A Brief Discussion on the Application of Intelligent Lighting System Technology

Li yuchang

Linyi University School of Mechanical and Vehicle Engineering，276000；

Abstract: This paper briefly elaborates on the general visual characteristics of Homo sapiens, investigates common methods for residential lighting design from aspects such as the purpose of illumination, residential illuminance standards, determination of lighting methods, selection of light sources, and choice of luminaires. It also provides typical lighting designs for various rooms in residences. Furthermore, it emphasizes that any lighting design must first analyze the visual information required for the intended activities, ensuring the lighting system achieves an optical environment that meets visual needs while conserving energy and realizing green lighting. The paper analyzes the control principles, advantages, disadvantages, applicable scenarios, and precautions of several commonly used intelligent lighting control methods. It also examines the characteristics and application scopes of various indoor illuminance calculation methods (point-by-point method, lumen method, and unit power density method) and designs a lighting system for a specific living room. Additionally, it proposes the system functions of a residential intelligent lighting control system, studies the software and hardware design methods of the system, adopts the AT89C51 microprocessor as the controller, programs in assembly language, and implements effective anti-interference measures to ensure operational reliability. Through debugging and trial operation, the system fully achieves the designed functionalities.

Keywords: light environment, residential lighting, intelligent control

Current research on intelligent lighting systems both domestically and internationally faces the following issues:

① Existing intelligent lighting systems abroad primarily focus on controlling illuminance as a quantitative metric, with research mainly concentrated on office lighting for energy-saving purposes. However, the latest findings in lighting technology indicate that non-quantitative metrics (such as comfort and artistic quality) have a greater impact on indoor lighting environment quality.

② Some domestic intelligent lighting control systems can achieve centralized control and display, demonstrating a degree of intelligence. However, they can only control the on/off function of a single lamp or a group of lamps in a room, lacking scene control capabilities, brightness adjustment, or the ability to create diverse lighting effects.

③ There are very few intelligent lighting control system products specifically designed for residential lighting environments, indicating significant development potential.

1 Advantages of Intelligent Lighting Systems

An intelligent lighting control system utilizes computer technology, supplemented by other methods, to automate lighting control, providing an appropriate lighting environment while reducing energy consumption and operational costs. Compared to manual lighting control systems, intelligent lighting systems offer numerous advantages, including creating ambient atmospheres, improving work environments, enhancing productivity, achieving energy efficiency, extending light source lifespan, and facilitating maintenance and management.

2 Research Significance of Intelligent Lighting Systems

The study of residential intelligent lighting control systems not only contributes valuable experience to the cutting-edge international research topic of intelligent lighting control but also enhances the quality of residential lighting environments and property value. Additionally, it provides a reliable approach to energy conservation and environmental protection, serving as one of the key technologies for achieving sustainable living environments for Homo sapiens. This field holds vast application prospects.

3 Specific research significance includes:

① Improving the quality of residential lighting environments.

② Reflecting the human-centric lighting control philosophy, where lighting control rules are determined based on human behavior patterns and residential lighting environments, creating personalized, artistic, comfortable, and elegant home lighting atmospheres.

③ Integrating into intelligent residential systems as part of Broussonetia papyrifera.

4Main Components

4.1 Controller Selection

The PLC is selected as the system controller.

Programmable Logic Controller (PLC)

A Programmable Logic Controller (PLC) is a digital electronic system designed for industrial applications. It employs a type of programmable memory for internal program storage, executing user-oriented instructions such as logical operations, sequential control, timing, counting, and arithmetic operations. It controls various types of machinery or production processes through digital or analog input/output. PLCs and their associated peripheral devices are designed to integrate easily with industrial control systems and to facilitate functional expansion.

The primary functions of a PLC include logic control, timing control, counting control, step (sequential) control, PID control, data control, communication, and networking. Since PLCs are specifically designed for industrial environments, they exhibit strong anti-interference capabilities and high reliability. However, they cannot read data from external memory.

