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Design and Implementation of Standby Power Saving Smart Socket with Wireless Sensor Network

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Abstract

Most Electrical Appliance in home still use electricity while turned-off. Turned-off electric appliance generally still require standby power when they are plugged in. In this paper we proposed a way to reduce standby power of electric home appliance and ZigBee based smart meter for smart grid application. The proposed socket supplies the appliances with power when the user turns them on. Our socket shuts the electric power off and reduces the standby power to zero when the user turns them off. The proposed design uses a microcontroller unit (MCU) receives signals from a Core Balanced Current Transformer (CBCT) and from a Pyroelectric Infrared (PIR) sensor which detects the user approaching the socket and provides MCU to control the relay On/Off when used as an appliance switch for shutting off the standby power. The components used in the proposed design are low cost and consume only 0.5 W. The MCU monitoring program provides both automatic detection of the user by the PIR sensor and detection of power consumption. The MCU measure the instantaneous current values and send it to data center computer through ZigBee module which acts as a smart meter for smart grid application.

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Keywords: Smart Meter, Smart Grid, Power Consumption, Standby power, Electric Home Appliances, PIR Sensor, Relay, ZigBee, Current Sensor.

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1. Introduction

Plugged-in Electric Home Appliance consume electric power even it is turned off, because it require standby power. More number of home devices increase power consumption in two aspects, normal operation power and standby power. This two kind of power consumption are proportional to the number of home appliances. Most modern home appliances contain digital electronics components like clocks, memories, remote controls, microcontrollers and instant-on features that consume electricity whenever they are plugged in. Most of the home appliances are plugged in 24 hours a day and 7 days a week. This build-in digital electronics in home appliances are for the convenience of the user. The microcontroller inside the appliance is in standby state awaiting user commands while the appliances are either plugged in or turned off. An adapter supply standby state power to microcontroller which has no power off switch. The adapter, which is very inefficient at low power, consumes between 4 to 8 Watts or about 100 to 200 Watt-hours daily, which is not only many time the power actually used by the microcontroller but also enough to run a compact fluorescent light for about 10 hours. The reduction of standby power is greatly necessary to reduce the electricity cost in home.A simple solution to eliminate the standby power consumption of an appliance would be unplugging switch from the power outlet or turning OFF the switch. To do this user need to interact directly with the appliance for manual control, this will cause inconvenient for user. Some commercial products [1] and [2] recognize the device's operation of standby mode automatically and enable power cutoff in a standby mode. But that products only cut off the power and user must manually activate the power supply, as the power supply cannot be controlled automatically or remotely. Many researches were performed to reduce standby power of home electric appliances [3]-[7]. Those technical research deals only either standby power reduction alone or electrical energy monitoring alone.

In this paper we present a design to reduce the standby power of a socket with smart meter. The circuit in the proposed design consist of a few common components with low cost and low power consumption. This low standby power socket consume low standby power and it can be used by existing appliances. Installing this socket is easy, it saves power more efficiently and it is cheap. Therefore, it is suitable for use in most home appliances.

The organization of this paper is as follows. In Section II we propose circuit design and a programming logic of the low standby power socket. In Section III we describe the measurement of the power consumption of our design to verify the total power saved and we show the wireless communication of smart meter. In Section IV we draw the conclusions.

2. Circuit Designs Of The Low Standby Power Socket

Standby power, often called vampire power, is electricity consumed by an electrical appliance when it is plugged. Most electric home appliances such as microwave ovens, induction stove are operated manually. Most control panels on electric home appliances are easy to operate, but when using a remote control, the user must still be near the appliance in question to turn it off again. Electric home appliance could still be running whenever the user has left. If the user is not around the appliances, then the electrical home appliance are not being used and should always be in the turned-off state. To reduce the total amount of standby power used we propose a design that detects the user approach to electrical appliance. PIR sensor is used to detect the user approach to the appliance. When user approach is detected by the PIR sensor, the power for the electric home appliances is enabled. In contrariwise, if user approach is not sensed by PIR sensor, the power is disabled as if the appliances were unplugged. If user approach is not sensed by PIR but the appliance is working, then the power continues to come from the socket until the work is finished. To achieve the above requirement we have use Current Transformer (CT) and signal conditioning circuit to detect the working status of appliance and also to measure the current for smart metering application. The block diagram of the proposed low standby power socket is shown in Fig. 1.

Fig. 1. Shows how a MCU controls the relay to supply the power for electric home appliances. The PIR sensor detects whether the user is approaching or not [8]. If user approach the appliance the PIR sensor send a signal to microcontroller. When user approach is sensed by PIR, the relay supply power to the appliances, and if no one nearby, the power source to appliance disconnected by relay. In order for the appliance to stay on after the user