modem communication. The project mainly focuses on theft detection, power optimization and providing the relevant energy consumption information to user. Where the user can monitor the energy consumption units from a web page by providing device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering and theft detection occurs in energy meter through PLC modem and theft detected will be displayed on the terminal window.

The block diagram of the Proposed IoT based electricity energy meter (consumer end) consist of power line communication modem, theft detection and Wi-Fi unit. In power supply unit we have a step-down transformer (Secondary 12 volt, 1A) is used to covert 230V to 12V from main supply. Here we have used a bridge rectifier to convert Alternating current to direct current. The capacitor is used to reduce the ripple and to get a smooth DC voltage. Use a heat sink to IC LM7812 and LM7805 for safeguarding it from overheating. Power supply unitdistributes power to all the components which requires Power. The PIC18F46K22 microcontroller module takes the calibration pulse data from the energy meter and performs the necessary control operations and sends the required information like number of units through Wi-Fi module. The MAX-232 which in the peripheral used as a logic level voltage converter for serial communication. LCD module is used to get visual information like no. of units, temperature and Wi-Fi configuration.

1. Traic Switch circuit for Load

Triac switch circuit comprises of zero crossing detector MOC3031 IC (zero cross based optotriac isolator) which is used to turn on and off load and BTA12 triac which is connected in parallel to snubber circuit comprises of RC which will avoid the inrush current and it is a good practice to use an RC snubber network across the triac to limit the rate of rise (dv/dt) to a value below the maximum acceptable rating.

The snubber circuit not just restricts the voltage increase in the time of commutation but in addition it stops transient voltages that takes place as a consequence of alternating current line noises.To limit the BTA12 TRIAC turn-on stress and optimize the BTA12 TRIAC immunity against fast voltage transients, the snubber resistance is fixed to the minimum value.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Zero crossing

When the input signal is activated, the internal zero-crossing circuit triggers the output as the AC load voltage crosses zero. The internal zero-crossing detector circuit monitors the output voltage and allows turn on, only if its value is below a definite level, which is close to zero. Since the output is only triggered at low load voltages and zero-crossing limits high inrush currents, consequently minimizing EMC effects and stress for the electrical load.

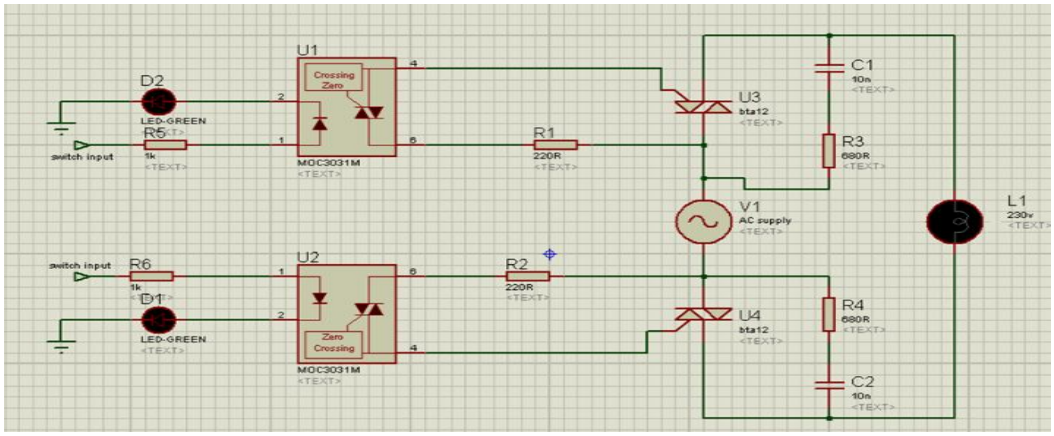

Fig 3. Triac switch circuit for Load

2. *Theft Detection circuit*

The theft detection circuit module has 2 circuits in it one is theft unit and other is normal unit. The theft detection circuit comprises of 1N4007 diode, MCT2E, BD139 transistor and Relay. 1N4007 diode is connected to MCT2E which has High Current Capability, Low Forward Voltage Drop and Low Reverse Leakage Current. MCT2E is an optocoupler, R9 and R10 resistors are current limiting resistors.

