

Construction of On-Line Monitoring System for High-Voltage Equipment Based on Smart Grid

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Abstract: With the development of smart grid, its technical content is increasing, and the requirements for online monitoring system of high-voltage equipment are becoming more and more strict. High-voltage equipment is a very important part of the power grid system, which must be monitored and protected. In order to improve the healthy development of the power grid, it is necessary to carry out online monitoring of high-voltage equipment, so this paper starts from the relevant technology of smart grid, and studies the construction of its detection system. This paper mainly uses the method of experiment and data comparison to compare and control the variables. The experimental data shows that the wave moment compensated by the data fusion algorithm is reduced to about 0.04%, indicating that the data fusion algorithm can effectively reduce the error.

1. Introduction

With the continuous development and progress of China's power industry, grid construction has also made certain progress. At present, large-scale and high-voltage equipment online monitoring system has been implemented in China. However, due to technical constraints and cost problems, it has not been fully covered and promoted. Based on the intelligent large-capacity power transmission mode, the technology of real-time detection is not mature enough. Therefore, this design proposes a remote automatic observation station for smart grid operation voltage equipment based on the network and combined with the existing hardware platform, which can make timely processing, analysis and diagnosis of all kinds of faults involved in power enterprises.

There are many practical theories to study smart grid system and high voltage online monitoring system. For example, some researchers suggested to establish a remote online monitoring system for high-voltage power supply based on ZigBee and GPRS technology to prevent power failure and heat leakage [1-2]. Some researchers also designed a new online temperature monitoring system powered by LED light source at the low voltage side to solve the power supply difficulties of wireless high voltage thermometer [3-4]. Other researchers briefly analyzed the specific application of high-voltage equipment online sensor technology in smart grid, introduced the characteristics and

current situation of China's smart grid development, and briefly described its role and benefits [5-6]. Therefore, this paper designs a remote real-time online monitoring system for high voltage equipment based on smart grid.

This paper first studies the smart grid, and expounds its basic composition and function. Secondly, the existing problems of existing monitoring technologies are analyzed. Then the thermal defects of power equipment and its diagnosis methods are analyzed, and the detection of sensor equipment is introduced by explaining the problems of thermal equipment. Finally, relevant data and conclusions are drawn through the design and experiment of the online monitoring system.

2. High-Voltage Equipment Online Monitoring System

2.1 Smart Grid

Smart grid is based on modern communication technology, network information technology and distributed computing. It combines a variety of advanced control methods to achieve effective management of power resources. The system can make full use of the complementarity between computers and remote communication equipment. In the smart grid, a variety of nonlinear models and algorithms based on fuzzy logic and neural network are introduced to carry out online monitoring of large-capacity units. This system not only has the characteristics of strong real-time and high real-time, but also can realize dynamic response and make timely adjustment to the equipment status according to user requirements to meet user requirements. With the development of smart grid, its application is more and more extensive, and the reliability of power system is required to be high. Therefore, it is necessary to establish a real-time online fault diagnosis process based on smart grid operation monitoring technology, collection, analysis and processing information [7-8].

Smart grid has the characteristics of high voltage transmission capacity and low loss. Therefore, in the power system, its main task is to optimize the distribution of electric energy. The construction of smart grid involves a lot of data information. Smart grid has high reliability, stability and security. The online monitoring system of high-voltage equipment based on smart grid is a very complex and huge comprehensive network with strong practicability and versatility. It includes not only the technologies related to power operation, but also many disciplines related to it. The construction of high voltage detection system based on smart grid can effectively improve the efficiency and reliability of high voltage signal transmission. At the same time, it can also guarantee the safety of users.

2.2 Problems in Existing Monitoring Technology

Most existing transmission line online monitoring systems are active monitoring systems, that is, the data acquisition sensors on the transmission line must use power [9-10]. According to the current situation of the national transmission network, the main reasons why the existing monitoring technology cannot be effectively promoted are as follows:

The existing transmission line sensors in use usually use microelectronic sensors, and the monitoring object is the transmission line. Therefore, the sensor works under the strong magnetic field modulation caused by high voltage and high current. However, microelectronic sensors are very sensitive to magnetic fields. Once the line is disturbed by lightning or high-frequency noise, the sensor will be affected, collecting incorrect data, and even damaging the equipment. The weatherability problem involves a wide range of transmission lines in China, and the working environment of the whole power grid is relatively complex. The sensor must be able to cope with various complex and challenging environments, such as high altitude, high humidity and dust.

