IOT based Smart Energy Manager for Low Voltage Consumers with Remote Monitoring and Control

S Banumathi¹*, P Preethika², S Shangeetha³, A Anusuya⁴
Department of Electrical and Electronics Engineering, M.Kumarasamy College of Engineering, Karur- 639 113, India.

bbanumathi1974@gmail.com

Abstract. Electricity consumption at houses and companies are calculated using digital energy meters installed in the consumer’s premises. The consumer will aware of the energy consumption rate only at the end of the period and get worried about the high electricity bill. This IoT based smart energy manager is capable of monitoring the electricity usage and send SMS/E-mail to the consumer when the consumed energy reaches beyond the threshold value. In addition to the above it aims to save energy by turning off the appliances from remote place when energy consumption gets exceeded. Remote monitoring and control of electricity is obtained with the help of Arduino, ESP-12E Wi-Fi module. The current sensor is used to measure the current consumption and gives input signal to the Arduino Uno, which is programmed to calculate the electricity bill. With the help of CritaC App IoT, IFTTT, it sends SMS/E-mail about the total energy consumption and electricity bill. The prototype model is implemented and test results are discussed in this paper.

1. Introduction
India is the second largest populous country and one of the fastest growing economies in the world. In 2017, according to the International Monetary Fund (IMF), the Indian economy was nominally worth $2.6 trillion; it is almost $10 trillion as a 3rd largest Purchasing Power Parity [1]. India is rich in natural resources but the demand on power increases continuously (Figure 1-source: 19th EPS report-National Electricity Plan, Central Electricity Authority, India) due to increasing population, in order to satisfy the power demand new technologies should be included [2]. Renewable resources such as solar, wind should be used effectively to satisfy the emerging demand [3-4]. Today technology plays an important role in day to day life, it makes our life simpler and enable us to stay connected to family and friends with almost no cost. Now- a- days, home automation can be done in smart phone for controlling appliances with the help of sensors inbuilt within it [5].

Arduino plays a major role in the IOT platform and used to develop lot of projects in all areas. Arduino consists of microcontroller, various analog and digital I/O pins. The microcontroller present in Arduino can be coded by C and C++ programming language. With the help of Arduino, it is easy to combine both hardware and software. Here arduino is chosen as the major component since, it is cost effective and compact in size and it can easily work with all types of sensors that are available. When arduino is connected to the Wi-Fi module, it can be accessible by the smart phones[6]-[13].

The proposed system provides energy monitoring and control with the help of CritaC IoT App which calculates the tariff and send a mail if it exceeds the threshold value. The threshold value
completely depends on the customer’s maximum demand at the home. By this system it is easy to monitor and control the energy, here controlling is done with the help of relay connected to every appliance that trips the appliances when it exceeds the threshold value.

![Peak Electricity Demand (MW)](image)

**Figure 1.** India’s Peak Electricity Demand Source: EPS

2. Proposed System

The proposed idea gives a detailed report on energy monitoring and controlling purpose with help of Arduino, ESP8266, current sensor and relay. The Adafruit IO platform continuously fetches the data from the Wi-Fi component connected to the current sensor that measures the current consumption of the appliances. The CritaC IoT App is used to view consumption of energy for every second through smart phone and the load can be controlled with the help of relay. Thus the relay can turn off load.

![Block diagram of IOT based smart energy manager for low power consumers](image)

**Figure 2.** Block diagram of IOT based smart energy manager for low power consumers
automatically, hence it is programmed in Arduino that if it exceeds the threshold value. The main objective of the proposed project are to (i) monitor the energy consumption (ii) display energy consumption in a smart phone through CritaC IoT App (iii) display the amount of energy consumption shown as bill and (iv) to control the appliances if the energy consumption exceeds the threshold value.

The general block diagram of the proposed system is given in figure 2. The loads are classified into predominant and non-predominant loads. In this work the maximum limit is taken as 5 units. If the power consumption is beyond the maximum limit, it is not necessary to switch off all the loads. Rather than switching off all the loads only non-predominant loads are turned off with the help of relay. Here the energy monitoring and control is not enough, power saving is very much important for future. By turning on and off of the predominant and non-predominant loads at correct time is necessary and it can be done with the help of this proposed project. The comprehensive implementation details can be

![Flow chart for proposed system](image)

**Figure 3.** Flow chart for proposed system
visualized using flowchart as shown in figure 3. The flowchart describes the function of proposed prototype in which when the tariff is greater than threshold value, the non-predominant loads are turned off by the relay which is programmed by the Arduino.

