

PAPER • OPEN ACCESS

Analysis and Countermeasure of Burnout of Electromagnetic Voltage Transformer of High Altitude Area in Western China

To cite this article: Li Hongbo *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **366** 012063

View the [article online](#) for updates and enhancements.

You may also like

- [Overheating Fault Analysis of Electromagnetic Unit in 220kv Capacitive Voltage Transformer](#)
Jianchun Xu, Wei Sui, Yebin Song et al.
- [Research on Simulation and Calculation of Temperature Field and Pressure of High Voltage Transformer](#)
Houyang Fan, Jian Wu, Xuan Fei et al.
- [Monitoring the metering performance of an electronic voltage transformer on-line based on cyber-physics correlation analysis](#)
Zhu Zhang, Hongbin Li, Dengping Tang et al.



ECS
The Electrochemical Society
Advancing solid state & electrochemical science & technology

DISCOVER
how sustainability intersects with electrochemistry & solid state science research

Analysis and Countermeasure of Burnout of Electromagnetic Voltage Transformer of High Altitude Area in Western China

Hongbo Li¹, Yongbin Bao², Pei Li¹, Wenqi Xu², Yanyan Zhang¹, Tailong Si¹ and Jiadong Guo¹

¹State Grid of China Technology College, Jinan 250002, China

²Yushu Electric Power Supply Company of National Power Grid, Yushu 815000, China.

13305318311@163.com

Abstract. 3 burning accidents of electromagnetic voltage transformer of Qinghai power grid in the southern high altitude area was introduced in this paper, and the cause of the accident was analyzed, which is due to a phase grounding line, then the other two phases voltage rising caused voltage transformer damaged; occurrence of Ferro resonance over-voltage, which resulting in serious core saturation, and the over-current caused voltage transformer damaged; due to open delta is short circuit, when the single-phase grounding fault occurred, because the voltage output of 100 V from open delta winding, a very large current is formatted, and a lot of heat is made, also led to the current in primary side very large, resulting in burning TV. In view of these three reasons, the corresponding prevention measures are put forward to ensure the normal operation of the power system.

1. Introduction

In the 3~35kV neutral point ungrounded grid, a large number of electromagnetic voltage transformers are installed on the bus line to monitor the Three-Phase phase voltage of power system. Because the power distribution units mostly adopt indoor cabinet structure, the installation of the equipment in the cabinet is compact, and the small volume voltage transformer is required. After many years of practical operation, the pouring type voltage transformer is small in size and reliable in operation, which is suitable for switch cabinet operation, and also meets the development requirements of switch cabinet without oil. In this paper, several 10kV electromagnetic voltage transformer burnout accidents in high altitude area of Qinghai power grid are analyzed and summarized; at last, corresponding preventive measures are put forward[1].

2. Accident Process

2.1 35kV Substation A

One day, 22:00, * line B phase line in 110kV substation * is grounding, At the same time, the C phase voltage is abnormal, and the #3521 circuit breaker is opened in the distance, and the equipment is required to be checked in the field. Through on-the-spot checking, Operation and maintenance personnel found that the cabinet closed door 35kV I bus open, the whole cabinet body deformation, side opening. After examination, the appearance of TV in A phase was normal, The B phase TV has a burn mark on the side of the C phase, and the C phase TV burst, harmonic elimination device crack.



And Figure 1 is the burning accident diagram of this TV.



Figure.1 the 35kV Voltage Transformer Burning Accident Diagram

2.2 110kV Substation B

The substation is 4200 meters above sea level. A dispatch notification is received at 15:16 a day, and the voltage of the B10kV bus voltage of the substation B phase voltage disappears. At 19:20, Operation and maintenance personnel arrive at the station to check 10kV and 35kV high voltage rooms, after entering, there was a strong smell of smoke. The protection action information of overcurrent I section on the protective device of * Road is found at 10:08. The operation and maintenance personnel apply for the 10kV bus TV to be checked carefully after the operation of the reacting scene. At 20:15, the operation and maintenance personnel opened the 10kV cabinet door, and found B phase TV burst. And figure 2 is the burning accident diagram of this TV.



