

Design of Street Light Intelligent Control System Based on ZigBee and FPGA

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Abstract. Urban street lights are an indispensable infrastructure to ensure the safety of citizens. The energy consumed by street lighting system lighting is considerable for saving lighting energy and management costs by improving the management and control system of street lights. Street light intelligent control system, making use of modern technologies such as network communication, computer, automatic control, etc., is built based on ZigBee and FPGA. The system can realize real-time remote intelligent monitoring of the single lamp, single pole and internal power supply equipment of the street light system. On the one hand, it can realize it through monitoring of the host computer software and using a variety of control methods to optimize street lighting; on the other hand, it can realize it through the intelligent control system for its real-time data acquisition, analysis and fault warning of system operation status. The management personnel can perform some related operations by managing the street light system through the computer in the monitoring center, or logging in to the management system through the intelligent network terminal.

1. Introduction

As the street lights were used as nightlights for urban roads, the control of lighting time has plagued urban management workers. It is very clear that the requirements for urban road traffic and public travel safety are determined as the time and quantity of street lights, but there is no uniform standard for such demand. The most common practice is to determine the lighting needs based on the sunrise and sunset times in the area. However, in most cities, there are few pedestrians and vehicles traveling from midnight to dawn. Although it is very clear that the requirements for urban road traffic and public travel safety are determined as the time and quantity of street lights, there is no unified standard for such demand. Another problem is that in recent years, most cities have adopted the method of closing partial interval lights or closing one side lights at night, but there are certain security risks in some ways. Anyway, there are many problems to be solved and a lot of energy-saving space for the management and control of urban street lighting systems.

2. Energy-saving management and control technology of street light system

2.1. Analysis of the invalid energy consumption of street light system

Firstly, in recent years, the use of urban street lights has continued to increase at a rate of about 25% per year, and street lighting has indirectly consumed valuable non-renewable energy. But a considerable



part of these energy is invalid energy consumption which not meet any usage requirements. The biggest part of the waste happen in the city from midnight to early morning. There is no specific lighting demand, but if some or all of the street lights are turned off, there will be a huge safety hazard for occasional vehicles and pedestrians.

Secondly, the brightness of the street light cannot adapt to the changes of ambient brightness for real-time adjustment. Since the brightness of the street lights is designed according to the maximum lighting needs, in the evening and early morning hours, although the ambient light is bright, the street lights still maintain the maximum illumination brightness, consuming unnecessary energy .[1].

Thirdly, for adjusting the opening and closing time of the existing urban street light management system, regular manual adjustments are necessary. Because the natural ambient light changes with the seasons, this method has a certain lag phrase, which also causes a part of the waste of electric energy.

In addition, due to the existing street light control system failure problem, some street lights work abnormally -- some lights are turned on during the period when no lighting is required. In the operation of the urban street light system, the above-mentioned reasons have caused huge energy waste, and people have been exploring the optimization of lighting control of the street light system.

2.2. Street light energy saving management and control technology

Due to the complexity and uncertainty of urban road traffic conditions, it is difficult to achieve idealized real-time coordinated control between street lighting effects and actual needs. However, with the development of modern computer technology, automation control technology and network communication technology, the energy-saving management and control technology of street light system has made great progress in recent decades.

Network communication technology enables networked interconnection within the street lighting system and real-time communication with the administrator. The automatic control technology allows the administrators to remotely control the operation of the lighting system through the network.

Firstly, the application of these modern technological means can change the traditional management control from manual to automatic, removing the way the manpower regularly adjusts the system opening and closing time. Instead, photosensitive sensors are used to automatically control the opening and closing of lights. Secondly, the communication mode between the systems is also changed from wired transmission to wireless transmission, and the used network is changed from a dedicated wireless communication channel to a public wireless transmission network with a wide coverage. Based on these technologies, the control systems have been widely used in streetlight management in large and medium-sized cities.

2.3. Optimization direction of existing street light management and control system

The street light control system, which is now widely used, has achieved remarkable results in improving management efficiency and energy saving. However, for the huge scale of urban streetlights, it is necessary to diversify of control modes and optimize the real-time monitoring, analysis and failure warning of system operation, further improve the effective utilization rate of energy of street lighting and reducing management costs. With intelligent management concepts and street lighting intelligent control systems based on ZigBee and FPGA technology, optimization of existing systems is expected to be realized.

