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A Wireless Controllable Group Lighting System for Electrodeless Fluorescent Lamps

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Abstract - A dimmable ballast system for the electrodeless fluorescent lamp is proposed. The proposed scheme is composed of the electronic ballast and the wireless communication part. They both are realized with one EPLD (Erasable Programmable Logic Device). The dimming levels of each lamps can be controlled by a management system through wireless communication technology. 10 ballasts are used for the group lighting system and the experiment results show the system works well.

1. Introduction

The goal of power management for lighting is to ensure the dimming and control capability on the electronic ballasts of the lamps. In addition to this capability of the ballast, the wireless control method is recently required for convenience and larger size of power management system for lighting.

Recently, the electrodeless fluorescent lamp which is expected as the next generation lighting has feature o f the extremely long life, due to it has no electrodes i n discharge bulbs. For the electrodeless fluorescent la mp, the use of dimmable electronics ballasts can furth er reduce power consumption in building areas where continuous full-power operation of the electrodeless fl uorescent lamp is not necessary.

In this paper, a wireless control of the lighting syst em for electrodeless fluorescent lamp was realized. 2.4 GHz RF network is built in the proposed system. And the EPLD used in the system has three main parts w hich are communication with RF module, gate driver f or the ballast, and indication of the current status of t he lamp.

2. Proposed Lighting Control System

Fig. 1 shows the overall system configurations of wireless control of the ballast for the electrodeless fluorescent lamp. In the figure, ZigBee PHY(Physical Layer) level and some parts of MAC (Media Access Control) level are adopted for the RF component of the system. L stands for the distance between RF transmitter and ballast, while N is the number of ballasts in the experiment.

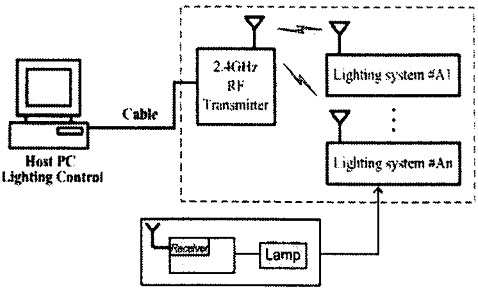
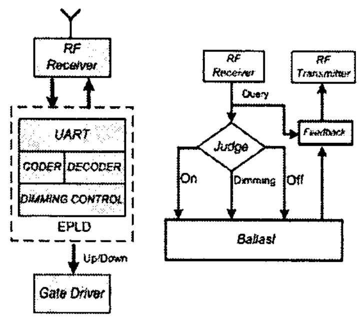


Fig. 1 Block diagram of a wireless control of the gro up lighting system



(a) (b)

Fig. 2 Block diagram and flowchart of lamp control commands

Fig. 2 shows EPLD inside the ballast as a communication block and command flowchart of the EPLD. In the figure, UART was employed to communicate the serial data with the RF module. The serial data are composed of a low star bit, 8 data bits, and 1 stop bit. The Baud Rate is 38400 Baud/s.

The operational principle of the EPLD is as follows:

Once the RF module sends the control commands to EPLD, the UART receives the commands and Decoder interprets them into the dimming control information. On the other hand, to read out the current status of the lamp, the dimming control sends the information on the current status to the Coder. Then, the Coder codes them and sends the coded data to UART. Finally, the RF module gets the information required though UART. The command flowchart shown in Fig. 2(b), summarizes the principles above. Table 1 and Table 2 show the single-control and group-control commands to control the lamp.

Table 1 Single-control commands of ballast

Commands	Functions
Increment Intensity	Increase 1% dimming level by one step
Decrement Intensity	Decrease 1% dimming level by one step
Power On	Turn on the lamp
Power Off	Turn off the lamp
Set Dimming Level	Set the dimming level
Query	Read the status and dimming level

Table 2 Group-control commands of ballast

Commands	Functions
Power On	Turn on all the lamp
Power Off	Turn off all the lamp
Set dimming level	Set all the dimming level synchronously

Fig. 3 shows a block diagram of the electronic ballast for the electrodeless fluorescent lamp. The electronic ballast requires EMI filter and power factor correction (PFC) circuitry in order to meet the requirements of EMI standards and DC link voltage is also be boosted to a constant value nearly 400V. The resonant inverter is adopted for a half-bridge circuit, whose resonant tank circuit is formed by inductor and capacitor, as same as conventional ballasts [2-3].

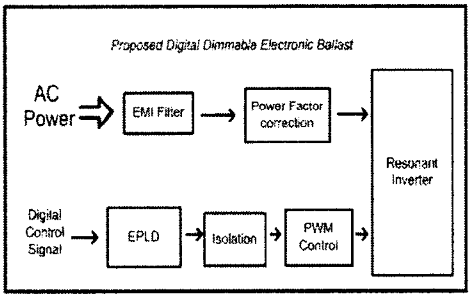


Fig. 3 Block diagram of the electronics ballast

The dimming method is based on the burst dimming method that controls the duty ratio for the two switches of the electronics ballast by intermittently modulated pulse signal. As it is almost impossible to synchronize the burst frequency and the switching frequency with an analog control circuit, we use the digital control circuit to realize the dimming method, as discussed in [4]. The digital control block diagram is shown in Fig. 4 [4].

