

## Research on Transformer Test Source based on Triple-frequency

Wang Qinghao, Li Xinyu, Liu Chenyang, Jiao Hongzhi, Hu Yang, Yue Chengcheng,  
Liu Qiang, Zhu Wenlong, Wang Kaizhi, Sun Fengwei, Yang Yingying, Bai Jiatian  
Fushun Power Supply Company, Liaoning Electric Power Company Limited, State Grid, China  
fushunpowersupply@163.com

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**Abstract.** The purposes of measuring the transformer load losses and short-circuit impedance are checking whether they can meet the standard requirements. The traditional transformer short circuit test method were analyzed in theory and combined with engineering practice, how to improve test methods have been researched and explored is this paper. The proposed method can provide a good theoretical basis and experimental evidence for the transformer short circuit test.

### Introduction

In power system, whether transformers are in reliable operation will cause a critical impact on the stability of power system. Short circuit test as the transformer factory, transfer, overhaul and the pilot project after the failure can ensure that the transformer can meet the electricity transmission quality and reliability requirements[1].

In practical engineering, however, due to the large capacity of the test transformer, if in accordance with the test transformer rated current for test, the desired test power capacity, and ancillary test equipment is difficult to meet the requirements, such as the test power supply capacity is not enough. The capacity and size of the regulator, the intermediate transformer and the capacitor are insufficient.

Address these issues, this paper studies and discussions on how to improve the traditional transformer short circuit test methods can reduce the capacity of the existing pilot power, and reduce the size and weight of the test equipment [2].

### Transformer short circuit test

The main contents of the tests of the short circuit test is to test the transformer short-circuit impedance and load loss, which have very close relationship with transformer efficiency, parallel operation, and the system stability.

When test equipment capacity is limited, usually field trials can test single-phase power source can have been used in three-phase transformer short circuit test on site.

The test steps are as follows: first make the low voltage side leads short-circuit connection, then under rated frequency (50Hz), apply voltage to high side leads (AB, BC, CA) and measure the currents. Short-circuit test parameters have been measured three times when the applied voltage winding current reaches the rated current, and calculate the three-phase short-circuit  $P_K$  and short-circuit impedance voltage  $U_K$ .

$$P_K = \frac{P_{AB} + P_{BC} + P_{CA}}{2} \quad (1)$$

$$U_K \% = \frac{\sqrt{3}(U_{KAB} + U_{KBC} + U_{KCA})}{6U_N} \times 100\% \quad (2)$$

Where,  $P_{AB}$ 、 $P_{BC}$ 、 $P_{CA}$  are the two-phase load loss measured each time;  $U_N$  is single-phase winding rated voltage,  $U_{KAB}$ 、 $U_{KBC}$ 、 $U_{KCA}$  are the two-phase winding impedance voltage measured [3].

## The improved method of transformer short circuit test

When tested in accordance with the rated current of the test transformer, the capacity of the pilot power can be calculated as follows:

$$S_K = \frac{U_K \%}{100} \times S_N \quad (3)$$

Where,  $S_K$  is the desired short-circuit test power capacity (kVA);  $U_k \%$  is the percentage of transformer impedance voltage;  $S_N$  is the test transformer rated capacity (kVA).

Test power capacity is very large, so the requirements of large power capacity are unable to be met on site, and the regulator, the middle of the transformer should not meet the requirements either.

In order to reduce the required test capacity, the method of parallel compensation capacitor is to be taken. Under the conditions of power frequency, the test transformer is inductive, so the test power is mainly used to provide the inductor current. The inductive current can be compensated by capacitive current.

In accordance with the method described above to a large extent reduce the power capacity of the trial, but most likely for each test are more than ten pounds of weight over capacitor not only increased the floor space, transportation, handling, but also the wiring is difficult.

Taking into account the relationship between the power frequency and capacity of the capacitor, the frequency of the pilot power can be increased on the basis of the installation of compensation capacitor and the power capacity and the compensation capacitor capacity can be reduced, and the capacitor size and weight can greatly be reduced.