Figure.2 the 10kV Voltage Transformer Burning Accident Diagram

2.3 35kV Substation C

The substation is 3800 meters above sea level. At 22:19 one day, the dispatch department noticed that low backup protection of #1 main transformer in this substation have actioned. Measurement and control device display the bus-bar TV broken line and alarm. At second days 09:00, the dispatching department notifies the voltage anomaly of the 10kV bus in the substation. At 13:16, operation and maintenance personnel arrive at the scene, and found the 10kV TV door opened by burst. At 13:37, apply for the dispatch department to transfer the 10kV bus TV to the overhaul. At the same time, open the door to check, found TV explosion, at 14:40 the 10kV bus TV isolation after the restoration of power supply. And figure 3 is the explosion scene diagram of this TV.

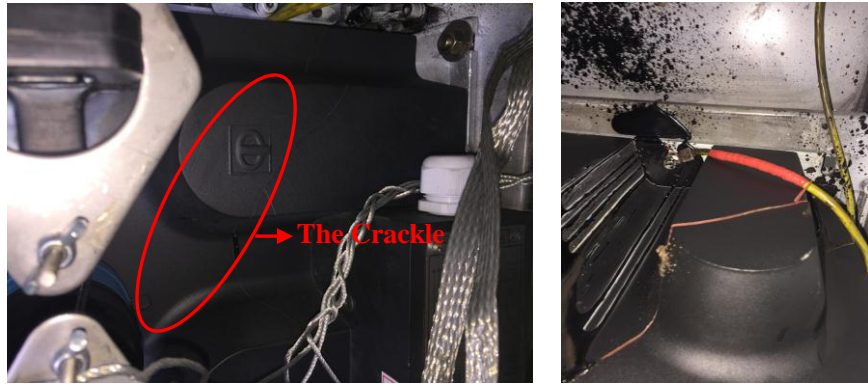


Figure.3 the 10kV Bus TV Explosion Scene Diagram

3. Analysis of the Cause of the Accident

3.1 35kV Substation A-caused by Single-phase grounding fault.

After investigation, we found that B phase of the single-phase ground fault occurred at 22:00, the phase voltage of A and C phase changes into line voltage, resulting in C phase 35kV voltage transformer explosion. When B is connected to the ground, the equivalent circuit diagram is shown in Figure 4.

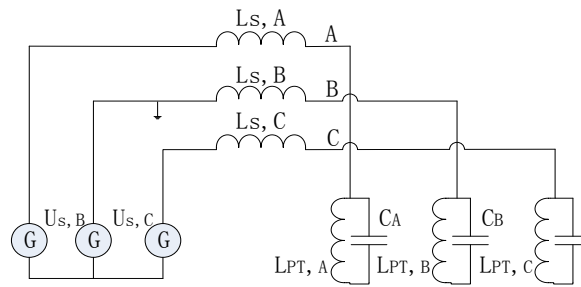


Figure.4 Equivalent Circuit Diagram of B-phase Grounding

The instantaneous flux of the C phase Φ_U is as follows:

$$\Phi_U = \sqrt{3}\Phi_m \sin(\omega t + \alpha - \pi/3) + [\Phi_r - \sqrt{3}\Phi_m \sin(\alpha - \pi/3)]e^{-(R_1/L_1)t} \quad (1)$$

From the formula (1) we can obtained that: The main parameters affecting the instantaneous magnetic flux in the core are the initial phase angle α and the remanence Φ_r when the failure occurs. It can be seen that when single phase grounding occurs, the voltage of the non-fault phase is abrupt to the line voltage; the core enters the saturation area and produces inrush current in the winding. When the core enters the depth saturation, its inrush can reach dozens of times of the steady current, and its heat is enough to cause the damage of the voltage transformer [2].

3.2 110kV Substation B-caused by ferromagnetic resonance

From analysis of the information collected from the protection device and its fault recorder, at 14:55 we found that U_a, U_b, U_c all change suddenly; U_b, U_c transcends the upper limit, and U_a goes beyond the lower limit. A-phase voltage disappears, indicating the occurrence of grounding fault in A-phase.

