IoT Based Energy and Demand Management System Using Arduino

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Abstract-

Electricity is one of the vital requirements for sustainment of comforts of life. Now a days, some of the industries crosses their power limit without knowing their power consumption. Due to this excess of energy consumption, the industries pay the penalty for the extra usage of energy. So, Energy management is very important and it is an effective use of energy to minimize energy cost without affecting production and quality. It will give awareness of usage of energy and also reduces to buy a new meter for knowing the energy consumption.

The demand management is defined as maintain the fixed demand. The penalty provide depend upon the term active power, reactive power, power factor and maximum demand. To monitor these term and we have to give awareness to reduce this kind of problems in the industrial sectors. Current sensor and voltage sensor is placed at electrical load to sense the current and voltage. Cayenne is the platform, we used to view the data for energy consumption along with Bill estimation and also it stores the data in the dashboard, where we can see the energy consumption for previous day or month or year. They should use cayenne to trigger a whole range of functions, to send alert notifications via email or SMS. Also we can give the graphical representation of Voltage, Current, Power factor, Real power, Reactive power, Apparent power and Electricity bill.Some of the industries uses trivector meter to measure real power, reactive power and apparent power. These devices are costly. This process is used to overcome these problem.

Index Terms—*Energy consumption, Energy monitoring , cayenne platform, Graphical representation, Demand management.*

I. INTRODUCTION

Today, smart grid, smart homes, smart water networks, intelligent transportation, are infrastructure systems that connect our world more than we ever thought possible. The common vision of such systems is usually associated with one single concept, the internet of things (IoT), where through the use of sensors, the entire physical infrastructure isclosely coupled with information and communication technologies; where intelligent monitoring and management can be achieved via the usage of networked embedded devices. Wireless Sensor Networks are regarded as a revolutionary information gathering method to build the information and communication system which will greatly improve the reliability and efficiency of infrastructure systems.

The power demands occur in both domestic and industrial sectors. Electric energy demand is increasing and the fossil fuels are diminishing due to rising consumption of energy. Moreover, the mismatch between demand and supply and lack of automation and monitoring tools have already caused major blackouts worldwide. For reducing the energy consumption wireless sensor networks(WSNs)is widely recommended for industrial monitoring.This method provides the communication using Internet of things (IOT) for transmitting the customer's electricity consumption and bill information that is calculated using Arduino UNO. So, consumer known their power consumption and will reduce their waste of power usage and also knows abouttheir daily power usages.This Energy Management System will provide real time energy monitoring and usage information that helps in real time energy management and electricity price forecasting.

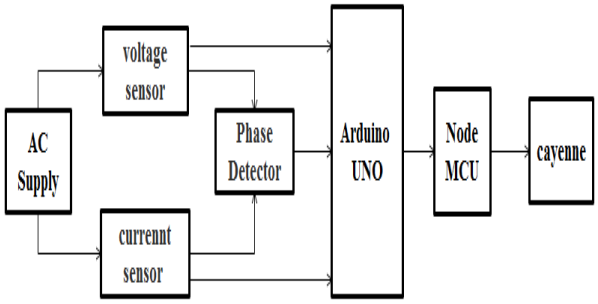
Data information is communicated using standard data access techniques combined with web interfaces. This enhances user's profits and save their time by pre-determined energy consumption details which will be closely related to the actual usage .The total energy cost is closely related to the power factorin industry. The 5% reduction in total energy cost for the LT industries for maintaining power factor at unity.

The2.5% reduction in total energy cost for the HT industries for maintaining power factor at unity and also provide penalty to decrease the power factor at below 0.85[2]. The consumer has no way to track their energy usage on a more immediate basis. So, Our process is used to solve this kind of problem. The

