

A Survey on Controller Based Energy Efficient LED Lighting System

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ABSTRACT: Nowadays saving energy has become one of the most important issue on which attention is required. The wastage of energy occurs due to inefficient use of electronics devices. So it becomes necessary to control and reduce energy consumption of such devices. The paper focuses on study of various methods used for energy efficient LED lighting system considering user satisfaction. The paper describes methods evolved so far and their comparison on the basis of power consumption, efficiency, wireless technology used and energy. Advancements in communication technology have introduced wireless control approach by using Zigbee, Infrared Remote Controls and Bluetooth.

KEYWORDS: Light Emitting Diode, Household LED Lighting System, Zigbee, Dimming Control

I. INTRODUCTION

Saving energy has become one of the most important issues these days. Due to environmental problems such as climate change and global warming it becomes necessary to introduce energy saving solutions. These environmental problems are tremendously caused by excessive use of energy. Specifically electrical energy used for lighting and its improper use accounts a great part of total energy consumption. A light accounts for approximately 20 percent of total energy consumption [8]. Existing lighting control system have simple on/off switches and illumination of light remains constant through daylight. User gets dissatisfied due to frequent on/off and insufficient illumination intensity in their current activity. Many lighting control systems are introduced in the market however due to their architectural limitations it cannot be applied to home and office buildings [8].

To overcome these problems new lighting control systems have been studied which becomes helpful to save energy. The most commonly used light sources include fluorescent lamps, incandescent lamp, compact fluorescent lamp (CFLs) and light emitting diodes (LEDs). The invention of light emitting diode significantly becomes useful because it reduces energy consumption of light as compared to other light sources. In traditional lighting system control is done through wired communication. This wired communication takes large network area and have more complexity.

Recently wireless communication technology has becomes more popular. It is an advanced technology for data transmission purpose. It is a two way communication, increasing the efficiency of energy delivery and less expensive in order to provide real time monitoring, diagnosis and control. IEEE 802.15.1(Bluetooth), IEEE 802.11(Wi-Fi), IEEE 802.15.3(UWB), IEEE 802.15.4(Zigbee) are possible ways for integrating sensors with wireless technologies in order to provide reliable data and to transform existing power systems into transfer grids[8].

Many new technologies and methods have been studied and implemented to lower the energy consumption of a lighting system. The paper describes study of various methods of lighting system have been done by various researchers in the world. The paper is organized as follows: in section II work related to the existing lighting control system is discussed; in section III presents comparison study of the system.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

II. RELATED WORK

There are many methods evolved on lighting control system. The methods can be broadly classified as:

- Wired and Wireless technologies
- Wireless using Zigbee and Bluetooth
- Server based and Stand-alone methods

The survey is described on the basis of these categories.

1. Wired and Wireless Technologies :

Mahalakshmi S. [10] proposed implementation of home lighting system using pulse width modulation technique and analysis of load priority. The system proposes to control over brightness and to manage the load of electric network. The author proposed two algorithm namely illumination decision algorithm and load priority algorithm.

In illumination decision algorithm, a threshold value is set based on LDR value. The illumination provided by the LEDs gets adjusted with respect to that illumination provided by natural light source. The threshold value is decided by observing daylight illumination. PWM technique is used to achieve variations in the brightness.

Load priority algorithm (LDA) is proposed to provide stability in the electrical network. The voltage consumed by each device is considered and comparison is done based on threshold value to know which device consumes more power and warning message is sent to user regarding to the overuse and wait operation is performed. By using the system electrical energy consumption reduces up to 43.695%.

For wireless technologies Zigbee and Bluetooth are deployed by several authors [2], [3], [4], [5], [8].

2. Using Zigbee and Bluetooth:

Chi-Huang Hung [7] proposed a home LED light control system with automatic brightness tuning for the difference in luminous decay. The system focuses on automatically adjusting driven current to avoid any difference in luminous decay. The system hardware architecture consist of the LED light source, the LED driver, the detection of environment illumination, the detection of LED brightness, microcontroller unit, communication unit(Bluetooth) and embedded remote controller. LED driver have an adjustable constant current source circuit, so it can accept the PWM signal input and change brightness automatically. The detection of LED brightness is carried out by measuring the LED intensity.

The light intensity is given as input through analog-to-digital converter to the MCU to determine the amount of luminous decay. Bluetooth wireless device receives control command from either the remote controller or Smartphone. So by using the system uniform brightness of the LEDs can achieves and consumes less power. The result shows that brightness of LEDs can be achieved in 10 steps. The paper gives 80% (increase) and 20% (decrease) in brightness level of LED tube.

Bluetooth has maximum data rate of 720kb/s and indoor range is 10 meter. However it can handle maximum 8 devices at a time and possibility of data collision is more. Hence to avoid these problems Zigbee technology is used as it has data rate of 250kb/s and indoor range is about 100 meter. Zigbee wireless technology is good for home automation. Following papers describes the use of zigbee technology in light controlling system.

