Investigation on the effect of the Secondary Connection mode on the Error Measurement of Voltage Transformer

SHI Qiang[1, a], LI Weiwei[2,b], LIU Kun[1] and ZHANG Peng[1]

[1]Sichuan Electric Power Corporation Metering Center, Chengdu 610072, China

[2]State Grid Sichuan Electric Power Research Institute, Chengdu, 610049, China

[a]email:awaityou1986@gmail.com, [b]email: liweiwei0830@163.com

Keywords: secondary wiring, voltage transformer, error detection, electric energy measurement

Abstract. Site error measurement of voltage transformer is important content of electric energy metering device administration, relating to accuracy of electric energy measurement and just trade settlement for power plant and power corporation. In this work, the error measurements of voltage transformer in different secondary connection modes were investigated. The effect of the secondary connection mode on the error survey data was discussed, and the optimal mode of secondary connection was found.

Introduction

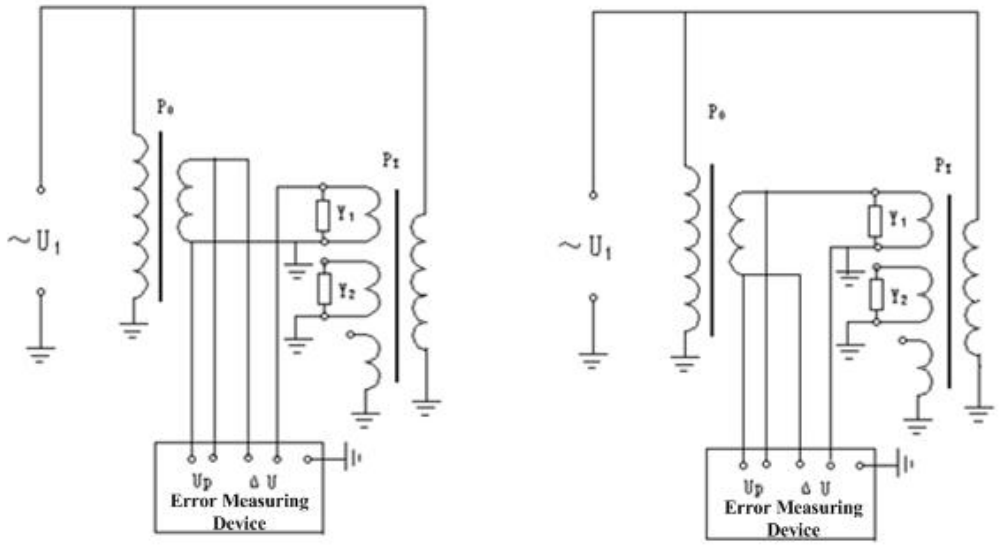
Equipped with multiple functions such as system monitoring, signal transformation and electrical isolation, power transformers have been the primary equipment used widely in power grid. At the same time, the error conditions and stability of the instrument transformer applied in electric power measurement directly affects the trade settlement between the two parties producing and supplying electric power, and plays a decisive role in strengthening the power management and in precisely calculating the generating capacity and power supply volume, regional mutual power supply capacity and line loss power expenditure. According to the Regulations on the Technical Administrative Code of Electric Energy Metering(DL448-2000) and the Verification Regulations on Power Transformer(JJG1021- 2007) as well as related regulations of State Grid Corporation of China, all the electric energy equipment(including voltage transformer) should receive on-spot error detection from corresponding departments authorized by the state government and the work should be carried out periodically [1- 3].

Principle of Error Measuring for Voltage Transformer

The Verification Regulations on Power Transformer (JJG1021- 2007) clarifies error detection methods of voltage transformer with its principle explained in Figs 1 and 2. The high-voltage power in Fig 1 is for testing transformer, mainly used to test electromagnetic transformer. Series resonance booster is applied in Fig 2, mainly used to test capacitor voltage transformer (CVT). In Figs 1a and 2a, it used secondary terminal of high voltage to detect error. If the error measuring device is only applicable to secondary terminal of low voltage side, approach of wiring and error detection is shown in Fig 1b and Fig 2b as follows.