D5 and D6 (freewheeling diodes) are used to avoid inrush current and capacitor which is connected in parallel to freewheeling diode will block AC. Relay output is connected to the microcontroller for theft identification. Theft identification is done on the basis of below truth table.

TABLE I
Theft identification truth table

Normal unit	Theft detection unit	Status
Off	Off	Normal
On	On	Normal
On	Off	Normal
Off	On	Theft detected

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

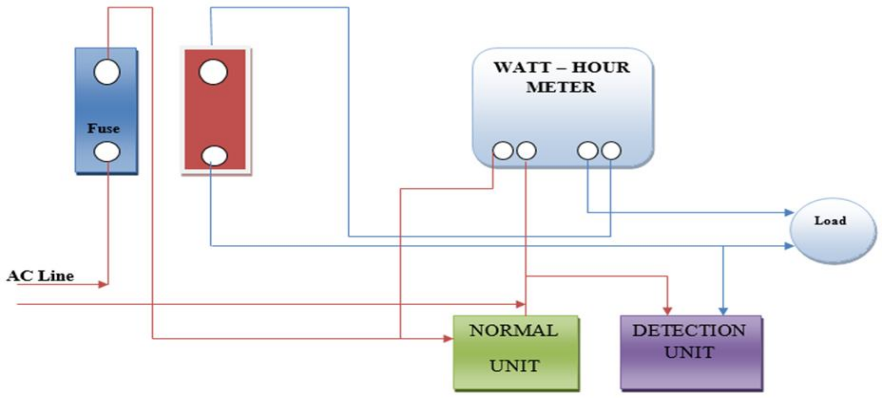

Fig 4. Meter configuration for Theft detection

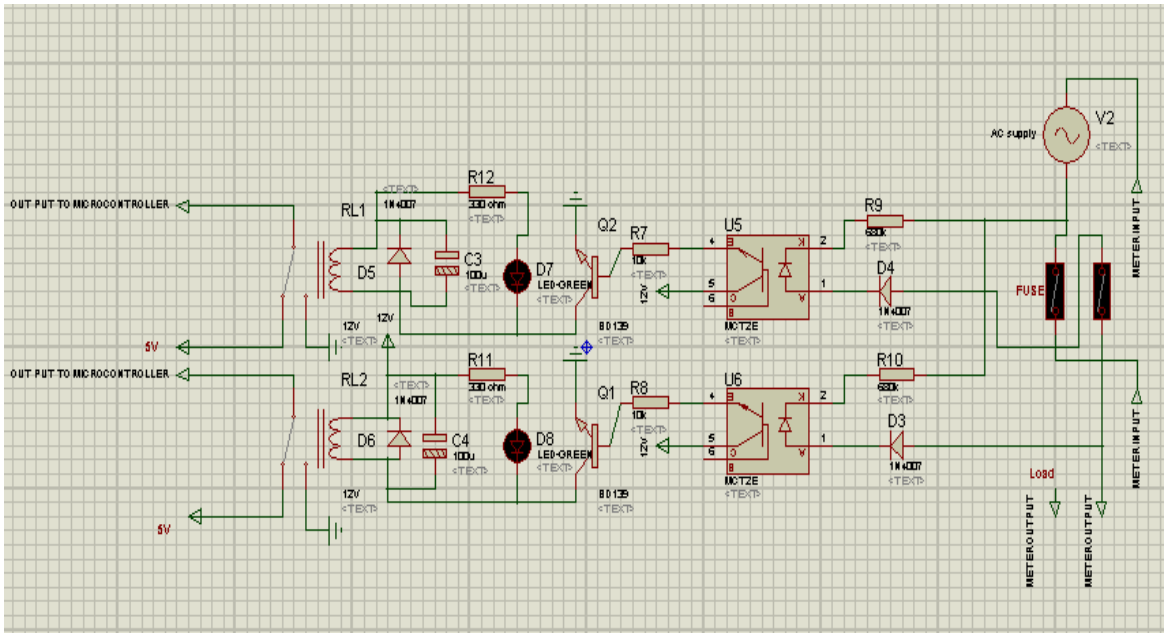

Fig 5.Theft Detection circuit

3. PLC unit

Power line communication modem is used to send and receive serial data over existing AC power lines. It has high immunity to electrical noise endurance in the power line and built in error checking so it never gives out corrupt data. The modem is in the form of a ready to use circuit module, which is capable of providing 9600 baud rate. Due to its small size it can be integrated very easily.

