Research and Design of Three-Phase Inconsistent Protection Circuit for Circuit Breaker Based on Chip Technology

Xiaoming Wang¹, Ke Zhou¹, Wenwei Li²
¹Electric Power Research Institute of Guangxi Power Grid Co., Ltd., Nanning 530023, China
²Qinzhou Power Supply Bureau of Guangxi Power Grid Co., Ltd., Qinzhou 535000, China

*Corresponding author’s e-mail: 496484606@qq.com

Abstract. The typical configuration of inconsistent protection of circuit breaker is that the auxiliary switch of circuit breaker is connected in series and parallel with start-up time relay, and the outlet relay is tripped by delay start-up. In order to improve the reliability of circuit breaker, this paper presents a new design idea of inconsistent protection of circuit breaker based on chip technology, and presents a phased digitized site designed with circuit breaker mechanism as a whole. The overall architecture scheme mainly consists of module and general control module. The phase-separated digitized local module realizes on-site acquisition of circuit breaker position and optical fiber transmission. The main control module realizes ontology inconsistent logic operation, exit and communication with spacer layer. The design scheme uses chip processing instead of traditional relay and optical fiber transmission instead of traditional cable, effectively avoiding relay and circuit differences. The misoperation often caused can greatly improve the reliability of inconsistent protection of circuit breaker.

1. Introduction
When three-phase inconsistent abnormal operation occurs in power system, it will produce zero-sequence component and negative-sequence component, which will harm generators and motors, interfere with communication systems, and also affect the correct operation of system protection devices. Therefore, the power system does not allow long-term non-full-phase operation. All the circuit breakers are equipped with three-phase inconsistent protection of the main body to ensure that the circuit breaker which is in abnormal state can be reliably tripped when the three-phase inconsistency occurs. At present, the conventional realization method is mainly to use the circuit breaker auxiliary switch to connect the start-up time relay in series and parallel, and start the trip of the outlet relay after delay, but in practice, the time relay, outlet relay and cable used in the inconsistent protection of the main body are in poor operating conditions, which often lead to the wrong tripping due to the deviation of the fixed value of the time relay, the abnormal insulation of the relay contacts, and the abnormal insulation of the cable, etc. [1-3].

In addition, with the development of intelligent, modular, integrated and digitized primary equipment, the traditional control loop implementation methods of circuit breakers will also change
with the high integration and deep integration of primary and secondary equipment [4-5]. Based on the analysis of typical configuration of inconsistent protection of circuit breaker and the factors affecting its reliability, a new design scheme of inconsistent protection of circuit breaker ontology based on chip technology is proposed in this paper, aiming at many existing operational problems and combining with primary and secondary fusion technology. The design scheme is replaced by chip processing and the traditional relay replaces the traditional cable with optical fiber transmission, which effectively avoids the malfunction caused by the abnormal relay and circuit, and greatly improves the reliability of the inconsistent protection of the circuit breaker.

2. The Typical Configuration and Reliability Analysis of Three-phase inconsistent protection

2.1. The typical configuration of three-phase inconsistent protection

The traditional control circuit is mainly composed of a large number of cables and various relays. The typical circuit of traditional ontology inconsistency protection is shown in Figure 1. A group of three-phase normally open contacts are connected in parallel and another group of three-phase normally closed contacts are connected in parallel. After the two are connected in series, a relay K16 with delay is started to determine whether there is three-phase inconsistency. When the three-phase of the circuit breaker is inconsistent, the two auxiliary contacts are always connected, and the K16 relay acts. When the setting delay is reached, the contacts are connected, the outlet relay K61 operates, and the tripping circuit of K61 is connected to the tripping circuit to trip the three-phase circuit breaker [6-7].

![Figure 1 The traditional control loop](image1)

![Figure 2 The reliability fault tree diagram](image2)

2.2. Reliability analysis

From the analysis in Figure 1, the starting circuit of inconsistent protection of circuit breaker body is taken from the auxiliary contacts of circuit breaker jumping position. The circuit is simple and its reliability is low. The probability of incorrect action of inconsistent protection of circuit breaker body caused by single component fault is very high. In order to analyze its reliability and influencing factors intuitively, the inconsistent protection of circuit breaker body is analyzed. On the premise of protecting fault mode, the reliability fault tree is constructed as shown in Figure 2.

As can be seen from Figure 2, any of the above unit faults can cause false tripping. Following is an analysis of the above-mentioned situations:

If the auxiliary contacts of the switch fail to turn over normally with the action of the switch, the K16 time relay will be activated, which will lead to three-phase tripping.

In the course of operation, cable will be damaged by environmental and external forces, which will affect circuit insulation. For example, breakage of control cable between switch mechanism box and sub-box may lead to start-up relay or trip of direct outlet.

Time relay and outlet relay are prone to abnormal contact insulation in outdoor operation environment. The relay affected by vibration during switching operation may also have the phenomenon of contact
jitter and switch-on. In addition, the time relay will have unstable operation time after long-term operation. All of the above situations will cause the trip of the breaker.

In summary, combined with the actual operation situation, the three-phase inconsistent protection configuration of circuit breaker has high operational risk, which is mainly reflected in the relay design and selection. For example, the inadequate anti-vibration capability of relay may cause the relay contact closure due to resonance, and the time delay of time relay may exist. Discreteness; Second, the aging of secondary components, relays and cables in outdoor poor operating conditions, etc. in the long-term operation performance gradually declined.

