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Research Article

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Solar Street Lamp Control System Based on ZigBee and GPRS

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ABSTRACT

The level of urban illumination supervisory control reflects not only construction levels but also the modernization degrees of the city. Traditional control and maintenance of street lamps is not enough more to modernization need. It is a necessity to design and realize a kind of higher autoimmunization, more credible and efficient long-distance monitoring and control system. The work takes GPRS (General Packet Radio Service) communication and ZigBee networks as the key technologies. It realized the unified control, monitoring and management of urban street lamp system by computers. And the entire Remote Terminal Unit is powered by the solar energy. Through the experiment result, it indicates that one month can save energy about 20%. So, the system has high reliability, strong applicability and can save manpower, reduce expense of electricity and improve management of street lamps in city.

Keywords: solar street lamp, GPRS, ZigBee, energy saving, reliability

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INTRODUCTION

With the development of city construction, people have a higher demand of urban landscape. Street lamp is indispensable factor for the beauty of the urban night view. The monitoring and control of street lamp is an important component of urban landscape. In the past years, the laying cost, constructing cycle and technology level, etc., all of these factors influenced the line monitoring and control method, and limited the application of street lamp remote control [1]. Most of the traditional controls to street lamps are manually operated method, time-control and light-control, which open or close the street lights at the stated hour. Otherwise, there are many street lamps that break usually present every road in big or medium city, which would bring many inconveniences to the habitants. Because the controller could not communicate with the management office timely, it is inconvenient for remote supervisory and management. So, the public facility management office is difficult to acquire the work conditions of street lamps of their district in time [2].

In this case, the street lamp patrol often takes labors inspecting method for grasping the working conditions of the equipment. The method of patrolling lamps at night and line in the day makes a waste of manpower and electricity, its monitoring and control effect is not ideal. Obviously, the traditional way could not meet the high lighting rate of modern society [3]. To solve the problems in this paper, we designed a remote street lamp control system based on solar-powered. Combined optical with time control, the solar street light could be controlled by remote wireless controller at the same time. Using the GPRS network, this system could realize remote data transmission easier to implement, and could decrease the cost of communications equipment.

EXPERIMENTAL SECTION

Time Calculation of Sunrise and Sunset

Suppose the figure of the earth is circular, and permits existing atmospheric refraction influence, sunrise and sunset time is the point when the sun's upper edge arrive the horizon. In other words, taking the standing plane of the observer as the referenced plane, the sun is at the location of -0.833º. When calculating the sunrise time, it supposed the sun location is 180º. Using the supposed location, it can calculate the sunrise location. Through the new location and by the iterative method, it can calculate a new location till it satisfied the calculating precision. The specific steps are as follows [4]:

Step 1: Calculate the days from A.D. 1/1/2000 (GMT) to the calculating day.
Step 2: Calculate the century number t from A.D. 1/1/2000 (GMT) to the calculating day

$$t = (days + U_{T0} / 360) / 36525 \quad (1)$$

In the first time

$$U_{T0} = 180 \quad (2)$$

Step 3: Calculate the mean longitude of the sun

$$L = 280.460 + 36000.770 * t \quad (3)$$

Step 4: Calculate the anomaly of the sun

$$G = 357.528 + 35999.050 * t \quad (4)$$

Step 5: Calculate the ecliptic longitude of the sun

$$\lambda = L + 1.915 * \sin g + 0.020 * \sin(2G) \quad (5)$$

Step 6: Calculate the dip angle of the earth

$$\varepsilon = 23.4393 - 0.0130 * t \quad (6)$$

Step 7: Calculate the deviation of the sun

$$\delta = \arcsin(\sin \xi * \sin \lambda) \quad (7)$$

Step 8: Calculate the time angle of the sun

$$GHA = U_{T0} - 180 - 1.915 * \sin g - 0.020 * \sin(2G) + 2.466 * \sin(2\lambda) - 0.053 * \sin(4\lambda) \quad (8)$$

Step 9: Calculate the modifier

$$e = arc\left(\frac{\sinh - \sin(Glat) \times \sin \delta}{\cos(Glat) \times \cos \delta} \right) \quad (9)$$

Where $h = -0.833°$

Step 10: Calculate new time of sunrise and sunset

$$U_T = U_{T0} - (GHA + Long \pm e) \quad (10)$$

Where $Long$ is the longitude of the city. When calculating the sunrise time, it selects "+"; when calculating the time of the sunset, select "-".

