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Research and Application of Low Temperature Operating Reliability of Monitoring Device of Core Earthing Current

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Abstract. This paper gives an analysis and investigation for the existing problems of traditional on-line monitoring devices of transformer core earthing under low temperature condition, such as poor reliability, high failure rate etc. Then design and develop a new on-line monitoring devices of transformer core earthing current for cold climate, and it has been on-line operated in Mohe Country Xilinji 66kV substation of Heilongjiang Province.

1. Introduction

With the in-depth development of condition-based maintenance and the construction of the Strong Smart Grid, condition monitoring technology is more and more widely used in substation. And, the on-line monitoring device of transformer core earthing current can timely and effectively check whether the transformer core is multi-point earthing, which plays an important role to protect the safe and stable operation of the transformer [1-2].

However, the winter average temperature is -30 ℃, even down to -50 ℃ in Xinjiang province, Inner Mongolia and northeast regions of China, so the on-line monitoring device of transformer core earthing current will be at a low temperature for a long time. This is undoubtedly a severe test for the devices. According to statistics of device operation from the State Grid Liaoning and Heilongjiang Electric Power Research Institute show that under the influence of the low temperature environment, the long-term operation reliability of the device obviously drops and the failure rate is high. At present, our research lags behind other countries on on-line monitoring technology of electric equipment at low temperature, so the lowest test temperature of on-line monitoring device is only -40℃ stipulated by State Grid company standard *Q/GDW 540.1-2010 Testing specification for on-line monitoring device of transformation equipment. Part 1: General testing specification*, which can not meet the environment requirements of low temperature operation of on-line monitoring devices in cold regions of our country [3].

Therefore, in order to improve the on-line monitoring technology of transformers core earthing current, this paper analyses and researches the main factors affecting the long-term reliability of the device low-temperature operation. Furthermore, the on-line monitoring device of transformer core earthing current has been designed and developed, which meets the requirements of long-term operation reliability at -55℃.

2. Analysis of the Main Factors Affecting the Long-term Reliability of Low-temperature Operation of the Device

2.1. Problems of Device Components Selection

If the working reliability of components under the condition of low temperature is not considered when the device is in design and production, the characteristics of some key components will be changed and functions will be failed at low temperature environment. Thus, the device will appear some problems, such as abnormal start, frequent crashes, higher the failure rate and so on.

2.2. Problems of Material Selection and Fabrication Processing

Usually, the enclosure of the on-line monitoring device of the transformer core earthing current is metal materials. And the internal structural materials mainly include insulating materials, metal materials, current transformers, electronic components and the like. These materials will be shrinkage, poor ductility and embrittlement in the low-temperature environment. As a result, the enclosure of the device may not be tightly sealed, and the internal circuits or components may be damaged due to moisture.

3. Overall Design of Low-Temperature Type Device

3.1. Hardware Structure of the Device

As shown in Fig.1, the low-temperature type on-line monitoring device of transformer core earthing current mainly consists of the cored structure current transformer, the signal processing unit, the ARM processor, the display unit, the communication unit, the data storage unit, the clock unit and the intelligent electric heating unit [4].

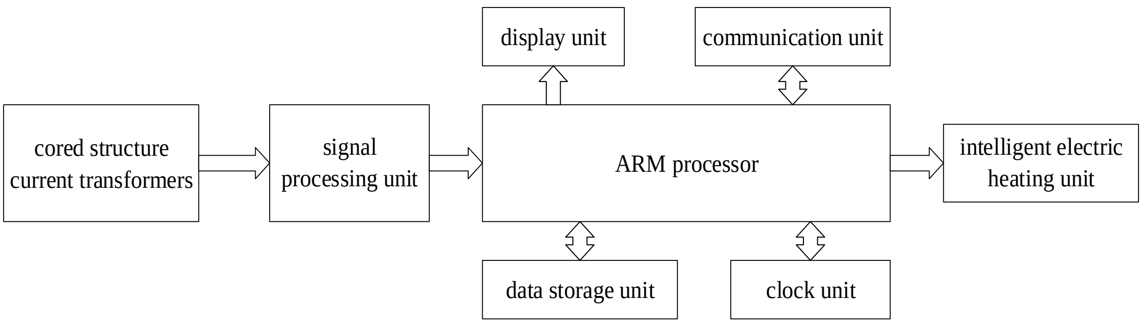

Figure 1. Hardware diagram of the device.

