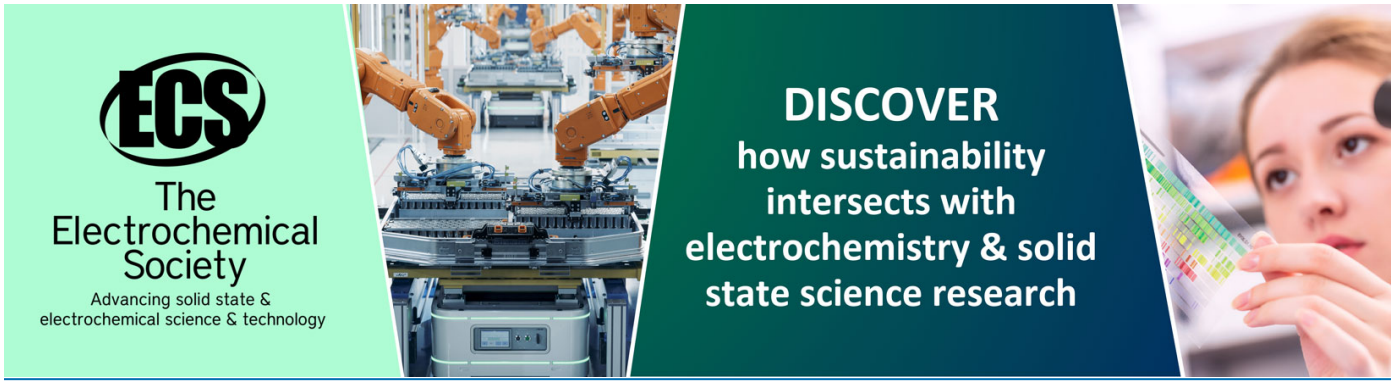
Intelligent Grounding Current Monitoring System for Iron Core of Power Transforme



IOP Conf. Series: Journal of Physics: Conf. Series **1314** (2019) 012049 doi:10.1088/1742-6596/1314/1/012049

Intelligent Grounding Current Monitoring System for Iron Core of Power Transforme

Wang Wei[1], Luo Qingsong[1], Tang Zhen[2].

[1] Zhengyang Avenue in Chongqing Zhengyang Industrial Park

[2] No. 2 Huilongguan Beinong Road, Changping District, Beijing

12041743@qq.com, 2081492402@qq.com, tzcnbj@163.com

Abstract. In the process of stable operation of power transformer, one-point grounding of iron core should be ensured. When two or more points of grounding occur, it will cause transformer operation failure, even burning iron core, affecting the safe operation of the power grid. At present, the monitoring of transformer grounding point mostly adopts the current transformer monitoring mode, only after uploading the detection data to the server, the comparison prompts that manual intervention is needed in the later stage, which increases the processing time and increases the risk of power grid problems. From the point of view of intelligent monitoring, this paper designs an intelligent transformer core grounding monitoring system. When the fault of multi-point grounding is detected, the resistance value of current limiting resistance is calculated immediately according to the magnitude of current, and the series resistance is introduced to limit the current of grounding circuit. At the same time, the fault alarm is given, indicating that manual intervention greatly reduces the occurrence of transformer faults. The processing time reduces the probability of deterioration in case of failure and improves the stability of transformer operation.

1. Introduction

The role of power transformer in power system is very important. The safe and stable operation of transformer will affect the reliability of power supply and the normal operation of the system. To ensure their safety is the key to the reliable operation of the substation system. The main fault of power transformer is caused by the core problem, and the core fault is mainly caused by multi-point grounding and poor grounding. In normal operation, the transformer core must be grounded to avoid discharging due to the increase of suspension potential. In normal operation, the grounding current of iron core is usually very small, usually less than 100 mA. When the transformer has two-point and multi-point grounding fault, a current loop will be formed between the grounding points. The grounding current of iron core will increase to several amperes or even tens of amperes. Under the action of potential difference between the two grounding points, circulation current will be generated, which will lead to overheating of local iron core. The decomposition of insulating oil may also cause the grounding piece to fuse or burn out the iron core, lead to the potential suspension of the iron core, generate discharge, cause light gas action or heavy gas action tripping, even damage the transformer, resulting in major accidents of the main transformer. Therefore, timely detection of transformer multi-point grounding status and effective measures will play an important role in reducing power grid faults, improving the utilization of equipment and reducing the economic losses caused by faults. This paper studies the on-line monitoring system of transformer multi-point grounding. It not only monitors the operation status of transformer in time and effectively, but also compensates the transformer by series

resistance immediately when the fault occurs, and transmits the detection information to the server in real time. The server gives the corresponding fault indication according to the criterion, prompts manual intervention, and minimizes the impact of the fault.

