Study of Intelligent Robot for Insulators Based on Electric Field Method

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ABSTRACT

Insulators are used for insulation and support of power lines. For this reason, the inspection is necessary to improve the reliability of the live-line. This paper aims to solve some key technical problems of insulator string detection in overhead transmission line, and designs an insulator string detection robot with good performance and suitable for transmission line environment in China. The quality criteria of insulators for the deep research of W and electric power industry standard insulators and the existing detection methods; the insulator string at the same time to carry out resistance detection, field detection, visual inspection and hydrophobicity detection, to achieve a comprehensive evaluation of the performance of porcelain insulator. The method can comprehensively reflect the insulator state and reduce the misjudgment probability of insulator detection. Realize remote data remote control of robot, remote video real-time transmission, and analysis and storage of measurement value. Through the research on electromagnetic interference of UHV 1000kV voltage level, put forward the robot control interface circuit, multilayer shielding shell photoelectric isolation and control system and the robot is such measures, successfully overcome the electromagnetic interference problem. The application of the insulator string detecting robot reduces the skillful labor intensity of the insulator string detection, ensures the stability and reliability of the power grid operation, and promotes the development of the power robot technology and the construction of the smart grid.

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INTRODUCTION

At present, the construction of our country's power transmission line is in a period of sustained and rapid development. Insulators for transmission line application in China in accordance with the structure of main sub disc type porcelain or glass insulator strings and cylindrical insulator two, divided by material with porcelain insulator, glass insulator, composite insulator and other categories of the king. In the daily operation of insulators, due to the influence of a series of factors, such as high and low temperature difference, pollution and lightning stroke, the insulator sheet is prone to damage, and the low value piece or even the zero value insulator sheet appears. Therefore, it is necessary to comprehensively analyze the performance characteristics of insulators, find out the problems in the operation of insulators, and propose reasonable solutions to improve the operational reliability of transmission lines.

The need for power detection technology workers a string, the detection devices to each insulator with the insulating rod, generally large cross line insulator string length up to ten meters, the artificial detection operation is very difficult. Therefore, the automatic crawling device is developed both at home and abroad, which is used to assist or replace manual detection, and the insulator string detection robot is produced and developed in this context.

Inspection Robot Research Status Tension Insulator String

A new type of robot climbing structure proposed by Jinzhou Power Supply Bureau, The robot is frame structure, through the snow slide sacrifice to achieve sliding back and forth in the shape on the insulators, the device is provided with a motor control system, W motor drive along the insulators move back and forth. When the probe detects the resistance of insulators, a real-time voice feedback system is used. Without autonomous climbing mechanism, the robot needs artificial pull wire to control the movement of robot up and down, which has great limitations.

A robot structure is proposed by the Wuhan Institute of High Voltage. The robot realizes automatic shift cleaning and detection, which makes the insulator detection work more labor-saving and increases the operation safety. The device consists of the following parts: air compressor system, pneumatic logic element, clamping and shifting system and cleaning system. The device is big in volume, complicated in control unit, creeping forward, low in moving efficiency, and the robot is on the side of the insulator, which is very serious and requires higher mechanical processing.

The Xi'an Power Supply Bureau proposes a robot structure. The left side is a hanging insulator string detecting device, and the right side is a tensile insulator string detecting device. Through the pull rod, the detecting device slides on the insulator surface and detects insulators one by one. The device can not detect the insulator string autonomously.

The insulator detection equipment function can achieve detection work of insulators, and each have their own characteristics, but there are still some limitations in application, such as the application of single insulator type, slow detection speed and detection of low voltage level, generally only one item on the insulator state detection, diagnosis is also so one-sided. The situation is prone to misdiagnosis. At present there is to achieve rapid and efficient detection of insulator detection
Design of Pressure Control System of Insulator Detection Robot

The control system of insulator detection robot is mainly composed of robot body control system and ground station control system. Data communication and video communication system between the independent of each other, one hand to avoid interference between the signals, on the other hand, the failure of a system under the condition of a system can also continue to work, increase the reliability of the robot.

The signal from the remote MCU data acquisition remote control simulation and digital joystick button, and the acquisition amount of digital filtering necessary, composed of data packets according to a certain agreement by the wireless data transmission module to the robot data receiving module, the robot will receive the data according to the protocol, and execute the corresponding action. The MCU collection of the robot's own state information and the environment temperature and humidity real-time transmission to the ground remote control system, remote control system of robot ground will parse information received after the display on the LCD screen, easy to control personnel.