Step 11: If $U_{T0} - U_T$ >0.1º, then take U_T as the new time of sunrise and sunset, starts the calculation from step 2; If $U_{T0} - U_T$ <0.1º, then U_T is the GMT time of sunrise and sunset.

Step 12: The above calculations take degree as the unit, 180º equals to 12 hours. After changing the unit from degree to hour, it could get the time of sunrise and sunset of the calculating place

$$T = U_T / 15 + Zone \quad (11)$$

Where, Zone is Time Zone of the calculating place.

GPRS

GPRS is the abbreviation of General Packet Radio Service. It is a new kind of carrying network developed from the traditional communication technology of GSM (Global System of Mobile Communication), in order to supply packet data services for GSM user.

In terms of the bearer data service, GPRS has many obvious advantages. Through the multiplexing of the GSM slot time, the data transmission rate of GPRS is very high; its theoretical peak value could up to 171.2kbps, but the practical bandwidth is about 20kbps to 100kbps. Different network users share one GPRS communication channel, when one user need send or receive data, the channel resource was occupied. Through multiplexing of many users, the channel resources of wireless network are utilized efficiently. So, it is fit to the small flow rate data transmissions, which is very fit for the situation that there are much data to transmit but the time is not continuous. The turn-on time of GPRS is very short; the time of packet switching is shortening to less 1s, so it could provide timely connection. GPRS support the protocol of TCP/IP and X.25; they are widely used in the Internet work, so it has the global wireless access technology with Internet and other packet networks. The charging way of GPRS is flexible, it is charged according to the data traffic. Every GPRS user has superiority of online forever. At the same time of data transmission, GPRS could make voice communication. To the wireless data communication service, SMS has obvious price advantage. The GPRS user could select the charging way according to the need himself, monthly payment, or yearly. Generally speaking, GPRS is economic and practical, especially for the mobile equipment, or for the district of not easy erecting wire network [5][6][7].

ZigBee Protocol

ZigBee (IEEE 802.15.4 standard) is a rising wireless network technology which is of short space, low complicacy, low power consumption, low data rate and low cost. It is suit for industrial and home intelligent control, supervisory and remote control. Compared with other wireless networks, LR-WPAN (Low-Rate Wireless Personal Area Networks) needs very few infrastructures. The highest transmission rate of the network is 250kbps; it is fit for the situation of smaller message throughput. The time of signal transmitting and receiving is short, and it takes sleep mode in non-working time, the ZigBee node module is low power consumption. When it has the requirement of transmitting data message, the sent data package must wait for the confirmation message of the other, and respond the confirmation message. If it is not receive the confirmation message, it must send again. Thus, it guarantees the reliability of the transmission [8]. ZigBee offers green and global wireless standards connecting the widest range of devices to work together intelligently. ZigBee lets the researcher easily and cost-effectively add intelligent new features that improve the efficiency, safety, security, reliability and convenience of their products [9].

System structure and function

The street lamp intelligent supervisory control system was composed of RTU (Remote Terminal Unit), ZigBee network and supervisory control centre, as shown in Fig.1.

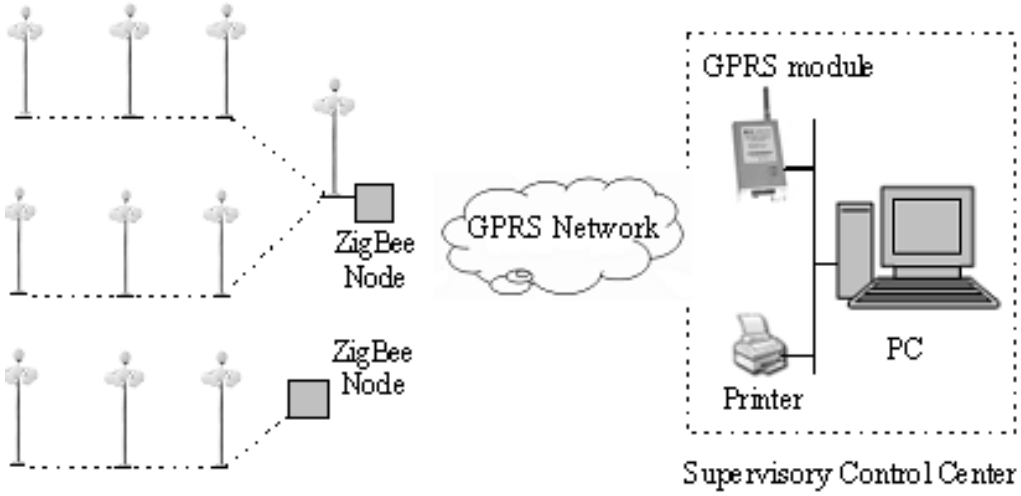

Fig. 1 The composition of the supervisory control system

The supervisory control centre was the nuclear part of the system; it was composed of personal computer, GPRS module, GPS (Global Positioning System) module, Printer, UPS and so on. The supervisory control centre functions as the telemetry and tele-control, and does the work of maintenance, management, statistic and analysis. The RTU