Because the power neutral point of the system is insulated to the ground, the neutral point of the primary winding of the voltage transformer is directly grounded, and the open triangle zero sequence winding open circuit. The 35kV line is unloaded line, the line to ground capacitance is larger than the line impedance, and line voltage will increase. And when the bus-bar is unloaded or less line, closing

the charge or eliminating the ground fault during operation, the ground capacitance of the power grid is matched to the excitation inductance of the B phase voltage transformer. When a grounding fault occurs in A-phase, the condition of the excitation of ferromagnetic resonance is produced, which makes the core of the voltage transformer saturate and produces the neutral point displacement. These conditions are met, so the judge is ferromagnetic coil voltage transformer Ferro-resonance, excitation inductance decreases, the saturation voltage transformer excitation current depth will increase sharply, and finally burned B-phase TV. Figure 5 is the voltage waveform diagram when a metal grounding fault occurs in A-phase.

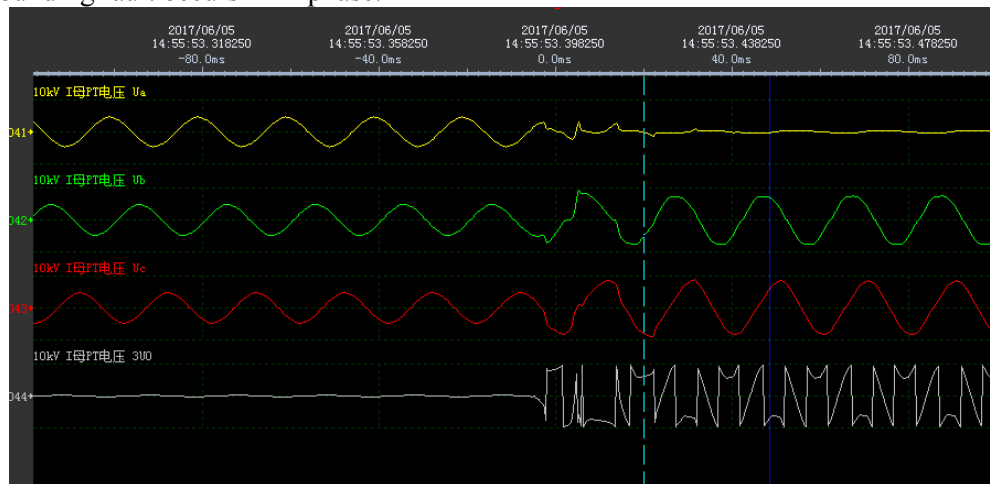


Figure.5 Voltage Waveform Diagram When a Metal Grounding Fault Occurs in A-phase

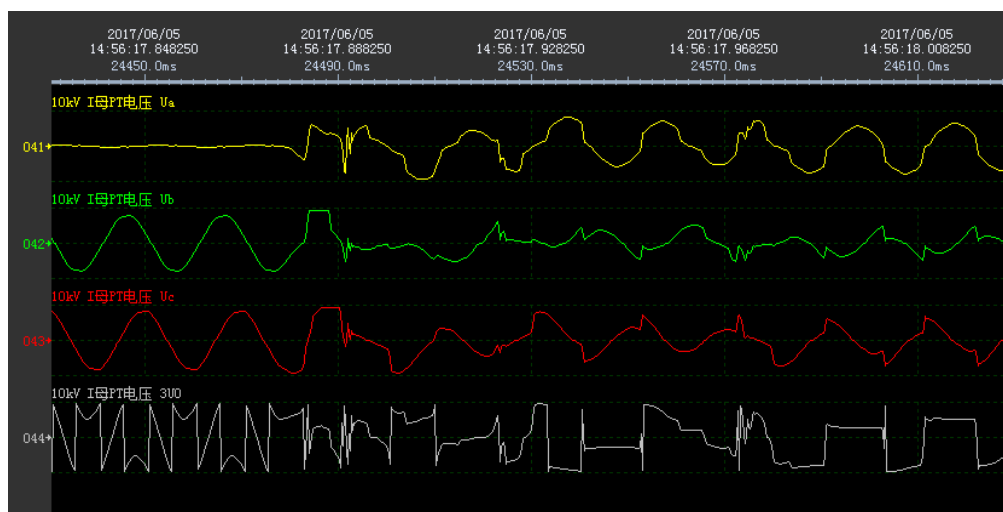


Figure.6 Voltage Waveform Diagram with Ferromagnetic Resonance

In the medium voltage power grid, the voltage transformer is directly installed on the bus. Because of the capacitance of the circuit, the TV will form a zero sequence circuit with the inductance of the transformer, and the system equivalence diagram is shown in Figure 6.