There are no relevant technical indicators and binding certification standards for the existing monitoring equipment in the network environment. Therefore, the existing monitoring equipment often has the problem of system performance degradation in long-term operation.

Although the device manufacturer repeatedly reduces the power consumption of the sensor, the sensor must also undertake the task of collecting and transmitting data, so the power consumption of the entire system is still a problem. The weight of optical equipment does not meet the requirements of the State Grid, that is, the total weight of a single monitoring unit installed on the grounding conductor/cable should be less than 2 kg.

2.3 Thermal Defects of Power Equipment and Their Diagnosis Methods

According to the impact and damage caused by thermal defects of on-site equipment, the severity distribution of equipment defects is divided into three levels: general, serious and dangerous thermal defects. Because external defects can only be measured directly in infrared, and can also be measured indirectly in infrared, there should also be significant differences between the temperature rise range and temperature limit of these three types of thermal defects.

Temperature threshold recognition is the comparison between the surface temperature measured at the monitoring point and the temperature of the relevant equipment during normal operation according to the established standards. Although the fault can be evaluated in this way, it is usually more serious if the fault can be found and cannot be predicted in advance. Most of the equipment in the substation is three-phase equipment. When the equipment operates normally, the three phases are basically balanced and have the same infrared thermal characteristics. However, the probability of three-phase simultaneous failure of the same equipment group is very low. Therefore, three-phase comparison can quickly and effectively detect equipment abnormalities. Phase cross-correlation refers to comparing the temperature of different positions of the same phase of the same equipment, which makes it possible to effectively determine the fault type and location through the temperature difference between them. The identification method is the difference between the temperature of a group of equipment with thermal defects and the temperature of the corresponding normal position, which is related to the difference between the temperature of the monitoring point and the ambient temperature, namely:

$$\Gamma = \frac{s_1 - s_2}{s_1 - s_\beta} \quad \Gamma = \frac{s_1 - s_2}{s_1 - s_\beta} \quad (1)$$

Where, Γ is the temperature difference ratio, s_1 is the abnormal temperature of the monitoring point, s_β is the normal temperature of the same group, and is the ambient temperature.

Through the temperature difference ratio, the relative deterioration degree of the temperature contact resistance of the fault detection point relative to the contact resistance of the same group of normal devices can be determined, so that the method can be easily distinguished, and the error caused by the measurement conditions and working conditions can be reduced, because similar devices have the same structure. Working environment, charging rate, etc. Basically the same. In normal operation, their temperature and temperature rise should be approximately the same. By comparing these devices, abnormal temperature points can be detected quickly and easily [11-12].

2.4 Design of Online Monitoring System

The whole system is composed of three parts, namely online monitoring part, terminal power supply part and communication mode part. The online monitoring part includes information collection and analysis, the current detection part of the terminal equipment includes the energy

storage system for ground wire current detection and solar current detection, and the communication mode selection part includes the hybrid transmission part for wireless and optical fiber communication [13-14]. The main components of the online monitoring system are: main control center, communication network, monitoring equipment and monitoring information. The main control center is the main control center of any online monitoring system. Communication network is the channel connecting the monitoring center to the monitoring center and monitoring equipment. The monitoring terminal is an important part of the transmission line status monitoring and high-voltage transmission line online monitoring system. The selection of power supply for monitoring terminal equipment of high-voltage transmission line is mainly considered from the perspective of power stability and continuity of monitoring terminal equipment, power system scope, power cost and power output power[15].

The establishment of communication network is the key link in the design of online monitoring system for high-voltage transmission lines. Communication network is the connection between monitoring center and monitoring facilities. The communication quality in the communication network is an important support that affects the reliable operation of the online monitoring system. Network carrier communication uses the grounding cable of the transmission line as a means of transmitting carrier signal. Optical fiber communication is one of the pillars of today's communication network. Optical fiber communication is a communication mode, in which light wave is carrier signal and optical fiber is transmission medium.