If the test transformer has been approximated by a series connection of inductance and resistance, the compensation capacitor and the test transformer form a parallel circuit[4].

$$C = \frac{L}{[R^2 + (2\pi fL)^2]} \quad (4)$$

Resistance is very small, the compensation capacitor can be approximated inversely proportional with the power frequency square. When the power frequency is 3 times of the power frequency, the capacitor capacity approximately can be reduced to 1/9, the size and weight of the capacitor decreases [5].

## Simulation

The Triple-frequency Power test method can be simulated under the PSCAD environment. Figure 1 shows the simulation circuit, where T1 is the test transformer; the rated voltage is 66/11kV, the rated current 0.477/2.86kA; the rated capacity of the transformer is 31.5 MVA, the impedance voltage  $U_K \% = 10\%$ , the secondary side of the T1 is shorted.

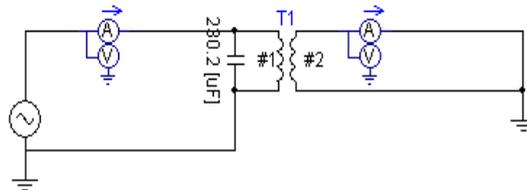


Figure 1 The short circuit test simulation circuit

Let the short circuit test be taken under the 50% rated capacitive current, the primary side test current  $0.5I_{1N} = 0.2385\text{kA}$ ; and at this time the measured primary voltage  $U_1$  is 3.298kV. If all of the current is regarded as inductive, then the compensation capacitive current should also be 0.2385kA, the corresponding capacitor capacity is calculated as follows:

$$C = \frac{0.5I_{1N}}{2\pi f U_{1-50\%I_N}} = \frac{0.2385}{100\pi \times 3.298} = 230.2\mu F$$

The 230.2μF compensation capacitor size and quality are more significant. In this case, if we raise the frequency of the pilot power to reduce the required compensation capacitor capacity,

making the capacitor size and weight greatly reduced.

When the compensation capacitor and the test transformer composed of a parallel circuit parallel resonance occurs in the 150Hz conditions, the required capacitor capacity is:

$$C_{150Hz} = \frac{L}{R^2 + (2\pi fL)^2} = \frac{L}{R^2 + (2\pi \times 3fL)^2}$$

Without considering the resistance, the above equation can be changed to:

$$\begin{aligned} C_{150Hz} &\approx \frac{L}{(2\pi \times 3fL)^2} = \frac{1}{9} \times \frac{L}{(2\pi fL)^2} = \frac{1}{9} \times C_{50Hz} \\ &= \frac{1}{9} \times 230.2\mu F = 25.57\mu F \end{aligned}$$

In this way, only a small capacity of the capacitor will be able to achieve the purpose of full compensation of the load test. Figure 2 is the circuit current waveform when the test transformer primary current 50 percent rating, under a triple-frequency tests power.

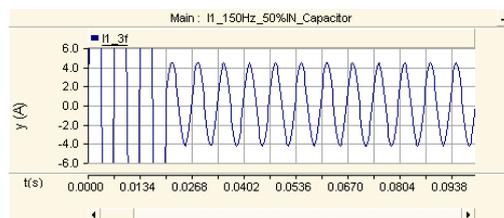


Figure 2 The primary current waveform (150Hz)

## Site practice

The compensation capacitor banks for transformer short circuit test in the past have large number, and a lot of difficulties for handling, wiring and measurement. In the field test, if power frequency high, the compensation capacitor capacity is greatly reduced, can be light weight, small-capacity, and multi-tap for the short circuit test. Figure 3 shows the test wiring on site.



Figure 3 The transformer short circuit test diagram on site

This new test method can be carried out in 50% ~ 100% primary rated current short-circuit test, and reduce the compensation capacitor capacity limit on the test.

## Conclusions

Through the addition of the capacitance compensation, the triple frequency power experiment can make test power output current be reduced, greatly reduce the capacity of the power; by increasing the power frequency to 150Hz, without increasing the power capacity it can reduce the capacity of the compensation capacitor to ensure that the compensation effect. The improved method is proved by engineering practice be simple and convenient, and save a lot of manpower and resources. Therefore, the improved method has a good engineering guiding significance and application value.

## References

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