An Analysis of a shutdown caused by a misoperation of differential protection of high-voltage auxiliary transformer

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Abstract. In response to an accident of misoperation of the high-voltage factory transformer differential protection, the cause of the misoperation was investigated and analyzed from the perspective of the volt-ampere characteristics of the current transformer and the protection operation information, and it pointed out the abnormal interruption of DSP memory caused by the malfunction of differential protection, and put forward the corresponding treatment and preventive measures.

1. Introduction
Unit 9 was connected to the grid at 08:03 on February 9, 2019. At 9:03 when the load of 159MW plant power was switched, the second plant B set high plant changed differential protection action, and the unit was disengaged. After carrying out a series of inspection tests, it was preliminarily judged that the device occasionally malfunctioned and withdrew from the protection contained in the B2 cabinet 2BJ protection box of the generator and transformer group protection of Unit 2 Pressure branch overcurrent, branch A overpressure overcurrent, branch B overpressure overcurrent, branch A zero sequence overcurrent, branch B zero sequence overcurrent, branch A quick break, branch B quick branch, branch zero sequence overcurrent Disabled. At 20:40, the unit was reconnected to the grid, and at 21:01, the plant power was switched. The device was not activated[1].

Figure 1. Operation trend of Unit 2 of a company.
1.1. Equipment Overview
(1) The company's development and transformation group adopts Beijing Guangyao Power's complete set of digital generator transformer protection devices imported from Canada's GE company. The main and backup protection are completely dualized, and the non-electricity protection is an independent protection configuration.

(2) Zhenjiang Huadong PZH-1C quick cut device is used for the quick cut of 6kV auxiliary power.

(3) The No. 2 high plant transformer differential protection area is the No. 2 high plant transformer and the 6kV side common box seal mother.

1.2. Main equipment inspection
(1) The oil chromatographic test of the No. 2 high plant is qualified, the appearance of the transformer is normal, and the outgoing box of the low voltage side of the No. 2 high plant is normal.

(2) The mechanical characteristic test of the 6kV factory-used three-section bus inlet switch 2301 is qualified, the switch insulation is qualified, and the switch body has no obvious discharge marks.

(3) Check # 2 high plant transformer belt 6kV side common box seal mother A branch insulation 2 megohm, No. 2 high factory transformer belt 6kV side common box seal mother B branch insulation 1 megohm. Consider three-phase parallel measurement plus normal weather.

After the above inspections, it was determined that there was no defect at one time[2].

1.3. Inspection of electrical secondary equipment
1) Test the No. 2 generator-transformer group protection B2 cabinet high factory variable differential protection, respectively, the differential protection channel accuracy test, the ratio braking characteristic test, the second harmonic braking test, the high current test impact test The above test data are all qualified;

2) Check the DC resistance of the secondary circuit of the B2 cabinet differential protection and the insulation of the loop cable, the test data are all qualified, and tighten the current secondary circuit screws;

3) Due to the dampness of the current transformer body of the low voltage side of the Gaochang Substation, there are discharge marks on the secondary shielding layer. The volt-ampere characteristic test was carried out on the high and low voltage side current transformers of Gaochang, and the test data was qualified. See Figure 2, Figure 3, Figure 4.

Figure 2. A-phase volt-ampere characteristics of low-voltage side current transformer
1.4. Inspection of electrical secondary equipment
Check the record of the fault recorder, and the protection of 6kV A branch current and voltage during differential protection action is shown in Figure 5. Since the auxiliary power is switched in parallel, the voltage does not change, the current AB phase has a small displacement, and the C phase has no change, which affects the circulation current. Furthermore, the differential fixed value is 0.346 pu, based on the low-pressure side. The recording shows that the current has a decay trend with time, and the maximum value of the high and low voltage side differential value has not reached the differential fixed value[3].
Moreover, when the generator is turned on on November 26, when the factory power is switched, the current of branch A is shown in Figure 6, which is consistent with this time.