parameters were all transmitted to the supervisory control centre, including voltage, current, active power, power factor and so on. In the centre, the parameters were analyzed and displayed as the form of figure and table, which could provide a basis for the decision of street lamp managers or workers [10]. On the other hand, the supervisory control centre sends the specific order according to the concrete conditions. The control mode includes time-control, light-control, group-control and single-control.

RTU includes parameters collecting module, kernel control module, LCD module, keyboard module, and so on. The composition of RTU was pictured in Fig.2. All of the RTU are powered by solar energy [11]. Through the potential transformer and the current transformer, the parameters of the street lamp were transmitted to the parameters collecting module. The collecting module uses ATT7026 which is the special chip to measure electrical energy of the street lamp to acquire and process data. The collected data were transmitted to the kernel module through SPI (Serial Peripheral Interface), and displayed on the LCD module. Through the keyboard module, it sends the control message to the kernel module of ATmegal128. The ATmegal128 transmits data or messages to the ZigBee terminal node. The terminal node could inter-transmit data with neighboring nodes. All the data were collected to the converged nodes, and transmitted to the supervisory control centre through GPRS network [12].

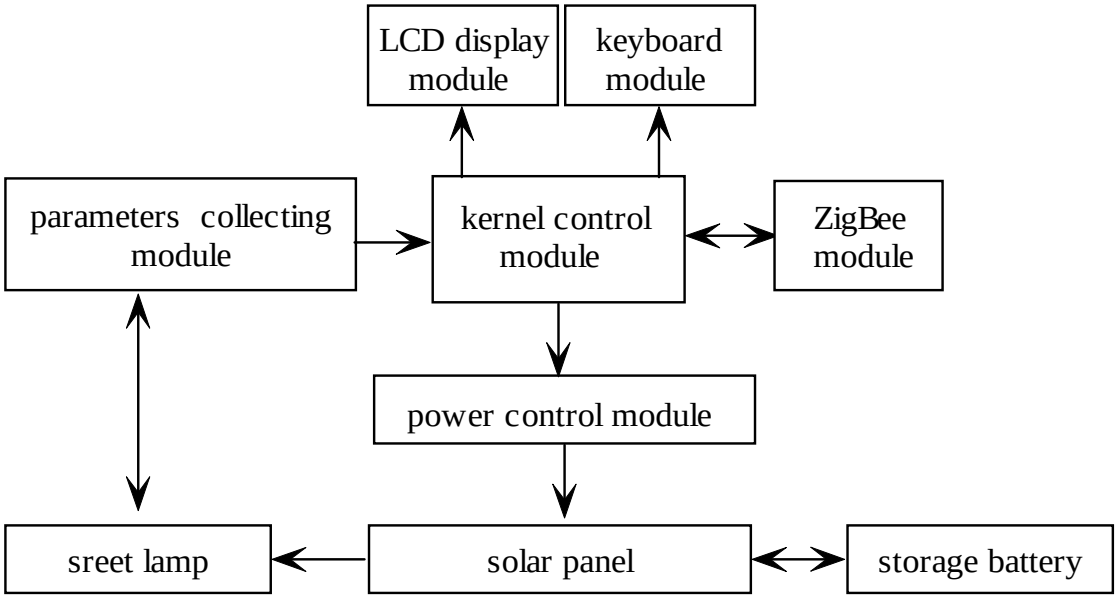

Fig. 2 Schematic diagram of the RTU

RESULTS AND DISCUSSION

The intelligent street lamp control system adopted advanced control method; it could enhance the municipal level of hardware, improve the reliability of the city illumination and find the fault timely. According to the change of the seasons and weather condition, it made rational use of resources. Thus, it could save power resources and raise people's living standards. Otherwise, the system could reduce the patrolling workload of the workers and raise working efficiency. It realizes the target of intellectualization, high reliability and low cost of the monitoring and control system.

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