Energy Monitoring and Management using Internet of Things

S.Balamurugan

Department of Electrical and Electronics Engineering

KCG College of Technology
Karapakkam, Chennai 97

sbalamurugan1496@gmail.com

D.Saravanakamalam

Associate Professor, Department of Electrical and Electronics Engineering
KCG College of Technology
Karapakkam, Chennai 97

saravanakamalam@kcgcollege.com

Abstract- **Energy management is becoming a trending topic in the 21st century. It includes planning and operation of energy production and energy consumption units. One of initial steps for an effective energy cost control program is the assessment of energy consumption and pattern of energy usage. This is the place where Energy Monitoring comes into picture. It is a technique based on the standard management axiom stating that "You cannot manage what you cannot measure". It serves as an effective guide for energy management. Unlike energy meters which are installed at locations which cannot be accessed easily, this monitoring system can be installed within the house i.e. nearby the switchboard or distribution box. By this way the people can get an idea of how much energy they are consuming in real time, inside their house itself. By uploading the data into the cloud, detailed consumption of energy will be available for every month, every day and every hour. This serves as a tool for Energy management. Apart from this, the loads in the houses can also be controlled remotely via computers/smart phones in case of overloads or when a person is not available at home.**

Index Terms **- Energy Monitoring, Energy Management, Arduino, IoT**

I. INTRODUCTION

India is currently facing an increase in demand and reduction in supply. We have to make new ideas in order to sustain well in the future. India is the fourth largest consumer of energy with consumption of over 600 million tons of oil equivalent. Coal is a major source of power to India's energy needs and even though the country produced 500 million tonnes of coal in 2012-13, it is still not enough to satisfy the country's growing power and energy crisis. According to one census, 77 million households in India still use kerosene for lighting. This case is very worse in rural India where up to 44 percent of households lack access to electricity. India meets its electricity demands with 67 percent from thermal resources, which includes coal and gas , 19 percent of the corresponding demand is met with hydropower, 12 percent from renewable sources, and 2 percent from nuclear energy.

Many experts in the energy sector state that solar and nuclear power as an important means of generating power, India will need greater capacity and efficiency in all sectors to meet India's energy needs. Efficient energy management is crucial today and an innovative and optimised way for on efficient management of energy is proposed here. The proposed system provides necessary information to the citizens to help them understand their basic energy requirement and help in setting a limit for their consumption.

All India (Anticipated) Power Supply Position in FY 2016-17

Region	Energy			Peak Power		
	Requirement (MU)	Availability (MU)	Surplus(+) / Deficit(-)	Demand (MW)	Supply (MW)	Surplus(+) / Deficit(-)
Western	379,087	405,370	+6.9%	51,436	56,715	+10.3%
Eastern	151,336	135,713	-10.3%	21,387	22,440	+4.9%
Northern	357,459	351,009	-1.8%	55,800	54,900	-1.6%
North-Eastern	16,197	14,858	-8.3%	2,801	2,695	-3.8%
Southern	310,564	320,944	+3.3%	40,145	44,604	-10.0%
All India	1,214,642	1,227,895	+1.1%	164,377	169,403	+2.6%

FIGURE 1: ALL INDIA ANTICIPATED POWER SUPPLY POSITION 2016-17
Source: http://www.cea.nic.in/reports/annual/lgbr/lgbr-2016.pdf
Load Generation Balance Report by Ministry of Power

II. PROPOSED SOLUTION

The main idea is to provide an Energy monitoring and Management system houses. By this way the people can get an idea of how much energy they are consuming in real time, inside their house itself. By uploading the data into the cloud, detailed consumption of energy will be available for every month, every day and every hour. This serves as a tool for Energy conservation. Also, the loads in the houses can also be controlled remotely via computers/smart phones.
The objectives of the project are as follows

- To install an energy monitoring device within the house premises (near switchboard or distribution box)
- To display the Voltage, Current, Power, Energy, Units consumed and Cost in real time
- Set a predetermined cost for a month and give a warning if the cost exceeds the set value
- Uploading all the calculated values into the cloud
- Real time access of data in the internet
- Comparison of data with previous months/days for effective energy management
- Controlling of appliances or loads through internet