2.1. Hardware setup

The hardware setup consists of Arduino Uno, relay, load, current sensor, bread board, ESP-12E module and a smart phone (Figure 4). Here the output can be viewed with the help smart phone. The loads are connected with the arduino, where ESP-12E module is used for transferring data to Adafruit Io platform. This chapter describes the components involved in this work.

The Arduino Uno is an open source Micro Controller board based on the microchip Atmega328P. The board consists of both analog and digital input & output pins that can be interfaced with other circuits. The Uno board is different from all other boards by featuring the ATmega328P microcontroller programmed as a USB to serial converter. Here, Arduino is used for serial communication with ESP12 by writing code for both transmitting and receiving data. The loads are connected to the arduino uno board as it has two analog to digital pins.

Current sensor is able to sense the flow of current in the appliances, which can detect AC or DC current. It generates a signal proportional to the current. The generated signal could be in any form and it is connected to Arduino to calculate tariff and bill using mathematical formulas (figure 3). Current sensor is the key component of the project that can able to sense up to 30A current. This module operates with Hall Effect principle.

![figure 4](image)

Figure 4. Experimental setup of smart energy manager

ESP-12E module is a Wi-Fi module that helps to connect the mobile phone with the sensor components. The module connected to the current sensor that collects the data from the sensor and it is transferred into mobile phone through Wi-Fi. The code written for ESP-12E module is also connected to Adafruit IO with AIO user name and AIO key that used to trigger when the electricity bill exceeds the reference value. In this project, the module is only used for transmitting and receiving data.

Features
32 bit LX106 RISC microprocessor
80 to 160 MHZ adjustable clock frequency
128 KB RAM and 4MB flash memory
802.11b/g/n HT40 Wi-Fi transceiver

2.2. Software modules

Adafruit IO platform is mainly used for storing electricity energy meter reading and communicates to CritaC IoT app. It can trigger when the bill amount exceeds the threshold value. In Adafruit IO
platform a new dashboard is created for energy meter. AIO key is generated that consists of username and password which can be used for CritaC IoT app. Then feed for power and bill are created.

CritaC IoT App is an android app that used to connect devices with mobile phone or tablet by which appliances can be easily controlled anywhere in the world. The appliances like light, fan, etc...Can be controlled with the help of this app. It helps the user by sending notification about the energy consumption, thereby it can take quick actions directly to control device by turning off.

IFTTT is both the website and mobile app which is mainly used to do more with all applications. IFTTT stands for If This Then That. IFTTT is used for triggering Gmail or SMS for energy meter when bill increased beyond the threshold value. Create the new applet to connect the Adafruit IO to the Gmail, which helps to trigger as Gmail or SMS.

3. Result and discussion

Smart energy manager works as an energy monitor and controller [6]. When all the appliances are working at a time it consumes lot of energy and it goes beyond the threshold value. In order to reduce the power consumption of the appliances the relay is used to control with the help of Arduino. The energy consumption and tariff can be viewed with the help of CritaC IoT App that monitors continuously with the help of current sensor. It continuously collects the data from the Wi-Fi module and displays in the smart phone. When the energy consumption is beyond the threshold value, the user is intimated with SMS or E-MAIL.

The figure 5, 6, 7 describes how to create new dashboard for energy monitor and control in Adafruit IO. After creating a dashboard it is ready to link with Gmail through IFTTT (Figure 8). In order to trigger it is necessary to monitor a feed on Arduino IO as shown in the figure 9. The complete action field (figure 10) will send a Gmail and review and finish work is shown in the figure 11.

The output in the experimental setup (figure 4) shows the current consumed by the loads and the maximum limit or threshold value fixed in the IOT server. It also display the bill amount for the power consumed totally, if it exceeds the threshold value the non-predominant loads are turned off with the help of relay automatically that programmed by the Arduino. In the proposed prototype experiment kit only two incandescent lamps are connected as loads. When the lamps consume power more than the maximum limit then one lamp is automatically tripped off with the help of relay. The power consumption and tariff is continuously viewed by CritaC Iot app in the smart phone. Based on the data retrieved by sensor, the chart is drawn by android app as shown in the figure 12.