In the case of the shutdown of equipment power, the standard voltage transformer(P_0) is connected with the tested transformer(P_x) in parallel; then, the secondary circuit of the tested transformer is linked with secondary load(Y_1,Y_2); through comparing the secondary output voltage values of standard voltage transformer and tested transformer with rated secondary load and lower limit load, the error measuring device is used to calculate the error value of the tested transformer [4-5]. Errors of voltage transformer include ratio error (ratio difference) f_U and angular error (phase difference) d_U.

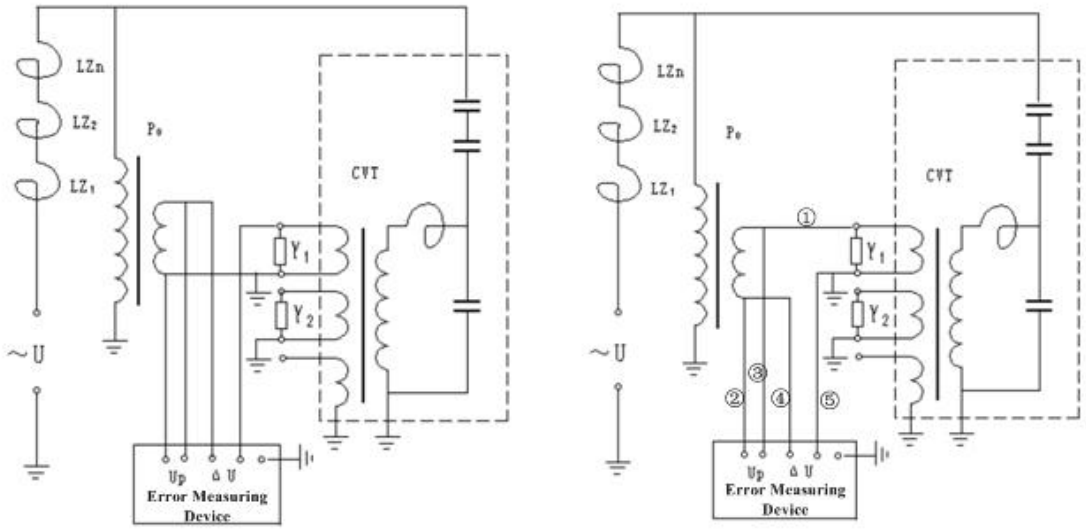
Metering winding (1a, 1n) of the tested voltage transformer is connected with the secondary load Y1 and protective winding to the secondary load Y2, while the remaining winding is free from such connection. The rated secondary load of the tested voltage transformer refers to the maximum secondary load allowed on the nameplate of the transformer equaled with both that of the metering



(a) error detection by high voltage terminal (b) error detection by low voltage terminal

Figure 1 Wiring diagram for error measurement of electromagnetic transformer

P_0—standard voltage transformer, P_X—voltage transformer be tested, Y_1, Y_2—voltage load box



(a) error detection by high voltage terminal (b) error detection by low voltage terminal

Figure 2. Wiring diagram for error measurement of CVT

LZ_1～LZ_n—resonance reactor, P_0—standard voltage transformer,
CVT—capacitor voltage transformer be tested, Y_1, Y_2—voltage load box

winding and the protective winding, and the lower limit of the secondary load refers to the secondary load produced when 1a, 1n is connected to 2.5VA, and 2a、2n to 0VA. Y1 and Y2 achieve shifts of different secondary load through load box.

In order to reduce the influence of the internal resistance of the test lead wire and contact resistance on error testing, and to ensure that the voltage values of the voltage transformer are precisely delivered to the error testing device, usually a strong input resistance is designed to fit the error testing device.

Experimental Condition

Existing experimental facilities are applied to simulate the on-spot actual testing in labs and capacitor voltage transformer is selected as the test object. The nameplate information is as follows: Type: TYD110/√3-0.02H, Scale: 0.2, Ratio of transformation: 110/√3/0.1/√3, Rated secondary load: 50VA(metering load)/100VA(protective load), manufacturing period: Aug 2009.