The robot carries 4 cameras, are forward-looking camera, camera, camera and camera to observe the surrounding environment detection, the surrounding environment observation camera is equipped with a pan tilt unit, can view real-time remote control from the ground tilt insulator detection robot peripheral status. In addition to the normal view of the insulator, cracks and induced corrosion of the insulator, the forward looking camera can also take pictures of the water repellent insulators so as to carry out the hydrophobic test of W. The four video signal is transmitted to the image segmentation, video combination processing, a good combination of video by video transmission module is transmitted to the ground station, the ground receives the video signal and real-time display, video, according to the need to play W video playback, the robot can complete W work in manual mode, which is entirely by remote control the robot control the start and stop detection action; can also complete self detection in the laser sensor, proximity switch help.

Design of Robot Remote Control System

Insulator string detection robot data remote control system as shown figure 1. The remote controller is equipped with two analog joystick, through the acquisition of remote sensing potentiometer to determine the robot's corresponding action. In order to improve the accuracy and reliability of simulation of remote sensing potentiometer data acquisition, the system uses the median average filtering method to collect the rocker potentiometer and each switch values, this method has the advantages of good anti-interference performance, stable etc. In addition, through the simulation of collected on the rocker potentiometer values for further processing, the unified data collection to correction to the correct range; the amount of the switch using median average filtering algorithm and debounce filtering algorithm, to ensure that the switch is reliable and correct.
Design of Robot Force Wireless Data Transmission System

The stability of the wireless data transceiver module directly determines the reliability and stability of the robot, this paper selects the AC4490 wireless transceiver module AeroComm, communication distance up to 6km distance under the condition of the module design, compact structure, strong scalability, verification of frequency hopping spread spectrum technology field, and increase the output power, ensure the integrity of data. The wireless data transmission frequency of the robot is about 900MHz, and the anti-interference of the wireless signal is strong.

We divide the robot's wireless data transmission system into server and client, the robot remote controller is server, and the robot ontology part is client. The data transmission control unit is used for receiving the outgoing data packets, and the sending and receiving of the data packets are realized by the control of the transceiver module.

Design of Electromagnetic Shielding for Robot

The insulator string detection robot can operate on the line insulator string with the highest 1000kV voltage level, and the stable operation of the detection system and the control system can not be separated from the reliable electromagnetic shielding design. In order to realize the voltage level of 1000kV electromagnetic shielding, we use a multilayer circuit interface control case shielding, photoelectric isolation, control system and the robot's overall total measures such as, after a lot of experiments, finally successfully overcome the design problem of anti-electromagnetic interference.

In the strong electromagnetic environment, the tip of the insulator string detection robot and the external interface prone to point discharge phenomenon, serial communication module is vulnerable to breakdown, damage, lose the original function. In order to solve this problem, the interface of photoelectric isolation measures, increase the light pot device in between input and output, realize the electrical isolation, the output signal to the input signal interference, this method can improve the anti-interference ability and system stability, prolong the period of use, effectively improve the efficiency of signal transmission.

Because of the thin single strand by high frequency current, high frequency impedance will greatly reduce the grounding effect, so the robot grounding system to be abandoned thin single wire grounding wire, the current due to the skin effect, the robot adopts ribbon wire grounding. Deal with the ground to avoid oxidation and corrosion. The direct connection of the grounding wire and the ground plane avoids the use of other connectors as part of the ground circuit, resulting in a decrease in the
grounding effect. The casing, the robot and the control system are connected together in order to eliminate the accumulation of static electricity.

The Test of Insulator Detection Robot

In order to verify the function and performance of the insulator string detection robot, a large number of experimental studies have been carried out, including analog line insulator string detection test and insulator string detection test of the actual line.

In order to further verify the performance of insulator detection robot, insulator detection test was carried out on 600kV East DC transmission line. The robot moves along the tension insulator string, and each passing piece of insulator swings the detecting probe back and forth to detect the resistance value of the insulator. When the test is completed, the detection task is not carried out when the high-voltage side tower is returned. In the robot detection process, the four micro cameras carried by the robot transmit the video images in real time through the wireless transmission system. During the test, the sag radian of the real line insulator string has no influence on the robot's operation, and the robot can move back and forth along the insulator string. The visible light camera and the wireless transmission system operate normally, and the video image is stable and clear. Insulator resistance tester works, when the probe contact two adjacent insulator steel cap, the detector will send "drop" sound, on behalf of the insulators meet the insulation requirements, and record all the resistance of insulator.

CONCLUSIONS AND PROSPECT

The robot can drape and detection of insulator level running on the highest voltage of 1000kV double insulator strings, can carry out resistance detection, electric field detection, visible light detection, hydrophobicity detection and a series of live working project, through the analysis of test results to evaluate the state of insulator string. Insulator detection robot has been successfully applied to the national network of Shandong electric power company, Shanxi electric power company, Hebei provincial power company and a number of provincial grid companies, the robot successfully increase detection of insulator strings, improve the detection accuracy of insulator, ensure the reliability and stability of power grid operation, promote the construction of the development of robot technology and the power of smart grid.

REFERENCES