Features:-

- Transmit and Receive serial data at 9600 baud rate.
- Powered from 5V / 12V.
- It has built in Error Checking.
- Direct interface with microcontroller UART TXD, RXD pins.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

Fig 6. PLC modem.

4. ESP8266

Fig 7.ESP8266 Wi-Fi module unit

The PIC18F46K22 microcontroller module takes the calibration pulse data from the energy meter and performs the necessary control operations and sends the required information like number of units through Wi-Fi module.

B. Design Implementation flow chart

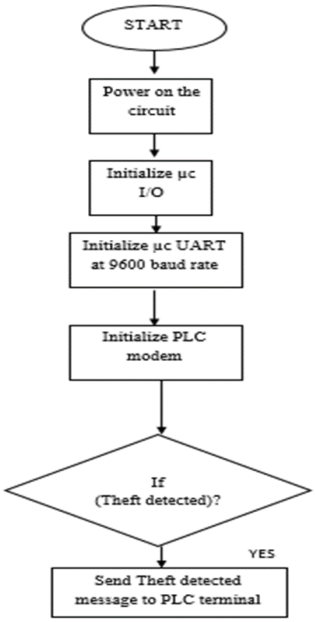

Fig 8. Theft detection Flow chart.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

The above fig 8 shows design implementation of Theft detection unit. When theft detection occurs, theft detection unit detects and PIC microcontroller sends necessary information through PLC terminal to service provider end.

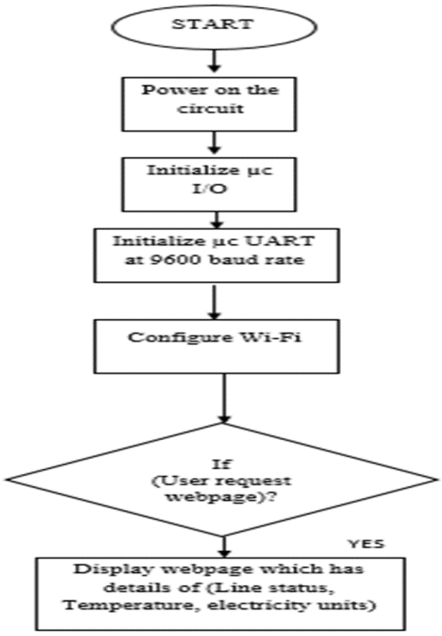

Fig 9. User interaction with webpage.

The above fig 9 shows user interaction with webpage. When user enters device IP address in the webpage then, ESP8266 Wi-Fi unit grants access to it and provides Line Status info, Temperature and No. of units consumed.

IV. RESULT

The subsequent pictures express the outcomes or outputs that entire proposed project can get after step-by-step execution of all the sections of the entire unit.

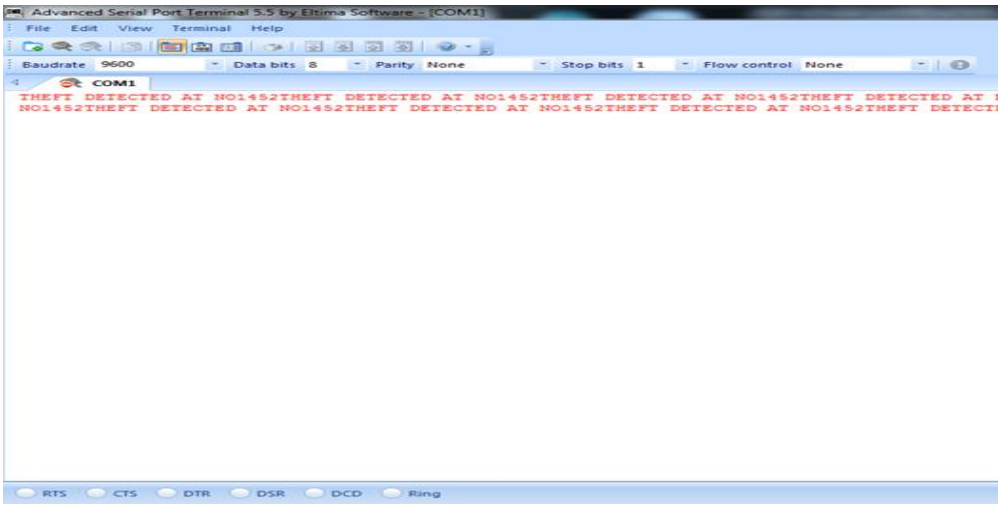

Fig 10.Terminal window showing theft detected

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

From fig 10 we can see, when user try to tamper meter, the theft detection unit detects theft and it sends theft detected information to Tx PLC through µc, which is then displayed on windows virtual terminal of the service provider using Rx PLC.

