The solution of intelligent lighting
Control and management
for urban street lights

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Technology Company Ltd.
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1. Overview

With the development of urban construction, urban lighting construction is more and more important in the city's image. The government has not only invested a lot of financial and material resources to increase and improve road lighting, landscape lighting and public lighting, but also put forward higher requirements of energy saving and intelligent control for them to let the management of urban lighting more modern.

By adopting the advanced intelligent lighting control and management system for street lights, the city can give unified management and control on turning on or off road lights, monitoring the state of the lighting system and the street lamp in real-time to ensure high effective, stable and all-weather operation and reduce power consumption effectively.

Wireless intelligent lighting control and management system offered by Shenzhen Solar-led Lighting Technology Company Ltd is taken power line communication technology as the core and makes use of power line communication to realize the control on far end street lights, including controlling on-off of street lights, adjusting the brightness of street lights, monitoring working states of street lights, managing working modes of street lights, giving an alarm of fault street lights, outputting energy saving report, and so on. This solution can save a large number of electric charge and management cost and bring huge economic benefits and social benefits.
2. Overall solution design

2.1 System design ideas and principles

2.1.1 Design ideas

With advanced software and hardware and communication system, the system consists of monitoring and dispatching center, wireless communication network, power line technology, concentrators and slave controllers to meet remote control requirements for urban road lightings. Through real-time remote control, telemetry, remote communication and remote adjustment, it is very flexible to give effective management of throughout the city street especially for important activities such as important leaders’ visit, major business activities, important holiday celebrations, and so on. It is also able to monitor, discover and report the fault street lights in real time to make them maintained in time to improve the image of the city.

2.1.2 Design principles

- **Advanced technology**
  Adopting advanced processing, control, communications equipment and technology
- **High reliability**
  Adopting the most mature technology of software and hardware adopts the mature technology to ensure stable operation and anti-interference
- **Strong scalability**
  Wireless communication and modular structure easy for expanded capacity and extended performance
- **Saving investment**
  System equipment with high performance price ratio
- **Simple implementation**
  By using power line communication technology to avoid relaying cables and install quickly
- **Standardization design**
  Adopting the products in line with domestic and international communication and electrical standards

2.2 System structure

2.2.1 Advantages of system solution

1) The street lamp monitoring system is adopted advanced distributed control system solution, which acts monitoring center located in the street lamp management department as the core and far-end control terminals(concentrators) located in every road section as distributed control nodes by power line communication technology.

2) The two-way communication between the monitoring center and concentrators is used in the communication between China Mobile’s wireless public data network (GPRS), China Unicom’s wireless public data network (GPRS) or the use of the optical fiber, twisted pair and other cable networks.
3) Communication between concentrator and slave controllers is adopted power line communication technology to control all of the single lamps which can avoid relaying the cables and save investment.

4) With independent operating system, concentrators can be separated from the monitoring center to execute the command and data preservation. In the monitoring center power outage or other system failures and temporary failures of mobile network, concentrators can independently perform preset various timing task and management system.

5) It can be directly upgraded to a single lamp control system to avoid duplication of investment. And the system can adapt to the street lamp management department in the future energy saving transformation and upgrading, such as the installation of LED street lamp, etc., which can directly achieve remote control and dimming function and avoid the second transformation.

6) With automatic routing and carrier sense protocol of power line communication technology, it can ensure the stability of the system effectively and reduce the false alarm rate.

7) The system makes use of Lonworks bus type structure, which the failure of any node in the network will not affect the operation of the system.

8) System equipment design is compatible with EIA-709.2, EIA-709.1, EN50065-1 international standards and provides the interface with other industrial standards (such as Modbus, etc.), which can be developed for the second time, product upgrades and open interface.

