

Research Article

Intelligent Control System for Power Management in Enclaves/Buildings based on WSN

Madhani Ravali Prasuna^{†*} and Bhaktula Suneetha[†]

[†]Department of ECE, Vardhaman Engineering College, R.R. Dist, Telangana state, India

Accepted 15 July 2015, Available online 16 July 2015, Vol.5, No.4 (Aug 2015)

Abstract

The design and development of a smart monitoring and controlling system for household electrical appliances in real time has been reported in this paper. The system principally monitors electrical parameters of household appliances such as voltage and current and subsequently calculates the power consumed. The novelty of this system is the implementation of the controlling mechanism of appliances in different ways. The system is a low-cost and flexible in operation and thus can save electricity expense of the consumers.

Keywords: ARM 11, ZIGBEE, Ethernet, USB Camera

1. Introduction

The WSNs are increasingly being used in the home for energy controlling services. Regular household appliances are monitored and controlled by WSNs installed in the home [G. Song, 2007]. New technologies include cutting-edge advancements in Information technology, sensors, metering, transmission, distribution, and electricity storage technology, as well as providing new information and flexibility to both consumers and providers of electricity. The ZigBee Alliance, wireless communication platform is presently examining Japan's new smart home wireless system implication by having a new initiative with Japan's Government that will evaluate use of the forthcoming ZigBee, Internet Protocol (IP) specification.

There are several proposals to interconnect various domestic appliances by wireless networks to monitor and control such as provided in [C. Suh, 2008; K. D. Nguyen, 2011]. But the prototypes are verified using test bed scenarios. Also, smart meter systems type have been designed to specific usages particularly related to geographical usages and are limited to specific places. Different information and communication technologies integrating with smart meter devices have been proposed and tested at different flats in a residential area for optimal power utilization but individual controlling of the devices are limited to specific houses.

Wireless Sensor Network

Wireless sensor network (WSN), which integrates sensor technology, wireless communication

technology, embedded computing technology and distributed information management technology, has been under rapid development during recent years [W. Huiyong, 2013]. A wireless sensor network is a collection of nodes organized into an interactive network. Each node consists of processing capability (one or more microcontroller's chips) and contains types of memory, with a Zigbee transceiver module and also, each node have a stable power source and up to the last part of a node, it is accommodate various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc method. Such systems can revolutionize the way we live and work therefore in this project we want to use WSN technology to control and manage energy in building.

2. Related Work

Here, will discuss the related works done about smart home systems based on the wireless communication technology. Energy Management using the ZigBee technology to reduce the power wastage and system control. The suggested system consists of an automatic power cutoff outlet, a ZigBee hub and a server [N. K Suryadevara, 2010]. The power outlet with a ZigBee module cuts off the ac power when the energy consumption of the device connected to the power outlet is above a fixed value. The central hub collects information from the power channels and controls these power channels through the ZigBee module. The central hub sends the state information to a server and then a user can monitor or control the present energy usage using the user interface. This facility may create some easiness for the users. The system has been

*Corresponding author: Madhani Ravali Prasuna; Bhaktula Suneetha is working as Associate Professor

functions to the system are the ease of modeling, setup, and use. From the consumer point of view, electrical power consumption of various appliances in a house along with supply voltage and current.

3. Design and Implementation

The measurement of electrical parameters of home appliances is done by interfacing with fabricated sensing modules. The details of the design and development of the sensing modules are provided in the following sections. The output signals from the sensors are integrated and connected to XBee module for transmitting electrical parameters data wirelessly. The XBee modules are interfaced with various sensing devices and interconnected in the form of mesh topology to have reliable data reception at a centralized ZigBee coordinator. The maximum distance between the adjacent ZigBee nodes is less than 20 m, and through hopping technique of the mesh topology, reliable sensor fusion data has been performed. The ZigBee coordinator has been connected through the Serial port of the Raspberry pi, which stores the data into a array of system. The collected sensor fusion data have been sent to an intranet residential gateway for remote monitoring and controlling the home environment.

A) Voltage acquisition

The step-down voltage transformer is used to convert input supply of 230–240 V to 10 VRMS AC signal. The secondary voltage is rectified and passed through the filter capacitor to get a dc voltage. The details are shown in Fig. 1. The available dc voltage is reduced by a potential divider to bring it within the measured level of 3.3 V of the ZigBee. This output signal is then fed to analog input channel of ZigBee end device. The acquired voltage signal is directly proportional to the input supply voltage. A voltage regulator is connected to the rectified output of voltage transformer to obtain the precise voltage supply of 3.3 V for the operation of ZigBee and operational amplifier.

