The influence of secondary wrong wiring of voltage transformer on measurement error

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Abstract. In this paper, the influence of mutual opposition error between the standard secondary line at the end of the test bench and the tested secondary line in the error test of voltage transformer is analyzed, and the corresponding solutions are proposed for the wrong wiring.

1 Introduction

Voltage transformer is the key equipment of power system, The voltage transformer handover test is an effective detection method in the equipment handover process, and the error measurement is an important verification item in the voltage transformer handover test.[1] During a routine inspection of 10kV voltage transformers, technicians found that the errors obtained in this batch of voltage transformer error tests did not match the voltage transformer error characteristics. In the article, we analyze the problems that occurred during the test, find the root cause of the error, conduct in-depth research, and give corresponding solutions.[2]

2 Test phenomenon analysis

The equipment used in this test includes：HES-1C test bench, regulator, booster, 10kV voltage transformer standard, load box. The test phenomenon is as follows：
no alarm signal is generated during the test, the ratio difference in the fully loaded data is positive, showing an upward trend, angle difference is negative, showing a downward trend. In the light load data, the ratio difference and angle difference are both negative. According to the phenomenon of this test, the technicians look for the cause of the failure.Common problems during the error test include reverse polarity, secondary open circuit, wrong wiring, etc.The test bench HES-1C has a polarity check function. When the error test is normal wiring, it can check whether the polarity of the transformer is correct.[3]

If the polarity is abnormal, an error alarm will be generated when the voltage is raised with a voltage regulator. Since there is no alarm signal in this test, the problem of reverse polarity is first ruled out. [4]Because of the abnormal error in this test, the test bench, voltage regulator, booster, voltage transformer and load box are replaced and sent for inspection in turn, and no

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abnormality is found. Then the test wiring is carefully checked, and it is finally found that the source of the error is the standard secondary line T_0 of the voltage transformer at the test bench and the tested secondary line T_x, which causes an abnormal error. This article analyzes and discusses this kind of wrong wiring in depth.[5]

3 Problem analysis

When testing the voltage transformer in the laboratory, the technician compares the measured voltage transformer with the standard voltage transformer of the same rated transformation ratio.

The booster supplies the same primary voltage of the standard voltage transformer and the measured voltage transformer are supplied with the same primary voltage from the booster. The secondary voltage of the standard voltage transformer passes through the standard circuit of the transformer calibrator. The difference between the secondary voltage of the measured voltage transformer and passes through the differential loop of the transformer calibrator. Error data is read by transformer and calibrator.[6]

This test uses the measurement error of the low potential end of the comparison circuit, the voltage transformer verification circuit diagram is shown in Figure 1 below.In the picture is a voltage regulator, used to adjust the output voltage.is a booster, which cooperates with a voltage regulator to provide the measured voltage transformer plus the rated load, is a standard voltage transformer, and its voltage ratio is the same as the voltage transformer under test. HE is a transformer calibrator, used to test the ratio of the differential voltage to the phasor of the secondary voltage, that is, the error of the tested voltage transformer relative to the standard voltage transformer. When the voltage transformer standard secondary line and the tested secondary line are exchanged at the end of the error measuring device, the wiring diagram is shown in Figure 2. [7]We carry out two error measurements for

correct wiring and wrong wiring of a batch of transformers. Table 1 is the measurement data of Dalian

Jin ye voltage transformer A, B, C.

Table. 1 10kV Error data of correct wiring and wrong wiring of voltage transformer