2.2.2 System structure diagram
2.2.3 System hierarchy diagram

System hierarchy diagram of intelligent management of street lamps

- Monitoring Center
- Location 1, Location 2, ..., Location n
- Concentrator 1, Concentrator 2, ..., Concentrator n
- Group 1, Group 2, ..., Group n
- Slave controller 1, Slave controller 2, ..., Slave controller n

2.2.4 System function overview

- **Control of on-off of street lights**
  Control of on-off of any single street lights, any loop of street lights or self-defined group of street lights
- **Dimming control**
  Dimming control of any single street lights, any loop of street lights or self-defined group of street lights
- **Status check**
  Checking status, current, voltage of street light and electric quantity
- **Timing control**
  Timing control of on-off and sectional dimming of street lights
- **Alarm of fault lamps**
  Alarm of fault lamps to monitoring center and display the number of fault lamps
- **Power line guard against theft**
  Display alarm information when the power line was stolen
- **Display of system**
  Display system structure and relevant important information of street lights
- **Data report**
  Generate electricity, lighting rate curve and report analysis etc.
- **Data storage**
  Data storage of execution history of system equipment

2.2.5 System features

- Installation and construction is simple and fast, no need to lay the line and save costs.
It can automatically be carried out power on or power off every day and can ensure to power on or power off according to different time of work days and holidays through the managements of different locations and routes.

Prolong the lifespan of luminaire obviously and reduce the replacement number of luminaire by controlling on-off and brightness of street lights.

Remote setting parameters of nodes to carry out flexible control on each node, for example, lowering the brightness of street lights when people and cars are scare in the middle of the night to reduce power consumption and prolong the service life of lamps.

According to the weather situation and the actual light intensity of illumination, it can automatically control on-off and brightness of street lights, for example, turning on street lights in the bad weather in time.

Through settings in the computer and concentrators and preventing unauthorized operation, it can ensure that street lights are reliable and safe to be in operation...

3. System composition and technical parameters

Intelligent lighting control and management for urban street lights consists of three parts including monitoring center, concentrators and slave controllers.

3.1 Monitoring center

3.1.1 Hardware composition of general control center

As the control center of the urban road lighting, the general control center is responsible for the automatic control and management of road lighting. The general control center is composed of a monitoring workstation, a master control server, printer, UPS, communication equipments and a large screen. At the same time, the system has the network interface. The system can be easily set up for LAN of the street lamp management department as long as it accesses server, management workstation, etc., and achieve lighting monitoring data and image information sharing through the network.

3.1.2 Configurations of control center

- Monitor workstation
  By using industrial control computer, the mean time to failure of continuous operation is 30000~50000 hours.
- Server
  Selecting famous brand server
- Printer
  Selecting A4 laser printer
- Large display screen
  Large screen display system can use the projector, rear projection display according to the specific situation of the monitoring center. It can also be used for large screen high-definition plasma display or road lighting dedicated LED electronic display.
3.1.3 Software of control center

The intelligent lighting control and management system developed by Shenzhen Solar-led Lighting Technology Company Ltd. is a set of tailor-made software of intelligent control for the management and maintenance of urban road lightings. It sets communication, information management, and electrical group state control as a whole.

Monitoring software uses a modular structure and the user can put into configurations flexibly and gradually according to the actual needs and financial resources, material resources. Alarm analysis and display module, on-off time management module of street lights are the cores of the monitoring and management software. The monitoring software adopts super intuitive graphics structure, real-time and accurate analysis, judgment, positioning and marking fault. Intelligent monitoring software is based on the B/S architecture of distributed management system, which is divided into three parts including application program, data processing service and protocol processing service. Each part can run on different machines, be supported by different operational system and be connected by different communication network to improve the scalability, maintainability and reliability of the monitoring software system.

- **Features of software of control center**
  - **Openness of software**
    The system uses the standard protocol and interface and communicates interconnect and exchange to other software modules or hardware devices to reduce the dependence on the device manufacturers and software manufacturers and extend the system's active life.
  - **Easy for expand and upgrade**
    The system can easily increase or reduce the measurement points and can be free to upgrade and expand. The system can be extended to the actual number of street lamp terminal more than 100,000 intelligent street lamp terminals.
Solution of intelligent lighting control and management for urban street lights

- **Easy for maintenance**
  The system provides convenient debugging tools and inspection tools to facilitate the maintenance of engineers.

