The Research of Insulator Resistance Live Detection System Based on Robot

Jinpeng Tan, Fangyu Gao, Dongfeng Qiu, Xueneng Huang, Guangbin Xu, Xianning Li, Chongjie Ma, Hongpu Miao and Su Fang

ABSTRACT

With the rapid development of power grid construction, the Power grid is becoming more and more expansion; the reliability of the equipment operation is the important precondition for the safe and stable operation of power grid. The insulator is an important component of the primary equipment of the power grid. So it is important to research high efficient, accurate equipment to detector the insulativity of insulator.

This paper is based on current problems of insulator detection, An online insulator detection device based on intelligent robot is studied. By installing the equipment onto the robot, the robot will be able to detect online. There is no need for artificially high screening tests to reduce the worker’s strength. The DC ultra-high-voltage transmission line is the latest transmission. The research on these insulators is scant. Through the experiment, device for detecting the insulator resistance was developed. Through experiment, proved the feasibility of this approach.

INTRODUCTION

With the development of our country’s economy, the power industry as economic leading industry, has developed rapidly and the grid scale expands unceasingly. Insulator is one of the widely used equipment in electric power system.

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Insulators are exposed to a complex environment in the long run of a power system, such as lightning, ice and snow, cold and hot, dirty and exposed to wind and rain and other factors under the strong electric field, current and strong mechanical stress, therefore there is a high probability of failure after install the power grid.

At present, the robot inspection is efficient, reliable, low cost from geographical influences. It has been widely used in the field of power line inspection, and is used to observe the running state of high voltage transmission lines and insulators. According to the detection of insulator operation condition, experts and scholars have carried out a lot of research; a series of detection methods for insulator faults are proposed. For example, ultrasonic method, field measurement, leakage current method, UV pressure. In view of the existing detection methods, the accuracy is not high, complex operation, heavy workload, high risk, the detection result is not intuitive pressure. Research and design of a robot based on insulator resistance live detection system is developed. The measuring system is debugged by using high voltage laboratory simulation field, the debugging results show that the detection system can detect the low value insulator in the insulator string accurately, and through wireless communications, real-time transmission of measurement data to the lower computer display and storage, to meet the design requirements of the project.

Detection Method of Insulators

Generally, the main faults of insulators are the decrease of insulator impedance, the cracks in insulators, the damage of insulators surface, pollution flashover and so on. According to the experts and scholars of different insulators in the presence of faults show different phenomena explored all kinds of test methods, these methods can be divided into two categories: non-power detection method and detection method of power. The detection method includes non-power ultrasonic detecting method, infrared spectroscopy, laser Doppler method and ultraviolet imaging method, radio wave method, and power detection methods including electric field measurement, leakage current, pulse current method etc. Non electric quantity detection method is non-contact detection method, It mainly uses the non-electric characteristics of the acoustic wave, temperature field, vibration frequency, light wave and electromagnetic wave produced by the deteriorated insulators to detect, Easily affected by environmental factors. It is non-contact, and relative to the electricity detection method will be more secure, But it needs to add peripherals auxiliary equipment, some equipment cost is very high, is not conducive to large-scale promotion. The electric quantity detection method belongs to the contact type inspection method; therefore, it is necessary to pay attention to preventing the personal safety of the operator. But it does not need to add peripheral equipment, the measured values can directly reflect the quality of insulators, the accuracy is relatively high. In this paper, an impedance detection robot based on wireless communication remote control is developed, the robot is small in size and fast in
detection, which can greatly improve the efficiency of on-site detection of insulator resistance and is suitable for porcelain insulator strings of different angles. The design of the measurement system mainly includes the design of hardware and the design of software. The hardware includes the design of the detection terminal and the robot. The software includes the design of the operation interface, the detection of the terminal program and the design of the robot receiving end program.

