Research and Application of DC Multi-functional Information Pole

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Abstract: With the progress of electronic information technology and the development of smart cities, DC power supply and distribution technology and multi-functional information pole construction have received more and more attention. As the underlying perceptive carrier, the multi-function information pole is indispensable in the smart city construction. Combining multi-function information poles with DC technology is an innovative solution to the development trend of smart cities. This solution is designed by considering the requirements of electrical, communication and peripherals, we can further reduce power loss, improve reliability and safety by taking power from DC distribution network directly. The DC multi-functional information pole described above has been successfully connected to the DC distribution network of a compound in Huai’an, Jiangsu Province. The demonstration application of DC power supply from multi-functional information pole at the terminal distribution network level has been realized.

1. Introduction
With the development of smart cities and 5G-infrastructure, road lighting is changing from the traditional single lighting mode to intelligent multi-functional integration mode which build an urban data Internet based on the underlying information collection of the IoT[1].

At present, LED luminaires have been widely used in the field of road smart lighting. Compared with traditional high-pressure sodium lamps and other lighting methods, LED lights with the controllers can save about 40%-70% of electrical energy and substantially improve energy utilization efficiency[2]. The literature [3] proposes an easily scalable and deployable management system that combines urban building and road lighting, which has some commercial value. The literature [4] takes the integrated project of light poles in the main city of Hangzhou as an example to conduct a study on the technical framework and key points of urban road smart lighting IoT, and analyzes the technical theory and practical application of multifunctional poles from the perspective of smart IoT. The literature [5] proposed an integrated system of municipal street lights and electric vehicle charging piles based on low-voltage DC power supply technology, which ensures efficient road lighting and promotes the development and application of electric vehicles through centralized rectification of 220V AC power. All the above studies are theoretical and application studies of multifunctional poles from the perspective of smart lighting and smart IoT, and no practical application cases based on DC power supply mode are mentioned.

Based on the existing research on low-voltage DC and multi-functional poles, this paper designs a multi-functional pole with full DC power supply, relying on the DC distribution system, and the multi-functional mount module can be powered by the DC step-down module only, which can be adapted to a variety of peripheral power supply modes, simplify the internal electrical system design of the pole, and improve the power utilization rate. The research results have been successfully implemented in a
hospital in Jiangsu Province, which fully proves the possibility and safety of multi-functional pole application under DC power supply scheme, and plays a certain demonstration and leading role for the application of DC technology in lighting field.

2. DC multi-functional information pole
Due to various factors such as municipal planning, power grid structure and standardized equipment, AC power is still a mainstream power supply method for smart streetlights, but the unified and convenient AC power network has problems such as higher energy loss and poorer safety. The main grid structure of DC power distribution system don’t involve problems such as frequency stability and reactive power, while reducing the use of AC/DC converters, streamlining the electrical energy conversion link. It improves the safety of electricity consumption and reliability of power supply while reducing the loss in the process of electrical energy conversion and transmission.

2.1 DC multi-functional information pole system
DC multi-functional information pole is powered by DC power directly, which connects multiple peripherals to realize multi-pole unification through DC chopper. From the perspective of functional equipment application, it is adapted to multiple types of functional equipment such as LED light source, video monitoring, wireless AP, etc. It reduces the AC/DC conversion process and improves the efficiency of power utilization. It reduces the safety risk during the operation of multi-functional pole. The DC multi-functional information pole is mainly composed of two parts: hardware equipment and software platform. The information interaction is completed through the communication network composed of gateway and network cable. The random combination is achieved by the free matching of peripherals including smart lighting 5G base station, video monitoring, one-key alarm, new energy consumption, electric vehicle charging, convenient mobile device charging, environmental monitoring, traffic monitoring, municipal broadcasting, LED multimedia display, wireless wifi, parking space monitoring, simple seat and all. It is suitable for a variety of application scenarios such as campus, scenic spot, community, park, shopping district and road.

2.2 DC multi-functional information pole application exploration
From the perspective of municipal applications, multi-functional information pole applications require safety and reliability. The realization of the functions with multi-functional information pole depends on the underlying terminal system composed of multiple peripherals. Ensuring the power supply level and power supply reliability is the basis for the normal operation of hardware devices. By screening and summarizing a variety of peripherals existing in social, the typical electrical parameters are shown in Table 1.

| peripheral | Power supply parameters | POE power |
|------------|-------------------------|-----------|
| LED lamp   | 50-35W, AC220V          | No        |
| Camera     | 10-60W, DC12V/DC24V/AC220V | Yes     |
| Environmental Sensor | 15-30W, DC12V/DC24V/AC220V | No    |
| One-touch alarm | 5-15W, DC12V/DC24V/AC220V | Yes  |
| Broadcast speakers | 15-40W, DC12V          | Yes      |
| LED display screen | 800-1200W/m2, AC220V | No       |
| Wireless AP | 10-30W, DC12V/DC24V/DC48V | Yes |
| 5G base station | 200-1400W, DC48V | No    |
| Convenient charging | 10-30W, DC48V/DC24V/DC12V | /     |

As can be seen from Table 1, the peripheral products of the multi-functional pole on the market in order to match the AC mains, most of them have AC220V products for customers to choose. From the current survey results, most peripheral products have DC power supply model production, only the LED
Lamp and LED display screen are still dominated by AC220V product models. LED lamps and LED displays are composed of several LED grains, each LED grain is equivalent to a diode, most of the LEDs on the market are DC LEDs, therefore, DC-type drive is the most common way to drive LEDs. As the current LED street lights still use AC mains power supply, AC power needs to be converted to DC power, through the DC driver circuit to achieve LED power supply, direct DC power supply can essentially reduce the AC-DC conversion process.

