Design and Implementation of Smart Home Power Management System Based on WSN

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***Abstract-* Wireless mechatronic systems consist of numerous spatially distributed sensors with limited data collection and processing capability to monitor the environmental situation. A smart monitoring and controlling system for household electrical appliances in real-time has been reported in this paper. The system principally monitors the electrical parameters of household appliances such as voltage, current and subsequently calculates the power consumed. The controlling mechanism of appliances is based on traffic condition during peak demands. The developed system is a low costand flexible in operation and thus can save the electricity expense of the consumers.**

***Keywords-* Wireless Sensor Network, Power Management System, Household Electrical Appliances, Home Automation, ZigBee.**

I.INTRODUCTION

In recent days, the power is lacked due to increase in usage of power in industries, homes, other applications, etc., The people uses more electronic devices and home appliances so the power required for these devices becomes more. Also, the sufficient power cannot be generated by artificially or naturally due to some reasons.This problem can be solved by controlling the usage of more power. The recent technology such as Wireless Sensor Network (WSN) and ZigBee techniques are used for monitoring and controlling the power consumed by the devices. This paper describes the monitoring and controlling of residential power management system.

The WSN's are spatially distributed autonomous sensor. It is used to monitor the physical or environmental conditions such as temperature, sound, pressure, etc., the wireless sensor network which contain the sensors, controller, memory, and transmitter/receiver. The ZigBee is a high level communication protocol which is used to create a Personal Area Network. The ZigBee technology is widely used in home automation for security and energy management. Wired sensor networks have already been reached and deployed in many applications over a decade, because of the wireless extension; smart grids have witnessed a tremendous upsurge in interest and activities in recent years. 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, the 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 and the IEEE 802.15.4g standard to help Japan create smart homes that improve energy management and efficiency.

It is expected that 65 million households will equip with smart meters by 2015 and it is a realistic estimate of the size of the home energy management market. Smart Grid and wireless sensor networks provides an intelligent functions that advance interactions of agents such as telecommunication, control and optimization to achieve adaptability, self-healing, efficiency, cyber security and reliability of power systems while reducing the cost and providing efficient resource management and utilization.

In order to connect various domestic appliances and have wireless networks to monitor and control based on the effective power tariffs have been proposed, but the prototypes are verified using test bed scenarios. Also, smart meter systems 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. Considering performance and cost factors related to design and development of smart meters and also predicting the usage of the power consumption have been demonstrated. However, low-cost, flexible and robust system to continuously monitor and control based on consumer requirements are at early stages of development. In this paper, a low-cost, flexible and real-time smart power management system which can easily integrate with the home monitoring systems.

The current values of home appliances are sensed by using hall effect current sensor and they are monitored in Lab VIEW has been proposed in this paper. In existing method, ASM010 current sensor is used. It produces the non-accurate output voltage when the surges present in the load. So, the power cannot be calculated correctly. But the Hall Effect current sensor produces the accurate output voltage without any loss. So the accurate power can be calculated. This is discussed in this paper.

II.RELATED WORKS

In this section, we briefly discuss the existing works about smart home power management system based on WSN. Nagender et.al [1] proposed the electrical home appliances can be monitored and controlled by using the current and voltage sensors. In this method, the current is sensed by using ASM010 current sensor and they are monitored in PC by using CSharp programming. The ASM010 current sensor does not produce the accurate output i.e., 5% loss in their output. The figure 1 shows the functional block diagram for existing method which has both monitoring and controlling circuits.