The signal conditioning circuit in the system mainly realizes that the signal can be sampled by the microprocessor and converted into analog and digital. In order to convert negative voltage signal into positive voltage signal, subtraction mode is usually used to form differential input and eliminate the influence of common mode voltage. The relationship between input and output is shown in formula (2):

$$U_1 = -\frac{Z_5}{Z_3}U_m + (1 + \frac{Z_5}{Z_3})U \quad (2)$$

As long as the Z4 and Z5 adjustable resistors are slightly adjusted, the output voltage u can be converted into formula (3):

$$U_1 = (5 - U_m)/4 \quad (3)$$

When monitoring the status of electromechanical equipment, various physical parameters must be measured. Signal processing plays a very important role in data acquisition. These analog quantities must be converted into digital quantities. A/D conversion is a basic element in industrial control and data acquisition.

3. System test and Verification

3.1 Online Monitoring System

Communication means between integrated monitoring terminal and base station, data transmission between monitoring center and optical cable management platform, data transmission between WDS wireless network bridge tower and data transmission between 4G tower and monitoring center. This helps to maintain the stability of data communication, save communication costs and reduce the power consumption of the system. The application of WiFi+5G communication technology can overcome the limitations of 2G/3G, ZigBee, Bluetooth and other communication data transmission speed, and complete high-speed and high-quality information transmission. The design adopts the improved STM32F205 series, the system operating frequency

is 80MHz, and the chip core has built-in high-speed memory. All STM32F205 series devices have ADC, universal timer and PWM timer.

3.2 Test of Zero Flux Low Current Sensor

The purpose of the ratio difference test is to verify the amplitude transmission accuracy and linearity of the self-made zero-flow micro-current sensor. The block diagram of the test circuit is shown in Figure 1 below. The standard current signal is sent from the calibrated watt counter, the input current is monitored by the precision resistor's 7 multimeter, and the sensor output voltage is monitored by it.

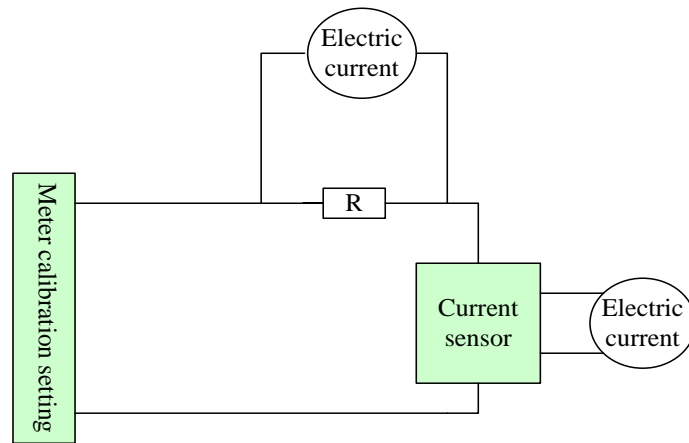


Figure 1: Test Circuit

Table 1: Results of Control the instrument Controller

	Input current	Input voltage
1	0.3	4.3
2	0.5	5.8
3	0.7	6.3
4	0.9	7.9
5	3	22
6	6	60
7	9	95
8	20	210
9	50	500
10	100	1000
11	500	5000

During the test, the control instrument controller monitors according to the multimeter, and the data is shown in Table 1. The test current of 0.3~500mA is generated horizontally to ensure the accuracy of current output. Record the corresponding voltage at the output end of the current sensor for analysis. It can be seen that the current sensor has good differential accuracy and linearity.

The purpose of the angle difference test is to check the magnitude of the measured sensor angle difference relative to the current. The ammeter console outputs the standard current signal, the precision resistor reduces the reference voltage signal, the current sensor outputs the measurement signal, and the dielectric tester measures the angle difference. The test results show that if the current amplitude changes with time, the ratio difference will become relatively large, but the accuracy of the sensor angle difference can reach less than 1, meeting the design requirements.

In order to check the anti-electromagnetic interference performance of the sensor, a test method simulating the electromagnetic interference environment of the substation is used. In the electric field fault test, about 110kV pressure probe is placed next to the object as the interference source, so the interference intensity is about 15kV/m. Without electric field interference, the deviation change of the sensor output signal is monitored by the contrast of the deviation measuring bridge. In the magnetic field interference experiment, the sensor is placed in the center of the magnetic field, with the intensity of about 110A/m, which is obtained through the large current of the cable. The aberration change of the output signal of the sensor without magnetic field interference is monitored by comparing the aberration measurement bridge.