III. BLOCK DIAGRAM

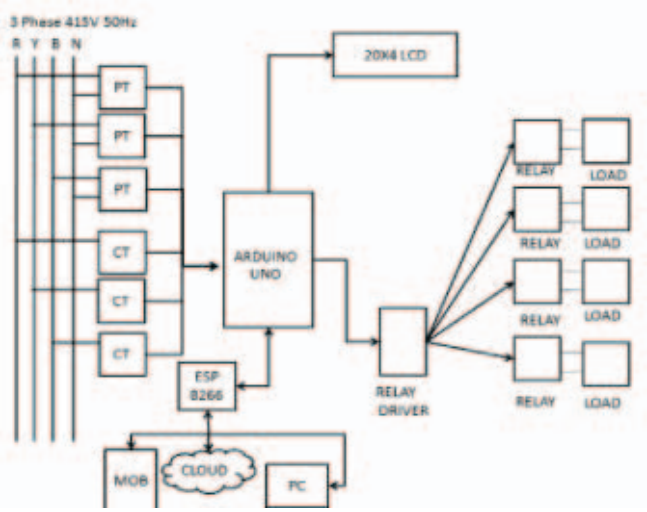

FIGURE 2: BLOCK DIAGRAM

The project is implemented using microcontroller, Wi-Fi module, Relays, LCD, Current Transformer and Potential Transformer

IV. CIRCUIT DIAGRAM

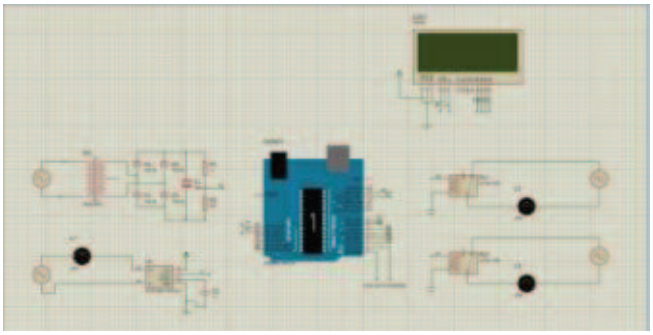

FIGURE 3: CIRCUIT DIAGRAM SIMULATED IN PROTEUS

IV. METHODOLOGY

1.Microcontroller

Arduino UNO (AtMega 328P) microcontroller has been chosen for this project. Arduino is an open-source developing platform wherein the hardware and software are easy to use. The boards are capable of reading analog inputs like light on a photoresistor, or a touch switch, and can turn it into an output signal as per the programmers need like activating a relay, energizing a motor or uploading some data to the internet. Arduino has been a popular choice for different projects and applications. The Arduino software is easy-to-use for beginners, and at the same time flexible enough for advanced users. It can be installed on any operating system like Mac, Windows, and Linux. Arduino boards are very cheap yet powerful compared to other microcontroller platforms.

2.Wifi Module

The ESP8266 is a low-cost Wi-Fi module which comprises of a TCP/IP stack and a in-built microcontroller produced by Shanghai-based Chinese manufacturer, Espressif Systems.

Western manufacturers AI Thinker Technologies were the first to notice the release of the ESP-01 module and started their own production. This tiny module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using simple AT commands. There was no documentation of the details of the chip and the commands it received at that time. Owing to its very less price and limited number of components, it allowed hackers to explore the module and make Chinese documentations of it. The ESP8266 consists of 1 MB built-in flash, allowing the devices capable of connecting to Wi-Fi.

Features:

- 802.11 b/g/n
- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack
- 1MB Flash Memory
- Integrated low power 32-bit CPU can also be used as application processor
- SDIO 1.1 / 2.0, SPI, UART
- Standby power consumption of < 1.0mW

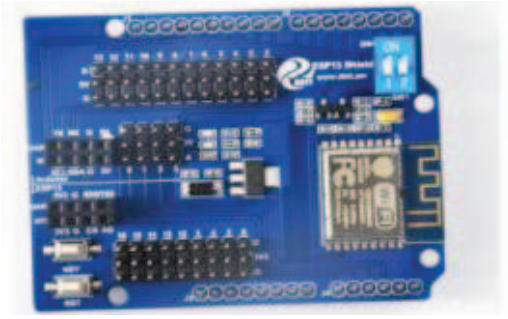

FIGURE 4: ESP8266-13 WIFI MODULE

3.Relays

A relay is can be defined as an electrically operated switching device. Many relays use an electromagnet to mechanically operate a switch. Relays are mainly used where it is necessary to control a circuit by a digital output signal, or where several circuits must be controlled by one signal. Magnetic latch type relays usually require one a digital high signal (say 5V) to move their contacts in one direction, and another signal to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in situations where power distortions should not be able to alter the contacts. Magnetic latching relays can consist of single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the supply is in the opposite direction. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will go to transition.

