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Green House Energy Management System Using ZigBee Communication through Comparison of Energy Usage

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Abstract

To inculcate the green Home Energy Management System (HEMS) based on ZigBee communication. The feedback on energy consumption to energy users is known to be effective to reduce total energy use. A typical HEMS just shows the energy consumption of the whole home and home appliances. Users cannot figure out how efficient a home appliance is, compared to the others. So it is necessary to compare the energy usage of home appliances to that of the same kinds of home appliances. This paper describes more efficient green home energy management system to reduce power consumption in home area on energy comparison.

Keyword- HEMS, ZigBee, Enegry Usage, Home Appliance.

Introduction

As more and more home appliances and consumer electronics are deployed, power consumption in home area tends to grow. The current energy crisis and greenhouse effect require more efficient energy management in all areas. Users can control the energy consumption situation of household appliances, and can save 5% to 15% of the power consumption in each month on average [1] [2]. Therefore, reducing energy use in homes is a very challenging target to mitigate the energy crisis and the environmental problem. The technology to reduce and manage home energy use is known as home energy management system (HEMS). Architecture of home energy saving system based on energy-awareness was proposed for real-time home energy monitoring service and reducing standby power of home appliances [3]. A number of HEMS were proposed and developed [4]. The previous HEMS's monitored and controlled home devices, and showed home energy information. However, the previous works just showed the energy consumption information of homes and home appliances. Users cannot figure out whether a specific home appliance is energy efficient. It is necessary to compare energy usage of a home appliance to that of the same kind of typical home appliances or other's home appliances. This paper presents a green home energy management system through comparison of energy usage between the same kinds of home appliances.

Green Home Energy Management Related Work

In the proposed green home energy management system home appliances are connected to the electrical outlets.In fig. 1 home section I & II transmits the energy usage through Zigbee communication to the monitoring section fig.2. Electrical outlets are connected to the home section I & II fig.1and it measures energy usage by energy meter. The electrical outlets have a function of energy measurement of home appliances and the capability of ZigBee communication as in[5].The HEMS in the home server gathers the energy information from the electrical outlets and displays hourly, daily, weekly, and monthly energy usage of home appliances with this a user can figure out detailed energy information. . The electrical outlets also identify whether the connected home appliance is turned on or turned off and whether it is on the standby state or the normal state by measuring the consuming power. And comparison of energy usage is done by using reference or typical energy values of home appliances.

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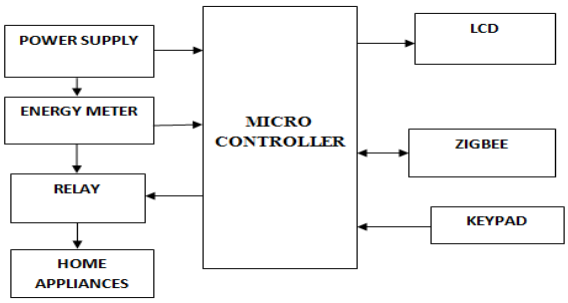

Figure 1 Home Section- I & II

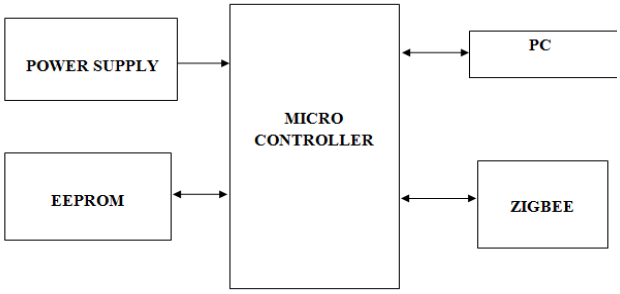

Figure 2 Monitoring Section

Power Supply for AVR 32 Micro controller:

This section describes how to generate +5V DC power supply. The power supply section is the important one. It should deliver constant output regulated power supply for successful working of the project. A 0-12V/1 mA transformer is used for this purpose. The primary of this transformer is connected in to main supply through on/off switch& fuse for protecting from overload and short circuit protection. The secondary is connected to the diodes to convert 12V AC to 12V DC voltage. This is filtered by the capacitors, which are further regulated to +5v, by using IC 7805.

