Research and Application of Electromagnetic Wave Signal Acquisition Device for Power System Circuit Breaker

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Abstract. Power circuit breaker is an important tool to satisfy the controllability and safety of power system. Therefore, to ensure the stable operation of the circuit breaker is to ensure the normal supply of electric energy. In order to better capture the electromagnetic wave signal radiated by the circuit breaker and better judge the state of the electromagnetic wave radiated by the arc of the circuit breaker, a new type of vibration trigger device specially used for collecting the electromagnetic wave signal radiated by the circuit breaker and its use method are proposed in this paper. This method can collect the electromagnetic wave signal of circuit breaker through the optimized design of vibration trigger device. The device uses all metal integrated cast aluminum shell and independent power supply. This device can effectively resist electromagnetic interference, and is convenient for the acquisition of electromagnetic wave signal. The device developed in this paper and its application method belong to the field of off-line detection of electrical equipment, and are especially suitable for vibration triggering of the device when collecting the radiated electromagnetic wave signal during the action of circuit breaker.

1. Introduction
In recent years, the proportion of power system safety accidents caused by high-voltage electrical equipment failures is on the rise, which may cause blackout accidents, cause huge losses to the national economic development, and even endanger the lives of operators and bring pain to countless families. As an important part of power system, circuit breaker plays the role of protection and control. The number of circuit breakers in the power system is extremely large, and its use range is very wide. Circuit breaker can not only carry no-load current and load current in high-voltage circuit, but also cut off overload current and short-circuit current quickly by relay protection device when system failure occurs. When the circuit breaker is switched on or off, the arc will be generated [1-2]. The rapidly changing electric field and magnetic field will excite electromagnetic wave. The electromagnetic wave contains information that can reflect the arc extinguishing ability, and then can effectively reflect the operation status of the circuit breaker.[3]

In practical engineering application, the electromagnetic wave in substation or test station is very complex. At the same time, because the action time of circuit breaker is very fast, it is very difficult to capture the circuit breaker radiated electromagnetic wave signal and judge the circuit breaker arc radiated electromagnetic wave [4-6]. However, when the circuit breaker acts, high-level triggering by vibration trigger device can achieve accurate acquisition of circuit breaker electromagnetic wave.[7]
The existing vibration trigger device is fixed with double-sided adhesive tape, which is time-consuming and difficult to dismantle. The double-sided adhesive tape is often firmly adhered to the steel structure of the circuit breaker, which can not only be cleaned but also affect the appearance. [8-10] In addition, the traditional plastic shell is directly in contact with the steel structure. The strong vibration of the breaker when opening and closing can easily impact the internal components of the vibration trigger device, and then affect the acquisition of electromagnetic wave. In view of these shortcomings of the existing devices, a new type of vibration trigger device is designed in this paper, which solves the problems in practical application.

2. Application of new type vibration trigger device

When the circuit breaker switch is closed, the distance between the moving and stationary contacts decreases gradually. When the dielectric resistance between the contacts is lower than the voltage between the moving and stationary contacts, the moving and stationary contacts will break down and then generate arc. At the moment of breakdown, the current between the moving and stationary contacts increases rapidly, and a sudden magnetic field is generated in the space. The magnetic field then excites a sudden electric field, which in turn excites a sudden magnetic field. In the reciprocating cycle, an electromagnetic wave signal is excited in the space. After the breakdown occurs, the arc between the moving and stationary contacts is a good conductor. The current change in the arc is close to the power frequency current, and it goes out naturally at the zero crossing point, so the high frequency electromagnetic wave signal will not be excited again. Therefore, the RF signal will only be excited once when the high-voltage development is switched on, and the electromagnetic wave signal will not be excited again during the subsequent arc combustion.

When the circuit breaker switch is opened, when the moving and static contacts are just separated and the dielectric resistance between the contacts is lower than the voltage between the moving and static contacts, the moving and static contacts will break down immediately, and then generate an arc, and then trigger an electromagnetic wave signal. After the breakdown, the current change in the arc is close to the power frequency current, the distance between the moving and stationary contacts increases gradually, and it goes out naturally at the zero crossing point, and the high frequency electromagnetic wave signal will not be excited again. Therefore, when the switch is opened, the RF signal will only be excited once, and the electromagnetic wave signal will not be excited during the subsequent arc combustion.