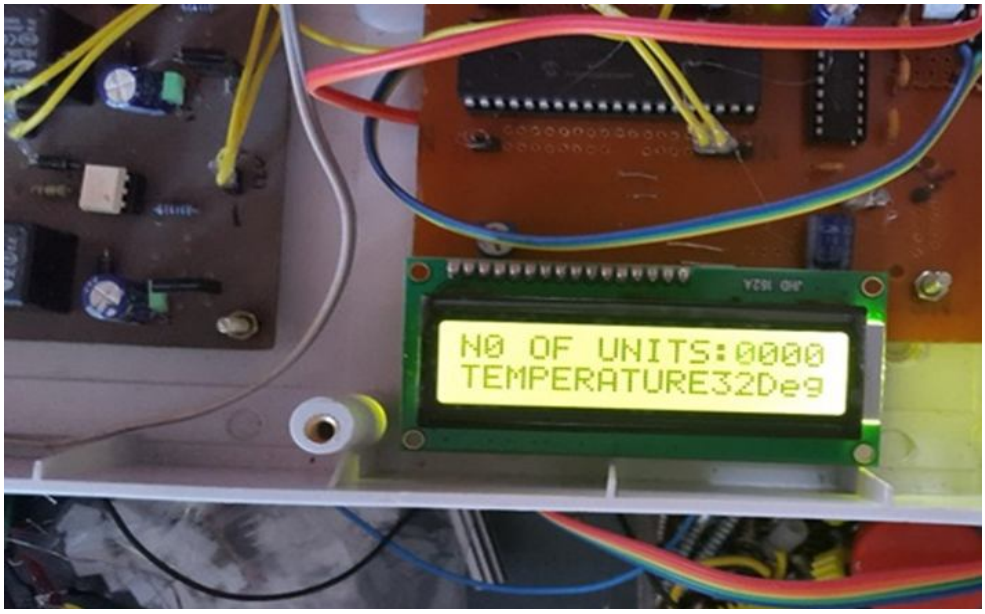

Fig 11. LCD display of IoT energy meter No. of units consumed and Temperature.

From fig 11 we can see LCD display of No. of units consumed by the various home appliances(i.e. in this project we have taken bulb) and present temperature of the house.