The operation and experiment of the power system show that when the inductance of the TV and the line are matched to the ground capacitance, it produces Ferro-resonance at different frequencies under certain conditions. With the increase of line length, 3 harmonic harmonic resonance, fundamental frequency resonance and frequency division resonance will occur in turn [3]. An equivalent circuit diagram of the system is shown in Figure 7.

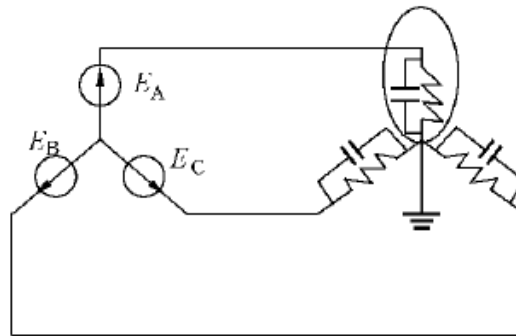


Figure.7 Equivalent Circuit Diagram of the System

3.3 35kV Substation C-caused by open-delta short circuit

After the field investigation, it was found that the two lines of C601 in the TV cabinet were bonded together with the N600 insulated wire skin as shown in figure 8. Unlock the secondary line of the TV side and check it. It is found that the secondary line N600 in the TV cabinet is connected with the L650, and the discharge coils of the N600 and the capacitor in the 10kV capacitor cabinet are found together. The open triangle is short circuited. Under normal conditions, the output voltage of the open triangle winding is basically 0, so the $3U_0$ is 0. The short circuit of the open triangle winding does not affect the normal operation of the voltage transformer. When a single-phase grounding fault occurs, the voltage of the open triangle winding output is 100 V. Once the connection is short circuited, that is, the secondary side of the voltage transformer is short circuited, which will form a very large current and heat, and will lead to a large current in primary side. It eventually led to the burning of TV.

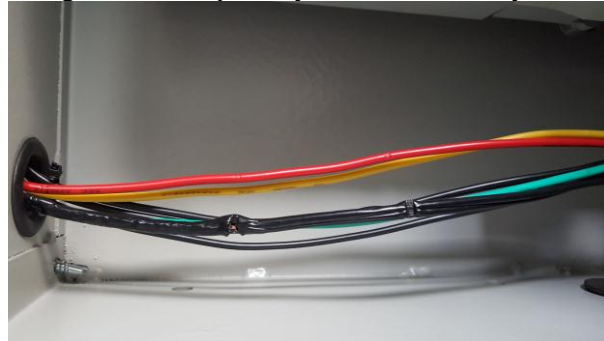


Figure.8 Secondary Connection Short Connection Schematic

4. Measures to Prevent the Burning of Voltage Transformers

4.1 Prevention and control measures of transformer damage caused by single-phase grounding fault

In this case, the measures taken are:

- 1) To improve the insulation level of the distribution network and reduce the condition of single-phase grounding;
- 2) To add appropriate arc suppression coil to restrain the occurrence of intermittent arc grounding;
- 3) To improve the excitation characteristics of the voltage transformer so that the voltage transformer is not easy to enter the saturation area.
- 4) To adopt a new type of heat resistant material to increase the heat resistance of voltage transformer.

4.2 Prevention and control measures of transformer damage caused by ferromagnetic resonance

In this case, the measures taken are:

1) Installing a micro-computer harmonic elimination device at the open triangle terminal of the remaining voltage winding.

This device can identify various forms of ferromagnetic resonance overvoltage, including frequency division, fundamental frequency, and three frequency doubling. When a certain resonance is determined, a specific harmonic elimination program is introduced. The open delta winding is short circuited, and the damping current is output to the grid, so that the resonance overvoltage is eliminated quickly. At the same time, it is noted that the voltage transformer is a full insulation design.