4.Input-Output Module

LCD (Liquid Crystal Display) screen is a display device and has numerous applications in many fields. A 20X4 LCD display has been chosen for this project. It is a display module consisting of 20 Columns and 4 Rows. This module is preferred over 7 Segment displays , the main reason being economical; easily to program; has no limitations for displaying special and custom characters. A 20X4 LCD can display up to 20 characters in a line and there are totally 4 such lines. In this LCD each character is displayed in 5x7 matrix format. This LCD has two registers which are, Command and Data Registers. The command register stores the commands which are to be given to the LCD. A command is an instruction given to LCD to do a predetermined task like initializing it, clearing the screen, setting the position of the cursor, control of the display. The data register stores the data which is to be displayed on the screen. The data to be displayed is converted to its corresponding ASCII Value and then sent to the LCD for display.

5.Current Transformer

In this project ACS712 Hall Effect Current Sensor is used. The device consists of a very precise, low-offset, linear Hall sensor circuit along with a copper circuitry path placed near the surface of the cast. The current which is to be sensed flows through this copper conduction path and generates a magnetic field. This magnetic field is sensed by the Hall IC which is then converted into a voltage proportional the current flowing. The device's accuracy is optimized through the proximity of the magnetic signal near to the Hall transducer. A precise and a proportional voltage is produced by the low-offset, chopper-stabilized Bi CMOS Hall IC, which already comes programmed after manufacturing for increase in accuracy .

The output from the device is a positive slope when the current flowing through the copper conduction path increases, which is the path used for current sensing. The internal resistance of this conductive path is typically 1.2 mohm in a practical case, thereby having low power loss. The thickness of the copper conductor improves the stability of the device even up to 5 times the over current conditions. The terminals of the conductive path are electrically isolated from the sensor IC pins. This allows the ACS712 current sensor IC to be used in areas that require electrical isolation without actually using opto-isolators or any other expensive isolation techniques.
The ACS712 is comes in a small, surface mount SOIC8 package. The lead frame is plated with 100% matte tin, which can also be used with standard lead (Pb) free printed circuit board during the assembly process.

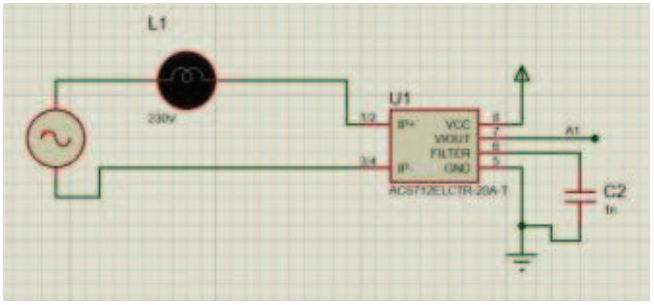

FIGURE 5: ACS712 CURRENT SENSOR CONNECTION FOR MEASURING CURRENT

6.Potential Transformer

A Potential transformer is used to step down the voltage of the AC sinusoidal signal to a lower level to make is easy to be measure using a small rated voltmeter. Primary side of P.T. is having large no. of turns. Primary is generally connected across any one line and earth. Hence, sometimes it is also called the parallel transformer**.** Secondary of P.T. consists of lesser number of turns when compared to primary and can be connected directly to a voltmeter for measurement. The voltmeter always has large resistance. Hence the secondary of a P.T. operates almost in open circuited condition.

