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XBee based Remote-Controllable and Energy-Saving Room Architecture

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Abstract - *This paper describes the room architecture to reduce the power consumption and to make the room easily controllable with a simple IR remote control of any home appliances. That particular room is consisting of automated standby power cut-off outlets, a dimming light and XBee controller. The automated outlet designed for monitoring the power consumption of outlet and completely cut off the power supply when the monitored power value is lies below the threshold. Based on XBee communication technique which plays a role of switches for the power outlet also control the dimming light. And it turns on the power outlet and dims the light in the room. The XBee controller has a very useful function of an IR Remote Control signal of home appliances connected to the power outlets. By this architecture a user can handle power outlet and dimming of light through one IR remote control in energy saving room.*

***Key Words*: *XBee, IR remote control, power consumption*.**

I. INTRODUCTION

Standby power is nothing but power consumption occurred at the device when it is turned off or even they are not performing any function this leads to the reduction in the total power. Nowadays the number of devices used as home appliances becomes very large if we accumulate the power consumption of each devices then the amount of power loss is around 15% of total household power. There were many wireless and wired power controlling and monitoring techniques to transfer the measured power. To reduce the standby power of electrical apparatus less than 1 W, International Energy Agency (IEA) proposed '1-watt Plan' [2].

The controlling and power monitoring ability is crucial to home power management. Communication also needed among the network components. There are several approaches for controlling and monitoring the power. In these systems, Power Line Communication (PLC), Ethernet, Bluetooth and ZigBee as wired or wireless networks are used to transfer the control information and the measured power. The signal transformation circuit is designed to measure the working power of the electric outlet [8]. PC, PDA or cell phone is used to transfer the information [6]. When the measured power is above the maximum load, the power outlet is electrically turned off through the solid state or mechanical relay for safety. The customer can know power consumption through remote units. Though, these earlier systems simply monitor the consuming power and protect the overload of the power outlet. Efficient power-saving methods are not provided to cut off unsuccessful standby power consumption. PC or a PDA is required not only to monitor and control the power outlet as a main central unit but also to deal with the home automation.

In this paper, we propose remote-controllable and energy-saving room architecture. To understand our proposed room architecture, the automatic standby power cut-off outlet and the XBee controller with IR code learning functionality are described and their operation mechanism is explained. In section II, the proposed automatic standby power cut-off outlet and the XBee controller are described in detail. In section III, the proposed room architecture is illustrated and the operation mechanism is explained. Section IV shows the implementation results of the proposed architecture. Finally, in section V, the conclusion is summarized.

II. PROPOSED POWER OUTLET AND XBEE CONTROLLER

A.Power outlet

The proposed power outlet is designed to include the capability of automatic power cut-off in standby power state. Fig.1 shows the architecture of the power outlet, which is composed of an AC/DC conversion, one two port relay, a power monitoring circuit and a microcontroller. The AC input is connected to the two port relay. One output port of the relay is connected directly to the AC output outlet and the other output port is connected to it via the power monitoring circuit. The power monitoring circuit consists of a transformer, rectifying diodes and additional components. It converts the measured power consumption into a voltage. The microcontroller digitizes the voltage and calculates the consumed power and based on this calculated power, it controls the relay to cut off the power supply. The AC/DC conversion circuit supplies the necessary DC power to the microcontroller in which XBee Radio Frequency (RF) module is integrated to communicate with the remote control unit. XBee is a wireless network which is aimed at remote control and sensor applications requiring for low power consumption and low data rates. A usual home appliance has two power state, normal and standby. In the normal state, a home appliance consumes a large amount of power. In the standby state, it consumes a small amount of power, which is not insignificant. As mentioned above, the standby power consumption amounts to 10% of entire household power. To more efficiently decrease total power

consumption, it is required to completely cut off the power supply at the power outlet in standby power state.

