Research on Live Detection Technology of Contact Ablation Degree of Power High Voltage Reactive Power Switching Switch

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Abstract. In power system, high voltage reactive power switching switch is an important control unit, which is an important tool to start the connection of power equipment. In order to ensure the safe operation of high-voltage reactive power switching switch, this paper proposes a new method for live detection of contact ablation degree of high-voltage reactive power switching switch to solve the lack of effective detection and evaluation means of contact ablation degree of high-voltage reactive power switching switch in power system. During the opening and closing process of high voltage reactive power switching switch, RF electromagnetic wave signal will be radiated, which contains information reflecting the ablation degree of contact. In this paper, through the detection and analysis of electromagnetic wave signal, the detection of contact ablation degree of high voltage reactive power switching switch is realized. This paper analyzes the influencing factors of radiated electromagnetic wave in the process of circuit breaker opening and closing. The anti-interference method of electromagnetic wave field detection is used to realize the live detection of contact ablation degree of high voltage reactive power switching switch. It effectively solves the problem of mutation detection of contact ablation degree of high voltage reactive power switching switch, and greatly improves the detection rate of contact ablation degree defects.

1. Introduction
The safe operation of high voltage transmission and transformation equipment has become an important factor affecting the safe, stable and economic operation of power system. High voltage switch plays the role of control and protection in power system. When it fails, it will directly cause power grid accident or further expand the accident, causing considerable economic and social losses. [1] How to effectively detect the working state of the high-voltage switch, find the early defects of the switch in time, deal with the defective parts in advance, and prevent the switch explosion and other malignant accidents, is of great significance to ensure the safe and reliable operation of the power grid.

Frequent action of high voltage reactive power switching switch is the main reason for contact ablation. And the contact ablation degree is the most important index to characterize the performance of high voltage reactive power switching switch.[2-3] At present, the contact ablation degree of high voltage reactive power switching switch is lack of effective detection and evaluation means, which has become one of the major hidden dangers of power system. The traditional detection method of contact ablation degree is electrical life method, which can determine the contact ablation degree of high
voltage reactive power switch by weighted calculation of breaking times and breaking current. This method can only reflect the gradual deterioration of contact ablation degree of high voltage reactive power switching switch, but can not reflect the sudden or abnormal deterioration of contact ablation degree. [4-5]

In this paper, a method based on RF electromagnetic wave detection is proposed to detect the ablation degree of high voltage reactive power switching switch contacts, which solves the existing problems and greatly improves the detection rate of serious ablation defects of high voltage reactive power switching switch contacts. It can effectively reduce the number of high-voltage reactive switching equipment accidents caused by the decline of contact ablation degree, improve the power supply reliability of power grid, and has obvious social and economic benefits.

2. Influencing factors of radiated electromagnetic wave

The electromagnetic wave signal excited by breakdown in the air during the action of the contact of the breaker contains a lot of information, but the characteristic quantity which can be used to represent the arc extinguishing state of the breaker is not clear. [6-7] Therefore, in this laboratory simulation experiment, two sets of electromagnetic wave test schemes are selected, namely, the radio frequency signals radiated during the operation and the signals after detection are sampled respectively. [8-10] RF signal is the original signal of contact radiation in the circuit breaker simulation experiment, which contains all the information contained in the circuit breaker action. But RF signal sampling requires high requirements for information acquisition equipment, and the minimum sampling rate is 5GS / s. But in such a high sampling rate, because of the limitation of storage depth, the sampling time is not more than hundreds of seconds. Detection signal is the signal obtained by envelope detection of the original signal, which retains the information of peak value and pulse number. The sampling of detection signal is relatively low in requirement for equipment, and it is relatively easy to be used in field test, and is widely used in partial discharge detection of electrical equipment. The electromagnetic wave signal acquisition equipment is shown in Table 1.

| Signal type   | Oscilloscope model | Sampling rate | Single sampling time | Storage depth |
|---------------|--------------------|---------------|----------------------|---------------|
| RF signal     | LeCroy 8620A       | 5Gs/s         | 400us                | 2M            |
| Detection signal | Fluke 190-204     | 0.2Ms/s       | 24ms                 | 10K           |

The actual breaker has too large breaking capacity. In order to meet the needs of studying the radiated electromagnetic wave signal in the process of opening and closing of the circuit breaker, a simulation test platform for opening and closing of small circuit breaker is designed. The experimental research is carried out on various factors affecting the performance of the circuit breaker. In the test, the contact is placed horizontally and fixed to complete the simulation opening and closing process. The design test platform is shown in Figure 1.

