Research on the online temperature measuring device in outdoor high-voltage isolation Switch

Ran Hu1*, Xuecheng Du2, Guojun Hu1, Meng Hong1, Rufeng Jiang1, Tengfei Wei1, Erhong Deng1 and Yongjian Li1

1 Shenzhen Power Supply Bureau Co., Ltd., Shenzhen, 518000, China
2 Sichuan Energy Internet Research Institute, Tsinghua University, Chengdu, 610000, China
*Corresponding author’s e-mail: huran@sz.csg.cn

Abstract. In view of the frequent overheat or even fusion accidents of outdoor high-voltage isolation switch contacts in operation, and they are serious threats to its equipment security and the reliability of power network. To mitigate and reduce the influence effected by abnormal heat of isolating switch contacts, this paper describes the structure of the temperature measuring device, the temperature chip, the wireless communication mode. Moreover, the on-line temperature measuring device’s characteristic of structure and function was summarized. The experimental data shows that the device has large measuring range, high precision, high reliability and availability. In order to understand the operation status of outdoor high-voltage isolators, the device can realize real-time measurement the temperature without the technical personnel at the scene.

1. Introduction
Outdoor high-voltage isolation switch is one of important current carrying electrical equipment in the power system. It is exposed to the outdoor for a long time, moreover, its dynamic and static contacts are easy to be polluted, aged and corroded by the environment. They are easily result in the frequent overheat or even fusion accidents of outdoor high-voltage isolator contacts in operation [1-3]. It is also easy to cause contact problems by frequent pulling and closing. With the increasing of power load, the overheat of outdoor isolator contacts is becoming more and more serious.

Through analyses of recent outdoor isolator burned events [4-5], it can be found that there are not effective temperature online monitoring measurements. The outdoor high-voltage isolation switch fault detection is mainly operated by regular inspection with artificial observation, which is a waste of manpower material and financial resources, such as infrared temperature measurement [6-7]. It is difficult to detect the abnormal overheat accidents in the high-voltage isolator in time. Therefore, the online temperature measuring device in outdoor high-voltage isolators has been developed.

The rest of this paper is organized as follows. The online temperature measuring device structure is detailed in section 2 followed by the wireless communication mode in section 3. In section 4, test results are presented on determining the online temperature measuring device’s characteristic of structure and function. Section 5 gives a conclusion.
2. Structure of online temperature measuring device

Being one of the most widely using high-voltage electrical equipment in power grid, the outdoor high-voltage isolating switch’s operational reliability and operation life will influence the stable operation of power grid, as shown in Figure 1. Along with the fast development of technology, the demand of better performance of high-voltage isolator is higher because of the improving voltage classes, therefore the overheating is becoming more and more intractable.

![Figure 1. The outdoor high-voltage isolation switch](image)

The online temperature measuring device in outdoor high-voltage isolating switch needs to measure the temperature of the dynamic and static contacts, and transmit the temperature data remotely based on the low-power wireless transmission system for users to analyse and query. Therefore, the online temperature measuring device comprises a power supply module, a temperature sensing module, a data processing module and a wireless communication module, as shown in Figure 2.

![Figure 2. Structure of online temperature measuring device](image)

2.1 Power supply module

Because the contact surface of outdoor high-voltage isolator is located at the high voltage, the online temperature measuring device is a low voltage device, and the power supply cannot be realized by an external low voltage power supply. The power supply scheme can be the power induction scheme based on the induction coil or the power supply of the battery. Battery power supply is not suitable for online temperature monitoring because of its short lifetime and disposable production. Therefore, the power induction scheme based on the induction coil was chose.
2.2 Temperature sensor chip

The integrated temperature sensor chip integrates the drive circuit, signal processing circuit and the logic control circuit on a single chip. It has the advantages of small size, ease of use, high sensitivity, good linearity and fast response. Currently, there are more chips to be used, such as ADT7410, HTU20D, and SHT20. The SHT20 chip is the next-generation temperature sensor chip of SENSIRION company. It is embedded in a DFN package, with a 3 x 3mm bottom surface and a height of 1.1mm. The sensor outputs a calibrated digital signal in standard I2C format. The resolution of the SHT20 can be changed by inputting commands (8/12bit or even 12/14bit RH/T). The sensor can detect the battery low state and output checksum, which helps to improve the reliability of communication. Temperature measurement range reaches -40-125 °C.

3. The wireless communication mode

The wireless communication system structure combines the local communication system and remote communication system. It includes online temperature measuring device, router, server, and monitoring platform, as shown in Figure 3. The local communication system transmits temperature data based on the 2.4G wireless network. The remote communication system transmit data via 4G network in wire module, and data is transmitted to remote server. Due to the high energy consumption of remote communication, at least 3 temperature measuring devices are need to be installed at the different monitoring point in an outdoor high-voltage isolator. The single temperature measuring device to transmit data using direct communication will consume a lot of energy and this method is uneconomical.

![Figure 3. The wireless communication system of online temperature measuring device](image)

4. Experiment Tests

In order to verify the performance and functionality of the online temperature measuring device in outdoor high-voltage isolators, some experiment tests were performed, such as temperature measurement range, linearity, high-low temperature tests.

4.1 Temperature measurement range tests

The online temperature measuring device was placed in the thermostat under normal temperature condition. Compared the thermometer’s data with the temperature measuring device’s data, the temperature measuring device output values were measured in the 0-140°C, and the test accuracy is ±1°C, as shown in Table 1.

| Thermometer (°C) | Online temperature measuring device (°C) |
|------------------|------------------------------------------|
| 1                | 1.368                                    |
| 17.5             | 16.042                                   |
| 36.9             | 37.642                                   |
4.2 High temperature tests

The online temperature measuring device was placed in the centre of the high and low temperature chamber under non-energized conditions, as shown in Figure 4, and the temperature was continuously raised to 60°C for 2 hours. The device’s functionality was tested under the energized conditions. The temperature measurement accuracy meets the specification requirements, as shown in Table 2.

4.3 Low temperature tests

The online temperature measuring device was placed in the centre of the high and low temperature test chamber under non-energized condition, and the temperature is lowered to 0°C for 2 hours, and the temperature measuring function was continuously tested. The temperature measurement accuracy meets the specification requirements, as shown in Table 3.
5. Outdoor high-voltage isolation switch application test

In application test, a 10kV power line located in Guangming district in Shenzhen City was chose to install the online temperature measuring device in an outdoor high-voltage isolator, as shown in Figure 5. The application test showed the temperature data was collected at high speed and in continuous mode for a long time, as shown in Figure 6. The Figure 6 shown the temperature data can be maintained at between 50-60°C. The stability of online temperature measuring device in a long time can also be seen from a large number of data, which shows that the Outdoor high-voltage isolator was normal.

![Online temperature measuring device](image)

Figure 5. The application test in the 10kV outdoor high-voltage isolation switch

![Temperature graph](image)

Figure 6. Results of the application tests in 10kV outdoor isolation switch

Given the above use case, it is evident that the online temperature measuring device in outdoor high-voltage isolating switch can realize remote temperature data acquisition and obtain good effect, be an effective way of collecting data without power company staffs.

6. Conclusion

In order to realize remote temperature data acquisition of outdoor high-voltage isolation switch, an online temperature measuring device was developed. The structure of the device and communication
system were introduced. The tests showed the range of device was 0-140°C and the accuracy was ±1°C. The experiment tests and the application tests demonstrated the online temperature measuring device in outdoor high-voltage isolating switch has large measuring range, high precision, high reliability and availability.

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