Indoor LED Light Switch with Step-by-Step Illumination Reduction

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Abstract

Dimming system using the wire or wireless communication method is used for the LED light dimming. This system requires a separate communication lines and modem. Such requirements have problems that installation cost increase and compatibility is low. Therefore, these methods are not suitable to apply indoor light.

In this paper, we describe the dimming controller to solve problems in conventional dimming system. Also, we present experimental results that show proposed dimming controller is valid.

Keywords: *LED light dimming system, Light switch dimming, Indoor light dimming*

1. Introduction

LED(Light Emitting Diode) is environment-friendly and has a longer lifetime compared to other existing light sources. Also, it is advantageous in saving energy due to its high luminous efficacy. [1]

As LED is a semiconductor device, it has excellent electrical traits especially compared to conventional light sources and therefore, can increase the energy saving effectiveness by integrating a dimming control system. Such dimming systems are generally designed so that the user can control the brightness of the LED light using wired or wireless communication.

However, making a system that uses wired communication has a drawback since separate communication lines are added and the installation cost increases. When using wireless communication, separate lines are not necessary but a communication modem that sends and receives wireless signals to be added. It increases the cost to make it difficult to be used for home or office environment [2, 3].

In this paper, aims to solve these problems by describing a dimming controller that controls LED light brightness not with separate communication lines or modem, but by turning on and off the light switch.

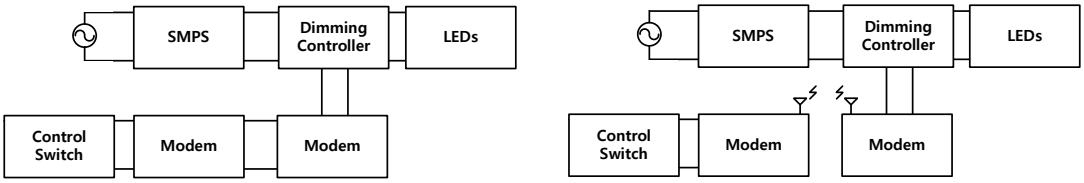
2. Body

2.1. Indoor LED Light Dimming Systems

LED light dimming systems is divided into the wire and wireless communication method. Wire communication method such as RS485, DMX512 and DALI dimming signals is transfer through separate communication line. This method is configured as

shown in Figure 1 (a). And this method has high reliability due to transfer the signal through the communication line but has disadvantage of increase the cost.

Wireless communication method is configured as shown Figure 1 (b). This method communication line is not necessary. Therefore cost of communication line is reducing. However the system cost is increase because the price of the modem is high. In addition, compatibility problems occur when using the other modem's manufacturer. [4]



(a) Wire dimming system (b) Wireless dimming system

Figure 1. LED Light Dimming Systems

Such dimming system is useful to implement a variety of functions such as load fault detection, timer and dimming control according to the surrounding environment. Thus, this system is applied in street lights, security lights and stage lights. However, this is not suitable for apply to indoor lights such as home and office due to the cost and installation problems.

Therefore, we proposed to apply appropriate system for indoor LED light dimming system without the separate communication line and modem.

2.2. Proposed System Configuration

Figure 2 shows the system block diagram of the LED light dimming controller using a light switch. Proposed system is consisted of a SMPS which supplies power to the LED, light switch to turn on/off, and a dimming controller that controls the brightness of the LED based on the on/off counts of the light switch.

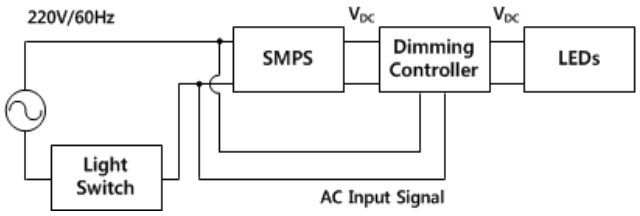


Figure 2. System Block Diagram

Figure 3 shows the internal block diagram of the dimming controller. SMPS supplies power to the MCU, and wave patterns of the AC input signal are sensed by the MCU. Through the inputted AC input wave patterns, the on/off count of the light switch is detected. This is used to control the brightness using PWM by turning on/off the FET, which is connected to the LED output.

