IOT Based Smart Power Metering

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Abstract- In India, plug load devices in building sectors are consuming close to 40 percent of the total electricity consumption. Though the share of plug load in building energy is increasing, very few studies exist on the plug level energy usage and consumption. In order to address the growing energy use of miscellaneous and electronic load (e.g. water heater), some measures need to be taken. Hence identifying needs, this project focuses on designing the devices that have built-in capability to measure and report the energy use or receive control input over the network. This study will help in creating energy awareness devices. Current sensor measures the current flowing through device then controller performs necessary calculations on the data and puts that data on the internet. By measuring current and voltage, we can analyze energy consumption, make the world smarter place and make better decisions using Internet of Things.

Keywords – *power monitoring, controlling device; internet of things.*

I. INTRODUCTION

In this new era of internet of things, we can connect the physical world to the internet. Physical world means literally everything like machines and appliances which are used in our jobs and at homes, etc. The things or objects can be changed into smart things by giving it unique identity in the world. the objects can share information and communicate with each other through web. We can anaylze and control the objects anytime, anywhere from the corner of the world.

Due to industrial growth and urbanization energy is basic need of our life. It is also known as strategic commodity. Any vulnerability about its supply of energy can undermine the working of whole economy, especially in creating financial aspects. It is the necessity to manage consumption of electricity due to limited availability of resources. So the aim should be to recognize and eliminate the misuse of electricity by figuring out which equipment utilizes how much amount of electricity. Building sectors are consuming largest electricity in India.

The electricity generation in India during 2005-06 was 6,23,819 Giga Watt-Hours (GWh). It increased to 1,022,614 GWh during 2013-14. The annual growth rate marked was about 6.10% [1]. The production of electricity is continuously increasing due to population. The energy consumption in domestic and commercial sector is increasing in much faster rate. According to energy statistics 2013 of India's National Statistical Organization (NSO) [2], shows electricity accounted for domestic sector is 22% and commercial sector is about 9% during 2011-12.

An essential method for advancing more exact management of the assets and for developing new awareness about the expenses of the energy is smart metering. Smart meter is exceptionally intended for checking energy utilization and commanding each electronic equipment. IoT products can be integrated in all energy consuming equipment (air conditioning systems, electrical switches and sockets, lamps, appliances, plumbing, etc.) or in building envelope elements such as doors and windows, offering users the possibility to optimize energy efficiency, micro-climatic conditions and safety [3]. The power of electrical device is calculated by utilizing intelligent meter and it sends the deliberate information over the web for monitoring and commanding the electronic devices. Tremendous associations over the globe are doing work on smart meters for enhancing effectiveness of the power use and into reducing power utilization in different buildings.

II. RELATED WORK

There are various techniques available for measuring the energy use of electronic devices and report this data over the network. The techniques are plug load monitoring system, non-intrusive load monitoring system, device-level load monitoring system.

Communicating power supply (CPS) includes electricity metering which measures the power consumption of device, computation, and interaction between the electronic devices. Smart meter connected to the internet, increases energy awareness amongst devices and users [4]. This paper [5], aims at improving accuracy of disaggregation algorithm by using ON/OFF events with smart meter data to calculate energy consumption of individual devices. Clamp-on current transformer is used in non-intrusive load monitoring system (NILM) system, for measuring the current consumption. NILM system has no direct contact with main supply. So it is safer method [6]. Non-invasive inductive current sensing technique [7], is used for current measurement of plug load devices, without breaking circuit of plug load devices. Maximum energy is consumed by plug loads in enterprises [8]. To monitor and control electrical energy of plug loads like HVAC, there are multiple solutions available such as Building management system but there is no solution to analyze and trigger automatic action of plug loads in real time. Therefore,

PLEMS solution is used to identify the consumption pattern of any appliance using a weighted moving average model.

Internet of things has helped many organizational systems to improve efficiency, increase the speed of processes, minimise error and prevent theft by coding and tracking the objects. Computing and communications has its future in the technological transformation brought by the IOT, rapid technical innovation in the fields ranging from wireless sensors to nanotechnology are responsible for the further development of IOT. Each object will be tagged for identifying, automating, monitoring and controlling [9].

