Special Vehicles to Prevent Touching High-voltage Lines Monitoring and Warning Device

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Abstract: Domestic regional special vehicles and construction personnel high-voltage electrocution accidents always occur, resulting in large-scale equipment and socio-economic losses. Based on this, in order to effectively reduce special vehicles touching high-voltage lines causing safety accidents, this paper researches and designs a safety monitoring and warning device for special vehicles touching high-voltage lines, mainly including sensor monitoring templates, signal transmission templates and monitoring and warning alert templates, through the decoding of different template principles, combined with electric field induction and wireless transmission principles, the safety distance of high-voltage lines is relevant to explore, then when Special vehicle objects into the safety distance threshold, that is, to start the information monitoring alarm, to remind the construction of special vehicle equipment and personnel away from electrocution, to ensure safe production. Through the monitoring and warning device, the rationalization, economy and safety of high-voltage line can be achieved.

1. Introduction
Currently, with the continuous innovation and development of high voltage and UHV, there are growing construction types under the high-voltage lines. At the same time, the manual / mechanical construction difficulty and risks are intensifying, resulting in more casualties and higher equipment consumption. Therefore, to effectively avoid the safety accidents caused by manual / mechanical work and high-voltage line transit, it is extremely critical to develop a safety device for the monitoring and alarming of the transmission line electric field [1].

Related studies suggest that external force intervention is the core point for the destruction of high-voltage transmission lines, which not only seriously damages the transmission safety of electric lines, but also brings harm to social economy, life and health [2]. Among them, external force intervention is dominated by the touch damage caused by special engineering vehicles. To this end, we should avoid accidents through the high-voltage anti-touch safety monitoring and early warning device. When the construction of mechanical special vehicles cannot keep a safe distance from the high-voltage transmission lines, the monitoring and early warning device sends out voice and warning instructions to remind the construction personnel, prevent the external discharge caused by safety accidents [3-4], and divide a reasonable and safe touch distance.

This paper targets the areas within the jurisdiction of Jilin Siping Power Supply Company. The survey concluded that about 19 safety accidents caused by special vehicles touching electric lines occurred in the past 20 years, leading to intensified living power failure, 3.42 million kilowatts power routes and power loss and more than 2.56 million direct or indirect economic losses. Therefore, it is imminent to reduce the safety accidents from the safety construction of special vehicles. Through the effective control of special vehicle anti-touch early warning devices, the accident rate within the
jurisdiction has been reduced by about 60%, and the economic loss has decreased by more than RMB 1 million. At the same time, it has effectively realized the trinity prevention system (site operation, background monitoring and remote control early warning transmission) of special vehicle anti-touch high voltage line, which greatly improves the efficiency of safety accident prevention and ensures the people's life stability and health. This paper analyzes the working principle of preventing high-voltage electric shock monitoring and early warning, hardware and sensor design, so as to improve the prevention efficiency of special vehicles and reduce the economic cost and excessive loss of human resources.

2. Electric monitoring and early warning design for special vehicles

2.1 Overview of electric monitoring and early warning design
Figure 1 specifically describes the application function of anti-touch monitoring and early warning platform for high-voltage electric lines. The safety system of the platform is mainly composed of sensor center, signal collection and control center, monitoring and early warning center. The main function of the sensor center is to monitor and prevent the proximity, touch and destruction of the high-voltage transmission line device according to the signal strength of the power plant during construction, and then to transmit the information collected back to the template of the signal control center; The signal control center is mainly divided into signal conditioning circuit center and SCM. The main function is to complete the transmission information filtering processing and extract different electric field intensity signals to be analyzed and judged by SCM (comparing different signal value with threshold or limit value). When the transmission signal reaches the threshold, the alarm signal will be sent to the monitoring and early warning alarm center; The alarm center receives SCM electric field signal, obtains the alarm position information through GPS, and operates with emergency braking at any time to protect the safety of special vehicles and equipment in the construction process, and realize the manual / intelligent anti-touch alarm work of special vehicles [5].
2.2 Basic construction of electric monitoring and early warning design hardware

This paper designs a special vehicle anti-touch monitoring and early warning platform based on intelligent data signal transmission and sensor function characteristics. The hardware composition of the platform is mainly divided into data signal end and monitoring and early warning end. Among them, the main hardware at the signal end includes basic power, sensor, signal conditioning circuit, SCM and wireless automatic transmission, etc.; the hardware of monitoring and early warning end is mainly divided into wireless automatic receiving device, GPS positioning device, monitoring and early warning device and emergency braking device. The two hardware modules coordinate and cooperate to jointly set up an electric monitoring and early warning platform.

