Defect Treatment and Cause Analysis of DC Grounding Fault in 500kV Substation

Lida Zheng¹, Qiongliang Chen² *, Jianqing Zhang¹, Zhe Zhang¹, Yuxin Liu¹

¹State Grid Zhejiang Electric Power Co., Ltd. Maintenance Branch, Hangzhou Zhejiang, China
²State Grid Wenzhou Power Supply Company, Wenzhou, Zhejiang, China

*Corresponding author: chenqiongliang@sgcc.com

Abstract. The substation DC system is the most important power source for signal acquisition, protection and control of the power system. During the operation of a DC system, DC faults can occur due to incidental causes. This article briefly studies and analyzes a DC ground fault in a 500KV substation, introduces the method of finding DC ground faults, and the reasons for their formation. The following points are for reference only.

Keywords: DC, Direct grounding, Condensation.

1. Introduction
DC power supply system has a very important role in 500KV substation. In general, DC power supply network is mainly distributed in the relevant equipment and indoor and outdoor installations. Due to the influence generated by the outdoor environment, the probability of DC ground fault generated by the substation is relatively high, which will have a certain impact on the safety and stability of the system operation.

One point of grounding in a DC fault does not directly cause secondary hazards to the system, and serious effects are usually due to two points of grounding. In order to avoid generating two points of grounding, when a point of grounding fault occurs, it is necessary to solve and deal with it through reasonable and effective measures to prevent adverse effects on the operating equipment and the device from misfiring or refusing to operate, resulting in overstep tripping.

2. Fault phenomenon
On Thursday, August 6, 2015, the background monitoring reported that the insulation of the negative busbar in one section of the control busbar was reduced: checking the insulation device, the positive and negative busbar section was +86V and -24V to ground, and the positive and negative busbar section two was 20V and -89V to ground. The insulation monitor branch circuit is selected as No. 5 (DC power supply for 5011 switch protection screen) and No. 13 (DC power supply for 5023 switch measurement and control unit). The background shows that the signal terminal No. 63 of 5022 switch protection is frequently changed, and the screen of 5022 switch protection (Xuji) is swiped, showing that the tripping position of phase B of 5022 switch is frequently changed (the normal closing state should be 0).
3. **The cause of the fault**

DC control bus section one and section two both show a voltage drop. It is suspected that a series connection of positive. The negative voltage of one section of the control bus and the positive voltage difference of the second section of the control bus is 44V (normal 110V), so if a series connection occurs it should be them. 5022 switch B phase tripping position frequently changed position, indicating that the possibility of anomalies in this branch is high. Frequent change of trip position requires positive power, and the positive power may be provided by another group of DC power supply (such as control bus section two positive power), then 5022 switch protection should supply power for DC control bus section one.

4. **Method to find a DC grounding fault**

The DC system operated by the substation is designed according to the national network standard, coming with two DC bus DC section I and DC section II. If there is a branch DC ground condition, the corresponding DC bus will be a voltage drop. According to this condition, the branch circuit of the bus that generates the fault can be found accordingly.

5. **Inspection and handling process**

(1) check 5022 switch protection drawings, indeed a section of the DC control bus supply, 5022 switch B phase trip position is directly provided by the switch normally closed auxiliary node, the cable from
the site on the 5022 switch PLC sink cabinet. In the 5022 switch protection screen, the opening potential of B-phase tripping position (37) is measured, sometimes -24V and sometimes +21V, while the opening potential of A and C-phase tripping positions (35 and 39) are -24V. Measured 5022 switch protection screen power supply positive potential of +86V, therefore, this 21V potential is basically judged to be related to the DC control bus section two positive potential.

(2) View the PLC sink control cabinet terminal row diagram, found then 5022 switch protection switch normally closed auxiliary node of the terminal row immediately below the auxiliary node to the fault recorder. Suspected and fault recorder positive power supply, disconnect the fault recorder positive power supply, measure the DC control bus a section, control bus two voltage for +55V, -55V, back to normal, to confirm that this circuit caused by shorting.

(3) Section by section down the line, shorting point in the 5022 switch B phase mechanism box. Moisture was found inside the institution box, condensing on the top of the institution box, on the glass window, and dropping small drops of water from time to time.

(4) Dry out the interior by opening the box and ventilating it as well as drying it in the sun. Re-seal the structure, sprinkle water on the top of the structure box as well as the walls, and then check the inside

![Figure 3. Terminal block of PLC control cabinet.](image1)

![Figure 4. Dropping small drops of water.](image2)
of the structure box, and found that several screw holes on the door of the structure box were seeping inward, and there were also traces of rusty water flowing downward below the holes. After re-drying, the operator will seal the hole processing, check to switch protection, so record the insulation between the two sub-nodes to ground each other = 200M to meet the operating requirements.

Figure 5. Several screw holes on the door of the structure box were seeping inward water.

6. Effectiveness of ground fault handling methods
Be alert when there is water on the glass walls of the structure windows, as this indicates severe condensation and should be dealt with promptly. The cable inside the structure box is connected to the structure box from the bottom of the structure, which does reduce the inflow of rainwater from the inside of the cable air plug structure, but if there is moisture flowing in elsewhere inside the structure, the water will quickly flow to the low-lying cable jacks and cause a short circuit. This requires only a little process to handle, such as adding a sheath, which can be requested from the manufacturer at the time of purchase. Structure box heater is controlled by the temperature and humidity controller in the convergence box, for different cabinets of the institution box of abnormal temperature and humidity is not normal regulation, can be changed to a constant cast.

Figure 6. Water will quickly flow to the low-lying cable jacks and cause a short circuit.
7. Conclusion
This article introduces the inspection and treatment of a type of DC ground fault in a 500kV substation, analyzes the way to deal with direct ground faults through scientific investigation and research, and also elaborates on the water in the institution box leading to condensation, as well as the corresponding phenomena shown. The inspection of ground faults is guided by this form. The phenomenon and treatment of the above contents are commonly found in the DC system of 500kV substation, and also apply to DC elimination in other voltage levels with two independent DC bus substations. Reasonable handling of DC ground fault can, to a certain extent, guarantee the safety and stability of substation operation and provide people with high quality and efficient power services.

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