Figure 5- Creating new dashboard in Adafruit IO
**Figure 6**- Choosing the feed

**Figure 7.** Setting minimum and maximum values

**Figure 8.** Linking Adafruit to SMS/E-mail using IFTTT
Figure 9. Monitor a Feed on Adafruit IO

Figure 10. Complete action field-Gmail

Figure 11. Review and finish
4. Conclusion

The energy monitoring and control has become more vital in the present scenario and power saving is very much important for future. By turning on and off the predominant and non–predominant loads at correct time with the help of this proposed project the energy can be saved.

This paper presented about energy monitoring and control with the help of smart phone that comprises with platform such as Adafruit IO, CritaC IoT and IFTTT. The experimental analysis of the proposed system clearly showed that it is applicable for domestic and industrial sectors and it is easy to install in both sectors.

References
[1] Ravi Kishore Kodali, Subbachary Yerroju. 2018. Energy Efficient Home Automation Using IoT, International Conference on Communication, Computing and Internet of Things, February 15-17, Chennai, India. A reference.
[2] Balamurugan S, Saravanan Kalamal D. 2017. Energy Monitoring and Management using Internet of Things, International Conference on Power and Embedded Drive Control, March 16-18, Chennai, India.
[3] Hariprabhu M, Sundararaju K. 2019. IoT based Fault detection in Solar Panel using Arduino UNO with Wi-Fi Module ESP 8266, International Journal of Recent Technology and Engineering (IJRTE) vol 8 no 4 pp 2630-2633.
[4] Firas A. Hadi, Samah Shyaa Oudah, Rafa A. Al-Baldawi. 2020. An Economic Study of a Wind Energy Project Using Different Sources of Wind Data, Iraqi Journal of Science 2020, Vol. 61, No. 2, pp: 322-332.
[5] Sumi L, Ranga V. 2016. Sensor enabled internet of things for smart cities, Fourth International Conference on Parallel, Distributed and Grid Computing, December 22-24, Waknaghat, India.
[6] Lazar Berbakov, Marko Batić, Nikola Tomašević. 2019. Smart Energy Manager for Energy Efficient Buildings, International Conference on Smart Technologies, July 1-4, Novi Sad, Serbia.
[7] Siti Syaidatul Syazlina Mohd Soleh, Mohamad Md Som, Mohd Helmy Abd Wahab, Aida Mustapha, Nurul Ain Othman, Mohd Zainuri Saringat. 2018. Arduino-based Wireless Motion Detecting System, IEEE Conference on Open Systems, November 21-22, Langkawi Island, Malaysia.
[8] Barret, S. F. 2013. Arduino Microcontroller Processing for Everyone. Third edition, 8(4), pp: 26-28.
[9] Saikat Mukherjee, Arpita Ghosh, Subir Kumar Sarkar. 2019. Arduino based Wireless Heart-rate Monitoring system with Automatic SOS Message and/or Call facility using SIM900A GSM Module, International Conference on vision Towards Emerging Trends in Communication and
[10] Apurva Singh, Harsh Mehta, AnujNawal, Gnana O.V, Swathika. 2018. Arduino Based Home Automation Control Powered by Photovoltaic Cells, Second International conference on Computing Methodologies and Communication, February 15-16, Erode, India.

[11] Swati Dhingra, Rajasekhara Babu Madda, Amir H. Gandomi, Senior Member, Rizwan Patan, Mahmoud Daneshmand. 2019. Internet of things Mobile: Air pollution Monitoring system. IEEE Internet of Things Journal, 1-1, volume 6, issue 3, pp: 5577-5584.

[12] Ayad Ghanay Ismael, Kitab, Mohammed Qasim Kamal. 2017. Arduino IoT Home Automation System for IR Devices, International Conference on Current Research in Computer Science and Information Technology, April 26-27, Slemani, Iraq.

[13] Dinesh Kumar S, Vengatesh R, Subiramani K, Thangamani P, Rajeshwaran M. 2018. Effectiveness and utilization of energy is compute by auditing system using IOT device in college desmesne, International journal of pure and applied mathematics, Volume 118, issue 20, pp: 2115-2125.