Wiring principle of the test equipment is demonstrated in Fig 2(b). The different ways of secondary wiring are shown in Fig 3. In on-site testing, single core cable is applied to the connection between the tested voltage transformer and the standard one (line one in Fig 2(b) and line I in Fig 3). Three-core cable is applied to the connection between standard voltage transformer and error testing device (line 2,3,4 in Fig 2(b) and also line II in Fig 3). The mode of wiring of line I and line II is much more stable, requiring only direct connection. Single core wire is also applied in the connection between tested voltage transformer and error testing device(line 5 in the Fig 2(b)) , whose connecting mode is shown by a dotted line in Fig 3 with 4 ways and they are: ①the wire share the same side with line I and line II ; ②the wire, together with line I and line II winds the standard voltage transformer. ③the wire, together with line I and line II winds both standard voltage transformer and electric reactor. ④the wire, together with line I and line II winds standard voltage transformer, electric reactor and transformer.

In accordance with methods in the regulations, error testing of tested voltage transformer is carried out according to the above-mentioned conditions respectively. Fig 4 is the scene of the test carried out in the lab.

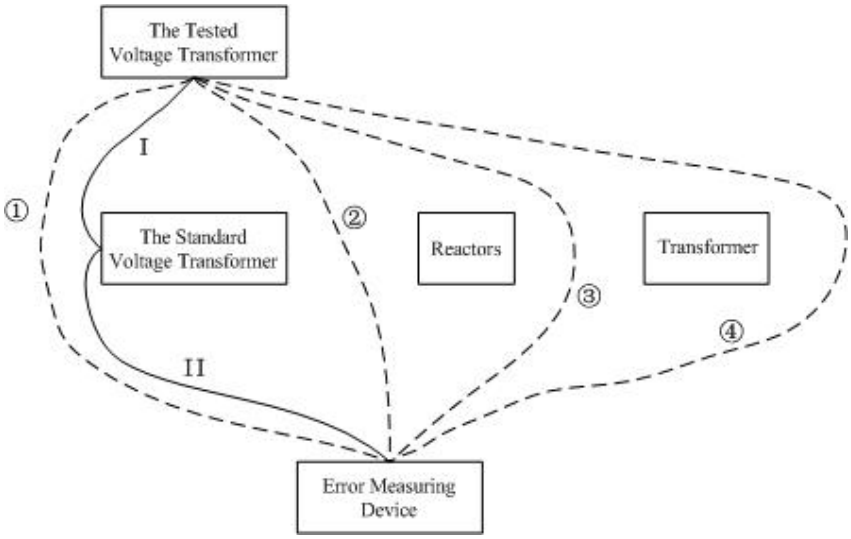


Figure 3. Different ways of secondary wiring

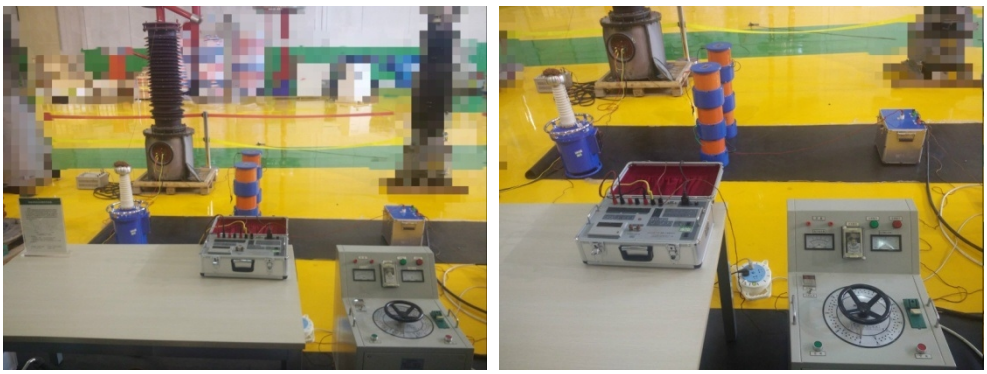


Figure 4. The test in laboratory

Data Analysis

Error test data is listed in Table 1. The following results have been found through the comparative test: among the above-stated conditions, there is a big difference in the error data of the test object; the ratio difference value in the second condition increases 0.1% compared with that in the first condition, while the phase difference decreases 1 degree; the ratio error value in the third and fourth condition reduces 0.2% compared with that in the first condition, while the phase difference increases about 5 degrees; in the lower limit load, the trend and scope of error variation is almost at the same level. Both the third and the fourth conditions exceed error limit of level 0.2 required in the Verification

Regulations on Power Transformer(JJG1021- 2007), which requires the ratio difference should be controlled no less or more than 0.2%, the angular difference within 10 degrees.