A. Various Protocols Available in IoT Architecture are:

- Web Technologies: CoAP(Constrained Application Protocol),
- DDS (Data-Distribution Service for Real-Time Systems) - a fast bus for integrating intelligent machines,
- MQTT(Message Queuing Telemetry Transport) - a protocol for collecting device data and communicating it to servers,
- XMPP(Extensible Messaging and Presence Protocol) - a protocol best for connecting devices to people, a special case of the D2S pattern, since people are connected to the servers,
- AMQP (Advanced Message Queuing Protocol) - a queuing system designed to connect servers to each other, etc. [11]

B. Organizations in IOT are:

- OMG (Object Management Group)
- OASIS (Organization for the Advancement of Structured Information Standards)
- ETSI (European Telecommunications Standards Institute)
- OGC (Open Geospatial Consortium)
- IEEE (Institute of Electrical and Electronics Engineers)
- IETF (Internet Engineering Task Force)

III. Proposed Methodology

Fig. 1 shows the proposed block diagram. This is divided into three section i.e. Analog measurement circuit, controller, and internet of things.

A. Analog measurement circuit

Our main goal is to measure the power use of electronic equipment. ACS712 current sensor is connected between supply and load to measure the current flowing through load. This current sensor is based on the principle of hall-effect. The principle states that whenever current carrying conductor placed in magnetic field, the voltage is created across its edges perpendicular to the direction of both current and magnetic field. The voltage generated is called as Hall voltage which is in microvolts.

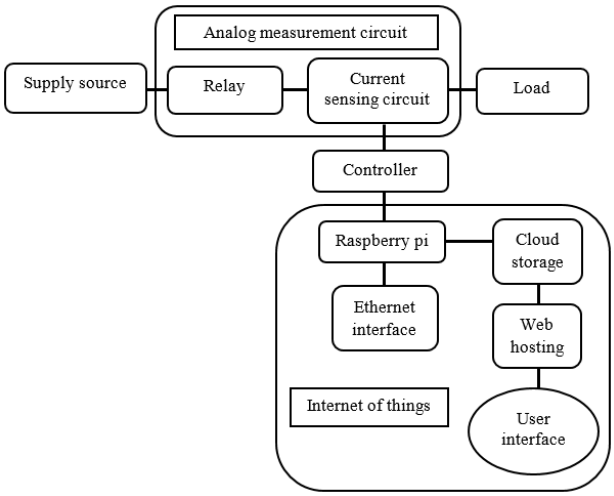


Fig. 1. Proposed block diagram

It is directly proportional to the current and magnetic field. ACS 712 current have inbuilt signal conditioner and filter circuit stabilizes and amplify the induced Hall voltage to an appropriate level. The ADC channel of microcontroller reads the measured current values. The measured data is send to controller for further calculation. Relay is used for controlling action (e. g. on/off) of the electronic equipment. Relay circuit receive control signal from raspberry pi which is send by user and executes the command.

In order to drive the relay, relay driver IC ULN2003A is used. Transistor works as an amplifier, if base lead gets sufficient amount of power, then transistor conduct from emitter to collector, and power the relay.

B. Controller

Arduino uno microcontroller is used which is based on ATmegha328. After receiving measured current data and input voltage from analog measurement circuit we have to calculate the power. The programming is done in Arduino software (IDE). This is the open source platform. This board also acts as network traffic controller. It receives the measured data from sensor and send calculated data to raspberry pi. The instantaneous output is provided to the current flowing through the terminals by ACS712. If the current is flowing in positive direction then ACS712 output voltage increases above Vcc/2 and sensitivity measured is also positive. But if current is flowing in negative direction then ACS 712 output voltage decreases below Vcc/2 and sensitivity will be in negative. The 10-bit ADC microcontroller oscillates total 1024 counts. Microcontroller calculate RMS value of the current using eq. 2.

A potential difference is created across its edges perpendicular to the directions of both the current and the magnetic field. This hall voltage is converted to RMS value using following equation.

$$Vrms = \left(\frac{Vcc}{2}\right) * 0.707 \quad (1)$$

The sensitivity of ACS 712 current sensor is set to 100mVperAmp. So that sensitivity need to be considered to calculate RMS current value using the following equation.

$$Irms = \frac{Vrms * 1000}{mVperAmp} \quad (2)$$

Power is calculated as follows

$$power = Vrms * Irms \quad (3)$$

C. Internet of things

Raspberry pi is the key learning platform for IOT. Raspberry pi is connected to the controller and the internet. Once the Ethernet connection is set then login to raspberry pi to start developing IoT platform. Python programming language is used. Raspberry pi send energy information to the internet connected server for monitoring energy use information of individual device. Cloud storage and web hosting is used for storing real-time energy data and allows other programs to access and monitor the data. The control signal send to raspberry pi using same server to turn on/off the device.These are the various steps to build IoT platform as shown in flow chart below.