A diode bridge is an arrangement of four diodes forming a bridge circuit that provides the same polarity of output for either polarity of input. Its widely used in the conversion of an alternating current (AC) input into a direct current (DC) output, also called by its name bridge rectifier. A bridge rectifier produces full-wave rectification from an AC input supply. The output from the secondary of the transformer is fed into the diode bridge rectifier configuration which gives a rectified full wave DC voltage. The output at this stage contains a huge amount of ripple. The reading is taken at this stage would vary by a very large rate and hence it will be very tedious to get a stable reading. One way to reduce this ripple is to use a filtering capacitor. The capacitor charges up to positive cycles of the peak value. When the voltage across

the capacitor decreases the capacitor begins to discharge .Again the capacitor charges when the voltage across it is greater than the voltage stored. It is then given to a Resistive divider, which gives an output of 5V that can be connected to the arduino analog port.

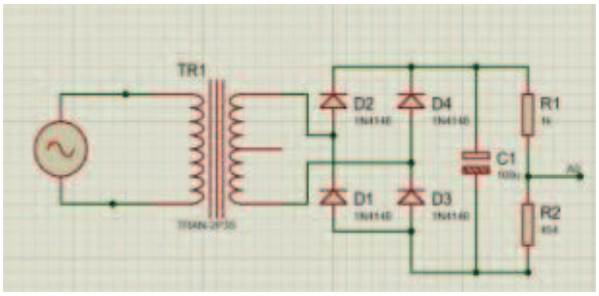

FIGURE 6: POTENTIAL TRANSFORMER CONNECTION FOR MEASURING VOLTAGE

V. WORKING

The Current and Potential transformer measure AC Current and Voltage and the analog value are fed to the microcontroller. The Analog value is converted into Digital using ADC (Analog to Digital Converter) inside the controller. The Voltage, Current, Power, Energy, Units consumed and Cost are calculated and the value is sent to the LCD for displaying. The calculated values are also uploaded to the cloud storage with the help of Wi-Fi module. An interactive webpage is developed to control the appliances remotely through internet and also for accessing the data uploaded .Upon receiving command from the user; the relay driver operates to switch on or off a particular load.

VI. UPLOADING TO INTERNET

Emoncms is a powerful online web application for processing, recording and visualizing energy, temperature and other data. Emoncms is completely freeware and open source An account is created and the API Keys are generated for the read and write of data, With the help of the API keys, one can send data to the Emoncms website from a remote device, in this case we are sending the measured values from the arduino to the emoncms website. The syntax of the API Key is as follows