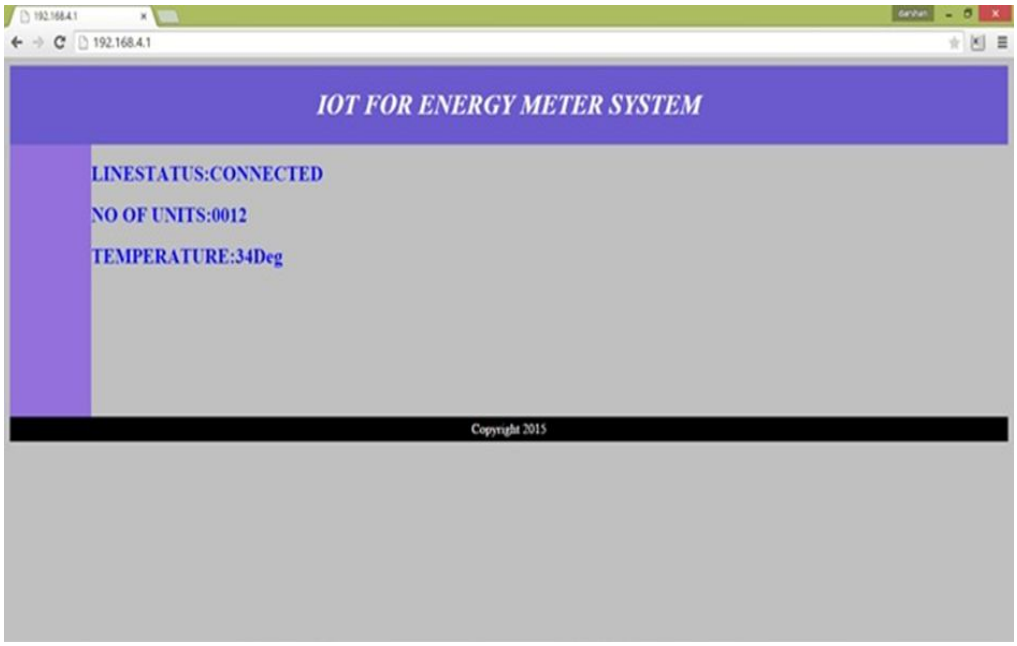

Fig 12. IOT Energy meter Webpage.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

From fig 12 we can see how consumer can monitor energy usage in units from webpage by providing IP address of the device and also he can see whether the line is connected/disconnected.

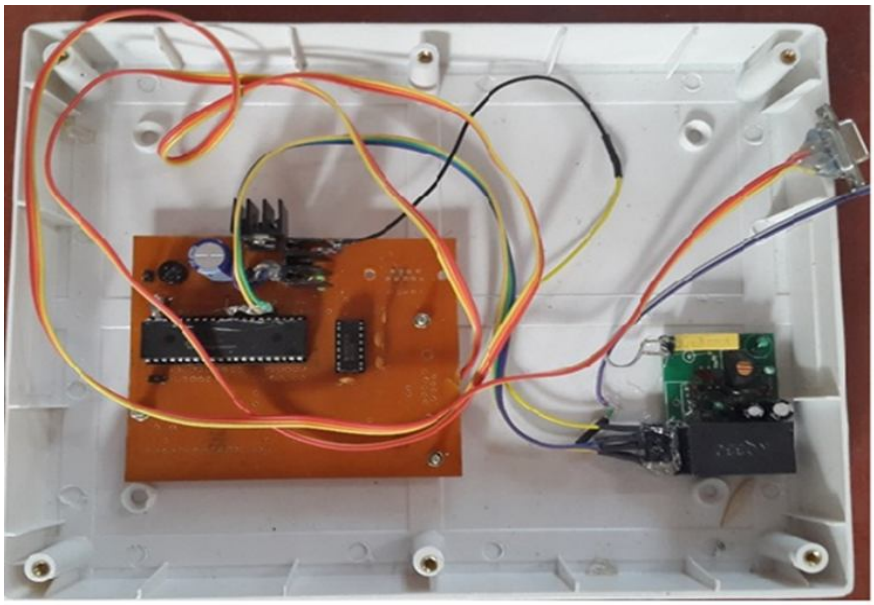

Fig 13.Service provider end implementation board

From fig 13 we see a service provider end implementation board which has PIC microcontroller and PLC modem for communication between consumer end IoT board and Service provider end.