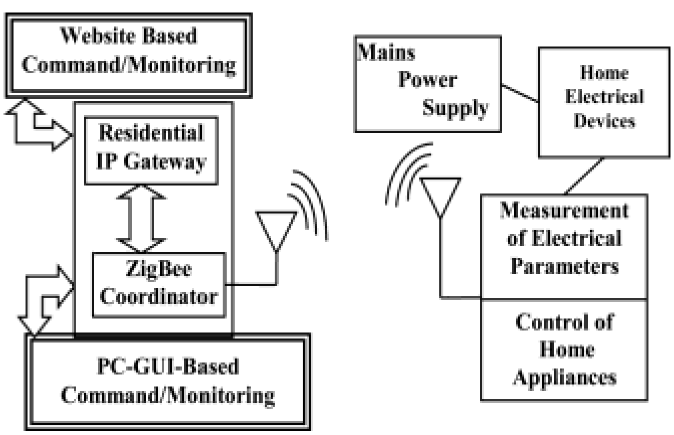
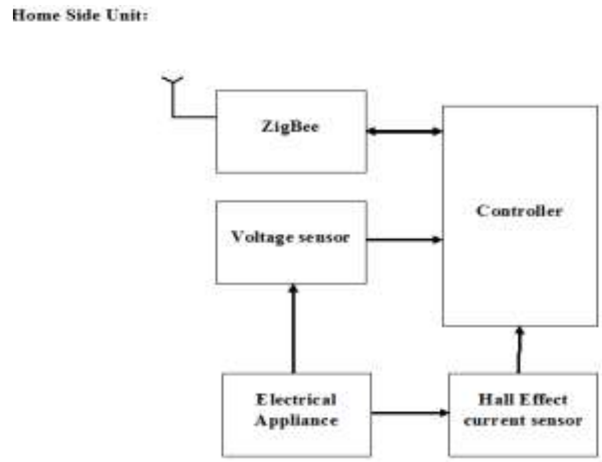


Fig. 1 Functional block diagram

The system has been designed for measurement of electrical parameters of household appliances. Important functions to the system are the ease of modelling, setup and use. From the consumer point of view, electrical power consumption of various appliances in a house along with supply voltage and current is the key parameter. The above figure shows the functional description of the developed system to monitor electrical parameters and control appliances based on the consumer requirements.

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 10 m, and through hopping technique of the mesh topology, reliable sensor fusion data has been performed.By analyzing the power from the system, energy consumption can be controlled. An electricity tariff plan has been setup to run various appliances at peak and peak-off tariff rates. The appliances are controlled either automatically or manually. The smart power metering circuit is connected to mains 240 V/50 Hz supply. The above mentioned home monitoring and controlling systems have limitations such as (i) The power loss is occurred due to current sensor, (ii) The CSharp program is difficult to the users.

III.PROPOSED METHOD

In this**,** the system has been designed for monitoring the electrical parameters of home appliances. Important functions to the system are the ease of modelling, setup and use.The figure 2 shows the functional block diagram of proposed method. In this, the current and voltage sensors which sense the current and voltage values of the home appliances. These values are transferred to PIC microcontroller. The PIC microcontroller has in-built analog-to-digital converter which converts the analog current and voltage values in digital form. These data are transferred to server unit by using ZigBee. The voltage, current values are viewed in Lab View.

Server Unit:

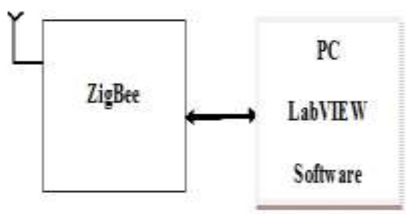


Fig.2 Functional block diagram of proposed system

A.MEASUREMENT OF PARAMETERS

1. Voltage Measurement:

In this, the voltage is sensed by using voltage sensor. The voltage sensor which act as a voltage transformer. The figure 3 shows the circuit diagram of voltage sensor. The voltage transformer used in the proposed method is the 44127 voltage step-down transformer. The striking features include two bobbins compartments including self-extinguishing plastics and very light weight (100 g). 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 available dc voltage is reduced by a potential divider to bring it within the measured level of 5V of the ZigBee. This output signal is then fed to analog input channel of ZigBee. 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 5 V for the operation of ZigBee and operational amplifier.

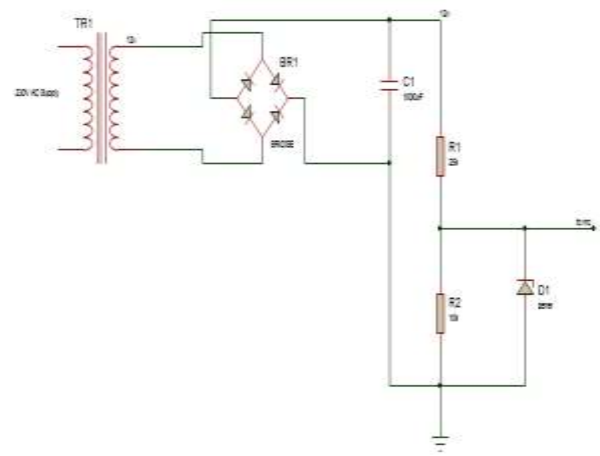


Fig.3Circuit diagram of voltage sensor

2. Current Measurement:

In proposed method, the current is sensed by using current sensor. The figure 4.2 shows the circuit diagram of current sensor. The Winson WCS2702 provides economical and precise solution for both DC and AC current sensing in industrial, commercial and communications systems. The unique package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, over-current fault detection and any intelligent power management system etc.