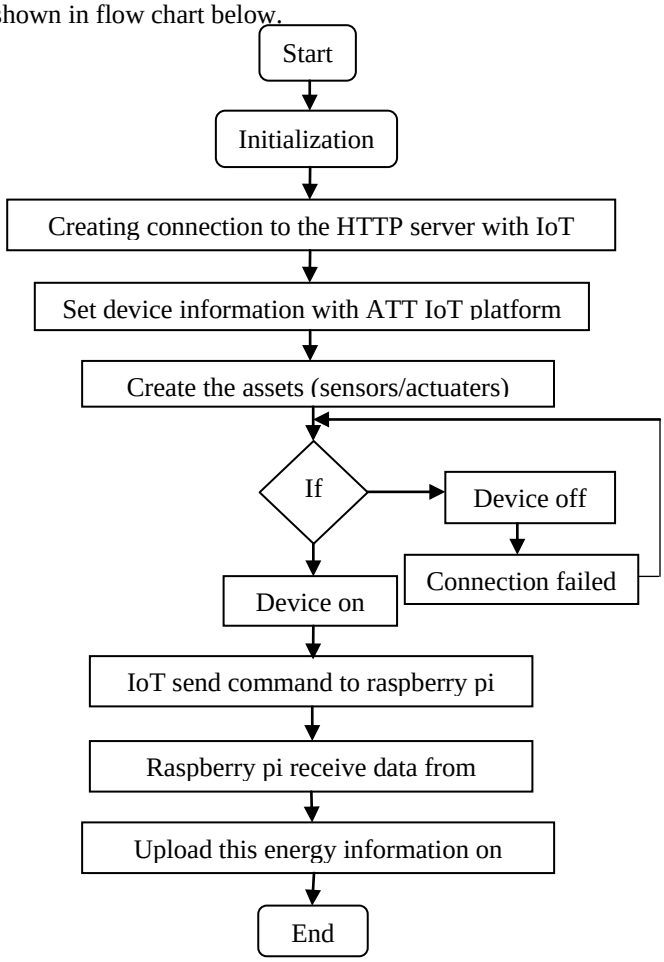


Fig. 2. Flow chart of IoT platform

Flow chart of proposed system.

1) Current sensors are interfaced to arduino.
2) Based on current sensors values we calculate the power consumption of each load.
3) Raspberry pi is used as gateway: to upload the power level on net & to remotely turn on & off the connected load.
4) Raspberry pi & arduino communicate via serial interface with each other.
5) Arduino gets the current consumed by the load & calculates the power.
6) Raspberry pi sends the "p" character to get those values from arduino.
7) Arduino then sends the power level in following format. "PW1#PW2#*"
8) Raspberry pi receives it & parse it to get 2 power levels.
9) It then uploads these values to IOT platform(Thingspek).
10) Concurrently program is running to turn on & off the load remotely. (Smartliving.io).
11) We will get the graph of power consumption of individual load on thingspeak.

IV. Results

The project obtained results can be divided into two parts namely:

1) Experimental setup
2) Web dashboard for user interaction with the system

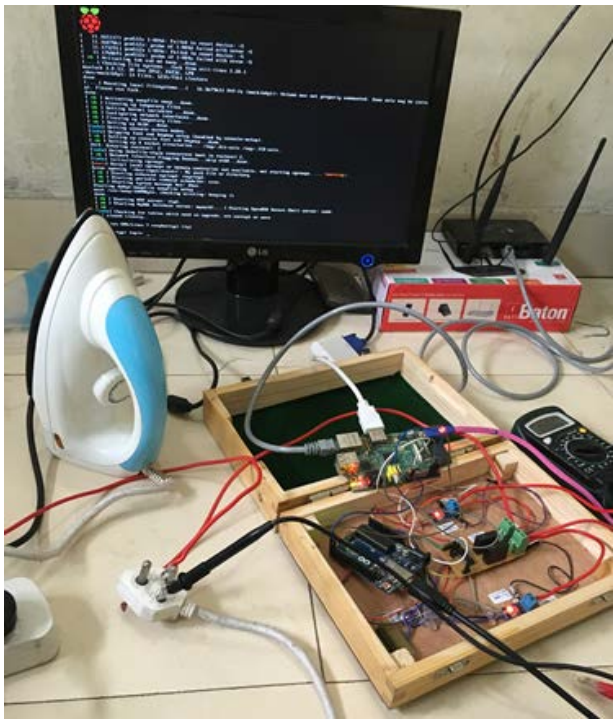
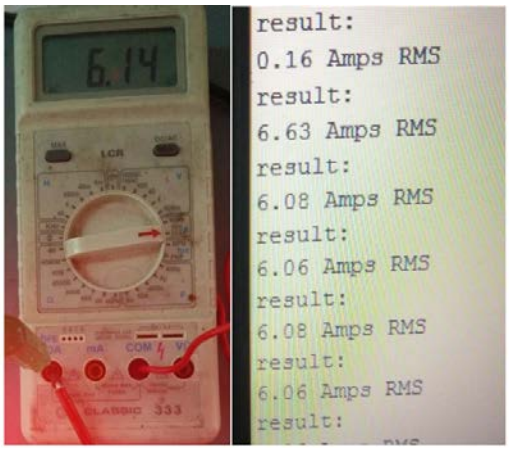


Fig. 3. Experimental setup

The experimental setup for the system is as shown in fig. 3 The ACS 712 current sensor gives precise current measurement for both AC and DC signals. These are good sensors for metering and measuring overall power consumption of systems. The ACS712 current sensor measures up to 20A of AC current. The relay circuit is used for control individual device remotely through IoT.

The power consumption of the neon tube is 1500watt. The AC current of neon tube is measured using wattmeter and current sensor shown in fig.4.



(a) (b)

Fig. 4 AC current measurement by using (a) Wattmeter (b) current sensor

The mains supply voltage is 230V. The current of water heater is measured by wattmeter is 6.14A is shown in fig. 4 (a). Serial monitor of Arduino microcontroller shows the current is 6.08A is shown in fig. 4 (b).

Fig. 5 shows the web page application for the user interface with the system. Here connection to http server is created which is the part of the IOT platform.

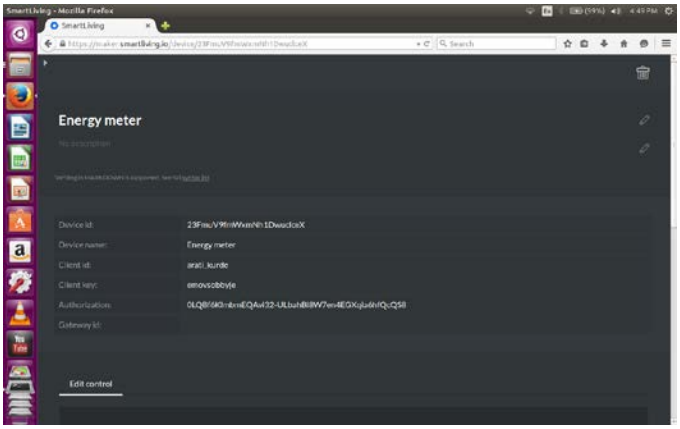


Fig. 5. Web page application for the user interface system

The IOT module is not able to automatically create new devices. Add new device manually on the makers website of IOT platform. In this two types of web page is used.

1. SmartLiving Maker, the AllThingTalk developer platform
SmartLiving, the AllThingsTalk developer platform to rapidly connect your things and interact with them. Connect and set up loads. Create device assets setup controls based on assets profiles.

2. ThingSpeak
This is open data platform to the internet of things. Send real-time data to the cloud for storage. Analyze and visualise the data.

After simulating program our device receives commands/data from the cloud through MQTT. MQTT is a protocol for collecting device data and communicating it to server. The device is controlled through SmartLiving Maker platform as shown in fig. 6.