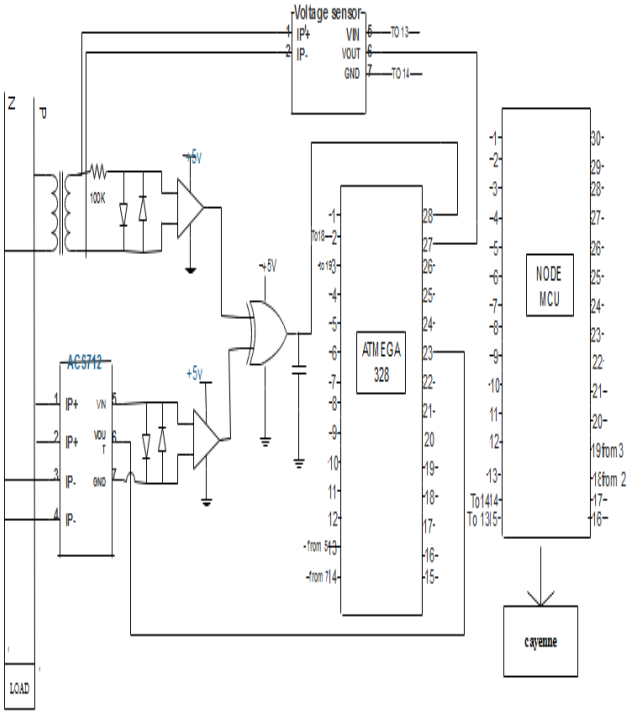
objective is to optimize the usage of energy in our campus. In order to optimize, we should know the usage profile of the entire campus. This will be helpful to manage their energy consumption and implementing an efficient energy management schedule. For connectivity a Wi-Fi connection can be used in this process. This collects energy usage information from all the buildings and also monitors the maximum demand. When the demand exceeds the threshold level, it will display in the Cayenne platform.

II. SMART ENERGY MANAGEMENT SYSTEM

Smart Energy Meter is designed so that it measures voltage and load currents by the use of voltage and current sensors instead of potential and current transformers and then feeds these values of voltage and current into power factor controller IC and energy metering IC the power factor and power calculations respectively [11].



The three important part of the block diagram is Arduino UNO ,NodeMCU and ACS712.The step down transformer is used andit converts 230V to 12Vac .The supply is fed to the arduino. Current sensor and voltage sensor connected to the arduino pin A0 and A1 respectively. The load connected to ACS712.The supply is ON, the current sensed by using ACS712. The data is monitored using arduino in the cayenne platform. The microcontroller takes this reading and sends it to website using NodeMCU.It is a Wi-Fi module, which provides internet facility for microcontroller. NODEMCU ESP8266 has one analog input. So,I have choose Arduinouno.It has multi analog-input. Here Arduino is used as a microcontroller. The Arduino can be provided with a 5V supply and ESP 8266 is powered by a 7.5V adapter. Arduino is programmed using Arduino IDE and the Wi-Fi module is programmed using AT commands in the same Arduino IDE. The zero crossing detector is also used. It consists of two op-amp and XOR Gate. One op-amp indicate voltage wave and other op-amp indicate current wave.XOR gate is used to measure power factor.Power factor is phase shift between voltage and current and the CRO is connected to the XOR Gate.The waveform is displayed it. The voltage, current and power factor readings are fed to the arduinoand calculate the real power,reactive power,energy and cost of energy using arduino coding.These The data is displayed on cayenne platform along with cost to be paid for consumption in graphical and gauge format respectively.



The design of Smart Energy Meter involves the measuring of load current and voltage using sensors and then feeding them to energy metering IC which converts it into the real power consumed by the load. Power factor is measured by measuring the phase shift between voltage and load current. Microcontroller used to perform the calculations related to power and energy consumed and shows the reading on LCD as well as it sends the reading of Smart Energy Meter with the help of GSM modem [12]. Active power, reactive power, voltage, load current, power factor and units (kWh) are measured and displayed successfully. Meter reading are sent from GSM modem and received on mobile successfully.

Two-way communication is done by smart energy meter between the meter and utility administration as well as between meter and customer so that customer is able to check the status of his

consumed energy units and can manage his load accordingly to reduce his bill. [13],[14].
The main features of smart energy meter are listed as follows;

- Get automatic reading of Energy Meter and sent it to cayenne platform as well as to utility.
- In reading it measures Voltage, Load Current, Real power, Reactive power, Power factor and units consumed.
- Utility is able to cutoff/restore the supply of the defaulter through Cayenne platform.
- Consumer is able to check the status of their load from anywhere in the world by Cayenne platform

Working of Smart Meter.

