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Microcontroller based power demand control and energy management system using zigbee

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ABSTRACT

The aim of the paper is proposed to reduce the electrical power demand in domestic and industrial sectors. Through this technique the power supply is controlled and supplied is achieved. The electric supply is turned off when it crosses above the threshold power level; this switching is done with the help of relays. The power measurement is done with the help of power measuring circuit which is connected across the supply and to the microcontroller in which the programs are embedded. The ZigBee is employed to control and communicate with the power outlets. By using IR remote controller the various power outlets can be electrically ON and OFF condition. Using this technique the various power loads can be cutoff in priority wise.

Introduction

In this technological world the electric power is the main source for the development and advancement. The technology develops the power requirement and increases the power demand. These power demands occur in both domestic and industrial sectors, which turn as the peak hour power cut. Due to this power cut industrial and domestic areas are affected. To avoid this uncomfortable situation our proposed system gives a solution to the power demand and energy management. The management of the power is also an important factor to reduce the energy demand, it means not only in the way energy is supplied but in the way it is used and reduces the amount of energy required to deliver various devices and loads [3,6]. This smart energy management is achieved with the Zigbee network and it communicate and control all the power outlets present in home and industry to make them ON and OFF the power supply[1,4,7]. In power demand control the microcontroller is the main device used to turn off power supply with the help of the relays[3,6,7]. These relays will cutoff the power to the loads with the command from the microcontroller. The power ON and OFF will be programmed according to the threshold power, working power and demand power. Whenever there is exceed in working power than threshold power then the microcontroller will cutoff the supply by obtaining the commands from Zigbee[1,8,14]. This power cutoff will be priority wise. The power supply is given to the devices like Zigbee and Microcontroller with help of AC/DC converters [2, 6].

Proposed power demand controller

The power demand control system the ZigBee is a coordinator that networks the microcontroller and various electrical loads [1,3,6,7]. The energy demand is controlled by the microcontroller, the threshold power to be used is programmed in it, when the working power is more than that threshold power then the microprocessor directs the relay to turn off the electrical supply to home so it is a controlling and power monitoring device. The power monitoring circuit consists of transformer rectifying diodes and additional components [3]. It converts the measured power consumption into a voltage. Then the microcontroller digitizes the voltage and calculates the consumed power [1,3,6]. Based on the calculated power, it controls the relay and various electrical loads. If more than one loads connected to a relay then it turnoff the electric supply to the load which consumes more power as shown in figure 2.1. The ZigBee is the wireless network which is remote control and sensor application for low power consumption [2,4,12]. The power outlet is to be designed to have a capability of automatic power cutoff mechanism using relays. It should be comprises of AC/DC conversion, two port Relay, a power monitoring circuit and a Microcontroller.

The outlet circuit periodically monitors the power consumption via the power monitoring circuit [1,4,5]. By using the ZigBee network communication the measured power is readed and transferred periodically to remote control unit such as Mobile Phones, Personal Computers (PC) and Personal Digital Assistance (PDA), so the Smart Home Energy Management [SHEMS] is achieved [3]. The power consumed and cost with respect to that consumed power is recorded and transferred periodically by this energy management networking. The power measurement and calculations are done by using this technique by assisting the computer so the energy management in both industrial and domestic sectors is achieved.

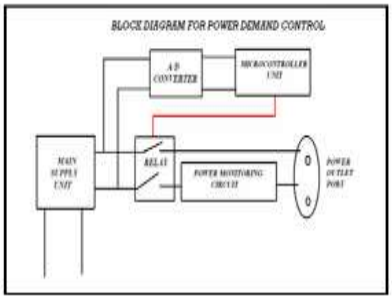

Figure 1: Block Diagram for Power Demand Control

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Load control method

One output port of the relay is connected directly to the AC output outlet and the other output is connected to it via the power monitoring circuit [3]. Then the domestic or industrial electrical load consumes some power for their working, that working power is calculated by the power measuring circuit. It converts the measured power consumption into a voltage. Then the microcontroller digitizes the voltage and calculates the consumed power[5,8,9].

When the monitored power is less than the threshold power then the electric supply is continuously supplied to the household and industrial purpose through power main outlet. Based on the calculated power, it controls the relay and various electrical loads as shown in figure 3.1 [14]. The system is not cutoff the total electric supply to the industry or the house hold purposes. It cuts the supply only to the load which consumes more power.

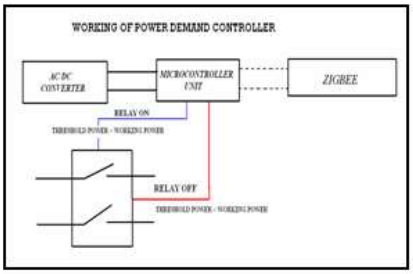

Figure 2: Proposed Of Power Demand Controller

Steps followed in load control method

At first the power consumed by each power outlets are measured by microcontroller. Using a single microcontroller we can control many number of relays[5,14].