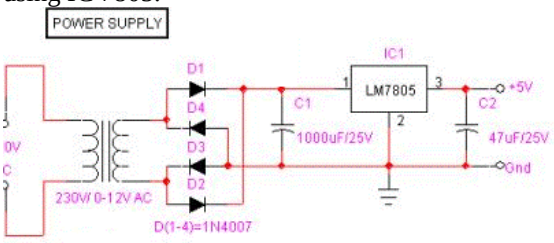

Figure 3 Power Supply

Electrical outlet measuring power and energy

Home devices consume a very small amount of power in the standby mode, it is more efficient to completely cut off the electric power supply to those home devices. An automatic standby power cut-off outlet can contribute to the reduction of home energy cost. Fig. 5 shows the architecture of the automatic standby power cut-off outlet and the state transition diagram of it [6], [7]. The voltage divider reduces the input AC voltage to the input voltage range of the power and energy measurement chip. The current sensing resistor converts the consumed current into the voltage. The measurement chip calculates the power and energy by using the voltage and the current. Through a digital signal processing, the exact power and energy is measured and transferred to the zigbee communication controller.

In fig.4 the electrical outlet has four kinds of state: boot, on, normal, and off as in[5]. After booing, the power outlet goes to the on state. After the guard time elapses, the normal mode starts and the microcontroller monitors the consumed power. When the measured power is below the threshold value for the predetermined time, the microcontroller decides the connected home device is in the standby power mode and turns off the relay to cut off the power supply to the connected home device. It goes to the off state. When it receives a wake-up command from the ZigBee controller, it goes to the on state. This state transition repeats continuously.

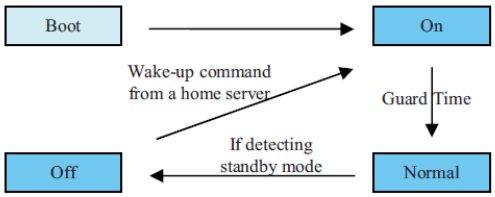

Figure 4 State Transition Diagram of an Electrical Outlet

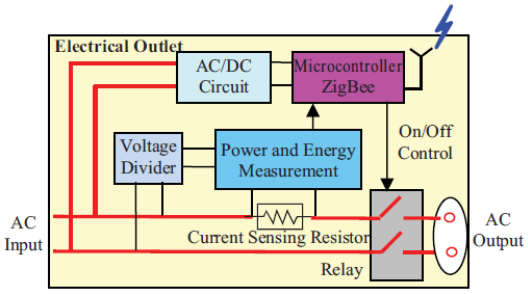

Figure 5 Electrical Outlet Architecture

For communication capability, the electrical outlet is equipped with the ZigBee/IEEE 802.15.4 WPAN network and communicates with the ZigBee coordinator of the home server for information transmission and receiving [8]. To measure the instantaneous power and the accumulated energy, an energy measurement microcontroller is used. The proposed electrical outlet includes the relay to control the electric power supply. The ZigBee controller manages the state of the relay according to the

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command of the home server. Likewise, the home server can manage the on/off state of the whole home appliances.

ZigBee Controller-

To control and wake up the power outlets, it is necessary to equip the ZigBee controller. Fig. 6 shows the configuration of the ZigBee controller and the connected end devices [6]. Each button is assigned to the power outlets. A user can wake up the target power outlet by pressing the assigned button. To wake up the power outlet without pressing the button, the ZigBee controller has an IR code learning functionality. Each button of the ZigBee controller can be assigned to the button of an IR remote control. A user can control and wake up the power outlet without coming close to the ZigBee controller by using the IR remote control.

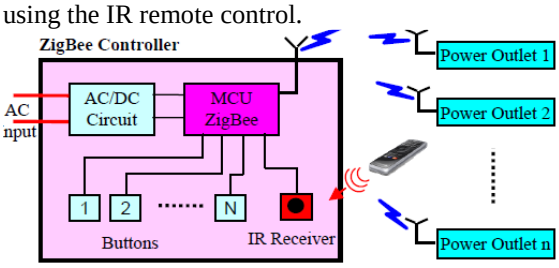

Figure 6 Zigbee Controller Connected with Power Outlets

Proposed Home Energy Management System

Fig.7 shows the architecture of the proposed HEMS. The home has two rooms and each room is equipped with two power outlet,as home section I & II and one ZigBee hub. The power outlets include a power measurement function to measure the power consumption and the capability of ZigBee communication.