According to the analysis of the test principle of detecting system, it has been found that in the condition ②, ③ and ④, because the secondary connection winds high-voltage apparatus including voltage transformer, electric reactor and transformer, induced current has been produced in the circuit of secondary connection through electronic-magnetic induction, thereby affecting the input signal of the error testing device and leading to an abnormal test result. Meanwhile, because high voltage produced in equipment such as standard voltage transformer, electric reactor and transformer differ from each other in terms of the phase position, and the distance between the secondary line and several high-voltage apparatus differs, thus, the induced current and phase position produced in the circuit of secondary connection are also different, further causing the extent and trend of the data variation of error test in the above-mentioned conditions.

The verification regulation stipulates the influence of wiring in the work on the error detection of voltage transformer should be controlled within 1/10 of the regulated intrinsic error of the tested instrument transformer. To the instrument transformer on the scale of 0.2, ratio error variation should be kept within 0.02%, angular variation within 1 degree. Thus, the second, third and fourth conditions fail to meet the measurement requirement. In real conditions, it is noted that the adoption of the first approach, that is, making all the secondary connection at one side of the high-voltage equipment, is able to avoid the development of induced current and improve the precision of the measurement result.

Electromagnetic voltage transformer and the capacitor voltage transformer share the same testing principle, thus they are also in coincidence with the announcements about the secondary wiring.

Table.1 Error detection date of the tested transformer in the different ways of secondary wiring

connection mode	error category	error (rated voltage)	secondary load(VA)	power factor
①	f/(%)	-0.003	50	0.8
	δ/(')	3.7		
	f/(%)	0.064	2.5	
	δ/(')	0.3		
②	f/(%)	0.096	50	
	δ/(')	2.8		
	f/(%)	0.159	2.5	
	δ/(')	1.0		
③	f/(%)	-0.290	50	
	δ/(')	5.8		
	f/(%)	-0.225	2.5	
	δ/(')	4.1		
④	f/(%)	-0.225	50	
	δ/(')	5.4		
	f/(%)	-0.161	2.5	
	δ/(')	3.8		

Conclusion

Experiments and researches have revealed the influence of different secondary wiring modes on the error testing results of voltage transformer and have indicated secondary induced current is the reason resulting in the variation of error test data. It is suggested that in the on-spot detection of voltage transformer, all the secondary wiring should be kept at one side of the high-voltage equipment so as to avoid the development of return circuit by the secondary wiring winding high-voltage equipment such as standard voltage transformer, electric reactor, and transformer. Or else, the induced current will be produced in the return circuit, affecting the accuracy of error test data and final test results.

References

[1] The state bureau of quality and technical supervision. JJG 1021-2007 Verification Regulation of Instrument Transformers in Power System [S]. Beijing: China metrology press, 2007. (in Chinese)

[2] DL/T448- 2000，the Technical Administrative Code of Electric Energy Metering [S]. (in Chinese)

[3] WANG Chun- qing，ZHAO Yu- fu，ZHOU Qi, et al. The Analysis of Present Operational Situation for Electrical Energy Metering Device [J].Electrical Measurement & Instrumentation, 2007, (7): 26- 28. (in Chinese)

[4] MENG Xiang- fu，LIU Yu- chao，LI Zhen- dong. Discussion the Improvement of Field Calibration of Capacitor Voltage Transformer [J].Electrical Measurement & Instrumentation, 2007, (7): 16- 19. (in Chinese)

[5] WANG yong- hui,GENG jian- po,YIN Jian- zhong, et al. Sites Error Survey of 550 k V Voltage Transformer in GIS [J]. Hebei Electric Power,2008, (6): 3- 5,14. (in Chinese)

[6] SUN Chong, WANG Kai, GENG Jian- po1, et al. The Research of Secondary Connection Method on Site Error Survey of VoltageTransformer.Electrical Measurement & Instrumentation, 2011, (11): 37- 40. (in Chinese)