In Figure 1, 1 represents 1 bracket, 2 represents insulation material, 3 represents connection, 4 represents fixed part, 5 stands for static contact, 6 represents moving contact, 7 represents connection, 8 stands for insulating rod, 9 represents fixed sleeve.

In the simulation experiment, some points should be paid attention to in the contact process of the breaking circuit breaker

1) In the process of opening and closing, the test platform should not be loose, swinging and other phenomena.

2) During the opening and closing process, the dynamic and static contacts of the circuit breaker shall be kept in the coaxial position to prevent the failure of effective opening.

3) The experimental support at the bottom of the platform serves as the grounding terminal to ensure reliable connection with the earth, so as to ensure the safety of the laboratory personnel.
(4) Epoxy resin is used as insulation material above the support to ensure that the contact is separated from the metal support, so as to prevent the contact from directly connected with the earth, causing the circuit current to be too large and the protection system will act.

The test shows that the radiated electromagnetic wave signal is affected by many factors. The higher the fracture voltage, the slower the action speed, the more serious the contact ablation and other reasons will make the amplitude of the radiated electromagnetic wave signal increase, the number of signals increase or the duration become longer. The amplitude of the signal radiated by the circuit breaker breaking capacitive load is larger than that radiated by the resistive load.

3. On site detection of electromagnetic wave

When the breaker acts, the breakdown between contacts will generate high frequency electromagnetic wave, which can reflect the arc extinguishing performance of the circuit breaker. However, because of the collection of many electrical equipment in the limited space of the substation, other equipment is easy to produce strong interference to the electromagnetic signal radiated during the circuit breaker operation, which affects the detection of electromagnetic wave signal, which leads to deviation of the judgment of the arc extinguishing performance of the circuit breaker.[11-12] Therefore, a method and device for anti-interference detection of arc extinguishing performance of circuit breaker based on vibration signal is proposed, which can realize the time domain anti-interference detection of arc extinguishing performance of circuit breaker.

The first is the feature extraction of vibration signal. The operation of high-voltage circuit breaker starts from the power on of electromagnetic iron coil. Then, the energy in the energy storage mechanism is released through mechanical linkage, and the moving contact is driven by force transmission and direction control. In the whole operation process, mechanical impact, friction, mechanical force and electric force between parts can stimulate mechanical vibration. The mechanical vibration propagates through the connection between the parts of the equipment, which can be measured on the transmission path and the base and shell of the switch. After signal processing, the information reflecting the mechanical state of the circuit breaker can be obtained. Vibration signal has the advantages of rich state information and high signal-to-noise ratio. The vibration signal is complex, but it can be used as trigger source to collect electromagnetic wave signal effectively.

Non electric signal has high requirements for the installation position and installation mode of the sensor. Especially for vibration signal, the installation and fixing mode, installation position and even angle deviation of vibration sensor may cause obvious changes in the measured signal waveform, amplitude or frequency components. In addition, the measured signals will vary with the different measuring environment and measurement time.[13] Therefore, further research is needed to ensure the consistency of measurement signal and the consistency of signal characteristics. Vibration signal is
difficult to be used as trigger signal because it is difficult to be consistent with the signal and repeatability of experiment. A scheme to ensure the consistency of non electric signal features is to find the characteristic quantity which is independent of installation position, installation mode, measuring environment and measurement time and can be used for state diagnosis. This depends on the research of new signal analysis and processing methods or new signal feature extraction methods.

After the circuit breaker receives the opening and closing operation, the electromagnetic iron coil is powered on, the energy in the energy storage mechanism is released, and the contact and accessories are driven to move through the force transmission and direction control. In the whole process, there will be many aftershocks, but the vibration signal is only used as the trigger source, so we only need to convert the first vibration signal into the rising edge electrical signal as the trigger. Therefore, the mechanical vibration is felt by the vibration sensor, and then converted into square wave output through the circuit, with the rising edge of square wave as the trigger pulse signal.

4. Conclusion
This paper studies the method of detecting the ablation degree of the contact of the high voltage reactive power switch based on the radio frequency electromagnetic wave signal detection. It can solve the problem that the existing methods can only detect the change of the ablation degree of the gradual contact, but can not detect the change of the ablation degree of the contact with sudden changes and abnormal ones. The detection rate of the serious ablation defects of the contact of the high voltage reactive power switch is greatly improved. At present, there are many high voltage reactive switch in the power grid, and the contact ablation degree is lack of effective detection means. This technology has a broad application prospect.

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