2. Current detection methods and processing methods for multi-point grounding

Insulation resistance measurement method, Disconnecting the grounding wire of iron core and measuring the grounding resistance of iron core with megaohmmeter, if the insulation resistance is zero or very low, it shows that there are many grounding faults between iron core and ground in other places. The disadvantage of this method is that it needs power-off measurement, and it is difficult to realize in the process of transformer detection in operation.

Current measurement method, If the current of grounding wire is less than 100 mA, the transformer grounding is normal. If the measured current value is several amperes or even tens of amperes, the multi-point grounding fault can be judged.

Chromatographic analysis,This method is to analyze the gas content in transformer oil by gas chromatography. When the chromatographic analysis shows that acetylene exceeds the prescribed range, it can be considered as a dynamic grounding fault. When the insulation resistance is zero or the circulation current occurs, it can be confirmed that the transformer has a multi-point grounding phenomenon.

Among the three methods mentioned above, oil chromatography is the most widely used and technically mature method, but it has a large investment, and can only be judged when the characteristic gas in transformer oil reaches the attention value. When the fault is not serious, it is difficult to find the problem in time, and there is lag, and when the ratio of characteristic gas is not the standard value, it is difficult to accurately judge the type of fault. The method of measuring iron core insulation resistance is also widely used in the field, but it can only be carried out during the power cut and maintenance of transformers, and there are some limitations in operation. The method of measuring iron core grounding current is the most rapid, direct and sensitive method among the above methods. At present, this method is to send the measured data to the server in real time, which is based on the fact that the monitoring personnel are responsible for the measurement of iron core grounding current. Whether to send an alarm signal to judge and take measures, because of the randomness of the fault occurrence time, it requires real-time monitoring by personnel. When the fault occurs, then take measures to deal with it, which delays the real-time processing time and increases the probability of fault expansion. Therefore, this paper designs an adaptive transformer multi-point grounding monitoring system, through real-time monitoring transformer core. The magnitude of the grounding current signal, the Fourier transform of the collected data, the threshold value is used to judge whether there is a multi-point grounding fault. When the fault is found, the alarm is given to the monitors. At the same time, the linear resistance is switched to calculate the minimum resistance value of the grounding current, so that the system can run under the condition of grounding resistance value to prevent further deterioration of the fault and wait for manual intervention. It reduces the probability of transformer failure.

3. Scheme Design of Intelligent Transformer Core Grounding System

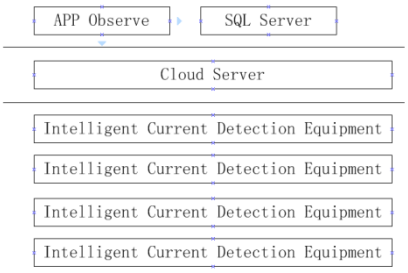
Intelligent transformer core grounding system is composed of on-site monitoring equipment network, local service statistics display, cloud server and mobile terminal display. The overall architecture of the system is shown in Figure 1.

(1) Equipment layer. The monitoring equipment is installed near the iron core grounding point of the main transformer to complete the collection, processing and logical comparison of the iron core grounding current. According to the set action logic, when the fault occurs, the resistance value satisfying the normal operation is calculated, then the suitable resistance value is cut in, and the measured data and state value are sent to the local service statistics through Modbus communication mode. Host;

(2) Local monitoring layer. Real-time receiving the current value and status value detected by field equipment can configure and set parameters for field personnel to view. In addition, staff can configure the working parameters (communication parameters, measurement period, resistance start threshold and alarm threshold) of the device by monitoring the background. When the measurement results are abnormal, the device will send an alarm message to remind the staff to deal with it in time. At the same time, the collected data is transmitted to the server in the cloud through LAN. The data storage and playback system of the monitoring system can retrospect the historical data, and play back the waveform when the fault occurs. Combined with the data of other monitoring systems, the overall analysis of the whole substation can be realized.

(3) Cloud servers. Software as a service and platform as a service are adopted to facilitate users to view and access data directly through browsers or mobile apps.

(4) Mobile display. Users can view monitoring data in real time and set alarm threshold through mobile app.