3. Design of system signal transmission for electric monitoring and early warning control device

3.1 Introduction to the system signal transmission process

Figure 2 is the flow chart to master the core process of anti-touch high-voltage monitoring and early warning device and deeply explore the signal transmission mode of monitoring and early warning device. As shown in Figure 2, the wireless module signaling mainly consists of the following three components: (1) Device system data integration and query acquisition (SCM, sensor, wireless terminal, etc.); (2) The signal is judged by the wireless module for voice alarm (SCM, driving circuit and wireless communication mode, etc.); (3) Remote control and analysis of data via inter + Internet terminal.
terminal, wireless transmission module, etc.). It suggests that the wireless module judges the key points of the signal conditioning circuit, which can not only effectively analyze the electric field detection and transmission signal, but also play a role in monitoring and early warning and user information acquisition, ensuring the stability and transmission of the monitoring and early warning system.

Figure 2 Signal transmission mode of monitoring and early warning control device
3.2 Introduction to SCM module
With the advantages of good stability, fast operation, low energy consumption, low voltage, large current and complete functions, SCM can not only work in a hostile environment, but also be favored in the intelligent electric power monitoring industry with low economic costs. The basic structure of SCM system is composed of capture/comparison module, calculation module, simulation module, serial port module, enhanced addressable USART module and converter module. At the same time, it also has temperature control sensor and reference power supply. The computing module interprets the sensor data information to find the optimal solution and realize reasonable simulation and numerical calculation, which is transmitted to the threshold calculation area through the serial port module. In case of higher simulation value, emergency braking measures or monitoring and early warning are performed to improve the safety of construction workers for special vehicles. The temperature control sensor ensures the safety of SCM and avoids the damage caused by the external environment.

3.3 Monitoring and early warning signal transmission module
The monitoring and early warning signal transmission module refers to the electrical signal being wireless output by the sensor when the high voltage power transforms the peripheral magnetic field signal into an electrical signal. The transmission module specifically includes basic hardware such as sensor, SCM, conditioning circuit, threshold determination and user acquisition monitoring information data. In this process, SCM of high rate and stable performance is used as the wireless transmission module to store and collect the electric signal data. After that, the electromagnetic signal is converted into a voltage signal. The conditioning circuit will effectively amplify the useful electrical signal, and reduce the degree of noise interference to avoid the losses in transmission. Finally, when the transmission signal passes through the threshold critical, it is determined whether it exceeds the warning signal. In case of exceeding the limit, the early warning signal is transmitted to the user set at one time through SCM, so as to complete the transmission of monitoring early warning signal, realize the timely acceptance of information by the alarm device, avoid accidents and ensure safe production.

3.4 Safety early warning distance design
To strengthen the safety of special vehicles in the power construction process, the safety alarm device is set up under different sensitivity perception levels and voltage levels to analyze the monitoring and early warning distance. The results are shown in Table 2. With the increase of voltage from 10KV to 330KV, the perception distance increases by 8m, suggesting the increase of safety distance under the higher voltage level and the large changes in distance under different levels. Therefore, when the safety distance between the special vehicle and the voltage level is less than GB distance, SCM control solenoid valve in the safety alarm device realizes monitoring and early warning, and the safety distance is determined combining with the alarm noise level to remind the construction staff of safety.

When the construction of special vehicles exceeds the early warning distance, the emergency brake device will be shut down to ensure the safety of personnel and equipment, and achieve the purpose of effective monitoring and early warning, and the standard of production safety.

| Monitoring and early warning perception distance (m) | Different voltage levels |   |   |   |   |
|--------------------------------------------------|--------------------------|---|---|---|---|
| Perceptibility (1)                               | 4                        | 5 | 7 | 9 | 12 |
| Perceptibility (2)                               | 3                        | 4 | 5 | 7 | 10 |
| Perceptibility (3)                               | 2                        | 3 | 4 | 6 | 7  |
4. Electric field principle and sensor correction analysis of special vehicles

4.1 Electric field distribution law of the high-voltage AC electric line
In the early 1830s, electromagnetic field theory rose gradually. The practical study of electromagnetic field began with Maxwell's open interpretation of Fundamental Equations of Electromagnetic Fields in the 1860s. Electric field strength is the physical index parameter describing the characteristics of electric field and is the product based on electromagnetic field theory. It refers to the existence of an electric field space around the charged conductor with a certain impact on the surrounding particles, indicating a certain electric field exists around and gives a certain direction to the surrounding particles. In the electric field in the same direction, the ratio of electric field intensity and charge quantity remains unchanged. This means that the electric field strength is a physical index that can analyze and eliminate the interference of different ground conditions and temperature conditions, and indirectly infer the touch safety distance of high-voltage circuit line with the electric field strength index.