Chi-Huang Hung and Ying-Wen Bai [2] proposed half control method for white light LEDs by using embedded remote controller with zigbee communication. The system primarily includes embedded remote controller and LED light control module (LLCM). For home lighting control, the LLCM consist of LED array controller, a microcontroller module, a zigbee module, an environment light sensor and a human detecting sensor. In each group of LLCM there is a human detecting sensor is used incorporated with a light sensor. When there is a presence of human body in a room, human body detection sensor senses the human and gives signal to the controller. At the same time, light sensor senses the intensity of light in the room and controller records the luminance at that moment. According to the condition, if a person is in room or not, controller adjusts the brightness of light.

Chi-Huang proposed a digital method called a halftone control method to control the brightness of LED array. Halftone method is used to transform different LED array patterns into gray patterns and use those different halftone patterns to control the LED on/off which can adjust the LED light brightness. By using the halftone method, Huang calculate and generate several patterns and provide more levels of LED light intensity. He uses 8×8 squares LED array in the experiment and chooses nine brightness levels of different values of halftone dots of 12.5% to 100%.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

Hence halftone technology only controls the LEDs on/off in the LED array to control the brightness.

Zigbee technology is used to send a brightness control signal as a distance measurement by means of embedded remote controller. Zigbee is used as a messenger in the design. When occupant has been detected, the LLCM uses zigbee to transfer the message to the other LLCMs to adjust the brightness in order to save power. The paper compared the system design with traditional lamps. Power consumption of the design is 33.37W where by using traditional lamps it is 64.57W.

J.Han [5] proposed more efficient home energy management system based on zigbee communication and infrared remote controls. The paper focuses on to reduce the standby power. Most of the electronics devices can be switched on/off by using remote controller. But it requires proper turn off as it still consumes power. It is nothing but a standby power. Hence J.Han proposed a system in which user can control the light and power outlets with both buttons of an IR remote control and zigbee hub.

The proposed architecture of home energy management system consist of home which has two rooms and each room contains one dimming light, two power outlet and one zigbee hub. The power outlet and the lights are the sensor nodes. Zigbee hub is connected to the dimming light and power outlets. There is a central control unit of the system called home server. Home server can manage and control the power outlet and lights through zigbee hub. It displays energy usages of each home device and user can be able to observe energy usages of each home device. So user can make effort to save energy. The paper presents the captured displays of the HEMS UI of home server. Hence result shows that total power consumption trend according to time.

Jinsung Byun [8] proposed an intelligent household LED lighting system considering energy efficiency and user satisfaction. The system uses multisensors and wireless communication technology in order to control LED light. The proposed LED lighting system can automatically adjust light intensity according to user's state and surroundings. Byun proposed a minimum light intensity control algorithm. First it requires signal of inconvenience received from resident via Smartphone and second is countdown timer that can interrupt system after a given amount of time has expired. By using the algorithm it is possible to achieve minimum light intensity. Therefore energy can be saved without any inconvenience to user.

The system uses 8-bit microcontroller which is a central control unit, two sensors motion detection and illumination sensors are used. These sensors are input to the microcontroller and if person is in room or not it decides the light intensity of a room. Zigbee module is used for communication purpose with other LED lighting devices. LED driver part is used to regulate same power to all LEDs. It consists of current controller modules for driving LEDs. The proposed system designed and implemented on testbed. The result shows the total power consumption for 14 days with and without proposed system. By using 42 W LED light without proposed system consumes power is 136.93 kWh and with proposed system it is 106.86kWh. It reduces the total power consumption of the testbed up to 21.9%.

3. Server based and Stand-alone method:

Y.Uhm [3] proposed design and implementation of power-aware LED light enabler with location-aware adaptive middleware and context-aware user pattern. The paper presents a LED light system with light sensors, motion sensors and network interface. The light enabler system supports zigbee and RS-485 for communication. To control the light management controller there is an intelligent power gateway (IPG).

The paper gives two kinds of light enabler structure that is server-based and stand-alone. In server based structure there is an IPG and many light enablers. It can manage and control large numbers of lights, such as buildings more efficiently. The system which includes only light enablers called stand-alone structure. In both structure there is an adaptive middleware facility which can be easily modified and changed to adapt to user's surroundings. The efficiency of the light enabler system is tasted by using two experimental testbeds for server-based and stand-alone structure. By using server-based power saving is 58% and 50% for stand-alone structure.

III. CONCLUSION

Electrical energy used for lighting consumes 20 percent of total energy consumption. Many researchers contribute their development work for saving light energy. The paper presented the study of various lighting control system from which it can be observed that by using different methodology energy can be saved.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 9, September 2016

It was observed that Halftone control method and Pulse Width Modulation control method are used to control the brightness of LEDs. Only low powers LEDs are used for halftone control method, hence PWM technique is generally used over halftone control method. Using PWM technique one can achieve uniform brightness level. Zigbee wireless technology is great for home automation system and can be easily communicate with other network devices as compared to other wireless technology. From the comparison on the basis of hardware requirement, power consumption, efficiency and energy saved by the system intelligent household LED lighting system is much better than other system[8]. The energy can be saved up to 50 to 70 %.

Highly sophisticated system with self correcting and solar operated can be expected in the years to come.

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