2) Parallel one resistance (incandescent lamp) in the remaining voltage winding open triangle terminal. Linear damping resistors or incandescent lamps are installed at the opening end of the TV open triangular winding. This method is simple and is especially easy to be realized. When the excitation characteristic of TV is good, it can play zero sequence damping effect, but because the resonance excited by non-metallic grounding cannot be restrained, the high voltage fuse of TV is easy to fuse.

3) Grounding the neutral point of the high voltage side of the transformer through the high impedance zero sequence transformer

The zero sequence TV is connected to a neutral point at TV, which is called the 4TV connection mode. The zero sequence measurement loops in Figure 9 is a measurement coil of the open triangle and zero sequence voltage transformer of a three-phase voltage transformer in series with positive polarity. It contains a few partial zero sequence voltages of the three-phase voltage transformer. At the same time, the zero sequence circuit is not too short, and the zero sequence current is not too large to avoid the burn out of the zero sequence loop winding. This method is more effective for eliminating resonance and restraining ultra-low frequency oscillation.

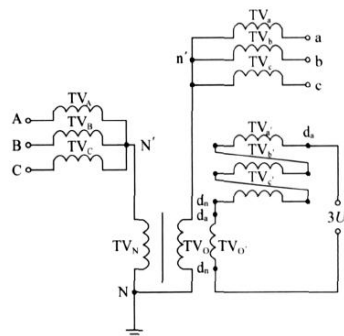


Figure.9 4TV Open Triangle and Zero Sequence Voltage Transformer Series Principle Diagram

4) To connected a LXQ type harmonic eliminator between the neutral point and the ground of the primary side of TV

The most important feature of the LXQ harmonic eliminator is that it can effectively limit the primary side inrush of TV, prevent the fusion of TV high voltage fuse and eliminate the resonance phenomena of various harmonics. The resonance overvoltage excited by non-metallic grounding can also be suppressed. In comparison, the principle of primary side harmonic elimination is to suppress the inrush, so that the resonance is not easy to expand at the beginning, and it is eliminated in the bud. The secondary side harmonic elimination is eliminated after the resonance, and there is a response time problem, so the effect of primary side harmonic elimination is better than that of the two harmonic elimination effects [4].

4.3 Prevention and control measures of mutual inductor caused by open triangle short circuit

The direct cause of the 10 kV voltage transformer fault is the short circuit of the two connection of the open triangle winding of the voltage transformer. If the secondary wiring of the secondary opening trigonometric winding of the voltage transformer is short circuited by the construction unit, it is difficult to find the conventional inspection and acceptance. When the equipment is running normally, the external check will not find any exception. Or the short connection of the secondary connection leads to the open triangle short circuit. In this case, there is no problem when the system is running

normally. Only when the single phase grounding fault occurs will cause serious damage to the voltage transformer equipment. Therefore, it is suggested that in the process of substation completion and acceptance and operation inspection, we should strengthen the wiring inspection of the secondary opening triangular circuit of voltage transformer, so as to avoid the occurrence of open triangular short circuit [5].

5. Conclusions

About the phenomenon of frequent burnout of 10~35kV electromagnetic voltage transformer in high altitude area of Qinghai power grid, It should be combined with the characteristics of high altitude, The reasons such as grounding fault of line, ferromagnetic resonance and open triangle short circuit are taken into consideration. The corresponding prevention and control measures are taken to avoid similar accidents and ensure the normal operation of the system.

Reference

- [1] Zhu Tao,Zhang Hua. Practical Operation Technology of Substation Equipment [M]. China Electric Power Press,2014:105.
- [2] Che Weihong,Chen Runying etc. Analysis of the cause of voltage transformer damage caused by single-phase grounding fault in 10kV power grid [J]. Guangdong Electric Power, 2016,29 (1): 113-117.
- [3] Lin Quan. The cause and solution of the explosion of 10kV electromagnetic voltage transformer [J]. Power Equipment, 2005,6(12): 71-73.
- [4] Zhang Li. Anti-resonance measures of 10kV voltage transformer [J]. Jiangsu electrical, 2007,5 (4): 40-42.
- [5] Chen Zhiyong. Fault analysis of 10kV voltage transformer caused by single-phase grounding [J]. Power safety technology, 2016,18 (6): 23-24.