To achieve time-based process control in this system, a real-time electronic clock is essential. If a real-time clock chip is used, the controller must be capable of reading external data. However, a PLC cannot be programmed to implement a real-time electronic clock or display time.

4.2 Display Devices

The main display options are LCD and LED displays.

（1） Liquid Crystal Display (LCD)

An LCD is a low-power display device widely used in portable instruments or low-power application systems. LCDs come in three types: standard segment LCDs, character dot-matrix LCDs, and full dot-matrix graphic LCDs. The LCD itself does not emit light but displays digits using natural or external light sources. Its advantages include low operating voltage, minimal power consumption, and low cost. However, it requires backlighting for visibility in the dark and has a relatively low refresh rate.

（2） LED Display

An LED display consists of light-emitting diode segments and comes in 7-segment and "rice" segment varieties. These displays are available in common-cathode and common-anode configurations.

Display methods include static and dynamic displays. In static display, the segments of the character to be displayed are continuously supplied with current, causing them to glow steadily. In dynamic display, the segments are intermittently supplied with current, resulting in discontinuous illumination. For example, when multiple characters need to be displayed simultaneously, current can be alternately supplied to each character, sequentially displaying the required characters.

Using LED displays can reduce hardware costs. LCD characters are relatively small and are only easily visible at close range. By adopting a dynamic scanning approach, the display of panel buttons, seasonal indicators, and light group statuses can all be implemented with LEDs, conserving hardware resources.

（3） Circuit

A dimmable electronic ballast is used to adjust the brightness of fluorescent lamps. This electronic ballast operates at a high frequency (40 kHz – 70 kHz), eliminating flicker while providing stable illumination. The DC 0 – 10V signal output from the D/A converter serves as the control signal for the electronic ballast, enabling dimming of fluorescent lamps within a 1% – 100% range. The dimmer for fluorescent lamps employs OSRAM's dimmable electronic ballast. This product is compatible with 18W, 36W, and 58W T8 tubes, as well as Dulux L 18W, 36W, and 55W energy-saving tubes, with both single-lamp and dual-lamp models available.

Dimming signal: DC 1 – 10V Luminous flux adjustment range: 1% – 100% Solid-State Relay (SSR) When a control signal is applied to the input of a random-type SSR, the AC load is immediately activated. If the control signal is a phase-shifted pulse synchronized with the AC grid, the load voltage can be smoothly adjusted within a range of 180° to 0°.

A phase-shift trigger generates wide pulses synchronized with the grid voltage at twice the grid frequency, phase-shifted from 180° to 0°, based on the control voltage. These pulses drive the random-type SSR to achieve phase-shift voltage regulation.

Thus, a random-type SSR alone can turn a lighting circuit on or off. When used in combination with a phase-shift trigger, it enables dimming of incandescent lamps from 0% to 100%.

The solid-state relay receives output signals from the controller to control the switching of lights. The phase-shift trigger and random-type SSR together enable 0 – 100% dimming of incandescent lamps.

References

[1] Department of Automation, Tsinghua University. Intelligent Information Processing and Intelligent Control [M]. Hangzhou: Zhejiang Science and Technology Press, 1998.
[2] Liu Wei, Yang Chunyu, Chen Zhonglin. Melatonin Affecting the Biological Rhythm of Homo Sapiens and Residential Lighting Environment Design [N]. Journal of Illuminating Engineering, 2002.
[3] Dai Yuxing. Technical Measures to Improve Residential Lighting Quality [N]. Journal of Illuminating Engineering, 2000.
[4] Chen Yicai. Intelligent Building Electrical Design Manual (Volume 1) [M]. Beijing: China Building Materials Industry Press, 1999.
[5] Jin Hai, Yu Lihua. Influence of Light Source Color Temperature and Color Rendering on Indoor Lighting Environment [N]. Journal of Illuminating Engineering, 2000.