Also, the internal battery supplies power the MCU when the switch is turn off. And recent dimming level is to be maintain when turn on.

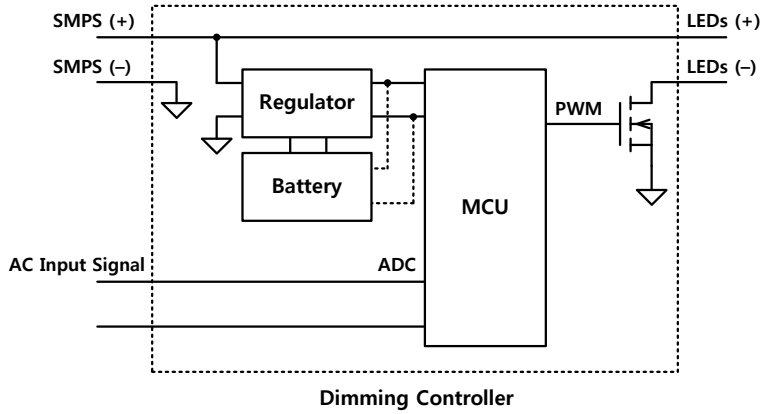


Figure 3. Block Diagram of the Dimming Controller

2.3. Principle of Operation

Figure 4 shows the wave forms of the dimming controller based on the on/off of the light switch. When the switch is turned on initially, the LED brightness is maintained at maximum value because the MCU runs in its initial state and permits a high state on the FET gate voltage(V_{gate}). If the switch is turned back on within a given time(T_{Dim}) after the switch is turned off and on/off is repeated 2 or more times within a given time(T_{Reset}), it will be recognized as a dimming control signal and permits a PWM signal at V_{gate}. This causes the current flowing through the LED to repeatedly go on/off and lower the brightness. Also, the number of times on/off is repeated within the given time(T_{Reset}) is counted and the LED brightness is reduced in a phased manner by reducing the duty of the PWM signal at V_{gate}.

On the contrary, if the switch is not turned back on within the given time(T_{Reset}) after being turned off, power supply to the MCU and LED is suspended and eventually the LED is turned off.

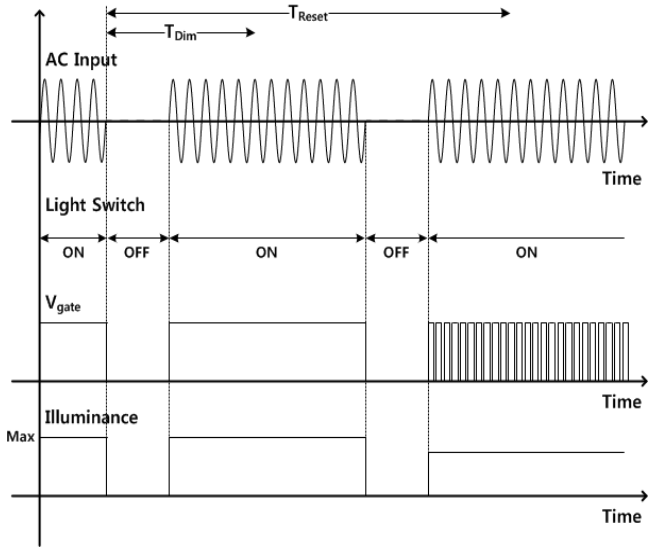


Figure 4. Wave Forms of the Dimming Controller

2.4. Program Algorithm

Figure 5 shows the algorithm of the MCU program. The count number is returned via the switch count process. The PWM duty varies depending on the switch number.