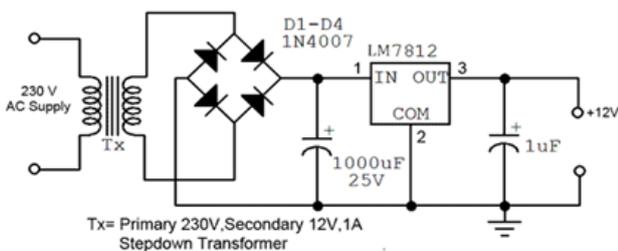


Fig 1 230V AC Step Down Transformer Circuit

B) Current acquisition

For sensing current, we used ACS712 current measurement sensor [V. N. Kamat, 2011]. The main features of this sensor include fully encapsulated PCB

mounting and compact size. The circuit design layout for current measurement is shown in. In this current sensor, the voltage is measured across the burden resistor of 50 Ω. The necessary filtering and amplification is required to bring the voltage with the necessary measurement level of ZigBee. The scaling factors for current measurement for two different ranges of currents are calculated.

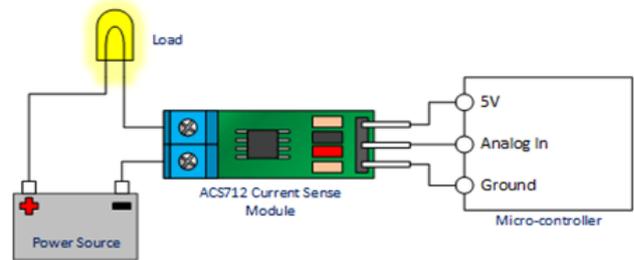


Fig 2 Current Sensor Connection to Load

The line wire is connected to the load, which is passing through the current sensor. With the use of current transformer, the electrical isolation is achieved which is important in many applications as well as for the safety of the electronic circuit.

To design the concentrator unit, a Raspberry pi (ARM11) processor board is used for control process unit of hardware and protocol operation. Also, the following communication protocols in the system have been developed:

- 1) ZigBee protocol which is used to develop and manage wireless sensor networks (this is a communication protocol between the local network equipments)
- 2) For better management of wireless energy network through End-Users, two methods defined. First, through a human machine interface (HMI) to view the system components locally and the second method used for remote control network (LAN) through a network.

C) Video Streaming

Not only controlling and acquiring the data over web, live video streaming of the load functionality is also achieved in our case using mjpg streamer.

4. Hardware

Raspberry Pi

The Raspberry Pi is a credit-card sized computer that plugs into your TV and a Keyboard. It is a capable little computer which can be used in electronics a project and for many of the things that your desktop PC does, like spreadsheets, word processing and games. It may also play high definition video. Its capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing videos, developing of programs in various languages i.e. python, java, C++ etc. Below figure shows the board.



Fig 3 Raspberry Pi Board with Arm Processor

Zigbee

Zigbee is a low-cost, low-power, wireless mesh networking standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries and the mesh networking provides high reliability and larger range. Zigbee has been developed to meet the growing demand for capable wireless networking between numerous low power devices. Zigbee is an established set of specifications for wireless personal area networking (WPAN), i.e. digital radio connections between computers and related devices.

USB Camera

Camera plays a vital role in automation purpose. The camera is used for monitoring of a room from a remote place. The camera used is a USB camera. Whenever the user clicks on to video button on loaded webpage, the corresponding room video will be streamed on to webpage. For this purpose we use a MJPG streamer.

5. Experimental Results

The prototype is in operation in a trial home with electrical appliances regularly used by an inhabitant. The following appliance were tested: 60W, 100W Bulb's,. In total, two different electrical appliances were used in the experimental setup; however, any electrical appliance whose power consumption is less than 200W can be used in developed system. The sampling rate for the fabricated sensing modules was setup with 50 Hz, so that electrical appliance usages within (less than 10 s) interval of time will be recorded correctly.