- **High reliability**
  The key parts of system are adopted with redundancy design and can be switched before the failure of server or pre-computer. The key data can be backed up automatically and are able to be recovered.

- **Security**
  The system has security management according to different operation level. Different level has different corresponding operating authority, and must enter the password to log in to the system.

- **Easy for operation**
  All procedures are graphic design and all commands are from the mouse operation.

3.2 Intelligent remote monitoring terminal controller (concentrator)

The concentrator designed and produced by the Shenzhen Shang Wright Lighting Technology Co., Ltd., is the key equipment of the electric energy information collection and remote control in the street lamp lighting system, and needs to be installed in the low voltage side of the low voltage distribution transformer of the road light box. It can collect data from RS485 interface electric energy meter and control street light through power line communication. It can transfer data to street light management department through TCP/IP, GPRS, CDMA timing or in real-time. The product adopts ARM core microcontroller and embedded operating system to offer accurate, real-time and simple control on street lights.

3.2.1 Standards and regulations

Products comply with IEC International Electrical Commission related standards and relevant national standards as follows:

- IEC61000-6-1-2005
- EN50065
- DL/T645-1997

3.2.2 Main features

- The concentrator adopts the integrated small industry level design with strong anti-interference ability and wide operating temperature range (the main control board reached -40°C to +85°C). It can normally collect all kinds of field signals under various interference conditions to ensure 100% of remote control rate and 100% of performance rate of remote control signal and not to make mistaken.
- When there is the occurrence of a computer or communication lines in the control room, the terminal will automatically turn on or turn off street lights according to the preset program to ensure the normal operation of the lighting circuits.
Because the monitoring terminal is generally installed in the environment of large interference, the designs of hardware and software of the terminal are adopts many kinds of anti-interference measures to guarantee the system reliability.

The hardware and software of the system are used self-recovery circuit processing when the system is reset caused by the strong interference to ensure reliable operation even if no person on duty.

Multi-protection measures for electric impulse and lightning are adopted for collected high voltage AC signals.

By modular design of uplink and downlink communication, it can be replaced on site without change the site to resetting parameters.

With powerful configuration function, product parameters can be modified in the local or remote control and it supports software online upgrade.

The concentrator has good electromagnetic compatibility, which can resist the interference of high voltage spike pulse, strong magnetic field, strong static electricity, lightning surge, and has a wide range of temperature adaptation.

### 3.2.3 Technical parameters

<table>
<thead>
<tr>
<th>Items</th>
<th>Min. value</th>
<th>Typ. value</th>
<th>Max. value</th>
<th>Unit</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power features:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input voltage</td>
<td>176</td>
<td>220</td>
<td>254</td>
<td>Vac</td>
<td></td>
</tr>
<tr>
<td>Working frequency</td>
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<td>50</td>
<td>63</td>
<td>Hz</td>
<td></td>
</tr>
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<td><strong>Power line communication:</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
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<td>Modulation mode</td>
<td>BPSK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Frequency</td>
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<td></td>
<td></td>
<td>KHz</td>
<td></td>
</tr>
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<td>5500</td>
<td></td>
<td></td>
<td>bps</td>
<td></td>
</tr>
<tr>
<td>Carrier signal transmission range</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Carrier signal receiving sensitivity</td>
<td>-80</td>
<td>-60</td>
<td></td>
<td>dBV</td>
<td>0dBV=2.82Vpp</td>
</tr>
<tr>
<td><strong>Other features:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Working temperature</td>
<td>-40</td>
<td>+85</td>
<td></td>
<td>℃</td>
<td>No including GPRS</td>
</tr>
<tr>
<td>Working humidity</td>
<td>5</td>
<td>95</td>
<td></td>
<td>%</td>
<td>No condensation</td>
</tr>
<tr>
<td>Dimensions(L×W×H)</td>
<td>300×180×100</td>
<td></td>
<td></td>
<td>mm</td>
<td></td>
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</tbody>
</table>

### 3.2.4 Brief introduction of functions

**Data collection function:**

- Data collection by RS485 interface electric energy meter

Products can be linked to the one with RS485 interface street lamp energy-saving equipment data acquisition which can receive real-time data circularly according to the
setting time.