3. Design concept of intelligent control system based on ZigBee and FPGA

3.1. Network architecture of the control system

The street light intelligent control system based on ZigBee and FPGA technology is interconnected by the main station of the control center through the public network and the intelligent control terminal. The main station layer consists of workstations, data servers and monitors. Administrators can access the master station layer through remote personal hosts or mobile intelligent terminals. The intelligent

control terminal includes an intelligent centralized controller disposed in the power conversion center and a single-light intelligent controller installed on the light pole. [2].

A single-light controller and a centralized controller use a mesh network based on ZigBee technology to implement interconnection and two-way data transmission. The intelligent centralized controller communicates with the primary station using a public wireless network. To ensure the safety of the control system operation, a firewall is set between the main station and the intelligent centralized controller, and between the main station and the remote management terminal.

3.2. Working principle of the control system

The street light intelligent control system based on ZigBee and FPGA technology sets the single-light as the control node with economical and applicable ZigBee technology, and realizes intelligent energy saving control and real-time monitoring of the operation status of street lighting system with design intelligent control module based on FPGA technology. The intelligent terminal control node collects the voltage, current, power and other parameters of the system in real time and transmits them to the intelligent centralized. The centralized controller automatically analyzes these operating parameters, makes decisions based on the analysis results through the intelligent management system, and gives relevant instructions to the single-light control system installed on the control node, which automatically adjusts the working state of the street lights. At the same time, the intelligent centralized controller uploads the monitored and analyzed data results to the control center, and the data server in the control center archives the data and results according to a predetermined procedure.

When the intelligent centralized controller finds that the control node is running abnormally through data analysis, it can generate an alarm signal of the relevant fault type and transmit it to the administrators of the primary station. The administrators can contact the service personnel in time according to the type of fault and the specific location.

4. Design of intelligent control system based on ZigBee and FPGA

4.1. Design of the main station layer

The hardware infrastructure at the main station level includes monitors, data servers, and system workstations. The main station layer realizes monitoring and controlling of the system with the automatic operation of the system management software preset on the workstation.

The administrators can remotely control the intelligent controller through the main station and adjust the control strategy for the street light system. And they can query the operation status of the internal facilities of the system and monitor the system status in real time through the monitor. [3] In addition, the workstation can also analyse the control node operating parameters of a certain area and assist administrators to make decisions according to the requirements of the administrators.

4.2. Module design of intelligent centralized controller

The intelligent centralized controller consists of a communication module, a ZigBee coordinator module, and a data processor module. The communication module is responsible for bidirectional real-time data transmission between the public wireless communication network and the control center. The ZigBee Coordinator module contributes to establishing wireless communication between the centralized controller and the single-light intelligent controller, receiving operational data of the control node in real time and transmitting control commands to the terminal controller. The data processor module intelligently analyzes and processes the system operating parameters and forms a decision to control the working state of the single-light illumination.

4.3. Module design of intelligent single-light controller

The design of the intelligent single-light controller mainly includes ZigBee communication module, data acquisition module, FPGA-based controller module and power module. ZigBee communication module uses ZigBee wireless communication technology to realize automatic sensing and interconnection

between control nodes, and establish two-way communication with intelligent centralized controller. The data acquisition module uses the sensor to collect system operating parameters and light intensity parameters [4].

Therefore, according to the instructions issued by the centralized controller, the FPGA-based controller make adjustments based on the lighting status of street light, such as time setting, light intensity, latitude and longitude, etc., to realize remote, real-time, multiple means of energy-saving management and control.

5. Conclusion

The optimized design of the street light intelligent control system can realize the remote control of the street light and monitor the main parameters of the system operation according to the actual lighting demand. According to the tracking analysis of the system operation status, the lighting control scheme is adjusted in real time through the intelligent management workstation. System fault analysis and early warning make system maintenance more efficient. So the use of street lighting intelligent control system based on ZigBee and FPGA technology has achieved significant energy saving effects.

References

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