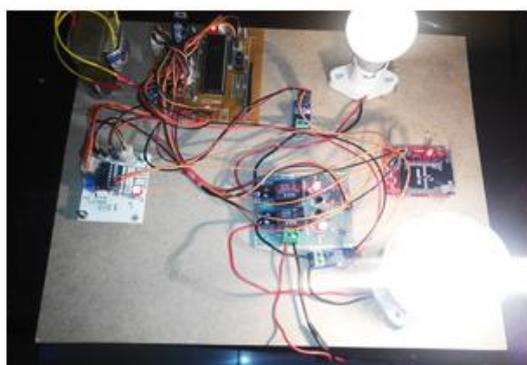


Fig 4 System with Load's connected



Fig 5: Master System Setup

The processed voltage, current, and power values are displayed on the graphical user interface running on a computer. The processed data are accurate and user friendly. The sensing system in the sensor node measures the parameters (voltage and current). The raw data (i.e., converted ADC values) are transmitted to the coordinator. The computer then collects the data from the coordinator and processes them. The computer then applies the necessary formulas to get the actual voltage, current, and power consumption of the electrical appliances. The voltage and current readings are processed using C sharp programming

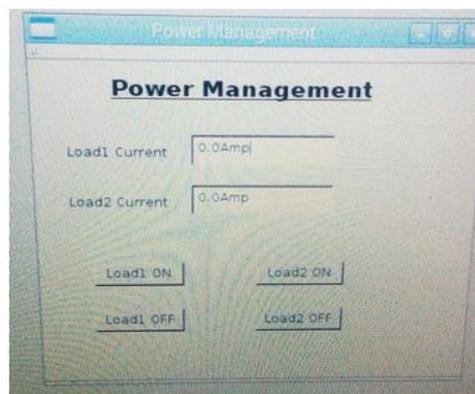


Fig 6: Values Displayed on GUI

A login page also be designed over the http server in order to provide authentication and security for the device control as shown in fig 7.

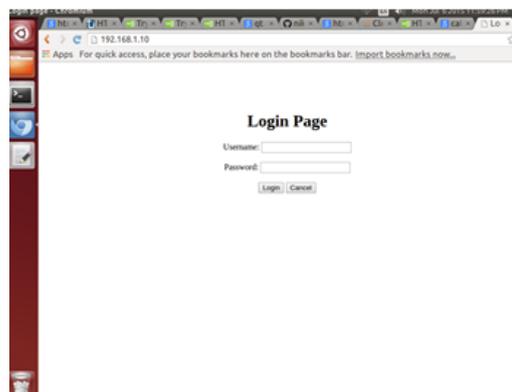


Fig 7 Login page

The below figure 8 shows the current consumed by the load over the web browser and also push buttons in order to control the load as per user necessity

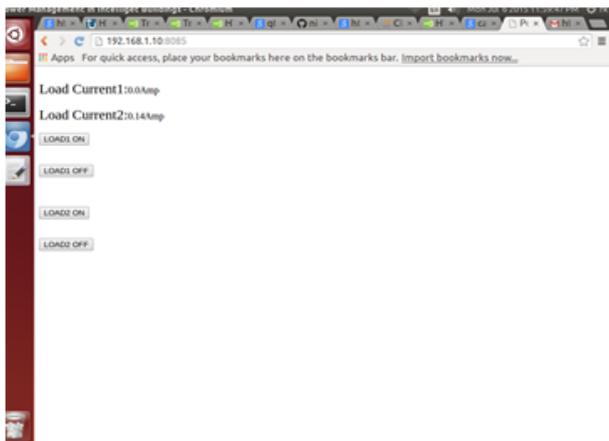


Fig 8 User Access and Data acquisition web page

Conclusion

A smart power monitoring and control system has been designed and developed toward the implementation of an intelligent building. The developed system effectively monitors and controls the electrical appliance usages at an elderly home. Thus, the real-time monitoring of the electrical appliances can be viewed through a website. The system can be extended for monitoring the whole intelligent building. We aim to determine the areas of daily peak hours of electricity usage levels and come with a solution by which we can lower the consumption and enhance better utilization of already limited resources during peak hours.

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Authors



Ms. Ravali Prasuna is working towards a Master of Technology in Embedded systems in prestigious Vardhaman College of Engineering, R.R. Dist, India.



Mrs. B. Suneetha is presently working as an Associate Professor of Electronics and Comm. Engineering in prestigious Vardhaman College of Engineering, R.R. Dist, India.