3. The New Scheme of Ontology Three-phase Inconsistent Protection

According to the former reliability analysis and the case of three-phase inconsistent malfunction of ontology in the scope of South China Grid, the reliability of traditional configuration operation cannot be guaranteed at present. It is necessary to find a new scheme to realize the three-phase inconsistent protection function of ontology. In this paper, it is mainly considering relay and cable problems, and a method of realizing three-phase inconsistent protection circuit based on chip technology is proposed. The scheme architecture is shown in Figure 3.

![Figure 3: The Schematic diagram](image)

In Figure 3, there are local acquisition modules in each mechanism box, which mainly realize the functions of circuit breaker position signal acquisition, data processing, GOOSE command sending and receiving, tripping and so on. The intelligent control module in each box communicates with GOOSE mode through optical fiber and the intelligent control module in the control box. The intelligent control module mainly realizes the chipping of the inconsistent protection function of the body, and replaces the traditional electromagnetic relay with soft logic. This scheme can effectively avoid the misoperation rejection caused by unreliable relays and abnormal cable insulation mentioned above. The hardware design and software algorithm design are described in detail below.
3.1. Hardware Architecture
From Figure 3, we can see that the hardware architecture of this scheme is mainly divided into two parts. The intelligent modules arranged in each phase mechanism are mainly composed of power module, digital input module, data processing module and export module. The hardware architecture of this scheme is shown in Figure 4.

In Figure 4, the CPU completes the position signal acquisition of the circuit breaker through optical isolation, and transmits the signal to the DSP through the internal CAN bus. The DSP is responsible for signal packaging and GOOSE communication with the upper layer. At the same time, the DSP is also responsible for the analysis of GOOSE commands, and the parsed signal is transmitted to the export CPU through the CAN bus.

In addition to the split-phase intelligent control module in Figure 4, another function module to realize ontology inconsistency protection is the general intelligent module, which hardware architecture is shown in Figure 5. The intelligent control module mainly uses controllers instead of traditional three-phase inconsistent loop composed of a large number of secondary cables and discrete components. GOOSE transmission is used to realize communication with spacer protection,
measurement and control equipment, and phase-separation control module of various agencies, so as to realize signal acquisition and intelligent control functions.

3.2. Software algorithm
The software algorithm of this scheme is basically consistent with the traditional ontology inconsistent configuration scheme. The circuit breakers three-phase closing or logic, three-phase dividing or logic is adopted, and then the and logic operation are carried out to determine whether three-phase inconsistency occurs. The logic block diagram is shown in Figure 6.

In Figure 6, GOOSE HA, GOOSE HB and GOOSE HC are three-phase closing positions of circuit breakers respectively, and GOOSE TA, GOOSE TB and GOOSE TC are three-phase opening positions of circuit breakers respectively.

In summary, the three-phase inconsistency protection of circuit breaker based on chip technology is mainly realized by the chip controller. The position of circuit breaker is transmitted to the intelligent control module in the central control cabinet by the optical fiber, and then the inconsistency function is realized by soft logic. If the circuit breaker has three-phase inconsistent operation state (phase A cannot be closed normally for some reason), the phase separation intelligent module transmits the collected position signal to the intelligent control module. At this time, the GOOSE HA received by the intelligent control module is 0, GOOSE HB is 1, GOOSE HC is 1, GOOSE TA is 1, GOOSE TB is 0, and GOOSE TC is 0. According to the logic in Figure 6, the three-phase inconsistency is judged, and GOOSE three-phase inconsistency tripping command is sent to each phase separation control module by delay.

4. Conclusion
Aiming at the problem of poor reliability of three-phase inconsistent protection of circuit breaker, this paper presents a scheme of inconsistent protection of circuit breaker based on chip technology. The scheme mainly consists of phase-splitting digital local module and total control module. The phase-splitting digital local module realizes local acquisition of circuit breaker position and optical fiber transmission. The main control module realizes ontology inconsistent logic operation, export and communication with spacer layer. This method uses chip processing instead of traditional relay and optical fiber transmission instead of traditional cable, which effectively avoids the malfunction caused by abnormal relay and circuit, and greatly improves the reliability of inconsistent protection of circuit breaker.
References

[1] JIANG Zhihan, MA Yingxin, GAO Xu, LIU We, DU Liyan. Reliability Analysis and Secondary Circuit Improvement of Three-phase Inconsistent Protection for Circuit Breaker [J]. Automation of Electric Power Systems, 2017, 41(11): 169-172.

[2] ZHAO Yi, LIU Hu. Analysis of the open-phase maloperation for 220kV breaker [J]. Shan dong Electric Power, 2015, 42(10): 72-80.

[3] ZHANG Jilong, YANG Bochao, GUO He. Cause Analysis and Improvement Recommendations on Breaker Jumping Fault [J]. HebeiElectric Power, 2011, 30(1): 27-28.

[4] ZHONG Jianying. Technology Development Summary of Smart High-voltage Switchgear [J]. High Voltage Apparatus, 2013, 49(7):110-115.

[5] ZHANG Meng, SHEN Chun-hong, ZHANG Ku-wa. Research of intelligent GIS [J]. High Voltage Apparatus, 2011, 47(3): 6-11.

[6] CHANG Fengran, ZHANG Hong. Non-three-phase protection of high voltage breaker [J]. Automation of Electric Power Systems, 2000, 24(11):62-64.

[7] LIU Qiuying, QIU Hongming, LI Qiang, et al. Malfunction causes analysis of circuit-breaker three-phase Inconsistent protection and countermeasures [J]. Jiang su Electrical Apparatus, 2012(7): 34-37.