**Hardware Design of the System**

The measurement system consists of three parts, which are computer control station, detection terminal and robot. The connections for each part are as Figure 1:

![Instrument composition](image)

**Figure 1. Instrument composition.**

The system is applied to the detection of the resistance of the plate type suspension porcelain insulators under the following high-voltage transmission lines. It is required to measure the resistance of insulators by measuring the quantity of insulators and determine the low value insulators. The hardware design shall meet the following conditions:

- Measurement system consists of three parts, the data transmission between parts to ensure stable and reliable, free from electromagnetic interference. In addition, the Computer Control Station wireless transmission distance and the ground station and the detection terminal must be greater than 100 meters. Greater than the height of general power towers.

- In the complex electromagnetic environment, the measurement signals will inevitably have all kinds of interference signals, such as high frequency signals and noise signals, so it is necessary to design low-pass filter circuit to eliminate all kinds of high-frequency signals and noise signals; problem between Detection terminal and robot, the system needs to match the Detection terminal with the robot. So the Detection terminal should first set aside out of the external expansion ports such as power interface in order to reduce the weight of the Detection terminal using the robot's own power, shape design, data transmission interface and the installation interface secondly detector must match the detection robot, the weight problem is needed to be focused on.

- The function of the hardware of the Detection terminal is to acquire the measurement data first, and then sampling the signals. Realize data calculation and result judgment in single chip microcomputer. If the resistance value of the insulator is smaller than the setting value. The alarm will remind relevant personnel on-site staff, convenient operation and at the same time the resistance data transmitted to the
ground station computer, the received data can be backed up and historical analysis of import and export database, insulator which can be convenient to query the entire tower on the data, judge the faulty insulator position.

The detecting terminal comprises a power supply module, a DC boosting circuit, a signal filtering circuit, a CPU module, an OLED display module and a wireless communication module;

- DC boosting circuit
- power supply module
- signal filtering circuit module
- CPU module
- OLED display module
- wireless communication module

After measuring and analyzing the hardware requirements of the on-line measuring instrument for the resistance of insulators. The overall framework of hardware design is constructed, and the hardware components are designed and implemented on this basis.

**DESIGN AND DEVELOPMENT OF SOFTWARE PART**

**Software Design of Detection Terminal**

In the process of detection, the validity and accuracy of measurement data need to be guaranteed. It is also necessary to minimize the error of measurement results and to automatically and intelligently judge whether the measured insulators are inferior insulators and that the data should be transmitted back to the ground receiving station reliably. The insulator detector work is carried on by the robot, so the carrying power is limited, so the design process of the system software should be saving, so the system can not replace the battery in stable working condition for a long time. The tester should first check itself to eliminate the situation that the battery is not enough and the communication is abnormal. In order to save power, in the absence of measurement, only the system microcontroller in the working state, all other module power is closed. Only when the metal arm and the insulator are in full contact, the MCU sends out the test command. At this time, the power supply of the detection circuit is opened, and the data sampling, data calculation and measurement, data result and wireless transmission are started. The system software flow chart is as Figure 2:
Software Design of Robot

The robot communicates wirelessly with the ground station. Perform an action command issued by a ground station. After receiving instructions from the ground station, the robot sends test commands to the detection device. When the monitoring device returns the measurement results, it returns the result to the robot, then the robot sends the results to the ground station and wait for the next command. The robot also performs the instruction of the ground station to its own operation. It has
an action library, such as move forward and back, angle change etc. These actions are performed by the actuator, while detecting the execution of the action by sensors. The system software flow chart is as Figure 2:

Figure 3. Flow chart of robot program.
Measurement Results and Discussion and Analysis

A series of tests have been carried out at the national Power Grid Corp UHV AC and DC test base. The scheme of detecting insulators without electricity test: first, choose porcelain insulators to test. A high accuracy and high resistance detector with a precision of 2% is used to measure the resistance of insulators as live insulators.

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Figure 4. The test data.

Throughout the test process, the robot is stable and safe, and meets the requirements of engineering design.

CONCLUSION AND PROSPECT

In this paper, the on-line detection of insulator resistance is studied. A robot based on insulator resistance detection system is developed and tested. The test results show that the measurement system can operate stably and the detection accuracy meets the requirements of engineering design.

REFERENCES