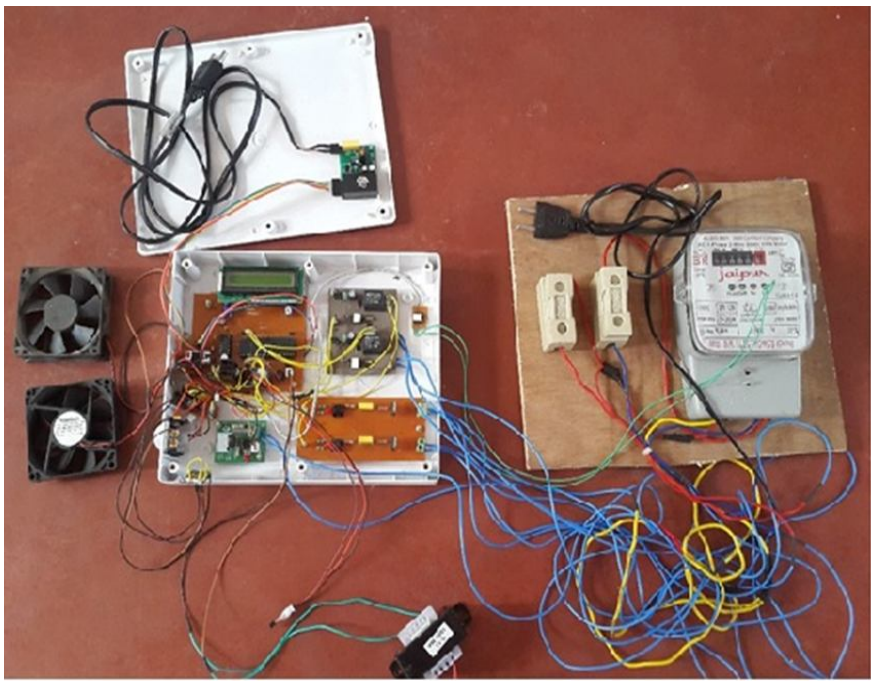

Fig 14. Consumer end implementation IoT Board

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

From fig 14 we see a Consumer end implementation IoT board which consists of ESP8266 Wi-Fi modem, PIC microcontroller and Theft detection unit for theft detection.

V.CONCLUSION and FUTURE ENHANCEMENT

Conclusion

In the era of smart city advancement, this project is concentrated on the connectivity & networking factor of the IoT .In this project, an energy consumption calculation based on the counting of calibration pulses is designed and implemented using PIC18F46K22 MCU in embedded system domain.

In the proposed work, IoT and PLC based meter reading system is designed to continuously monitor the meter reading and service provider can disconnect the power source whenever the customer does not pay the monthly bill and also it eliminates the human involvement, delivers effective meter reading, prevent the billing mistake.

The Project has achieved following objectives:-

- Ease of accessing information for consumer from energy meter through IoT.
- Theft detection at consumer end in real time.
- LCD displays energy consumption units and temperature.
- Disconnection of service from remote server.

Future enhancement

In the present system, IoT energy meter consumption is accessed using Wi-Fi and it will help consumers to avoid unwanted use of electricity. The performance of the system can be enhanced by connecting all household electrical appliances to IoT.

So, in future following objectives can be achieved to save power and avoid thefts:-

- We can make an IoT system where a user can monitor energy consumption and pay the bill Online.
- We can make a system where a user can receive SMS, when he/she crosses threshold of electricity usage slab.
- We can make a system which can send SMS to the concerned meter reading man of that area when theft detected at consumer end.

REFERENCES

[1] Landi, C.; Dipt. di Ing. dell"Inf., Seconda Univ. di Napoli, Aversa, Italy ; Merola, P. ; Ianniello, G, "ARM-based energy management system using smart meter and Web server", IEEE Instrumentation and Measurement Technology ConferenceBinjiang, pp. 1 – 5, May 2011

[2] Garrab, A.; Bouallegue, A.; Ben Abdallah, "A new AMR approach for energy saving in Smart Grids using Smart Meter and partial Power Line Communication", IEEE First International Conference on Renewable Energies and Vehicular Technology (REVET), pp. 263 – 269, march 2012

[3] 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, pp. 1474-1477, Dec,2003.

[4] 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, pp. 216-217, June, 2008.

[5] Steven Lanzisera, Member, IEEE, Andrew R. Weber, Anna Liao, Dominic Pajak, and Alan K. Meier, "Communicating Power Supplies: Bringing the Internet to the Ubiquitous Energy Gateways of Electronic Devices", IEEE Internet of Things Journal, vol. 1, no. 2, pp.153-160, march 2014.

[6] Andrea Zanella, Senior Member, IEEE, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, Senior Member, IEEE, and Michele Zorzi, Fellow, IEEE, "Internet of Things for Smart Cities", IEEE Internet of Things Journal, vol. 1, no. 1, pp. 22-32, February 2014.

[7] Poonam Borle, Ankitha Saswadhar, Deepali Hiwarkar, Rupali S Kali, "Automatic Meter Reading for Electricity",International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, no. 3,pp. 982-987, March 2013.

[8] http://wiki.iteadstudio.com/ESP8266_Serial_WIFI_Module.

[9] Microchip, "High-Performance Microcontrollers with XLP Technology PIC18(L)F2X/4XK22", DS41412F Data Sheet, 2010-2012.

[10] Microchip, "Microcontrollers with 10-Bit A/D and NanoWatt Technology PIC18F2420/2520/4420/4520", DS39631E Data Sheet, 2008.