4.2 Type of anti-touch monitoring and early warning sensors
With the rapid development of computer intelligent data, the anti-touch monitoring and early warning devices have become more intelligent. The electric researchers have simulated the electric field distribution characteristics around the high-voltage transmission lines and separately introduced the types of early warning sensors under different environments and electric field intensity in GB. (1) Spherical sensor: the working principle is that the electric field intensity is induced by the isolated conductor; the conductor forms current and charge to measure the distance between the target object and the electric line. It has three different forms of probe, with the characteristics of simple design and accurate measurement; (2) Ground reference field instrument sensor: it is used to measure the ground electric field intensity and complete the safe distance measurement task relying on the connecting principle of medium probe and indicator optical cable.

4.3 Sensor principle analysis
The sensor type used in this paper is a spherical sensor, with three different forms: 1D, 2D and 3D. Operating principles exist in different forms. For example, 1D spherical sensor is a metal hemisphere connected by hollow insulating materials, with the insulating material as a medium, and the metal hemisphere as a capacitor (see Figure 3 for a structural diagram). The measured distance feasibility analysis is determined by measuring the charge density. If the charge is remoter, the electric field strength gap between the sensors will be lower, and the error will be smaller. We can indirectly collect spatial electric field intensity information through charge information to determine the safe distance of the electric line and achieve the goal of intelligent safety monitoring and early warning.

![Figure 3 Structure diagram of power plant sensor - probe - electrode](image-url)
This paper analyzes the spherical sensor function and basic computing theory in the field of monitoring and early warning. The basic characteristics of sensor are calculated according to the first Maxwell's equation:

\[
\nabla \times H = J + \frac{\partial D}{\partial t} \tag{1}
\]

\[
J = \gamma E \tag{2}
\]

\[
\frac{\partial D}{\partial t} = \varepsilon \frac{\partial E}{\partial t} \tag{3}
\]

Where: \( J \) for current density vector; 
\( \gamma \) for electrical conductivity; 
\( D \) for potential shift vector; 
\( E \) for the power plant strength vector; 
\( \frac{\partial D}{\partial t} \) for the displacement current density vector; 
\( \varepsilon \) for the dielectric constant.

If the electric field direction of the spherical detection sensor is inconsistent, the surface charge density of the electrode is analyzed by the spherical sensor, as shown in formula (4).

\[
\sigma(t, \alpha, \theta, \phi) = -\frac{\varepsilon E(t)}{\alpha} \left\{ \frac{1 - \alpha^2}{1 + a^2 - 2a(\sin \alpha \sin \theta \sin \phi - \cos \theta \cos \alpha)} \right\}^{3/2} \tag{4}
\]

To accurately measure the electric line distance, this paper calculates the electric charge of the sensing probe of the spherical sensor, as shown in formula (5).

\[
Q_m = \int \int \sigma(t, \alpha, \theta, \phi) ds \tag{5}
\]

According to the calculation formula of the spherical sensor, when the sensor detection direction and the electric field direction are inconsistent, the spherical sensor radius (\( r \)) and the included angle will cause an error in the distance between the spherical radius and the real measurement. There are certain hidden dangers to the safety construction of special vehicles.

5. Conclusions

This paper expounds the composition and working principle of the sensor, hardware and other components of the monitoring and early warning device for special vehicles touching high-voltage power lines. Through the development and utilization of the monitoring and early warning device, the risk level of equipment in the construction process is reduced and the safety performance of power construction operation is improved. It is of positive significance to power safety and social and economic development. At the same time, the following two basic conclusions are drawn:

(1) In this paper, the monitoring and early warning platform studies and designs the anti-touch early warning device of high-voltage power line from the technical framework (signal transmission module, monitoring and early warning module, etc.), hardware data acquisition (receiving / transmitting sensor, SCM) and the implementation scheme of safety measures, and formulates the relevant early warning implementation scheme, which brings positive value to the development of state grid power.

(2) Monitoring and early warning system device combining the hardware equipment and big data software technology not only makes the special vehicles (crane, super-high car, lifting vehicles, etc.) effectively give equipment and personnel safety warnings during electric power construction, but also effectively reduce the construction length of electric line operation. The formation of the alarm device basically puts an end to the accident rate and strengthens the intelligent level of high-voltage transmission operation management.
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