# The Method of Shortening Transformer DC Resistance Test Time

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**Abstract.** Transformer DC resistance test is one of the routine test in the transformer core project, but the test efficiency is generally low.The paper ,through the analysis of transient process of large DC resistance measurement of transformer coil, core hysteresis phenomenon and the influence of residual magnetism on the measurement process.Improve the working principle, a method of fast measurement, large transformer DC resistance does not increase ,in other devices,characteristics of combination of YNd11 connection of three-phase transformer testing instrument and physical characteristics of the proposes. Field test proves that this method effectively utilizes the remanence, can get the main transformer winding DC resistance test results quickly and accurately.

## Introduction

Transformer is the core equipment of electric power system in the substation, in order to ensure the safe and reliable operation, related test in the transformer factory, after installation,in operation, before and after overhaul should.At the same time, the measured data of vertical and horizontal analysis, in order to make the correct judgment on the health status of equipment. Winding DC resistance test can check out the contact wire and the casing state, he location of each contact state of the tap switch.Whether the actual position match to the position of the tap switch.the quality of welding joint of the winding wire, welding quality wire and winding, winding used wire specification compliance with design requirements, multi strand and around whether strand broken, whether there is inter turn short cake, lead wire fault and other fault conditions[1-3].

Winding DC resistance test and compared with other tests is more time-consuming, such as the 220kV main transformer routine tests of DC resistance test time ,accounted for the total test time of 1/3. With the progress of science and technology, the improvement of the instrument, measuring the operation more simple, measured by time shortening. But some problems also appeared in the use of the process. For example, the limited conditions , relay can not pull in the power supply low voltage , liquid crystal LCD of very low temperatures is not displayed or garbled, occasionally,the buzzer ringing of instrument discharge time is no stopping etc. It is the cause of the instrument itself, or external conditions. There are also some situation is reason of user aspects, such as sometimes in the trial process, long charging time, digital disorder etc.. In order to solve this problem, this paper analyzes some problems in practical use[4, 5].

## Analysis of transient process of transformer DC resistance test

Transformer winding in the pass into the DC current, its equivalent circuit is shown in Figure 1.It is a first order circuit. A power supply voltage of US, inductance L, winding resistance is R, because the initial conditions for the io-=0, the circuit response to a first-order zero state response.

Differential equation of electric circuit:

$U_S=Ldi/dt+iR$

Solution

$i=U_S/R\cdot(1-e^{-t/\tau})$ , $\tau=L/R$

Charge current speed which achieve the steady state $I = U_S / R$ depends on the time constant $\tau$. The general circuit is switched on after 5 $\tau$ ,current has reached steady state value of 99.3%

(1-e-5=0.993), then think circuit is stable. Fig. 2 shows the time versus current curve.

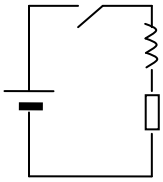

Fig. 1 The equivalent first order dynamic circuit

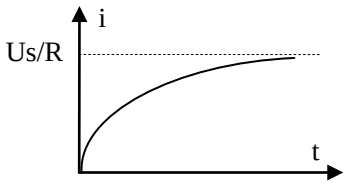


Fig. 2 The time versus current curve

Because of large transformer inductance L is large, the general high voltage side winding in hundreds of Heng, low voltage side number to tens, and DC resistance of R is very small, the high pressure side hundreds of milliohms, low pressure to dozens of milliohms. Therefore, the charging time will be very long, two aspects to shorten the test time starting from decreasing the inductance L and resistance R increased . A circuit increases the loop resistance mutation method, with columns with different winding charge reverse current to magnetic potential offset to maintain core main flux for degaussing method of zero so as to eliminate the transition process, improve the working voltage, increasing the test current, winding in series to help make the core magnetic flux saturation, helps the magnetic method using non linear relationship between the reduced iron core inductance. According to the charging curve of DSP sample calculation with the calculation speed measurement properties.

**Working principle of DC resistance tester**

As shown in Figure 3, the constant current charging, microcomputer sampling, voltage comparison, liquid crystal display, all controlled by a single chip microcomputer. Boot settings start, self correct, first put the high voltage to the windings of charging, charging to set the switching current value for the constant current charging until stability, test line connection from the winding, lead back to the voltage signal measurement with machine internal reference voltage signal is compared, amplification, A/D conversion, send CPU or single chip microcomputer computing, LCD liquid crystal display results are given, by all the CPU (or microcontroller) control, auto completion, the test is very convenient.