3.3 Data Fusion Algorithm Effect Test

The purpose of the data fusion algorithm effect test is to verify the influence of the fusion algorithm on eliminating the change of dielectric loss measurement results caused by the fluctuation of the reference signal, manually generate the phase fluctuation of the reference signal, and compare the change rate of the measured data and the data processed by the fusion algorithm under laboratory conditions.

The process is as follows: after the normal operation of the test circuit, set a measurement every 15 minutes on the industrial computer and conduct automatic continuous measurement. Based on the dielectric loss measurement data of each detection terminal, the initial value of the dielectric loss of the signal is obtained, and the predetermined value of the phase is set for each detection terminal on the industrial computer. Connect a 1.5m resistor in parallel to both ends of the 0.5 μ F capacitor, and move the reference signal phase back 0.003 (radians) from the original state. The industrial computer must conduct automatic continuous measurement every 15 minutes. Remove the additional 2M resistor and connect the 5K resistor in parallel to the 200 ohm resistor terminal of the reference signal circuit, so that the reference signal phase is 0.003 (radians) ahead of the original state. Statistical analysis of data.

4. Experimental Results

4.1 Dielectric Loss Measurement Data

From the test results, dielectric loss detection can accurately reflect the change of dielectric loss and has good stability. The specific dielectric loss is shown in Figure 2, Figure 3 and Figure 4. Figure 2 shows the specific phase shift test results of one of the detection terminals. The first part is the measurement results when the test circuit works normally. Figure 3 shows the measurement results after the reference signal is offset by 0.003 radians. Figure 4 shows the measurement results after the reference signal moves forward 0.003 radians.

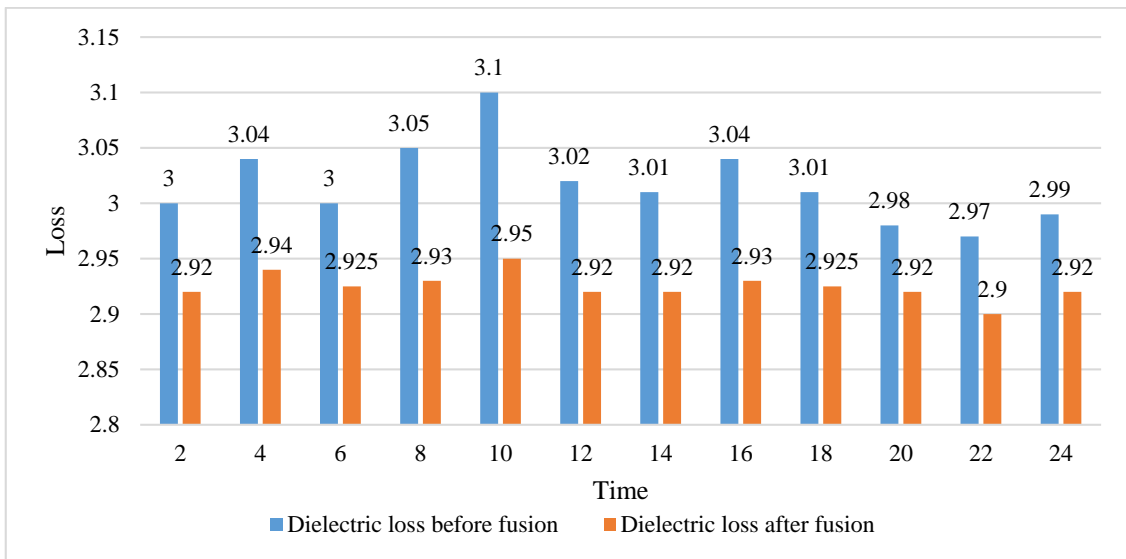


Figure 2: Curve of Interloss Measurement Data and Statistical Results after Normal Operation of the Test Circuit