NodeMCU communications network is used to transfer the electricity consumed data to the utility administration as well as to the customer when demanded. Smart metering communication is centralized meter reading, so meter readers don't need to visit each customer for data collection. However, for testing and maintenance meters may need to observe occasionally.

The main duty of Smart Energy Meter is to measure the meter reading and sends it to utility when demand as well as to costumer. The voltage and current sensors measure the RMS values of voltage and current and feed them to microcontroller, where calculations for active and reactive power are performed. In Smart Energy Meter we used sensors to measure voltage and current instead of current and voltage transformers. The reading from

A major feature of Smart Energy Meter is that utility company can cut off and reconnect the connection of energy of any user with the help of SMS without sending the person to perform the task manually [15]. It can be utilized in case when the utility company needs to disconnect a consumer due to non-payment of bills or some other reasons. Another major feature of Smart energy meter is that it gives alarm when the consumer load is exceeding the upper limit for which he got the utility connection [16]. In case consumer does not reduce his load meter automatically cut off the consumer connection. GSM

III. MAIN PARTS OF ENERGY MANAGEMENT

Smart Energy Meter is comprised of three main parts:

A. Voltage and current measurements
B. Power factor measurements
C. Wireless communication

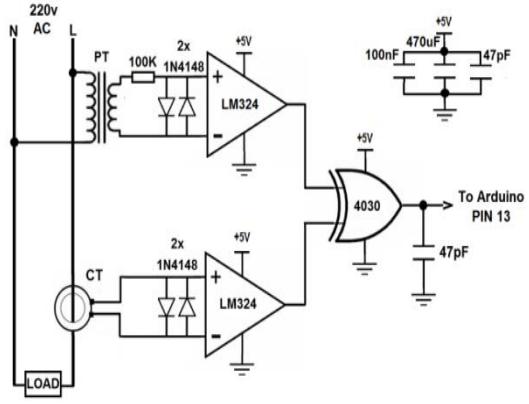
A. Voltage and Current Measurements.

In our project we used current and voltage sensor to measure voltage and load current. We used ACS712ELC-20A as current sensor that gives us RMS value of currents. Both AC and DC signals current measurement is precisely obtained by this current sensor. Current is measured by this sensor up to 20A. Overall power consumption, metering and measurements are taken by these sensors. Sensitive measurements of current are handled by using OPAMP stage. By adjusting the gain we measure very small currents. ACS712ELC-20A output voltage has linear variation with measured currents. Similarly we measured voltage by ACS712ELC-20A.

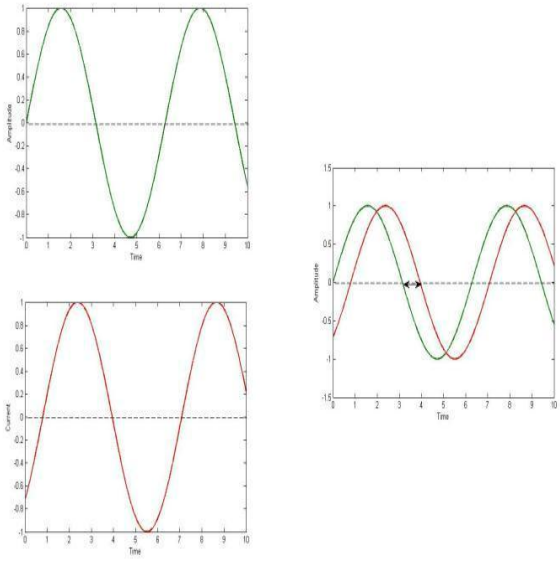
B. Power Factor Measurements.

Power factor is the cosine of angle between voltage and current. It actually measures how effectively the power is being converted into useful work. In our project we measured it by taking XOR of voltage and current waves with the help of microcontroller and LM358. We used LM 358 to convert weak sinusoidal signals to large square signals.

After XOR we get signal of double frequency as shown in figure 4 (c). We calculated the time of XOR signal and it is the power factor. For 50Hz the output of XOR can be 10 ms if power factor is 0. And "0" if power factor is unity. So the output of XOR lies between 0 -1 for a certain value of power factor.