The power utilized by each relays are able to measure and sends to microcontroller. It can be defined as following equation.

$$R_1=W_1;\ R_2=W_2;\ R_3=W_3 \ldots\ R_n=W_n \quad (1)$$

In each microcontroller the same calculation is done and powers are summed and they are sent via RF waves to the ZigBee coordinator. The data send by a Microcontroller1 is

$$M_1= W_{11}+ W_{12}+ W_{13} = PM_1 \text{ watts} \quad (2)$$

Similarly by Microcontroller 2 is

$$M_2 = W_{21} + W_{22} + W_{23} + W_{24} = PM_2 \text{ watts} \quad (3)$$

The ZigBee collects all data and sends to each microcontroller. These microcontrollers are now have to verify the working power with the threshold power. In the case it is within the limit is given as

$$PM_1+PM_2+PM_3<=\text{THRESHOLDPOWER} \quad (4)$$

If this condition does not exist then the data is

$$PM_1+PM_2+PM_3>\text{THRESHOLDPOWER} \quad (5)$$

Then microcontrollers have to check which consumes more power. That microcontroller will cut off the supply according to priority method.

The case is taken as $PM_2>PM_1>PM_3$ then the microcontroller 2 will only starts the process.

In the microcontroller 2 the following process is performed:

The microcontroller 2 verifies its working power of each relays as below

$$M_2 = W_{21} + W_{22} + W_{23} + W_{24} \text{ watts} \quad (6)$$

In the above equation the microcontroller will arrange the power values in ascending order. If W23 is the large power then,

$$W_{23} > W_{24} > W_{21} > W_{22} \quad (7)$$

Then the power with respect to relays are processed as

$$R_{23} > R_{24} > R_{21} > R_{22} \quad (8)$$

According to priority method the load connected to relay R23 consumes more power it is cutoff.

$$R_{23}= \text{OFF} \quad (9)$$

Then microcontroller check again with threshold power if exceeds then,

$$R_{24} = \text{OFF} \quad (10)$$

This process continuous till WORKING POWER <= THRESHOLD POWER

Remote control systems based on zigbee

In the both industrial and domestic sectors there was a several huge number of power outlets in various buildings and sectors. These power ports are mostly not turned off using the switches, due to this process the power loss occurs because of standby power consumption. The standby mode consumes 10% of the total power used [1,6]; It will be an unused energy. Incase of industrial sectors these standby power consumption will be more and they have to spend their economy unnecessary.

To control these power outlets our proposed system had equip the ZigBee controller with the Radio Frequency (RF) remote controller as shown in figure 4.1. This system has microcontroller with ZigBee RF module, several buttons switches and Infra Red (IR) receiver [11]. Each buttons on the remote controller will assigned to power ports, the required output port can be turned on and off by pressing the buttons on the controller.

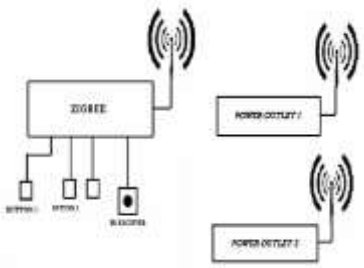

Figure 3: Remote Control Systems Based On Zigbee

The microcontroller does not has the RF transmitter and receiver as shown in figure 4.2, so it should be connected to it.

The data from the ZigBee and other microcontroller is to be received by the microcontroller and then it should send the data to the ZigBee[10,11,12]. The RF module does this job. This RF module interface between the microcontroller and ZigBee.

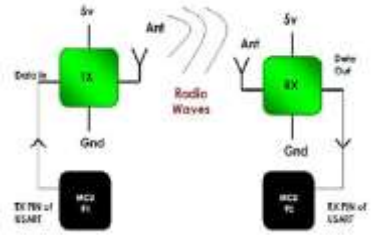

Figure 4: Microcontroller with RF Module

Interfacing zigbee with digital devices:

The Microcontrollers and Zigbee is consists of a RF module, so it can communicate with the digital devices.

So the PC is used to receive the data such as power consumed by each microcontroller, Relays and electric loads are sent periodically by the microcontrollers through Zigbee as shown in figure 5.1 [4]. So the energy management can be achieved and total power utilized can be measured, it is useful to know the effective utilization of electric power and if there is any wastage of power it can be rectified in future. Hence the unnecessary power wastage is reduced and electric energy is consumed.

Figure 5: Interfacing Zigbee With Personal Computer

The power consumed by each relays are measured by the microprocessors connected to it, then the power values are sent to the zigbee[4]. The outlet circuit periodically monitors the power consumption via the power monitoring circuit. By using the ZigBee network communication the measured power is readed and transferred periodically to remote control unit such as mobile phones, personal computers (PC) and personal digital assistance (PDA)[1,3]. The power consumed and cost with respect to that consumed power is recorded and transferred periodically by this energy management networking.

Conclusion

The power demand reduction and remote controllable energy management system was proposed for both domestic and industrial sectors. The over exploitation on the electricity was reduced by this method and the power is utilized within the threshold level in controlled manner. The ZigBee was implemented for the large area controller as well as communicator. The simplest circuit was given for this technique to perform the function simply and effectively. So as a result the utilization of the electric power in useful way and hence demand was reduced. In the area of energy management the ZigBee is a main co-coordinator that controls all the power outlets by communicating with it. The IR remote that controls the ZigBee by giving the instructions and ZigBee controls to microcontroller through RF signal by which the RF module was integrated on the controller [13]. Then the controller controls the supply. So the remote controllable energy management is achieved.

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