The time value and the T_{Reset} are compared when switch on from the off in switch count process. And increase the count value when the switch on and off within T_{Reset} is repeated

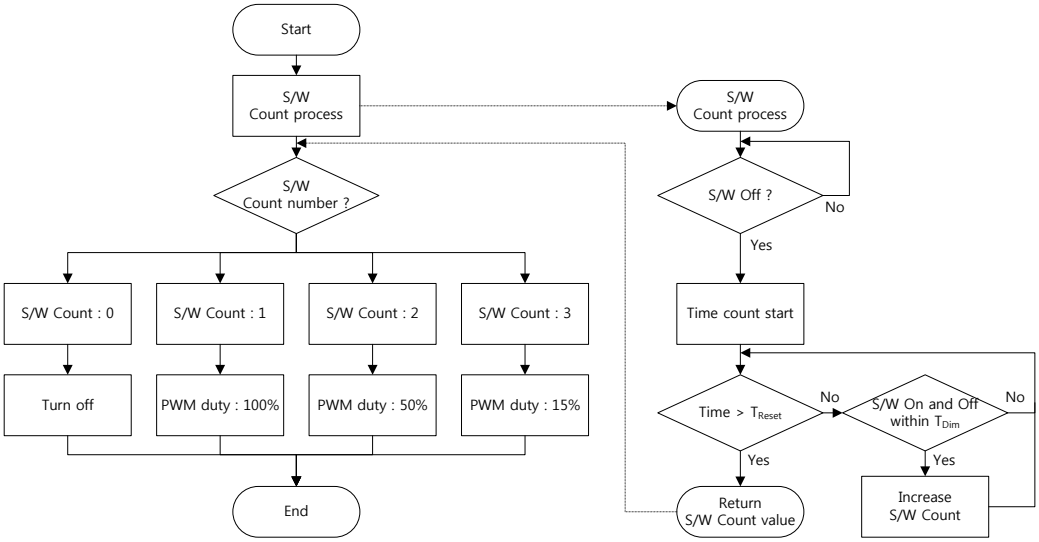
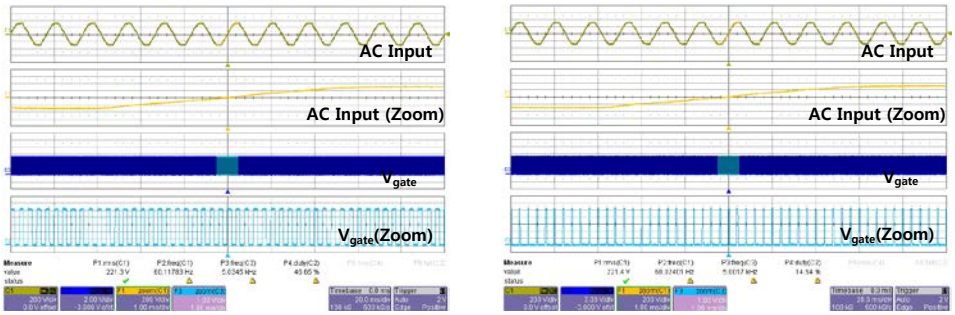


Figure 5. Program Algorithm

2.5. Measurement Results

Figure 6 shows the measured waveforms according to the number of switch on and off. In this case, the input is the same as the 220V 60Hz and V_{gate} PWM frequency is about 5 kHz. PWM duty changes to 46.6% and 14.5% respectively depending on the number of switch on and off count.



(a) Switch count : 2 (b) Switch count : 3

Figure 6. Measured Waveforms (according to number of switch on and off)

Figure 7 shows measured waveforms when switch on and off. When switch is off, AC input voltage is discontinuous. And V_{gate} waveform change after T_{Reset} depending on the number of switch on and off.