(a) circuit diagram for power factor measurement



Figure(a) **figure(b)**

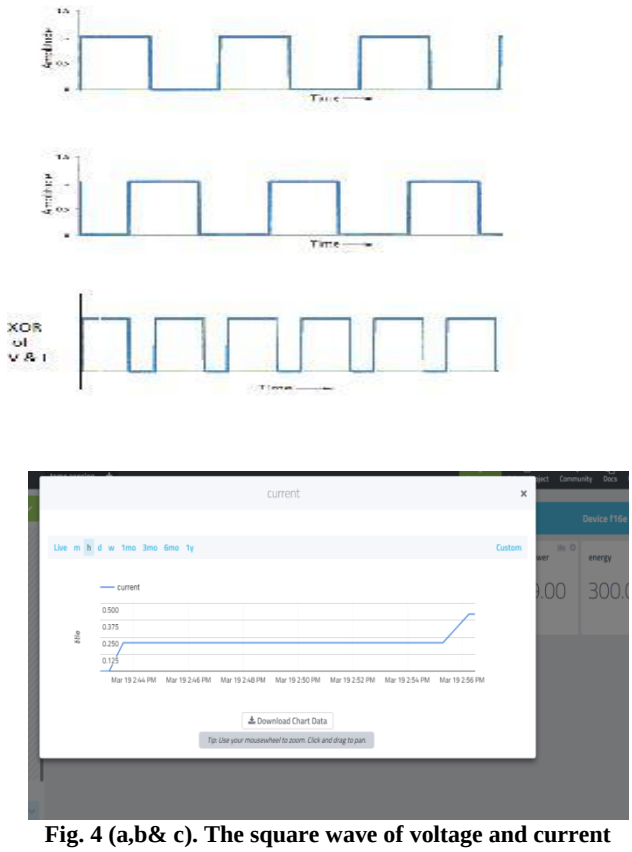


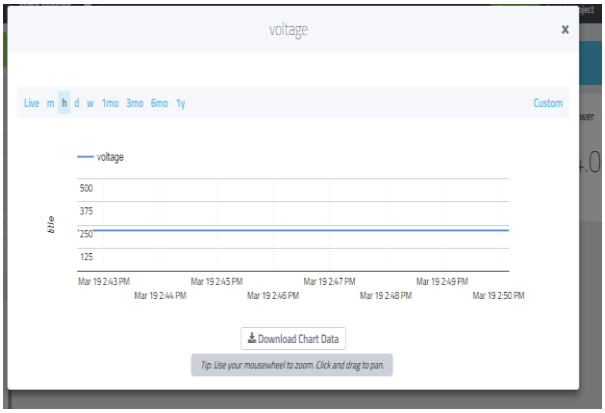
Fig. 4 (a,b& c). The square wave of voltage and current and their resultant after XOR operation.

1C) Wireless portion.

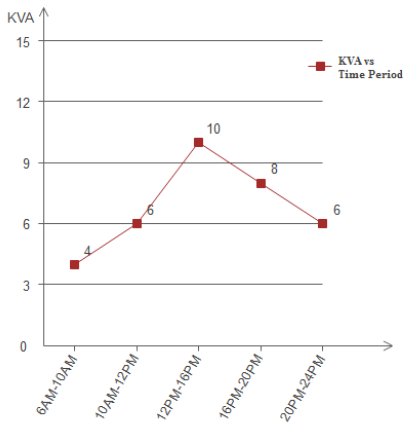
NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits. The firmware uses the Lua scripting language. Node MCU board that incorporates the ESP8266 chip on a standard circuit board.The board has a built-in USB port that is already wired up with the chip, a hardware reset button, WIFI antenna, LED lights and standard-sized GPIO(General Purpose Input Output) pins that can plug into a bread board. The NodeMCU DEVKIT board that comes preloaded with firmware can be purchased, which makes it a very economical device for prototyping and even for production use. In this board we connect a pin of RX and TX to the arduino board of TX and RX to detect the arduinodatas.