| Serial number	Secondary load	Rated voltage percentage	Correct wiringε	Correct wiringδ	Wrong wiringε	Wrong wiringδ
002647	30VA	80%	-0.103	+1.7	+0.104	-1.7
		100%	-0.108	+1.7	+0.105	-1.7
		120%	-0.108	+1.9	+0.109	-1.9
	3.75VA	100%	+0.160	+0.5	-0.159	-0.5
002573	30VA	80%	-0.104	+1.9	+0.109	-2.0
		100%	-0.112	+2.2	+0.119	-2.3
		120%	-0.121	+2.5	+0.123	-2.5
	3.75VA	100%	+0.150	+0.8	-0.147	-0.8
002609	30VA	80%	-0.105	+2.1	+0.110	-2.1
		100%	-0.108	+2.2	+0.111	-2.2
		120%	-0.113	+2.4	+0.115	-2.4
	3.75VA	100%	+0.159	+0.6	-0.155	-0.6
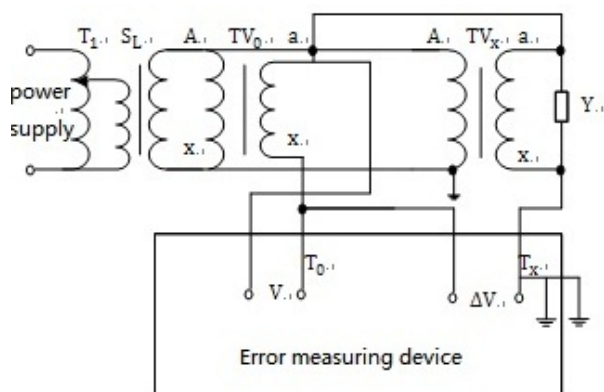
Figure 1 Correct wiring and compare lines (Low potential end measurement error)
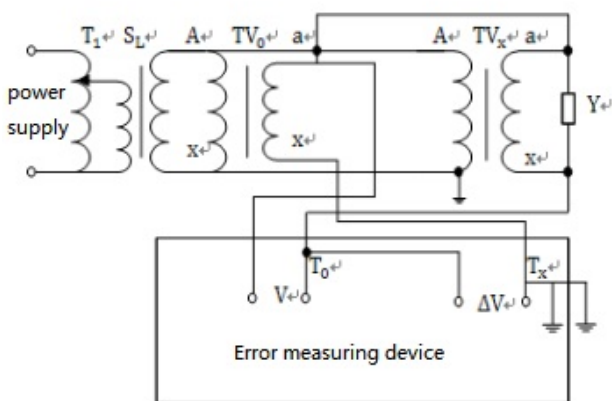

Figure 2 Wrong wiring comparison line（Low potential end measurement error）

Set the secondary voltage $\dot{U}_{20}$ of the standard voltage transformer as the working voltage: $\dot{U}=\dot{U}_{20}$

$$\Delta\dot{U} = \dot{U}_{2x} - \dot{U}_{20} \tag{1}$$

$$\Delta\dot{U}=\Delta U_r+j\Delta U_x \tag{2}$$

So the ratio difference and angle difference of the tested voltage transformer are：

$$f_u=\frac{\Delta U_r}{U_{20}} \tag{3}$$

$$\delta_u=\frac{\Delta U_x}{U_{20}} \tag{4}$$

K_u-- The switching coefficient when measuring the error of the voltage transformer.

K_x、K_y-- The degree of the calibrator in-phase disk and quadrature disk.

When T_0 and T_x are reversed, the measured error is as follows：

$$\Delta\dot{U}_w = \dot{U}_{20} - \dot{U}_{2x}=-\Delta\dot{U} \tag{5}$$

$$\Delta\dot{U}_w=\Delta U_{rw}+j\Delta U_{xw}=-\Delta U_r+j(-\Delta U_x) \tag{6}$$

$$\Delta U_{rw} =-\Delta U_r \tag{7}$$

$$\Delta U_{xw} = -\Delta U_x \tag{8}$$

$$\dot{U}_w = \dot{U}_{2x}$$

So the ratio difference and angle difference of the tested voltage transformer are：

$$f_{uw}=\frac{\Delta U_{rw}}{U_{2x}} = \frac{-\Delta U_r}{U_{2x}}=\frac{-\Delta U_r}{U_{20}} \times \frac{U_{20}}{U_{2x}}=\frac{-\Delta U_r}{U_{20}}\left(1 + \frac{U_{20}-U_{2x}}{U_{2x}}\right) = -\frac{\Delta U_r}{U_{20}}(1 + K_p) \tag{9}$$

$$\delta_{uw}=\frac{\Delta U_{xw}}{U_{2x}} \times 3438=\frac{-\Delta U_x}{U_{2x}}=\frac{-\Delta U_x}{U_{20}} \times \frac{U_{20}}{U_{2x}}=\frac{-\Delta U_x}{U_{20}}\left(1 + \frac{U_{20}-U_{2x}}{U_{2x}}\right)=-\frac{\Delta U_x}{U_{20}}(1 + K_p) \tag{10}$$