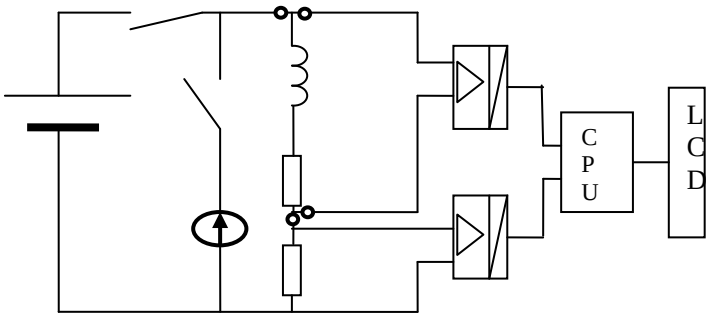


Fig. 3 Transformer DC resistance tester principle diagram

## Influence of core remanence of the testing process

The magnetization curve of ferromagnetic materials shows that, the magnetization process with hysteresis. The magnetization curve is a closed curve, the rise and fall of magnetization curves do not coincide. The flux density B always lags behind the magnetic field strength H, when H fell to 0, B is not down to 0 but dropped to a certain value Br, called the residual magnetic flux density. To eliminate the residual magnetism must reverse the magnetic flux density increases, the reverse magnetic field strength Hc corresponds to the B=0 called "coercive force". Large power transformer compare to small and medium-sized transformers, the remanent magnetization phenomenon is more serious. Schematic diagram of hysteresis loop is shown in Fig. 4.

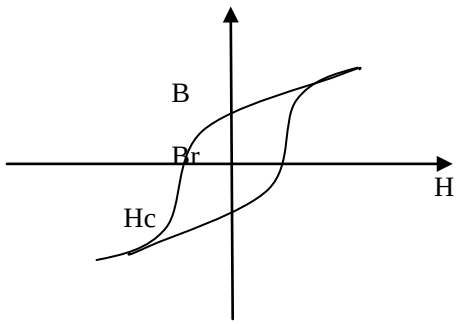


Fig.4 Schematic diagram of hysteresis loop

Therefore, in accordance with the test procedures, high, low voltage sequence measurement winding DC resistance,turn off the charging current,when at the high voltage side straight resistance test finished. there will be a certain amount of remanent core, bring certain influence is bound to low voltage side winding DC resistance test.

In the instrument for the DC resistance of 220kV 120MVA and above transformer DC resistance test, low voltage side winding generally charge 20A, high side 5A. First filling pressure tested, then do low, often more than an hour can get stable value, moreover, the charging process is slow, the reason is the hysteresis effect of core by the first test of the remanence.

## Transformer DC resistance test case

The test case environment parameters is in Table 1, and the test examples winding DC resistance data

Table 1 The test case environment parameters

| | | | | | |
|---|---|---|---|---|---|
| Test location | 220kVxindu transformer substation | Thetest time | 2011-01-02 | Temperature | 13℃ |
| Test equipment | No.1Main Transformer | The weather | Sunny | Humidity | 68% |

The test sequence and using time: AB low voltage side for about 6 minutes and 52 seconds, then AC takes about 6 minutes and 30 seconds, CB with 6 minutes and 2 seconds, in order to eliminate the influence of discharge last CB remanence ,reversed BC charge to instrument display charging to the 20A after about 10 seconds , BC continue to charge to the stable results about in 6 minutes and 20 seconds; high-voltage side of each branch joint (current 5A): tap 4 of A0, B0, C0; tap 1 of C0, B0, A0, tap 2 A0, B0, C0, tap 3 when C0, 0B, A0, and C0 in 01 minutes and 20 seconds ,0B in 57 seconds, A0 in 1 minutes and 30 seconds, tap 4 of A0, B0, C0, B0 in 1 minutes and 30 seconds, tap 5 of C0, B0, A0, B0 in 1 minutes and 27 seconds. Test use less time, and no long time charging and other abnormal.

Table 2 The test examples winding DC resistance data

| The low pressure side（mΩ） | ab | bc | ca | Ratio difference(%) |
|---|---|---|---|---|
| | 1.884 | 1.842 | 1.875 | 0.49 |
| The high pressure side（mΩ） | 0A | 0B | 0C | Ratio difference(%) |
| Tap1 | 303.2 | 303.1 | 303.1 | 0.03 |
| Tap2 | 297.3 | 297.1 | 297.7 | 0.21 |
| Tap3 | 293 | 293.7 | 293.3 | 0.23 |
| Tap4 | 288.2 | 287.5 | 288.2 | 0.24 |
| Tap5 | 283.3 | 283.3 | 284.1 | 0.28 |
| Tap6 | 278.4 | 278.1 | 278.7 | 0.21 |
| Tap7 | 273.9 | 274.1 | 274.4 | 0.18 |
| Tap8 | 269.4 | 268.6 | 269.4 | 0.29 |
| Tap9 | 264.9 | 263.4 | 263.9 | 0.56 |
| Tap10 | 271.6 | 269.9 | 272 | 0.77 |

## Conclusion

Because different manufacturers of the transformer design, process, DC resistance test may allow to keep more of the DC remanence. In order to eliminate the test inrush current and the occurrence of differential, that electricity generating in the transformer magnetic bias. Suggested by AO, CO, OB order to test winding DC resistance of transformer, because it can be slightly shorter testing time; then the testing line reversal changed to BO against, the direction of charge to instrument display charge to set several seconds after the discharge current the remanence, produced to offset the original test of single side direction of a problem.

By the abnormal phenomenon in the field trials led to our way of thinking, accurate and convenient high-tech instruments only in a good grasp of the principle of correct use, can avoid abnormal, improve test efficiency, better play its role, thus reducing the test power outage time, improves the reliability index, promote the healthy operation and development of power grid.

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