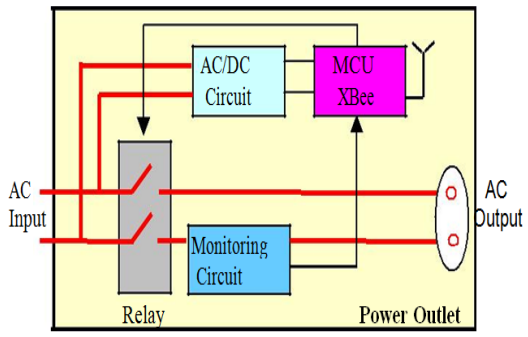

Fig1. Architecture of the automatic standby power cut-off outlet. MCU stands for Micro Controller Unit.

This proposed power outlet periodically monitors the power consumption via the power monitoring circuit. At first, it has its own threshold power in the memory of the microcontroller. When the connected home appliance is changed, the threshold power can be reconfigured by measuring the normal power consumption and the standby power consumption.

B. XBee Controller with IR Code Learn Function

In the usual room, there are several power outlets, several lights and one dimming light. To control these power outlets and lights, it is necessary to equip the XBee controller in the room. In this case lights become end devices and XBee controller works as a coordinator as well as controller the power outlet. The XBee controller can control and communicate with the power outlets and the dimming light. Fig.2 shows the architecture of the XBee controller and the system configuration through XBee communication. The XBee controller consists of an AC/DC conversion circuit, a microcontroller with XBee RF module, several button switches and an IR receiver. Each button switch can be assigned to the power outlets or the dimming light. If the first button is assigned to the first power outlet, to press the first button wakes up the first power outlet and makes it transit to the on state. Other two buttons can be assigned to the dimming light, one for 'light' function and the other for 'dark' function. If a user comes close to the XBee controller and pushes a specific button, he can control the power outlets and the dimming light.

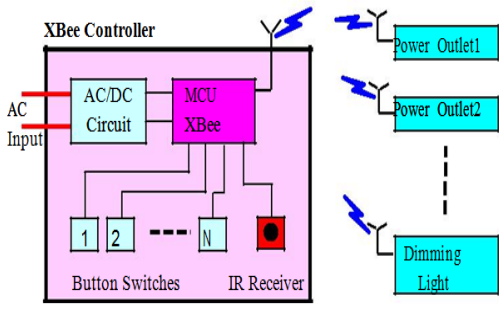

Fig.2. Proposed XBee controller with IR code learning function.

If the home appliance associated to the power outlet is changed, standby power can be different compared to the previous home appliance. It can be redefine to the desired value, first a user wakes up the target power outlet and then plugs a new home appliance into it. He turns on the new home appliance. Then he presses the button switch corresponding to the target power outlet and holds it. If he does not release that button for a little bit longer time, the microcontroller goes to the learning mode and measures the normal power consumption. When he releases the button, the microcontroller finishes measurement and memorizes the normal power. Second, he turns off the new home appliance. If he presses the button switch and holds it for a little bit longer time, the microcontroller goes to the learning mode and measures the standby power consumption. When he releases the button, the microcontroller finishes measurement and memorizes the standby power. Then, the microcontroller calculates the threshold power by using these two measured powers. A choice of calculation methods can be utilized. For example, the average of the normal and the standby power can be the threshold power.

When a user wants to turn on the home appliance connected to the power outlet, he needs to wake up the power outlet by pressing the corresponding button and then turn on the home appliance with an IR remote control. The power outlet turns off automatically, but it should be waked up by the user manually. And the user should always come close to the XBee controller and press the corresponding button to turn on a home appliance. To make the control more convenient, IR code learning functionality is added to the XBee controller. Fig.3 shows the IR code learning function block in detail. In general, an IR code stream is composed of a carrier and a baseband signal. A carrier frequency normally ranges from 19 kHz to 50 kHz with some duty ratio. It can be considered as a pulse stream having some high time and low time as shown in Fig.3. The carrier signal can be sampled and recorded by measuring the high time and low time of the output signal of the IR PD. The high time is calculated by measuring the time between the rising edge and the falling edge. The low time is calculated by measuring the time between the falling edge and the rising edge. As the carrier signal is a pulse stream having a constant pulse width, the measured and calculated high and low time can express the carrier signal completely. A baseband signal has time duration from sub millisecond to a few milliseconds. But it is not a constant pulse stream. It can be considered as repeated pulse streams having different pulse durations. It can also be sampled and recorded by measuring the high and low time of the repeated pulses after rejecting the carrier frequency component via the band pass filter. The consecutive inverting pulse times can describe the baseband signal. Therefore, the core processing unit can identify the IR code by analyzing these time information.