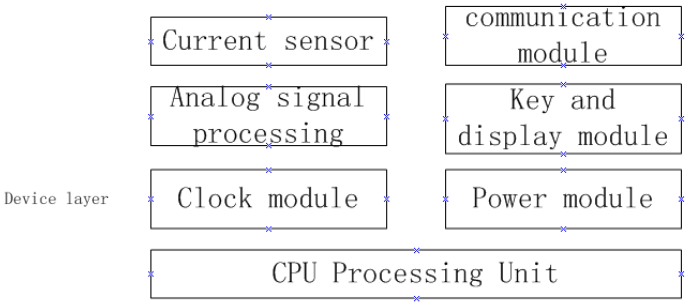


Fig 1 Overall framework of intelligent monitoring system Fig 2 block diagram of intelligent module

4. Hardware Design of Intelligent Grounding Monitoring System

The main hardware of intelligent grounding monitoring device is composed of high precision single-turn core-piercing sensor, power supply module, analog signal processing module, analog signal acquisition module, digital signal processing and clock management module, resistance value switching module and 485 communication module. The hardware block diagram is shown in Fig. 2.

(1) Power module

Because the intelligent monitoring module is installed on site and the power supply part is the heart of the whole system, two factors, electromagnetic interference (EMI) and electromagnetic tolerance (EMS), need to be fully considered in the process of power supply design. The input end of the power supply adopts a PI filter circuit to filter out the high frequency ripple and noise. In the power supply circuit of the central CPU processing unit and other units, the filter capacitor is added to absorb the noise on the power supply. Considering that the maximum withstand voltage of the acquisition system is 10V, in order to prevent the overvoltage caused by the sudden change of grounding current from intruding into the secondary measurement system and improve the reliability of the system, the TVS protection unit is adopted in the system. Transient voltage suppressor has the advantages of fast response time (meeting the need of nanosecond fast protection in protection system), large transient power, low leakage current, small deviation of breakdown voltage, easy control of clamping voltage, no damage limit, small volume, etc. So the TVS model used in this system is 1.5KE6.8A/CA, which can quickly clamp over voltage to safe voltage, and has played a very important role. Good protection.

(2) High Precision Current Sensor Module

Considering that the grounding current of transformer is less than 100 mA when no fault occurs, and the grounding current is ampere level when fault occurs, two sensors are installed in each transformer, and intelligent switching is carried out according to the current magnitude to ensure the accuracy in different measuring ranges. Small-range sensors are used to collect small currents below 1A, and large-range sensors are used to collect large currents. The sensor is installed in an open mode, which does not destroy the original electrical circuit and has no potential safety hazards.

(3) Signal conditioning module

The signal conditioning module is divided into analog signal processing module and acquisition module. The analog signal conditioning circuit uses analog's low noise instrument amplifier op07, and builds a second-order low-pass filter with resistance and capacitance. $f_p = 1 / 2 \cdot \pi \cdot R \cdot C$ Calculate the cut-off frequency. Determine the corresponding resistance and capacitance values. It can not only filter out the high-order harmonics, but also make the current signal of 50Hz distorted. The analog signal acquisition module adopts AD7606 of ad company, which is a high-speed 16-bit analog-to-digital converter chip with four synchronous input sampling channels and true bipolar analog input range: +10 V, +5 V. Because the frequency of the signal collected by this system is 50Hz, in order to maximize the original signal, the sampling rate of A/D is set to 50kHz, that is, 1024 sampling points are collected in one signal cycle. After converting into digital signal, the central CPU processing unit reads data into memory in real time and calculates it. The data is read in and saved in the data buffer, and then the next step is calculated.

(4) Clock and Key Display Processing Module

The clock module provides the time scale for the system and the time scale for the data recording. The key and display module is used for user interaction. Users can view system information by key, and set working parameters, alarm threshold, communication parameters and so on. Provide interface for field operation.

(5) Central Processor Unit

The acquisition and calculation of grounding current is the core part of the system. Considering the many tasks and the large amount of calculation, the CPU chooses STM32F767IGT6 high-speed CPU of ST Company. The CPU has 1MB flash memory capacity, 512kB SRAM memory capacity and 216MHz clock frequency. It can complete the Fourier transform calculation of the acquisition signal completely, and judges the results and transmits the data to the local area. Monitoring layer.

