Application of Practical Astronomical Timing Algorithm in the Lighting Control of Residential Street

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Abstract. With the development of this society, the street lighting system has become a part of the community infrastructure construction. Most of the traditional street lighting methods use simple area control and timing switches, it can’t change the switch time of street lighting intelligently according to the change of actual application scene. In order to overcome this deficiency, this paper has designed an intelligent astronomical timing algorithm and software control process, which can change the street lighting switch time manually or automatically, also which is programmed in the controller and monitored through the TD200 LCD display panel. In addition, the automatic switching on/off on holidays is also added in the street lighting. Practice of using this system has proven that this intelligent timing algorithm can effectively improve the efficiency of the lighting control system and save energy.

1. Introduction
With the progress and development of society, the street lighting system of the community has already become a part of the infrastructure construction of the community [1-2]. At present, designers have applied the concept of intelligent control in the street lighting control system of general communities. The application of intelligent control system has improved the management effect of the residential street lamps, decreased the maintenance personnel, reduced the maintenance difficulty, and saved electricity [3-5]. The in-depth study of the residential street lamp intelligent control system has great research value for improving the life quality of the community residents, enriching the amateur cultural life of the community residents, and improving the street lighting effect of the community [6].

At present, the more mature intelligent control system adopts microcontroller or PLC to design the main control system, and uses wireless communication or wired communication (such as power carrier) to realize the information interaction between the main control system and the street lamp sub-control systems in various zones [7]. Also, Sun le Studied the design points and automatic control technology of street lamp electrical system [8]. In the control strategy of street lamps, the automatic timing algorithm is generally adopted in the controller to control the switching on/off of street lamps.

2. Overall Design of the System
Through the selection of the street lamp control strategy, timing dimming switching method and communication method of the system, the overall design plan of the system is finally determined. This system includes three parts: single lamp control terminal, power carrier communication module and remote control center computer.

The community street lamp control system is generally controlled in the power distribution room because the area involved is relatively small. In this project, the community street lamps are controlled
centrally. Three control cabinets are located in the power distribution room, each of them is independently responsible for a part of the community street lamps. Due to the small number of points that need to be controlled, we chose the Siemens smart200 controller, and used the TD200 LCD text display panel as the monitoring equipment. We can complete the monitoring and setting through the LCD panel.

The overall system diagram is shown in figure 1.

![Lighting control system diagram](image)

**Figure 1.** Lighting control system diagram.

3. Design and Implementation of Software System

3.1. Design Requirements of System Software

According to the control requirements of street lamps, the software shall be divided into two parts: PLC control program and panel display program.

The main software requirements are as follows: the street lamp control must have two parts: manual control and automatic control. The switching on/off time of the street lamps can be adjusted automatically according to the sunrise and sunset times, and it can also be set manually. The holiday time can also be set. During the holiday time, the street lamps (including festive lamps) will automatically light up. The system can display the status of some electrical equipment.

It can be seen from the analysis of the design requirements that the system software, in addition to some conventional control programs, is mainly to complete the automatic switching on/off of street lamps, that is, to perform astronomical timing on the switching on/off time of street lamps.

3.2. Design of Astronomical Timing Program

We consulted some data and found that the astronomical timing of street lamps are generally based on the local sunrise and sunset times of each day, which are set as the switching on/off time. It is necessary to find out the sunrise and sunset times of each day and store them in the memory. The sunrise time of each day is read as the switching off time and the sunset time of each day is read as the switching on time. This method is accurate, but it requires a lot of work, and the sunrise and sunset data for one year shall be found out for storage, and once the application location is changed, it is necessary to find out the local sunrise and sunset time for replacement. In addition, at least 4 bytes are required for storing one time point, and more than 3000 bytes of data need to be stored for one year. For ordinary PLCs and microcontrollers, additional costs are required because they generally lack internal storage space.

Can we replace the traditional algorithm with a simpler and more practical astronomical timing algorithm? After thinking, we considered a practical astronomical timing algorithm. We only need to find out the sunrise and sunset times of the winter solstice and summer solstice in the local area, and find the difference between the two times. The time to switch on and off the lamps must change within this time range. Since the switching on/off time of the street lamp does not need to be very accurate, we divided this time evenly and adjusted it every once in a while. The switching on/off time adjusted...
every time is the same, so we can significantly simplify the program design. Take this project as an example: the summer solstice sunrise time at the project location is 4:54 and the sunset time is 19:34; the winter solstice sunrise time is 7:21 and the sunset time is 17:00. The sunrise time difference between the winter solstice and the summer solstice is 147 minutes, the sunset time difference is 154 minutes. The time difference of switching on and off the lamp every day within six months is less than one minute, and the program is difficult to implement. We have obtained a rule by evenly dividing and approximating the time: the time for switching on and off the lamp is adjusted for 5 minutes every 6 days, so that the time is adjusted for 150 minutes within 180 days of half a year, which is basically in line with the sunrise and sunset times. In addition, using such a simple algorithm can significantly simplify the control program.

The flow chart of the specific astronomical timing program is shown in figure 2. Part of the smart200 control programs are shown in figure 3.

![Flow chart of astronomical timing control.](image)

**Figure 2.** Flow chart of astronomical timing control.
3.3. Design of the Panel Display Program

The home page of the main menu displays the project name. Press and hold the Page Down key on the operation panel to page down to enter the display page of current date. Page down to enter the setting of switching on/off time. Press the Up and Down keys to set the Hour, Minute and Second, press Enter key to confirm after setting. Page down to display the current time, which is the real-time clock provided by the system. If it does not match the actual time, you can modify the settings at any time through the system menu. There are two menus that the user needs to operate, one is the main menu and the other is the holiday setting menu. The switching on setting is shown in figure 4.

The holiday setting menu includes the setting of 8 holidays. The user can set 1-8 holidays by themselves. The first four holidays are set as time period, for example, setting from October 1 to October 7, the last four holidays are set as a fixed time, such as May 1, if it is not set, the default is January 1. For the street lamps that should be switched on only on special holidays, they are allowed to be switched on and off like other street lamps only on holidays set by the user. The holiday setting is shown in figure 5.

There are 8 holidays on the display that can be set by yourself, the first four dates are time periods, the last four are independent holidays, if not set, the default is January 1.

4. Conclusion

The intelligent street lamp energy-saving control system described in this article can be designed according to actual needs, under the condition of ensuring normal lighting, taking into account the low
valley period of power consumption, using time-shifting and timing methods, and can automatically control the switching on/off of the street lamps at the set time, to achieve a good energy saving effect [4]. Of course, the popularization of intelligent street lamps is a big trend. This design needs to be further improved and optimized. For example, by installing a special sensor device, the switching on/off and the brightness of the street lamp are determined according to the switching on/off period of the street lamp based on the external environment. Since street lamp construction is a major project for people's livelihood and has strict requirements for stability, it is possible to meet the system stability requirements by adding redundant components in various parts of the system.

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