IV. TESTING AND RESULTS

The accuracy of Smart Energy Management is checked by comparing the readings that are displayed on the Cayenne of SEM. Smart Energy Management is also provide warning message to crossing the maximum demand. In this connection we use single load of 100W and checked its performance.



The testing of SEM provided accurate results, hence verifying the performance and accuracy of the system.



V. CONCLUSION

The paper describes the design and working of Smart Energy Meter and represents how Smart Energy Meter can be used for Automatic Meter Reading. It is the most economical implementation to develop mankind in this era of technology. With the present enhancement in the use of technology to facilitate mankind, it is an efficient and practical utilization of present networks. This paper also shows that how customer can manage the load by using Smart Energy Meter. It provides ease in taking the meter readings, accuracy, detection of faultyconditions, power factor calculation, less operation cost and removal of possible corruption related to meter reading.

VI. FUTURE RECOMMENDATIONS

I thought there are few possibilities which can also be done on this project in future as I have provided flexibility in the project especially in controller section. The future research should include the proper methodology for measuring the power factor of the load.

Recommendations for future are as follows:

- Power factor must be measured by different techniques.
- Linking of the data received by sensor to computer and developing a program which incorporates the tariff related to specific consumer and calculating the bill directly on the computer. In this way the computer will calculate the bill directly using the data received through sensor network.
- It also detects illegal use of electricity.

REFERENCES

[1] H. M. Zahid Iqbal and M. Waseem“ Automatic Energy Meter Reading using Smart Energy Meter” Conference Paper · March 2014.

[2] Ashna.k ,Sudhish N George. “GSM Based Automatic Energy Meter Reading System with Instant Billing” 978-1-4673-5090-7©2013 IEEE

[3] Mrs. Mahalakshmi N, Mr.KrishnaiahPararnesh and Ms. ElavarasiE"Design of an Intelligent SMS Based Remote Metering System for ACPower Distribution to HT and EHT Consumers", International Journal Of Computational Engineering Research, Vol. 2, Issue 3, pp. 901-911, May June 2012.

[4] T. Chandler, “The technology development of automatic metering and monitoring systems,” in IEEE International Power Eng. Conf., Dec. 2005.

[5] G. T. Heydt, “Virtual surrounding face geocasting in wireless ad hoc and sensor networks,” Electric Power Quality: A Tutorial Introduction, vol. 11, no. 1, pp. 15–19, Jan. 1998.

[6] M. Faisal and A. Mohamed, “A new technique for power quality based conditionmonitoring,” in 17th Conf. Electrical Power Supply Industry, Oct. 2008.

[7] P. RakeshMalhotra, Dr.R.Seethalakshmi “Automatic Meter Reading and Theft Control System by Using GSM P”.RakeshMalhotra et al. / International Journal of Engineering and Technology (IJET).

[8] (SarwarShahidi, Md. Abdul Gaffar, Khosru M. Salim , 2013) : Design and implementation of Digital Energy Meter with data sending capability using GSM network.

[9] V.Ramanathan,P.S.Kannan,V.Saravanan and P.S.Manoharan:”Electric Energy Generation,Utilisation and Conservation”charulatha publications.

[10] H. M. Zahid Iqbal and M. Waseem“ Automatic Energy Meter Reading using Smart Energy Meter” Conference Paper · March 2014.

[11] Ashna.k ,Sudhish N George. “GSM Based Automatic Energy Meter Reading System with Instant Billing” 978-1-4673-5090-7©2013 IEEE

[12] “Power factor metering system using arduino”http://ieeexplore.ieee.org/document/7981633.

[13] K. Rose, S. Eldridge, L. Chapin, The internet of things: an overview understanding the issues and challenges of a more connected world (2015), http://www.internetsociety.org/sites/default/ files/ISOC-IoT-Overview-20151022.pdf

[14] L. Atzori, A. Iera, G. Morabito, The internet of things: a survey. Comput. Netw. 54(15), 2787–2805 (2010)

[15] C. Dixon, R. Mahajan, S. Agarwal, A. Brush, B.L.S. Saroiu, P. Bahl, An operating system for the home, in NSDI. USENIX (2012).