3. Experimental Results

For the experiment of wireless control of the electrodeless fluorescent lamps, the following parameters are used:

- DC link voltage V_{DC} : 400 [V]
- Switching frequency f_S : 250 [KHz]
- Switching device (MOSFET) : IRF840
- Resonant inductor L : 158 uH
- Resonant capacitor C : 3.2 nF
- Lamp : Endura 150 W (Osram)
- Distance between RF transmitter and ballast L : 10m
- Number of lamps N : 10

Fig. 5 is a screenshot of the system controlling program. Settings constructed in this screen are as follows:

- Single lamp on/off
- Group lamps on/off
- Single dimming level setting
- Group dimming level setting

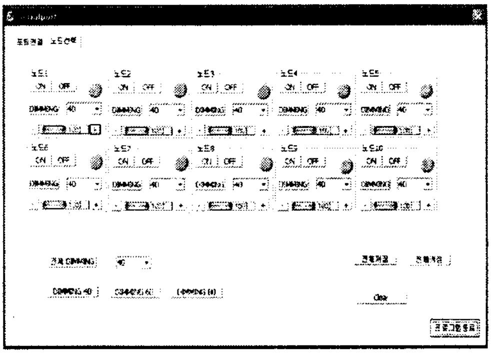


Fig. 5 Screenshot of the system controlling program

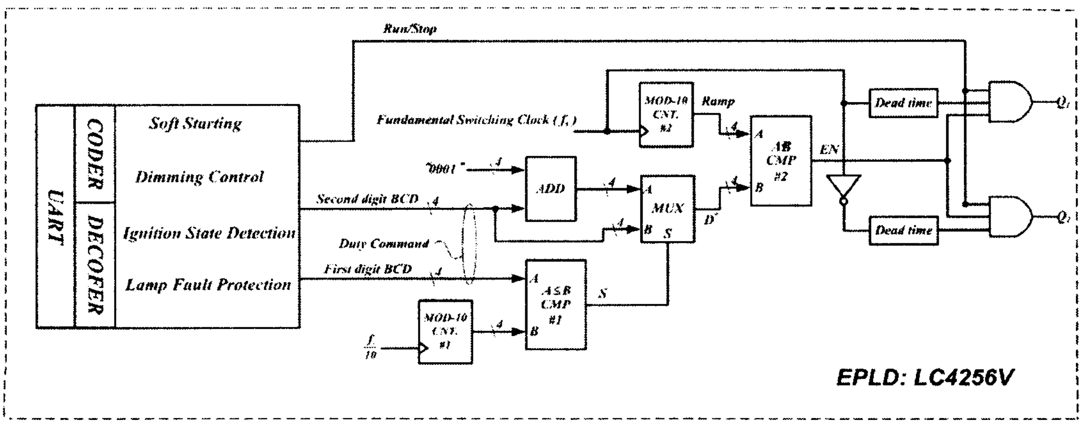
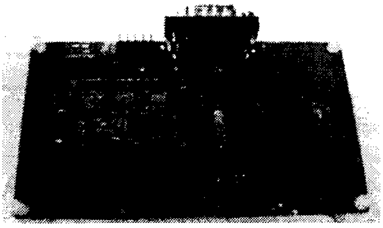
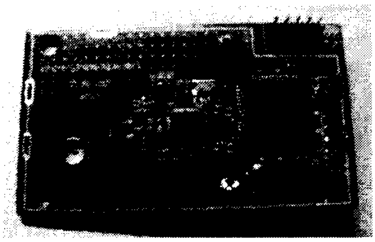


Fig. 4 Block diagram of the dimming algorithm [4]



(a) Prototype board of RF transmitter for system



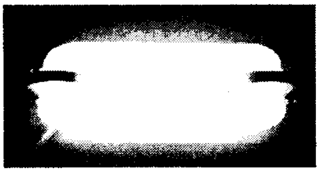
(b) Prototype board of RF transmitter for lamp

Fig. 6 Prototype boards of RF module

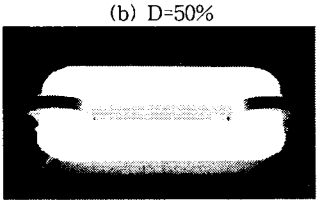
Fig. 6 shows the RF module including transmitter and receiver.

The dimming level realized in the test is in the range of 30 to 100, with 30 corresponding to 30% brightness and 100 corresponding to full brightness. Once full brightness has been reached, however, additional Increment Intensity Command will be ignored until the brightness reduced below full brightness. And the Decrement Intensity Command cannot decrease the intensity below 30%. Fig. 7 shows the dimming controlled results of the lamp. From the results, it can be seen that the luminescences is well controlled.

(a) D=100%



(b) D=50%



(c) D=30%

Fig. 7 Luminescences according to the duty ratio

4. Conclusion

In this paper, the wireless dimming control system for the electrodeless fluorescent lamp was realized. Through the experiment, it is confirmed that the dimming range of 30% to 100% could be achieved by the wireless control. In addition to dimming control, individual control and group control of the lamps also attained.

As a future task, extension of wireless distance and number of lamps should be considered.

[참 고 문 헌]

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