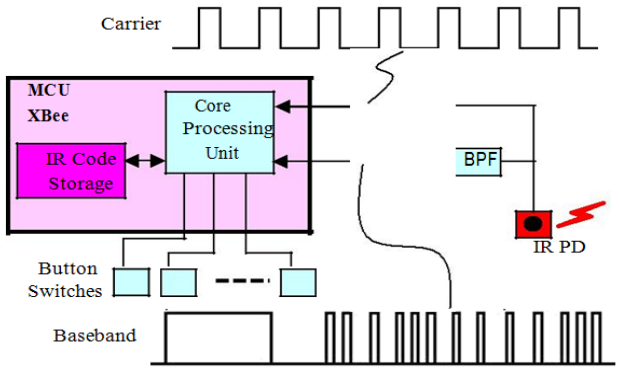

Fig.3. IR code learning function block for the XBee controller. PD: Photo Diode, BPF: Band Pass Filter.

The XBee controller works in two different modes such as **learn mode and operate mode**. In the earlier mode, a user can assign an exact button to read some IR code. The IR code learning process is done as follows. A user presses a button twice successively, which switches the XBee controller to the learning mode. Then he transmits the IR code of the remote control toward the IR receiving block. The core processing unit records the carrier and the baseband signal, and stores them at the IR code storage corresponding to that button.

III. PROPOSED ROOM ARCHITECTURE

Fig.4 (a) illustrates our proposed room architecture. There are two automatic standby power cut-off outlets and one dimming light. They are controlled by XBee controller which has four button switches. The first button is assigned to the power outlet 1 and the second one to the power outlet 2. The third and fourth buttons are assigned to the dimming light. As the XBee controller has a function to learn IR codes, the power button of an IR remote control can be assigned to the first button of the XBee controller. So it corresponds to the power outlet 1. When a user wants to watch television connected to the power outlet 1, he does not have to press the first button of the XBee controller to wake up the first power outlet.

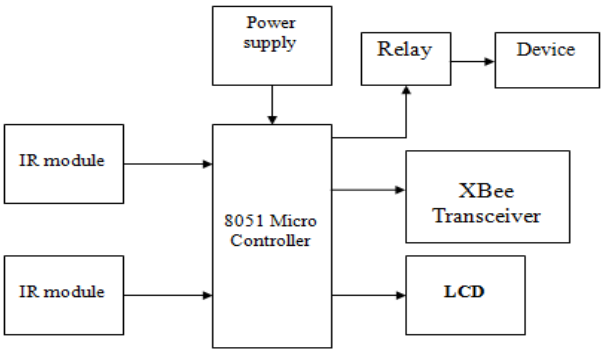

Fig.4 (a). Illustration of the proposed room architecture (for transmitter section).

A user can also assign the volume up/down buttons of the IR remote control to the third and fourth button of the XBee controller. So the volume up/down buttons correspond to the dimming light. He can control the dimming light with the IR remote control of the TV. By using a XBee controller with IR code learning functionality, a user can control the dimming light and the power outlets with one IR remote control of a home appliance like a TV. Similarly the receiver section can design by using same components as shown in fig 4(b).