In order to cooperate with the development and operation of the radiated electromagnetic wave signal acquisition system in the process of circuit breaker action, realize the field requirements and ensure the reliable triggering ability of the trigger device, a new type of vibration trigger device is designed in this paper. The device is novel in design, simple and easy to use, and has remarkable effect, which effectively solves the existing problems.[11-13]

This paper presents a new type of vibration trigger device for the acquisition of electromagnetic radiation signal in the process of breaker breaking. The concrete implementation method is to first install three strong magnets on the shell (all metal) of the vibration trigger device, and fix them effectively on the steel structure of the circuit breaker without falling off or moving. Then, because of the small hardness of strong magnet, a double-sided tape is selected on the surface of the strong magnet (no stripping is required near the steel structure). So the vibration trigger device will not break the strong magnet due to strong magnetic force when it is close to the steel structure surface of the circuit breaker, thus affecting the vibration triggering effect. The structure of the electromagnetic wave signal acquisition device radiated by the new circuit breaker is shown in Figure 1.
3. Application of new type vibration trigger device
During the assembly of the device, the circuit board of the vibration trigger device is fixed in the shell at first, and the upper cover is fixed with the fastening screw. When the power supply needs to be replaced, remove the fastening screw and open the upper cover. After replacing the power supply, fix the upper cover with the fastening screw. [14-15]

When using vibration trigger device to collect electromagnetic wave signal from circuit breaker, the new type of vibration trigger device is directly attached to the steel structure of the circuit breaker, and the place close to the circuit breaker body and smooth plane is selected to ensure that the strong magnet suction is sufficient.

When collecting signals, turn on the power switch and see the power indicator light on. When there is a vibration signal, the signal will be output through the signal output terminal.

In this method, the optimized vibration trigger device is used to collect the electromagnetic wave signal of the circuit breaker. The use of all metal integrated cast aluminum shell, independent power supply, can effectively resist electromagnetic interference. Double sided adhesive tape is pasted on the contact surface between the vibration trigger device and the steel structure of the circuit breaker to ensure sufficient insulation distance without affecting the fixation effect of strong magnetic force. The design can adapt to different types of circuit breakers, easy to install and disassemble, and has a wider range of applications.

Technical characteristics: (1) in the device for vibration triggering, all metal integrated cast aluminum shell is adopted. (2) In the double-sided tape, the thickness of the tape is 3 mm. (3) In the opening of the shell, the aperture shall be as small as possible, and the power switch, indicator light and signal output end shall be metal enclosed. (4) Among the strong magnets, the thickness of the strong magnet is 5mm.

The advantage of this device is that the vibration trigger device uses all metal shell and independent power supply, which can effectively resist electromagnetic interference. The strong magnet on the surface of the vibration trigger device can effectively ensure that it will not affect the measurement effect due to violent vibration. The double-sided tape on the surface of the strong magnet can ensure...
enough cushioning and shock absorption, so that the strong magnet is not fragile, and ensure enough electrical isolation distance. The design can adapt to different types of circuit breaker steel, easy to install and disassemble, and has a wider range of applications.

4. Conclusion
The vibration trigger device used in this device is used to collect electromagnetic wave signal, which has a new level of exploration on the use of electromagnetic wave signal. For those skilled in the art, the method proposed in this paper can have various changes and variations.

Compared with the existing vibration trigger device for collecting electromagnetic wave signal radiated by circuit breaker, the invention has the following beneficial effects: (1) all metal integrated cast aluminum shell, independent power supply, can effectively resist electromagnetic interference. (2) The strong magnet on the surface of the vibration trigger device can not only ensure that it is firmly fixed on the steel structure of the circuit breaker and is not easy to fall off or move, but also ensure effective electrical isolation. (3) The double-sided tape on the surface of the strong magnet can ensure that it will not be broken due to the strong magnetic force. (4) The design is beautiful, economical, easy to disassemble and convenient for field test.

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