(6) Communication Management Module

Multiplex isolation technology is used in transmission channel to further reduce the interference to signal. Magnetic isolation and optical isolation technology are used between sensor and host, which can greatly reduce the influence of interference on weak signal. Magnetic isolation can transmit signals, and also transmit energy to power the circuit inside the sensor. Through MODBUS-RTU communication protocol, the working parameters of the device can be flexibly configured: communication address, alarm threshold, communication parameters (baud rate parity stop bit), sampling time interval, data reading mode (real-time data/historical data), device clock time.

(7) Resistor switching module

When the core grounding fault occurs in the transformer operation, temporary measures are taken to limit the circulating current of the grounding circuit and prevent further deterioration of the fault. Before the series resistance, it is necessary to calculate the current size at this time, and select the appropriate value of the switching resistance according to the size, so that the node current can run in a safe range. In addition, it is necessary to calculate the thermal capacity index of resistance to prevent excessive current from burning out resistance, which will lead to the open circuit of transformer core. Based on the above factors, the current limiting circuit parallel connection mode shown in the following figure is adopted. According to the calculated resistance value, the CPU realizes the switching of each road resistance by controlling the solid-state relay. It can not only satisfy the function of limiting grounding current, but also avoid the open circuit of iron core grounding lead. As shown in Fig. 3, when the system detects that the current exceeds the standard, the resistors are put into the circuit successively: the system first opens K0, and the resistance values of R1, R2, R3 and R4 are connected in series to the grounding line; if the system detects that the current is still exceeding the standard, then it opens K1, which corresponds to the resistance values of two resistors connected in parallel to the grounding line; and then goes down in turn until the current is limited to less than 100mA. The current limiting resistors are 150, 300, 600 and 1200 respectively. If all switches are turned on and the current exceeds the standard, the system will automatically give an alarm signal to

the field staff, indicating that the core failure has been very serious. On the contrary, when the system detects that the current value has been limited in the regulation, it will also tentatively close K3. If the current exceeds the regulation again, it will turn on K3. If the current still does not exceed the standard, it will tentatively close K2, K1 and K3, and the current limiting resistance will be 1200, 600, 300, 150 and 0 ohms in turn.

5.Conclusion

In this paper, an intelligent monitoring system of transformer core grounding current is designed, which realizes remote monitoring of main transformer and remote switching control of current limiting resistance. In April 2018, the installation, commissioning and application of the device were carried out in Qianjiang Substation, Chongqing. It is mainly used to monitor the grounding current of the main transformer core in the station. The purpose is to verify the stability of the system and reduce the impact of unexpected factors on the test. Six iron core grounding current monitoring devices of the same type are installed in series on the main transformer core grounding wire of the station. The device realizes power supply and RS485 bus communication by cascade mode. At the same time, a monitoring background is arranged in the computer room of the centralized control room of the station, which is used to centralize the data uploaded by the monitoring device and monitor it. The device sets and manages parameters. After six months of experimental operation, the tested equipment has been running reliably and stored a large amount of monitoring data, which provides data support for maintenance personnel to check the operation status of transformers and improves the security and reliability of power supply system.

References

[1] Gao mingLiang. Research and development of on-line monitoring and protection system for grounding current of transformer core[J] . Science Mosaic，2016（2）： 64-66

[2] Wu Xiaobo, Peng Xun， Guo Shaowei. Research on Application of Grounding Current Detection Device for Transformer Core [J]. North China Electric Power， 2013（8）： 38-42.

[3] Chen Mingzhong. On-line monitoring system of transformer core grounding fault based on Labview [J]. Electrical Drive Automation， 2015（6）： 47-49.

[4] Xia Qiangfeng,Yuan Junxiang,Tu Huawei. Development of AC Induced Voltage Elimination Device for Transmission Lines [J]. Zhejiang Electric Power,2015,34（7）:66-68.

[5] Q/GDW 1894-2013 Technical Specification for On-line Monitoring Device for Grounding Current of Transformer Core [S]. China Electric Power Press,2014.

[6] Yue Lingping, Zhangzhiliang, Yu Qiang,. Operation reliability analysis of transmission line on-line monitoring system [J]. Zhejiang Electric Power,2014,33（6）:67-71.

[7] Wang Maojun, Gao Qiang, Geng Baohong. Application of WIA-based Grounding Current Monitoring Device for Transformer Core [J]. Northeast Electric Power Technology, 2014, 35 (10): 30-32.

[8] Zhang Xiaohui, Wang Maojun, Gao Qiang. Cause Analysis and Countermeasure of Abnormal Data of On-line Monitoring Device for Grounding Current of Converter Core [J]. Northeast Electric Power Technology,2017, 38 (3): 59-62.