- **Data collection by multifunctional electric energy meter**
  Products can be hung by the 1 multi-function electric energy meter which can collect and store data according to the setting time and send data to the master station when it calls.

**Data processing function:**
- The product can collect and store real-time data.
- The product can send data to monitoring center according to the setting time.

**Parameter setting and query function:**
- The product has the remote parameter setting function. All parameters in concentrators, RS485 interface electric energy meters, planning task of control of street lights, etc. can be set and inquired by remote master station.

**Alarm function:**
- The monitoring and alarm system of product is perfect. It can monitor the abnormal event information and report it to the master station according to the alarm set.

**Data transfer function:**
- Communication with monitoring center
  - Interface mode: supporting communication mode of GPRS/CDMA/TCP/IPv
- Communication with electric energy meter with RS485 interface
  - Interface mode: wireless private network or wired special network
  - Wired transmission distance: common wire is less than 50m and the new 50 μm multimode fiber is 1100m.
  - Wireless transmission distance: more than 1000m
- Communication with multifunctional electric energy meter
  - Interface mode: RS485
  - Transmission distance: ≤1000m
  - Communication rate: 300bps-9600bps
  - Communication protocol: communication protocol of DLT-645 multifunctional electric energy meter

**Remote control function:**
- The concentrator supports commands of remote control function of detecting lamps from the master station.

**Maintenance function:**
- The concentrator has remote software update function and short information maintenance.

### 3.3 Slave controller

The slave controller is a key part of street light control system. The core chip of slave controller is integrated power carrier circuit. The slave controller with professional hardware and software design has advantages of powerful functions, easy to implement, free to lay cable, reliability and easy to maintain.
The slave controller includes a power line communication modem which is in line with EIA-709.1, EIA-709.2 communication standard. The slave controller has integrated seven layer protocol of ANSI 709.1 and automatic routing algorithm, which provides a reliable network communication performance due to its excellent physical layer performance and automatic routing feature. The slave controller includes a current and voltage measurement circuit. It can collect the load working condition of slave controller in real-time and facilitate the statistics of street lighting rate, greatly reduce the work pressure of street light management department, increase work efficiency, and greatly improve social efficiency.

The slave controller provides a PWM signal at the same time providing a relay switch, which can support for the occasion such as the LED street lamp system with the need to be adjusted brightness.

**Main performance and features of slave controller:**
- Work in 220Vac power line
- The relay contact capacity is 10A/250VAC.
- Real-time collection of current and voltage
- Design of overload protection based on security
- Provide 1 PWM output signal for the use of LED dimming signal
- Carrier signal receiving sensitivity is up to -60dBV.
- Carrier signal transmission range under 1Ω load is 2~5Vpp.
- Power line communication is in line with EIA-709.1, EIA-709.2 international standard.
- Perfect power line communication
- Industrial working temperature: -40℃~+85℃
- Dimensions: 131.6mm × 68.5mm × 50mm (L × W × H)

### 3.3.1 Description of functions of slave controller

Internal function block diagram of slave controller is as below:

![Function Block Diagram]

The slave controller is an intelligent street light controller taken 8-bit micro-controller as its core. The micro-controller can deal with all of the data of slave controller and receive the work instructions through power line carrier, execute on-off of street lights, return data of current/voltage and overload signal.
The input voltage of working power supply for slave controller is 220Vac/50Hz. The rated working current is 2A.

A power relay inside the slave controller is in charge of on-off control and its contact capacity is 10A/250V. An additionally special circuit is designed to eliminate the contact action produced by electric arc perhaps and ensure the reliability of the work and extend the service life.

The special integrated circuit inside the slave controller is in charge of collecting real-time data of current/voltage of street lamps. The user can read the data in the background software.

Overload design is used to protect the slave controller. When the current exceeds the specified threshold, micro-controller will cut off the relay. At the same time, the overload signal is sent to the monitoring center. Usually, the overload protection will be within 1 second.