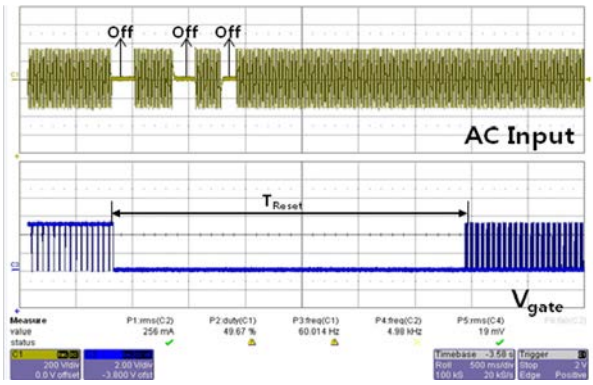


Figure 7. Measured Waveforms (when switch on and off)

Figure 8 shows the LED down light the proposed dimming controller is applied. Dimming system was to be implemented by connected the proposed controller and existing SMPS without any additional communication lines or separate switch.

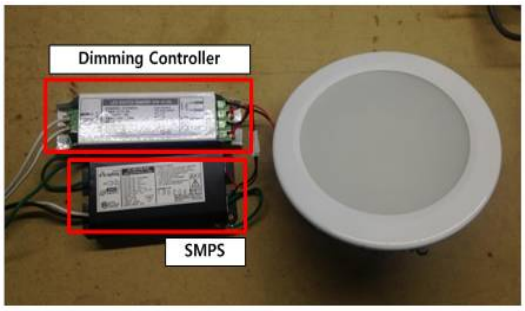


Figure 8. The LED Down Light with Dimming Controller

And Figure 9 shows change the brightness according to switch on and off count. It can confirm that the brightness changes depending on the value of the switch count.

(a) Switch count : 1 (b) Switch count : 2 (c) Switch count : 3

Figure 9. Change the Brightness according to Switch Count

Table 1 shows the measured values of input power, input current and luminous flux based on on/off count when using the proposed dimming control system for 10W, 30W LED down lights and 50W LED flat light respectively. Step1 shows maximum load, Step2 shows the measured value when the on/off count is 2, Step3 shows the value when the on/off count is 3.

Measured value can be seen that the change in the input current input power and luminous flux according to the number of switch on and off.

Table 1. Measured Values based on On/Off Count

Item	Unit	Test Result		
		Step1	Step2	Step3
Input Power	W	10.9	6.7	3.95
Input Current	A	0.052	0.035	0.026
Luminous Flux	lm	874	447	159

(a) 10W LED down light

Item	Unit	Test Result		
		Step1	Step2	Step3
Input Power	W	30.9	18.5	11.2
Input Current	A	0.142	0.088	0.058
Luminous Flux	lm	2608	1487	729

(b) 30W LED down light

Item	Unit	Test Result		
		Step1	Step2	Step3
Input Power	W	51.9	30.6	15.6
Input Current	A	0.238	0.142	0.077
Luminous Flux	lm	4757	2672	1165

(c) 50W LED flat light

3. Conclusion

In this paper, we have implemented the indoor LED light dimming system. Wire and wireless communication method is not suitable for indoor light due to the installation cost. Therefore, dimming controller is proposed using light switch for low cost and easy to install. Proposed controller is sensing the wave patterns of the AC input signal. And LED light brightness is controlled depending on the switch on and off.

Proposed controller is confirmed through experiments. Experiment results are shows that proposed controller and system is valid.

With the dimming control system proposed in this paper, we believe that additional installation time and cost for dimming control system can be reduced, and it will be suitable for home and office environments due to its superior compatibility with existing light system.

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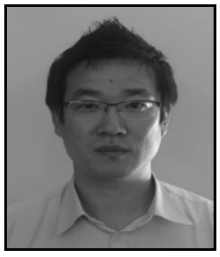

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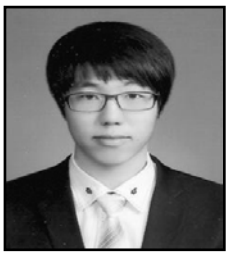

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