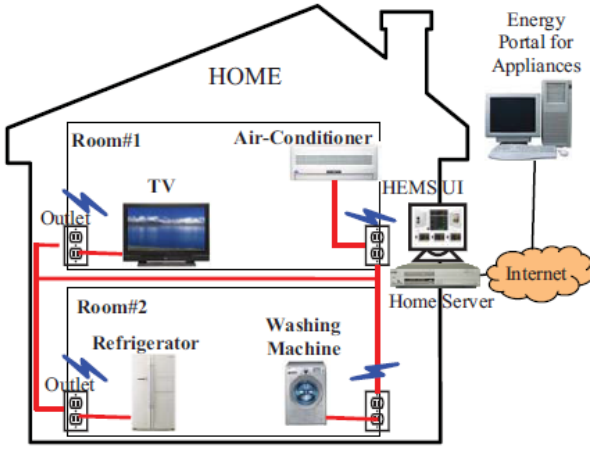

Figure 7 Architecture of the Green HEMS based on Zigbee Communication

The ZigBee network is well known as a low power communication method [8]. They measure the power and energy usage of home appliances and transfer the measured power and energy information to the home server through ZigBee network. A user can register the home appliance in the HEMS on the home server by assigning the electrical outlet number to it. The HEMS identifies the home appliances via the corresponding electrical outlet number. The electrical outlets measure the real-time active power consumption and the accumulated energy consumption of home appliances. The HEMS in the home server gathers the energy information from the electrical outlets and displays hourly, daily, weekly, and monthly energy usage of home appliances. A user can figure out detailed energy usage information in home.

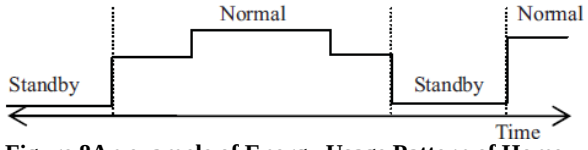

Figure 8An example of Energy Usage Pattern of Home Appliance

Fig.8 shows an example of energy usage of a home appliance. On the normal state, home appliances can consume different levels of power. The HEMS in the home server can figure out the accumulated time of standby state and normal state. It can inform a user of how long each home appliance was used on the normal state and how much energy it consumed during the time of normal state. A user can get the used time and energy usage of the home appliances. He can figure out the useless energy waste in the standby state and the operation energy usage in the normal state. So it is necessary to compare the energy usage of home appliances to that of the same kinds of home appliances of others or the reference home appliances.

Implementation Results

Fig.9 shows the implemented power outlet with power measurement function, a ZigBee communication module, and a
ZigBee hub. The power outlet uses an electric power metering chipset for compactness instead of an analog metering. It is composed of an AC/DC conversion part, a current measuring part, a voltage divider, a serial interface, and a power metering IC, which measures the reliable power consumption by multiplying the scaled voltage and the converted current through digital signal processing. The ZigBee communication module has one microcontroller with ZigBee RF module and 2.4 GHz antenna. The power outlet communicates with the ZigBee communication

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module via a serial interface. The energy characteristics of a home appliance in the list can be compared with the reference energy usage of the same kind of home appliances or with the same model.

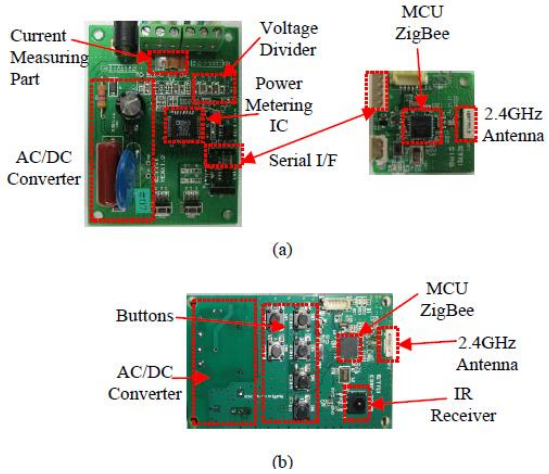

Figure 9 Implemented Board: (a) Power Outlet with Power Measurement Function and Zigbee Communication Model(b) Zigbee Hub

Conclusion

We proposed a green HEMS to change a user's behaviour through comparison of energy usage between the same kinds of home appliances. We implemented the electrical outlet measuring power and energy of home appliances and the HEMS on the home server. The configured ZigBee network is composed of the home server, the ZigBee hub, and the electrical outlets and appliances. The home server is a central control unit. The electrical outlets and the appliances are the sensor nodes. The home server can manage the power outlets and the light through the ZigBee hub. By comparing the energy usage of his home appliances to that of the reference, a user can check the relative energy efficiency of his home appliances. With the help of the energy usage comparison, a user can change the usage pattern of home appliances into more energy efficient one, or replace an energy inefficient home appliance into an energy efficient one. As a result, our proposed HEMS can contribute to reduce the total home energy use and mitigate the energy crisis and the environmental problem.

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