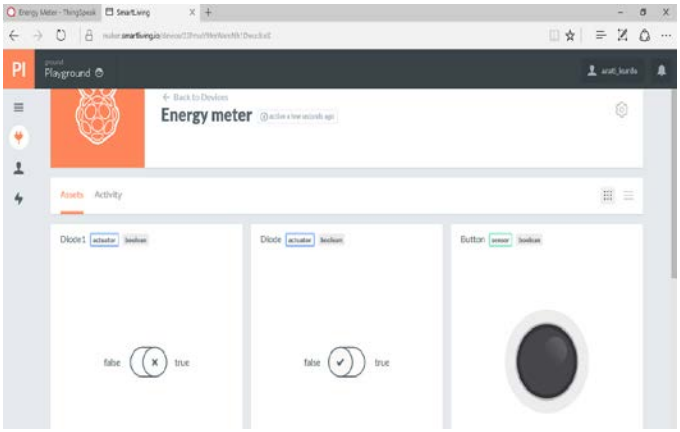


Fig. 6. push button to control device using IOT

ThingSpeak store real time data to the cloud. Plot the graph of energy vs. time of load as shown in fig. 7. So user can analyse and visualize the data. And send control command to controller to control the device using push button avaliable on moblie apllication or web dashboard.

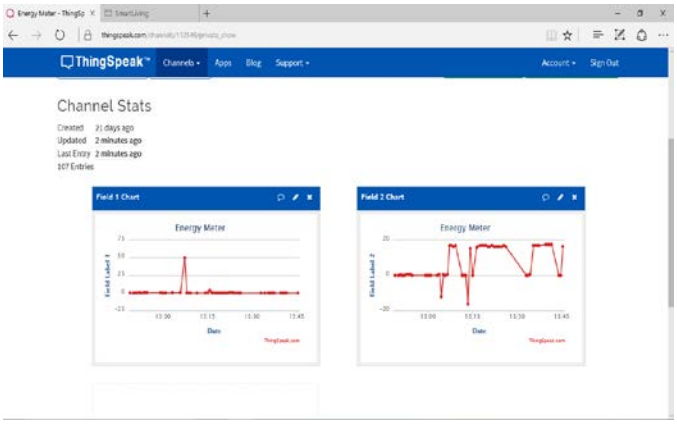


Fig. 7. Energy vs. Time analysis of load

V. Conclusion

Thus we have presented internet connected energy monitoring and controlling system that increases awareness of energy consumption amongst devices and users. Energy awareness enables the user to control the power state of the devices as per there needs which minimizes the energy use. In the coming future, each individual devices will have their own identity that can share and communicate the information over the IP network.

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References

[1] "Energy statistics 2015", www.mospi.gov.in
[2] "Energy statistics 2013", Central Statistics Office Ministry Of Statistics And Programme Implementation Government Of India, New Delhi.
[3] Marco Casini , "Internet of things for Energy efficiency of buildings," International Scientific Journal Architecture and Engineering.
[4] S. Lanzisera and D. Pajak, "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, April 2014.
[5] Christian Beckel and Silvia Santini, "Improving device level electricity consumption breakdowns in private households using ON/OFF events," ACM SIGBED Rev., vol. 9, pp. 32–38, 2012.
[6] D. Balsamo and Luca Benini, "Non-intrusive Zigbee Power Meter for load monitoring in Smart Buildings", Sensors Applications Symposium (SAS), IEEE 2015.
[7] Michael C. Lorek, Fabien Chraim and Kristofer S. J. Pister, "Plug-Through Energy Monitor for Plug Load Electrical Devices," SENSORS, 2015 IEEE, pp. 1-4, 2015.
[8] Animikh Ghosh, Ketan A Patil, Sunil Kumar Vuppala, "PLEMS: Plug Load Energy Management Solution for Enterprises," IEEE 27th International Conference on Advanced Information Networking and Applications, pp. 25-32, 2013.
[9] S. Madakam and S. Tripathi, "Internet of Things (IoT): A Literature Review," Journal of Computer and Communications, pp. 164-173, May 2015.
[10] Stan Schneider, "Understanding The Protocols Behind The Internet Of Things", Electronic Design (http://electronicdesign.com/embedded/understanding-protocols-behind-internet-things).
[11] Ángel Asensio and Roberto Casas, "Protocol and Architecture to Bring Things into Internet of Things", International Journal of Distributed Sensor Networks, Volume 2014 (2014), Article ID 158252.