The frequency of PWM signal is 400Hz, the electrical level is TTL and duty ratio is adjusted from 0% to 100%.

The high performance power line carrier routing module is improved according to the protocol of EIA709.1 and EIA709.2, which can be compatible with international standards while adding the automatic routing algorithm technology and realizing the protection of the stability of carrier system reliably.

### 3.3.2 Electrical parameters of slave controller

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Test condition</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
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<tr>
<td>1</td>
<td>Input voltage</td>
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<td></td>
<td>180</td>
<td>220</td>
<td>250</td>
<td>VAC</td>
</tr>
<tr>
<td>2</td>
<td>Relay action mode</td>
<td></td>
<td>Magnetic hold</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Relay contact capacity</td>
<td>220Vac</td>
<td></td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>A</td>
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<tr>
<td>4</td>
<td>Rated load power</td>
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<td>400</td>
<td>600</td>
<td>W</td>
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<tr>
<td>5</td>
<td>Overload current</td>
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<td></td>
<td>—</td>
<td>4</td>
<td>—</td>
<td>A</td>
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<tr>
<td>6</td>
<td>Voltage measurement range</td>
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<td>0</td>
<td>220</td>
<td>380</td>
<td>VAC</td>
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<tr>
<td>7</td>
<td>Voltage measurement error</td>
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<td></td>
<td>0.1</td>
<td>5</td>
<td>10</td>
<td>%</td>
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<tr>
<td>8</td>
<td>Current measurement range</td>
<td></td>
<td></td>
<td>0</td>
<td>3</td>
<td>20</td>
<td>A</td>
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<tr>
<td>9</td>
<td>Current measurement error</td>
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<td></td>
<td>0.1</td>
<td>5</td>
<td>10</td>
<td>%</td>
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<tr>
<td>10</td>
<td>Carrier transmission range</td>
<td>1Ω load</td>
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<td>1</td>
<td>3</td>
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<td>Vpp</td>
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<tr>
<td>11</td>
<td>Carrier signal receiving sensitivity</td>
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<td>—</td>
<td>60</td>
<td>—</td>
<td>dBV</td>
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<td>12</td>
<td>Voltage of PWM output</td>
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<td>4.8</td>
<td>5</td>
<td>5.1</td>
<td>V</td>
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<td>13</td>
<td>Frequency of PWM output</td>
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<td>380</td>
<td>400</td>
<td>420</td>
<td>Hz</td>
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<td>14</td>
<td>Duty ratio of PWM output</td>
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<td>—</td>
<td>100</td>
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<td>15</td>
<td>Working temperature</td>
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<td>16</td>
<td>Working humidity</td>
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<td></td>
<td>5</td>
<td>—</td>
<td>95</td>
<td>%</td>
</tr>
</tbody>
</table>
4. Quality assurance and after-sales service

4.1 Warranty period

The warranty period is three years under normal use from the delivered data.

- Replacement of hardware products during warranty period
- Free upgrade of software during warranty period
- Remote service during warranty period

4.2 Personnel training

According to customer’s needs, our company will give technical training for customers’ relative personnel to achieve a comprehensive understanding of the system’s functions and relevant technologies, and help them be independent of the installation configuration, daily use maintenance, general fault diagnosis and repair work.

Training contents are mainly as follows:

- System structure and relevant technology
- Installation and debugging of the system
- System administrator and user training

5. Successful application cases

- LED lighting intelligent control engineering in Humen town, Dongguan City, Guangdong province
- LED lighting intelligent control engineering in Qiaotou town, Dongguan City, Guangdong province
- LED lighting intelligent control engineering for Biandanya tunnel in Yichang City, Hubei province
- LED lighting intelligent control engineering for Nuliangshan tunnel in Yichang City, Hubei province
- LED lighting intelligent control engineering in Weifang City, Shandong province
- LED lighting intelligent control engineering in Liuzhou City, Guangxi province
- LED lighting intelligent control engineering in Zhanhua county, Taiwan province
- ......