3.2. Working Principle

The working principle of the on-line monitoring device is shown in Fig.2. The current on the transformer core earthing wire is coupled to the secondary coil and converts to a secondary current signal through the cored structure current transformer. This secondary current signal is processed first by the signal processing unit and then by the ARM processor. Calculated data can be displayed on the display unit, but also will be stored in the data storage unit as a data backup. The intelligent electric heating unit is used to heating the inside of the device to keep a constant temperature, so as to improve the reliability of the device operating under a low temperature environment.

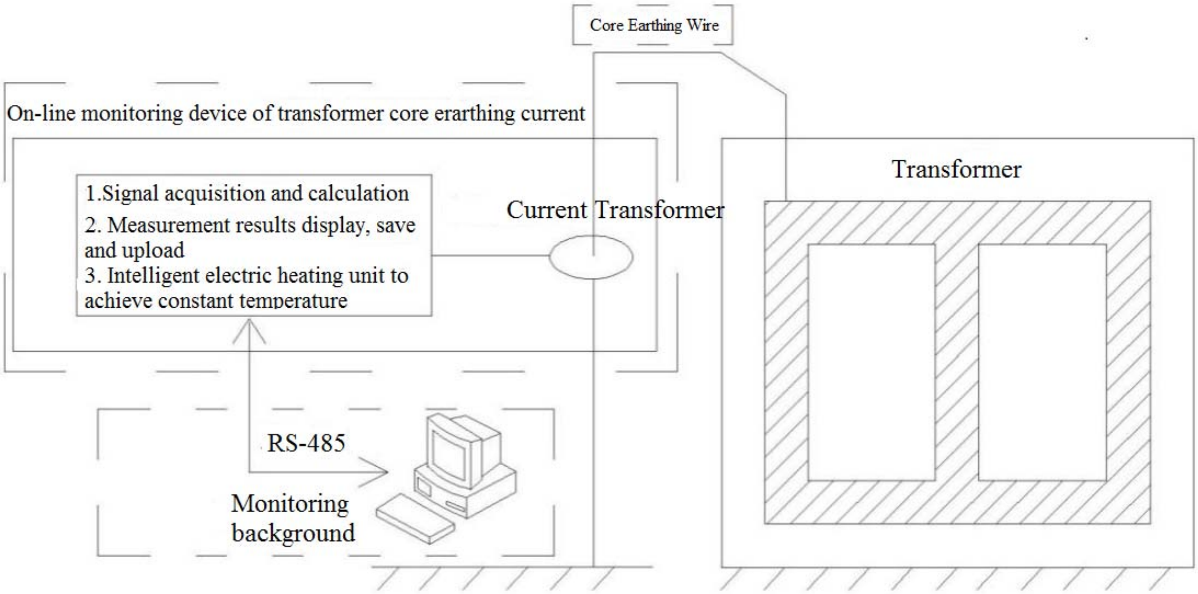

Figure 2. Work principle of device.

3.3. Reliability Design of the Device in Low Temperature Environment

3.3.1. Selection of Components. The components of devices are all military-grade (minimum working temperature -55 ℃) and industrial- grade (minimum working temperature -40 ℃). At the same time, the low-temperature vacuum fluorescent display (VFD) is used in the display unit, instead of the liquid crystal display, to ensure the normal display of monitoring data in low temperature environment.