The construction of 5G infrastructure, multi-functional information poles become a high-quality carrier for 5G base stations, and it is appropriate to use DC power supply for communication equipment such as 5G base stations.

From the point of view of whether to support POE power supply, the camera, One-touch alarm, broadcast speakers, wireless AP support POE power supply, to be able to communicate transmission at the same time directly from the gateway for low-power take power.

In summary, most peripherals support DC power supply and POE power supply, while LED devices are essentially DC power, standardized AC power products must be equipped with a power driver module converted to DC power supply for LED devices. Therefore, from the principle of the device, DC power supply compared to AC power supply, and peripheral power supply system is more compatible, reducing the AC-DC conversion link, reduce losses, improve efficiency, adapt the power supply mode also has a certain protective effect on peripherals.

3. DC multi-functional information pole technology program

Currently built DC multi-functional information pole projects still use AC 220V utility power, through the centralized distribution cabinet to complete the drive power normalization process, in the form of DC power supply directly to the LED lamps and lanterns. At the same time, intelligent lighting control is achieved by a combination of centralized controller and single lamp controller control mode. However, multi-functional information pole projects were still adapted to the AC distribution network, which changed the terminal part of the distributed drive power to a centralized drive power supply. It can’t achieve DC power supply with varieties of peripherals.

3.1 DC multi-functional information pole electrical topology diagram

As shown in the electrical topology diagram above, the DC multi-function information pole is lowered from DC375V to DC48V by DC/DC conversion module, further lowered to DC24V by DC/DC conversion module to power for HD IR camera, active speaker and other devices, and lowered to DC12V by DC/DC conversion module to power for environmental monitoring equipment, alarm and other devices. Compared with the AC power supply system, the power conversion link is reduced and the conversion efficiency is improved.
3.2 Communication topology diagram

![Diagram of Communication Topology]

As shown in Figure 2, the multi-functional information pole communication network is mainly divided into four stages from the data perspective: data acquisition, data processing, data display and data transmission.

Data acquisition is the bottom tentacle of the multi-functional information pole communication system. It installs multiple types of sensors to achieve lighting, video, alarm, environmental and other data monitoring that compose real-time data information collection to complete the database front-end resource reserves.

Data processing is the central brain of the multi-functional information pole which process and calculate peripheral data packages for the software platform to call, display and control.

Data display is the external display window of multi-functional information pole. It displays the real-time data of the multi-functional information pole system through a simple and clear platform interface, including lighting parameters, monitoring data, etc. It complete the human-computer interaction through the platform interface.

Data transmission is the nerve network of multi-functional information pole that compatibles with a variety of communication protocols, which organically integrates PLC, WIFI, Ethernet, GPRS,4G,5G, RS485/Modbus/DMX, CDMA and other forms of bus transmission to realize bidirectional data transmission between multiple peripherals and servers.

4. Conclusions

This article introduces the DC multi-function information pole and some related applications. Then, it introduces a technical solution of the DC multi-function information pole from both the electrical and communication aspects.

The DC multi-functional information pole described in this paper is applied to a power supply compound in Huai’an, Jiangsu Province, and the full DC system is perfectly adapted to the multi-functional information pole, the DC power supply is achieved from the municipal level to the application of the user terminal.

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References

[1] Zang F, Gu L.M, Wang P.Zh, Huang L.B. (2020), The Construction of New Smart City Ecological System Based on Iterative Upgrade of Urban Lighting, Zhaoming Gongcheng Xuebao, 31:14-18

[2] Mithilesh M, Ram T.S, Reddy M.C.S, Poovaraghan R.J. (2017), Smart Street Light Management System. International Journal of Engineering Science and Computing, 7:19153-19155.

[3] Yang Y.S, Lee S.H, Chen G.S, Yang C.S, Huang Y.M, Hou T.W. (2020) An Implementation of High Efficient Smart Street Light Management System for Smart City. IEEE Access, 2020, 8:38568-38585.

[4] Liu Y.Q, Zhang X.M, Gao J.H, Feng Y, Zhou X.S. (2019), Key Technologies of Internet of Things for the Urban Road Intelligent Lighting. Zhaoming Gongcheng Xuebao, 30:13-16

[5] Yin S.G, Liu J.M, Zhao X.L, Guo Z.Y, Lv T.G. (2014). A Low-Voltage DC Power Supply Technology Based Integrated System for Urban Street Lighting and Charging Piles for Electric Vehicles. Power System Technology, 38:571-575