The WCS2702 consists of a precise, low-temperature drift linear hall sensor IC with temperature compensation circuit and a current path with 98 mΩ typical internal conductor resistance. This extremely low resistance can effectively reduce power loss, operating temperature and increase the reliability greatly. Applied current flowing through this conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. The terminals of the conductive path are electrically isolated from the sensor leads. This allows the WCS2702 current sensor to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques and make system more competitive in cost. This current sensor has the minimum current range of 0-2 A. Depends upon the load the current sensor is used. In the proposed system two bulbs are monitored. The figure 4 shows the circuit diagram of Hall Effect current sensor.

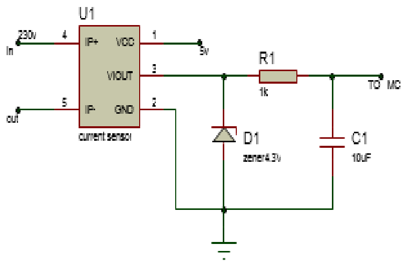


Fig 4: Circuit diagram of Hall Effect current sensor

3. Power Measurement:

The power values are calculated by using the formula,

P=V x I x Power Factor ………. (1)

Where,V- Voltage in volts

I – Current in milliAmperes or Amperes

Power Factor = 1, for resistive load

B. MONITOR AND CONTROL OF HOME APPLIANCES

The home appliances are monitored by using sensors and controlled by using two different methods such as automatic control and manual control based on the user requirements. The following figure 5 shows the hardware module of proposed method.

Fig 5: Hardware Module

Automatic Control:

In automatic control, the auto mode is turned on in the Lab View (Server Unit). So the control signal is transferred to controller (Home Side Unit) through ZigBee. The controller which controls the devices by using solid state relay. The solid state relay acts as a switch and also used to protect the load or devices from damage. This control is mainly used for working people.

Manual Control:

In manual control, the manual mode is selected in Lab view. An on/off switch is provided to directly intervene with devices. This feature enables the user to have more flexibility by having manual control on the appliance usage without automatic control.

IV. RESULTS

The prototype is in operation in a trial home with two loads i.e., two bulbs with different watts (60W and 100W). In this experimental setup only two bulbs are used, however any electrical appliances whose power consumption is less than 2000 W can be used. The processed voltage, current and power values are displayed on the Lab View software. The processed data are accurate and user friendly. The sensing system in the sensor node measures the parameters (voltage, current and power). The data are transmitted to the server unit. The computer then collects the data and processes them. The computer then applies the necessary formulas to get the voltage, current and power consumption of the electrical appliances. The voltage and current readings are processed using LabView. The figure 6 (a) and (b) shows the front end of the smart software system at the local residence.

Fig 6 (a):Voltage (V) and current (mA) values of Load1

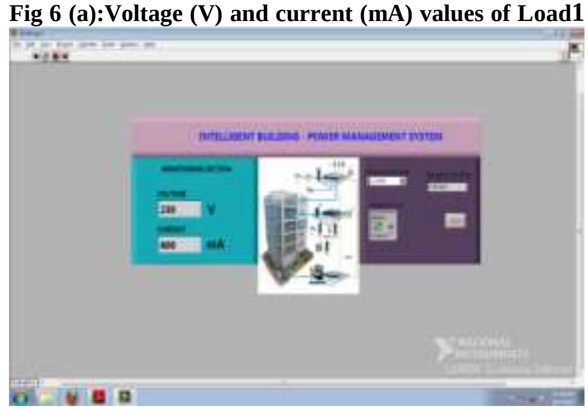


Fig 6(b):Voltage (V) and current (mA) values of both Load 1 and Load 2

V.CONCLUSION AND FUTURE WORK

A smart power monitoring and controlling system has been designed and developed toward the implementation of intelligent building. This system which monitors the electricity usage at daily peak hours and it shows the low power consumption after controlling which enhance the better utilization of limited resources during peak hours. In this, some power values are lost due to transmission of data between home side unit and server unit. So the power values cannot be calculated accurately. In future, the data will be validated to calculate the accurate power in the Lab View and also the system will be integrated with smart home recognition system in order to determine the wellness of the user in terms of power consumption.

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