An analysis of generator trip caused by mistransmitting high temperature signal from excitation transformer

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Abstract. The excitation transformer is a device that specifically provides three-phase AC excitation power for the generator excitation system. The excitation system converts the three-phase power to the generator rotor DC power through the thyristor to form the generator excitation magnetic field, which is adjusted by the excitation system thyristor trigger angle, to achieve the purpose of adjusting the motor terminal voltage and reactive power. This article analyzes an accident in which the excitation transformer high temperature signal is erroneously caused to cause the unit to trip. The unplanned shutdown accident is specifically analyzed from the aspects of on-site situation investigation, cause analysis, main problems exposed, treatment and preventive measures.

1. Introduction
The safe and stable operation of the generator excitation transformer is the prerequisite for the safe and stable operation of the self-excited unit, the prerequisite for stable power generation and full load power generation of the generator set, and the key to the reliable operation of the excitation system. The electrical power required by the excitation system is obtained from the generator outlet. The role of the excitation transformer is to reduce the generator outlet voltage to the input voltage of the power thyristor, provide electrical isolation between the generator end and the excitation winding, and also serve as the power rectifying impedance of SCR [1].

2. Accident overview
At 12:18 on July 11, 2017, generator 4 has active power of 289MW, reactive power of 89MVAR, machine terminal voltage of 20.2kV, machine terminal current of 8596A, excitation current of 2151A, and excitation voltage of 241V. 12:19, Unit 4 tripped, SOE first reason "generator tripped", generator and transformer group protection C screen "excited regulator tripped" action, 204 switch tripped, tripped turbine, boiler MFT tripped, factory power fast The cutting action is normal. After inspection and treatment, Unit 4 was connected to the grid at 20:30.

3. On-site investigation

3.1. Equipment overview
The excitation regulator of Unit 4 is ABB's UNITROL 5000 product and excitation variable model RESIBLOC. It was put into production in June 2006 and the last maintenance date was October 2016. The excitation regulator is equipped with excitation variable temperature protection. After the
excitation variable three-phase temperature measurement point is judged, the outlet alarms or trips after judgment. It has a temperature rise rate blocking function[2].

3.2. Consult the fault message of the excitation regulator
The excitation regulator operates in channel one, from the high excitation temperature alarm (130℃) to the high excitation temperature trip (150℃), the time interval is 57 seconds, the relevant information is shown in Table 1.

Table 1. Relevant fault message information of excitation regulator.

| Date Time       | Code | Description          | Remarks (instructions)                        |
|-----------------|------|----------------------|-----------------------------------------------|
| Tue Jul 11 2017 | -103 | -Trafo temp. alarm   | Excitation transformer overtemperature alarm return |
| Tue Jul 11 2017 | 119  | +Standby alarm       | Standby channel alarm                          |
| Tue Jul 11 2017 | -157 | -Stabilizer active   | PSS return                                    |
| Tue Jul 11 2017 | -119 | -Standby alarm       | Standby channel alarm reset                   |
| Tue Jul 11 2017 | 137  | +Standby trip        | Standby trip                                  |
| Tue Jul 11 2017 | 6    | Trafo overtemp.Trip  | Overtemperature tripping of excitation transformer |
| Tue Jul 11 2017 | 119  | + Standby alarm      | Standby channel alarm                          |
| Tue Jul 11 2017 | 103  | +Trafo temp. alarm   | Overtemperature alarm of excitation transformer |

3.3. Consult the fault message of the excitation regulator
There is no large fluctuation in the parameters such as generator current, voltage, excitation variable current before and after the “excitation regulator inter-jumping” action on the C-screen of the generator and transformer group protection of Unit 4[3].

3.4. DCS curve inspection
The excitation system only transmits a phase B temperature to the DCS. The maximum temperature of the excitation change before tripping is 88.8 ℃. The parameters are normal.

3.5. Excitation change inspection and processing
(1) Open the excitation transformer cover and measure the temperature of the three-phase winding of the excitation transformer and the temperature of the core with a temperature thermometer. The surface temperature of the winding is about 60℃ (measured value half an hour after shutdown).

Check that the appearance of the excitation variable temperature measuring point (PT100) is not abnormal. After the measurement point is led to the DCS, the temperature measurement element is heated by a hot air blower. Among them, the phase A measurement point has a jump phenomenon during the heating process. The temperature change of phase A is shown in Figure 1.
(2) Check the high and low pressure side fans for excitation, a total of 6 fans are operating normally.
(3) Check and pre-examine the excitation change, the data are all qualified.