https://emoncms.org/input/post.json?json={value:range}&apikey=1234567890

VII. RESULTS AND OUTPUT

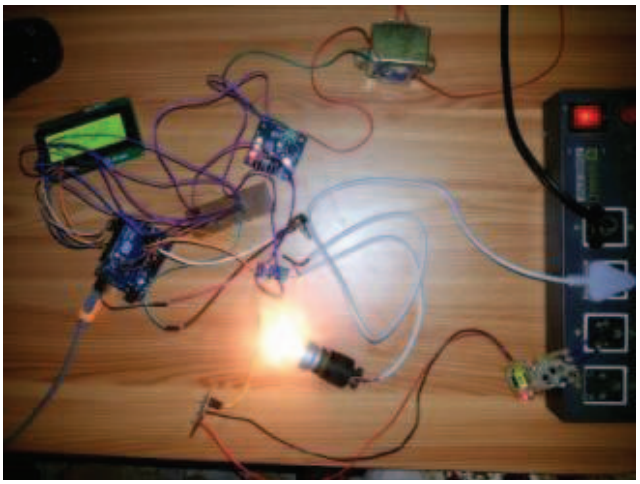

FIGURE 7: HARDWARE SETUP FOR MEASUREMENT OF ENERGY

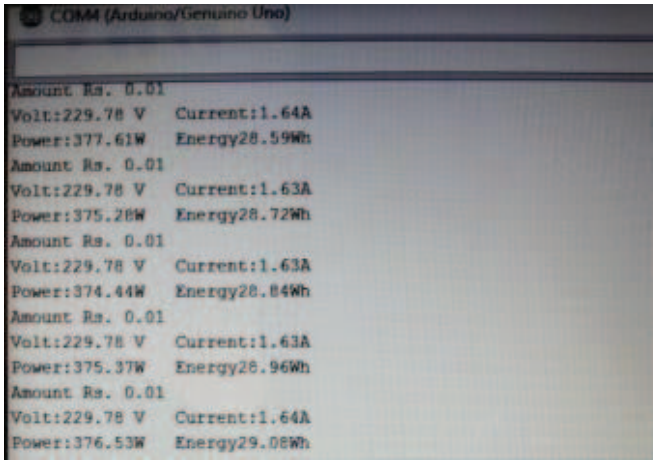

FIGURE 8: ARDUINO SERIAL MONITOR OUTPUT

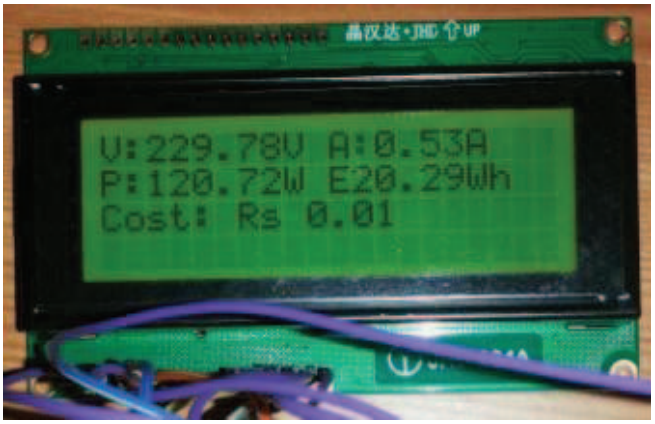

FIGURE 9: OUTPUT VALUES AS DISPLAYED IN LCD

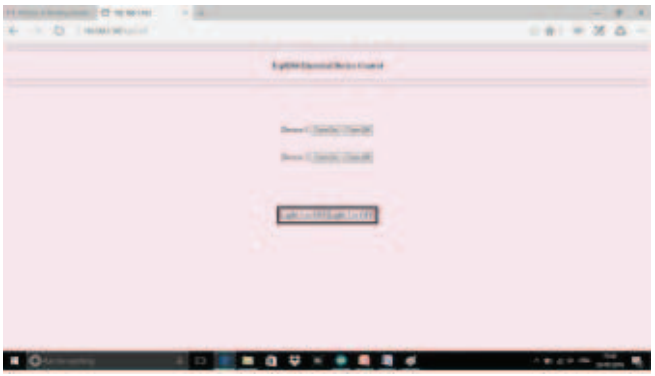

FIGURE 10: WEBPAGE DEVELOPED FOR REMOTE CONTROL OF APPLIANCES

FIGURE 11: EMONCMS DASHBOARD FOR VIEWING THE UPLOADED VALUES IN REAL-TIME

VII.CONCLUSION

This project uses only simple components and is more reliable. Less power consuming microcontroller is used and moreover it does not use any costly ICs or circuits, so in case any problem occurs it will be easy to replace. Not only do people can see how much they have consumed, they can also control their appliances using IoT which serves as an added advantage. By installing this project in commercial households, people can get an idea of how much energy they are consuming in real time. By setting a preset cost, they can limit their use of resources and thus able to save cost and energy efficiently. With the advancements in technology, there should not be any problem in connectivity of internet in the residential areas. If the persons are not at their homes and if they forgot to turn off any equipment, they can easily control it from anywhere in the world with a computer/mobile phone with an internet connection. The data in the cloud provides detailed consumption of power in a particular day, month or a year. By this way, they can mange energy by knowing where they are consuming the energy more. Hence this project serves as an effective tool for energy monitoring and management.

REFERENCES

[1] Measurement of Power and Energy Using Arduino; Research Journal of Engineering Sciences ISSN 2278 – 9472 Vol. 2(10), 10-15, October (2013); http://www.isca.in/IJES/Archive/v2/i10/2.ISCA-RJEngS-2013-115.pdf

[2] Detailed energy monitor system design ; https://openenergymonitor.org/emon/sites/default/files/DetailedSystemDesign.pdf

[3] Automatic Energy Consumption and Cost Monitoring System with GSM; International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering An ISO 3297: 2007 Certified Organization Vol. 5, Special Issue 3, March 2016 National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE'16)

[4] R. Dhananjayan and E. Shanthi"Smart Energy Meter with Instant Billing and Payment"-International Journal of Innovative Research in Computer and Communication Engineering March 2014.