3.3.2. Insulation Measures. The device enclosure is a double-layer structure. Between the two layers is embedded the Nano-aerogels, a new type of high-performance insulation, and the internal clearance is filled with the polyurethane foam. This design can effectively isolate the internal and external temperature of the device. In other words, it can concentrate the heat inside the enclosure as much as possible in the cold winter, and isolate external heat outside the enclosure in the hot summer. Therefore, effectively ensure that the internal components of the device can always work in the proper temperature range.

3.3.3. Design of Intelligent Electric Heating Unit. When the environment temperature is low for a long time, the temperature inside the device will decline if only relying on the enclosure material. Then, the internal circuit may not work normally. Therefore, while taking measures of thermal insulation, design and develop an intelligent electric heating unit, providing an auxiliary heating source.

As shown in Fig.3, the intelligent electric heating unit is mainly composed of the temperature control system, a main electric heating device and an auxiliary electric heating device, which are used for regulating the temperature inside the device.

Temperature control system is used for real-time monitoring and controlling internal temperature of the device. When the device is energized, according to the set temperature conditions and heating programs, the main electric heating device and auxiliary electric heating device will automatically heat the device. If the internal temperature reaches the certain temperature, the system will be automatically de-energized and stop heating.

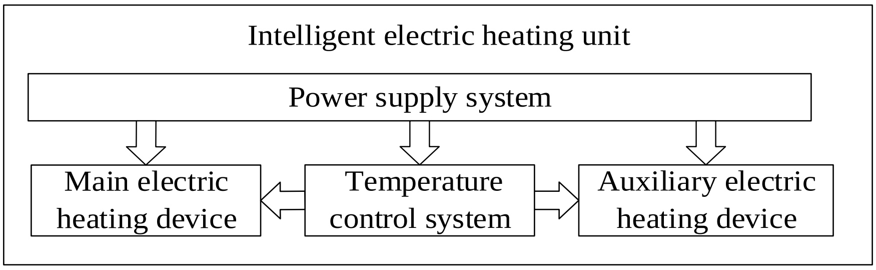

Figure 3. Structure diagram of the intelligent electric heating unit.

4. Device reliability test at the low temperature

In order to test the working performance and long-term operation reliability of the device in the low-temperature environment of -55℃, the device was tested and on-line operated in the laboratory of Liaoning Province Institute of Metrology and Mohe Country Xilinji 66kV substation of Heilongjiang Province respectively.

4.1. Laboratory Test

As shown in Fig.4, the device was tested for its tolerances of cold in a programmable temperature humidity chamber, with the temperature of -55℃ for 2 hours. This test method refers to GB/T 2423.1-2008 Environmental testing for electric and electronic products-Part 2: Test methods-Tests A: Cold (IEC60068-2-1: 2007, Environmental Testing- Part 2: Tests- Test A: Cold, IDT). And test results show that the device works normally.

Figure 4. Laboratory cold test.

4.2. Field Test

In order to fully verify the working performance of the device at the low temperature and reduce the impact of unexpected factors on the test, in June 2016, the device was installed, commissioned and applied at Mohe Country Xilinji 66kV substation of the State Grid Heilongjiang Provincial Power Co., Ltd., mainly monitoring station main transformer core earthing current. Three sets of the same type of low temperature type core earthing current monitoring device are installed in series on the core of the main transformer earthing line respectively, with cascading way to achieve power supply and RS485 bus communication. At the same time, a monitoring background is installed in a central control room of the station, centrally processing the data uploaded by the monitoring device, setting parameters and managing the monitoring device, as shown in Fig.5.

Figure 5. Device on-site operation.

5. Conclusion

At present, the low-temperature type on-line monitoring device of transformer core earthing current has been on-line operated nearly two years at the Xilinji 66kV substation. According to the field application, the measurement data is accurate and stable and all the functions are normal, so the device can work stably and reliably in the low temperature environment. The design and development program of the device meet the reliability requirements for on-line monitoring device of transformer core earthing current in the cold substation for long-term operation. Moreover, it can provide effective reference design and operation experience for applications of similar devices in low temperature environment.

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