2. Cause Analysis

No. 2 generator-transformer group protection B2 cabinet 2BJ protection box will send high factory transformer differential protection action during the process of factory power switch, then A set of protection will not be activated. After the B set of protection actions, the 2BJ protection box device cannot be reset by "reset", and after the device is tripped, the device mistakenly sends out the signal of branch A overvoltage overcurrent action, but after the device is turned off and repowered, the device tests are normal. After deactivating the protection function pressure plate included in the 2BJ protection box, the factory power supply device was not activated after starting. At the same time, checking the system and the fault recorder also found no abnormality. Therefore, the operation of the device should be accidental malfunction[4].

According to the on-site inspection results, consult the power plants and manufacturers that have experienced similar situations, and compare with the << GE test report of Guigang Power Plant T35 protection >>, the root cause of this failure is: memory abnormality, DSP memory abnormal interruption and Caused this failure. The instructions are as follows: The DSP included on the CT / PT sampling module is responsible for all analog calculations and sends the digital quantities to the CPU module. The memory on the DSP module contains a special coefficient for scaling the braking current and differential current. Judging that during this period, external factors (such as rapid interference of electrical quantities and speed exceeding the given parameters in the design of the UR relay) caused
the DSP memory to be interrupted, resulting in incorrect calculation of differential current and braking current, resulting in protection malfunction[5].

3. Main problems exposed

According to the 2015 document of the China Southern Power Grid Dispatching Center, "Notice on the Implementation of GE Protection Countermeasure Work for Grid-connected Power Plants and Users of 220 kV and Above Systems in China Southern Power Grid" The T35 and G60 sampling modules and software have insufficient self-diagnosis and anti-interference capabilities. The versions are V4.8 and V4.6, respectively. The version is too low and has not been upgraded in time.

4. Handling and precautions

(1) Carry out technical communication with the personnel of GE protection manufacturers of the development and transformation group to upgrade the software version. From the CPU version V5.72 onwards, additional measures can ensure that the data stored on the DSP module is reliable: through continuous write protection of "memory locations that should not be erroneously written" and allow patrol pointers to access unallocated memory address. That is: protect these memory addresses that are not used for data processing from being erroneously written. Therefore, when a memory failure occurs, it will only affect the memory address in the calculation process (DSP conversion), and the address that has been latched (write protection) will not be implicated, and the latched data is reliably sent to the CPU module[6].

(2) Hardware upgrade. Upgrade the new UR relay, the new CT / PT sampling module and the new CPU version have enhanced anti-interference ability, and added the sampling module self-diagnosis function, which can effectively prevent the protection from misoperation caused by similar abnormal conditions, such as the use of Analog data integrity verification and detection of analog measurement failure faults, monitoring the integrity of the CT circuit inside the protection device to prevent the relay from malfunctioning when the CT secondary winding fails, and blocking any protection function trips and monitoring when the CT / PT module detects invalid data. Moreover, GE's newly released CT / PT module is designed to implement hardware filtering using FPGA (Field Programmable Gate Matrix), which enables the filter to operate in an environment with a speed higher than the standard communication rate to ensure module data communication.

(3) Before the hardware and software versions are upgraded, in order to prevent repetitive trips, the protection included in No. 2 generator and transformer group protection B2 cabinet 2BJ protection box: high plant transformer differential protection, high plant transformer double pressure branch Flow, A branch overpressure overcurrent, B branch overpressure overcurrent, A branch zero sequence overcurrent, B branch zero sequence overcurrent, A branch quick break, B branch branch quick break, branch zero sequence overcurrent Invest after upgrading.

(4) Set B protection of No. 2 high plant transformer is disabled. Set A protection of No. 2 high plant transformer has been inspected before grid connection. The protection action is normal and can be put into use; Set A and B of main protection of No. 2 generator and transformer group are all put into operation, No. 2 High Factory Transformer has been included in its main protection scope. If the No. 2 High Factory Transformer equipment fails, the protection device will be fast and reliable.

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