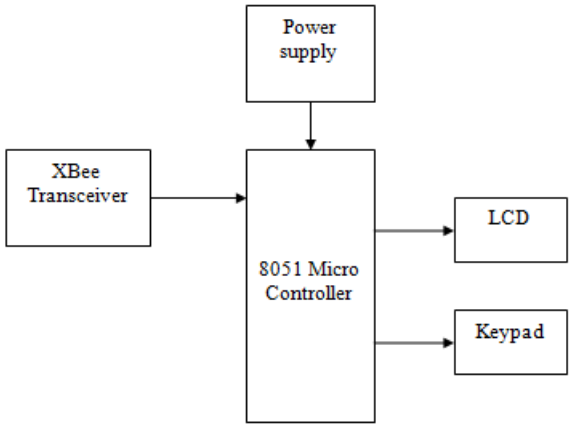

Fig. 4(b) illustration of Receiver section

As the illustrated room has energy-saving outlets and can be controlled by an IR remote control, it deserves a remote-controllable and energy-saving room.

IV. IMPLEMENTATION AND RESULTS

To confirm the feasibility of our proposed room architecture, we implemented the XBee controller with IR code learning functionality and the automatic standby power cut-off outlet. The variable resistor is used to calibrate the measured power. The power monitoring signal is input to the ADC (Analog to Digital Conversion) port of the microcontroller and is digitized. As the power monitoring voltage fluctuates a little bit, it is sampled at every one hundred millisecond and averaged over ten samplings. When the monitored power is below the threshold for two minutes,

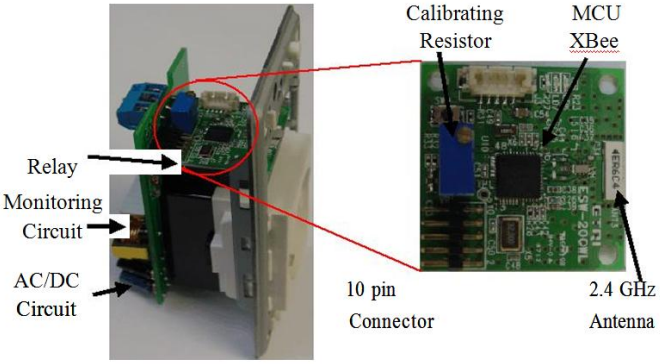

Fig.5: standby power cut-off outlet using XBee Controller.

Comparison of existing system with the proposed system can be drawn as follows by considering the power consumption and saving in terms of Kilowatts obtained from the different approaches such as PLC, Ethernet, Bluetooth, ZigBee and XBee. The following table shows the result of power saved in the case of using three home appliances and dimming light.

Technology used	Power consumed for 1 hour in standby mode(in KW)	Power saved for 1 hour in standby mode (in KW)
PLC	1	0
Ethernet	0.9	0.1
Bluetooth	0.8	0.2
ZigBee	0.6	0.4
XBee	0.2	0.8

V. CONCLUSION

We proposed remote-controllable and energy-saving room architecture. With the help of this architecture, a user can control the power outlets and the dimming light with an IR remote control of any home appliance and save the total power consumption of a room. To configure this room architecture we proposed the automatic standby power cut-off outlet and the XBee controller with IR code learning functionality. The proposed power outlet monitors the consumed power periodically. When the monitored power is below the threshold, the power outlet automatically cuts off the power supply to the outlet. This can reduce the wasted standby power consumption. As this power outlet can reconfigure the threshold power, every home appliance can be applied to this power outlet. To efficiently control the power outlets and the lights, the XBee controller with IR code learning functionality was proposed. Although the XBee controller can control the power outlets and the light through the on-board buttons, it can learn IR codes of the remote control of a home appliance and enables a user to easily control the power outlets and the dimming light with an IR remote control. We implemented the automatic standby power cut-off outlet and tested it with 37 inch flat panel TV. We also implemented the XBee controller with IR code learning functionality and tested it with a TV remote control. These results showed the feasibility of our proposed remote-controllable and energy-saving room architecture. In the future, if the XBee controllers in each room are linked together to the home server via XBee communication, the whole power system in home area can be managed in the remote area as well as in home.

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