3.6. Checking and processing of excitation regulator
(1) Check the FIO board and simulate the PT100 signal with a precision rheostat. The temperature signal is sampled correctly, as shown in Table 2.

| The serial number | Resistance (Ω) | Temperature display value (℃) |
|-------------------|----------------|-------------------------------|
|                   |                | A phase | B phase | Phase C |
| 1                 | 100            | 1       | 0       | 0       |
| 2                 | 110            | 28      | 26      | 28      |
| 3                 | 120            | 54      | 52      | 54      |
| 4                 | 130            | 80      | 79      | 81      |
| 5                 | 140            | 107     | 106     | 107     |
| 6                 | 150            | 133     | 131     | 133     |
| 7                 | 151            | 137     | 135     | 136     |
| 8                 | 154            | 145     | 143     | 144     |
| 9                 | 155            | 147     | 145     | 147     |
| 10                | 156            | 150     | 148     | 150     |

(2) Test the signal of DI and DO points is normal; check the secondary terminal block of the excitation regulator, the connection is tight, and there is no looseness; check that the board and components are not loose or overheated.
(3) During the start-up process, the excitation system channel switching test is performed, and the switching is normal, and the voltage fluctuation meets the requirements of the regulations.

4. Cause analysis
(1) The excitation system of No. 4 unit sends "exciting regulator joint jump" to the C cabinet of the generator-transformer protection group, which is the direct cause of the unit tripping.
(2) The reason why the excitation system sends "exciting regulator jump": the temperature rise rate blocking logic (10 ℃ / 0.1s) of the excitation regulator cannot effectively block the sudden temperature change. When the temperature reaches the high temperature trip setting value, it will
cause the excitation system excitation to change the high temperature protection action, triggering the "exciting regulator joint trip" signal. The temperature measurement and detection logic of the excitation transformer is shown in Figure 2.

(3) The temperature at the measurement point of the excitation transformer reaches the tripping fixed value Reason: The temperature rise of the excitation transformer at 20 °C in the fault record of the excitation regulator only took 57 seconds, and the voltage and current of the generator and the excitation system were not abrupt at this time, and the temperature of the excitation transformer body No abnormality, combined with the sudden change of the A phase in the temperature measurement element during the heating test, it is judged that the output of the A phase temperature measurement element has an abnormal sudden rise, so that the excitation change temperature calculated by the excitation system reaches 150°C tripping value, causing the excitation change The high temperature signal is sent by mistake to protect the malfunction[4].

![Figure 2. Logic diagram of excitation transformer temperature protection.](image)

5. Main problems exposed
(1) Existing inspection methods cannot guarantee the validity of the temperature measurement components installed on excitation transformers and other equipment.

(2) The terms of the excitation transformer thermostat "transformer high protection should be alarmed to prevent malfunction of the temperature controller" are not well understood in the investigation of hidden dangers of electrical equipment, and the temperature signal is not directly connected to the excitation regulator Check and identify the existing risks in the way and take preventive measures[5].

6. Handling and preventive measures
(1) Modify the parameter control words 6003, 6004, and 6005 of the two channels of the excitation regulator, cancel the high temperature trip and alarm functions of the excitation regulator, connect the three-phase temperature measurement points of the excitation transformer to the thermal DCS, and display the temperature measurement points. Set a 110 °C pop-up window alarm to realize the monitoring function, and at the same time strengthen the operation monitoring, and contact and deal with it if it finds over temperature.

(2) Check the related logic of the excitation regulator and modify the similar hidden dangers (no other factors that may cause temperature protection actions are found).

(3) Check whether the excitation regulator of other units has the same type of hidden danger, and refer to Unit 4 for rectification[6].

(4) Study and formulate the special inspection method and verification cycle of the temperature measuring element fixedly installed on the relevant equipment.
(5) Immediately organize a "safe production discussion" to further raise awareness, grasp risk pre-control, and effectively build a safe production foundation.

7. The conclusion
The excitation transformer temperature protection outlet method does not have clear requirements in the corresponding regulations and standards, which leads to the unreasonable configuration of the excitation transformer temperature protection outlet method in some power plants. Due to the failure of the excitation variable temperature measurement element, the unit trips occur frequently. The analysis case given has a good reference.

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