$$K_p = \frac{U_{20} - U_{2x}}{U_{2x}}$$

According to "Measurement Voltage Transformer" JJG314-2010 regulation, the standard device should be two higher accuracy levels than the tested voltage transformer, The actual error should not be greater than $\frac{1}{5}$ of the error limit of the tested voltage transformer. The daily verification of the voltage transformer level is 0.2,then the standard transformer standard is 0.05.That is:$|K_p| \leq \frac{0.05+0.2}{(1-0.05) \times(1+0.2)} = \frac{25}{114} \approx 0.22$.
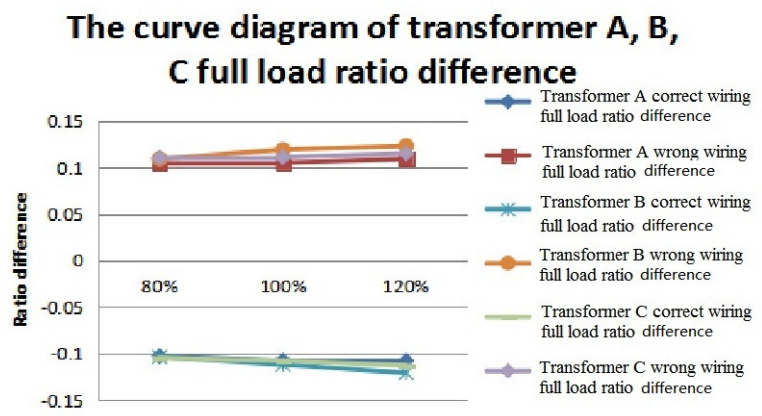
Figure 3 The curve diagram of transformer A, B, C full load ratio difference
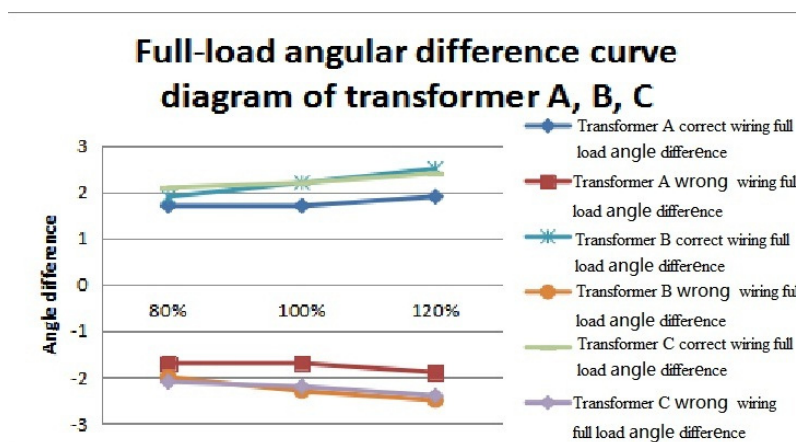

Figure 4 Full-load angular difference curve diagram of transformer A, B, C

Figure 3 and Figure 4 are the comparison diagrams of the ratio difference and the angle difference between the correct and incorrect wiring of the voltage transformer in Table 1.It can be clearly seen from Fig. 3 and Fig. 4 and formulas (9) and (10),after wrong wiring, the signs of the ratio and angle differences are opposite to those of the correct wiring, and the absolute value is not much different.[8]When the wiring is correct, the full load ratio difference is negative, and decreases with the increase of voltage,angle difference is positive and increases with the increase of voltage.The light load ratio difference is positive, and the angle difference is positive,When T_0 and T_x are reversed, the measured full load ratio difference is positive, and it increases with the increase of the positive voltage,the angle difference is negative and decreases with the increase of voltage,the light load ratio difference is negative, the angle difference is negative.[9]

4 Solution

Wrong wiring in the transformer error experiment, especially the wrong wiring at the end of the calibration station, often occurs during equipment replacement and equipment inspection,but this type of wrong wiring is slightly different from the wrong wiring of the tested terminal.The error of the voltage transformer tested by this type of wrong wiring will not have wrong polarity,

not easy to appear out of tolerance, and easy to be ignored, which affects the fairness, accuracy and reliability of the verification result to a certain extent.In order to effectively solve this problem, you can mark the wiring at the end of the error experiment test bench, or use different color lines to distinguish, to prevent wrong wiring during the equipment inspection or replacement process, which affects the detection accuracy.[10]

5 Conclusion

The above analysis of the abnormal error is caused by the wrong wiring of the voltage transformer in a laboratory, and corresponding solutions are proposed. In daily calibration work, the verification principle and verification circuit of general transformers should be proficient. For commonly used transformer testers, standard transformers, load boxes, etc., they should be verified regularly to ensure that the verification results are accurate.

Acknowledgments

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