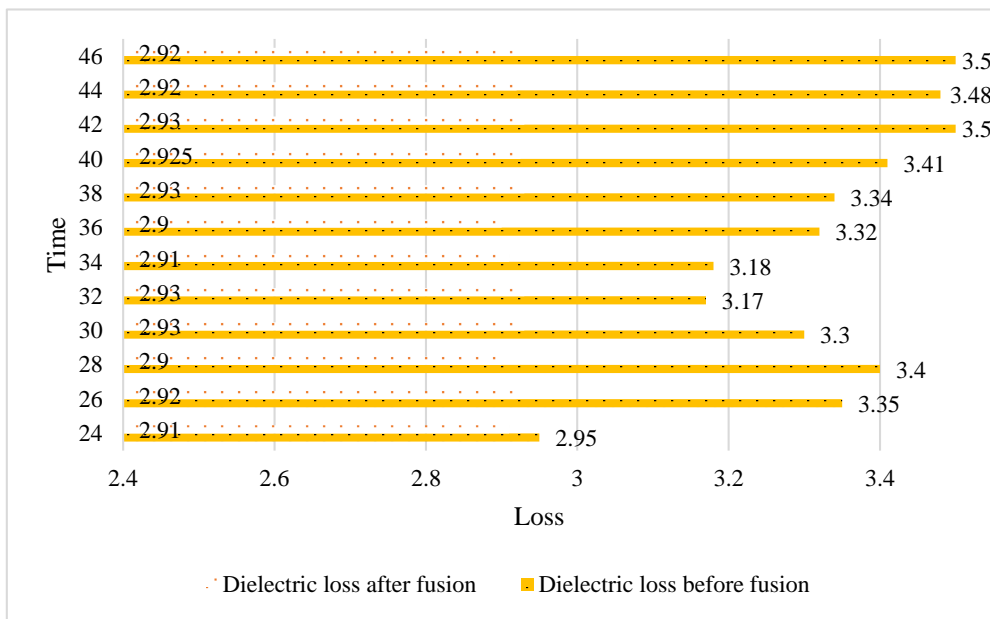


Figure 3: The Curve and Statistical Results of the Reference Signal

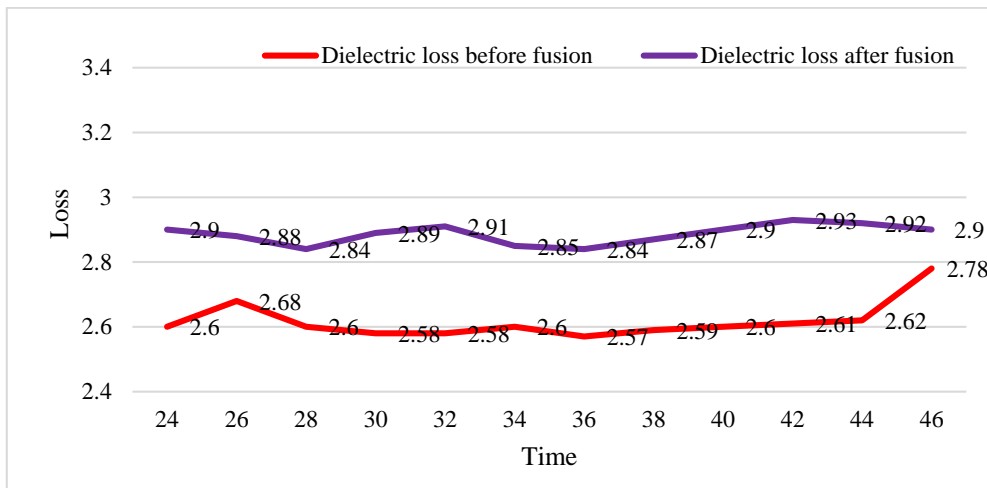


Figure 4: Interlesion Measurement Data Curve and Statistical Results when the Reference Signal Moves Forward

According to the test data of the phase device, if the fluctuation caused by the bias measurement is due to the fluctuation of the reference signal amplitude up to 0.30%. It can be seen that the fusion algorithm can effectively reduce the bias measurement error caused by the phase fluctuation of the reference signal, and effectively suppress the "common mode interference" introduced by other factors of the system (such as ambient temperature) at each detection terminal. The accuracy and reliability of the system developed in this paper have reached the design goal, and can meet the requirements for online monitoring of high-voltage capacitive equipment, which has great application value.

5. Conclusion

The monitoring of the operation status of power equipment is an important guarantee for the security, stability and sustainable development of the power grid. As an intelligent and information technology, the online detection system can realize real-time monitoring of it and transmit relevant information to the dispatching center. The detection system can collect, process and analyze the signals sent by users. Upload the data to the database through network transmission and complete the information interaction operation. The design has good real-time and stability. At the same time, it can meet the requirements of high voltage detection accuracy and reliability.

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