

The Research and Application of the Grounding Resistance Tester

Ge Changxin¹, Sun Fengwei¹, Wu Shaoyong¹, Bai Jiatian¹, Zhao Chuanzong¹,
Zhang Hua¹, Guan Ling¹, He Lishuai¹, Liu Peng¹, Wang Yi¹, Liu Zhitong², Li
Jianfeng¹

¹Fushun Power Supply Company, Liaoning Electric Power Company Limited, State Grid, China,

²Shenyang Power Supply Company, Liaoning Electric Power Company Limited, State Grid, China,

fushunpowersupply@163.com

Keywords: grounding resistance; grounding line; rogowski coil; different frequency power supply; lightning counter attack

Abstract. This paper analyzes the principle and test method of the grounding resistance. According to the analysis and calculation of the lightning accidents, prove the relationship between counter attack lightning and the grounding resistance. We also describe the basic principle of grounding resistance test. Basic method and disadvantage of grounding resistance test are introduced. We focus on the composition, working principle and advantage of the grounding resistance tester without dismantling the tower lead line, and we introduce the situation of field test. Confirm the grounding resistance tester without dismantling the tower lead line is no need to disconnect the tower grounding download, and it has the advantages of time saving, labor saving, strong anti-interference ability and high in precision. The device applicable scope broaden, the substation power equipment ground resistance test, but also applicable to the overhead distribution lines, tower grounding resistance test.

Introduction

Power transmission lines often suffer from lightning accidents. Below is the No. 22 tower in 66kV wusheng Line 2, which suffered the lightning at 16:24 on August 16, 2013. It is shown in Figure 1.



Fig.1 The flashover discharge diagram of the tower

State Grid Fushun Power Supply Company is responsible for the range, the 220kV voltage rating circuit and the 66kV voltage level line total 189 lines. In the last 5 years, the electric power line has 73 times of lightning trip accident, and the 42 time is caused by counter attack. In order to improve the reliability of power supply, lightning protection measures must be taken to reduce the occurrence rate of the line trip accident. Lightning stroke typical accident statistics are shown in Table 1.

Table1 Typical accidents statistics of power transmission tower

| Tower number | Accident time | Shielding failure | | Counter attack | indeterminacy |
|-----------------------------------|----------------------------|-------------------|-------|----------------|---------------|
| | | left | right | | |
| 220kV Zhongyong line1 No. 5 tower | At 23:20 on July 20,2011 | 1 | | 2 | 1 |
| 220kV Zhongling line1 No. 3 tower | At 20:19 on August 25,2012 | 2 | 1 | | |
| 220kV Fuyuan line No.12 tower | At 03:05 on July 4, 2013 | 2 | 3 | 1 | |
| 220kV Ligong line No.14 tower | At 23:10 on July 29, 2014 | 1 | | | 1 |
| 66kV Gunan line No.45 tower | At 22:43 on July 6, 2014 | | 2 | 4 | |
| 66kV Nanshi line No.44 tower | At 21:15 on August 1, 2015 | 2 | | 5 | 2 |

Analysis and calculation of the lightning accident

The tower grounding resistance is the standard to measure the grounding state. Ground resistance value is small, more can reduce counterattack lightning accident frequency, improve the lightning withstand level of the tower; on lightning protection of transmission line is of great practical significance[1-3]. As shown in Figure 2.

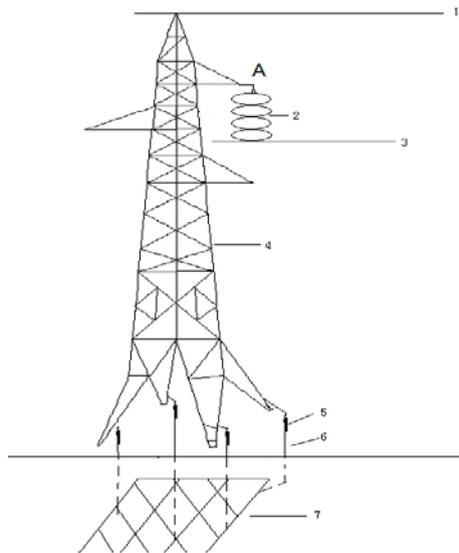


Fig.2 The tower grounding resistance and tower diagram

Note: 1- ground wire. 2- insulator string. 3- electric wire. 4- tower. 5- grounding bolt. 6- ground lead. 7- grounding grid

Calculation formula of the value of lightning:

$$U_A = I_R + HLdi/dt$$

Note: U_A — Lightning in the tower (A) voltage value (Unit: kV)

I — Thunder and lightning current (Unit: kA)

R —Grounding resistance (Unit: Ω)

H —A from the ground height (Unit: m)

L —The tower by lightning current showing inductance value (Unit: μ H/m)

Generally 0.67 H/m

di —The numerical value of the change of lightning current

dt —Wave head time of thunder current (Generally take 2.6μ S)

In the formula, the lightning current value (I) is constant. H, L, Di, DT, are determined by the (I), so they are all constant. R is the only variable, so the grounding resistance is very important.

Grounding resistance test method

The definition of grounding resistance, when the current is introduced into the soil by the grounding body, the soil resistance value of the earth body. It includes the resistance of the grounding device to the wire, the resistance of the grounding body itself, the sum of the earth body and the resistance of the soil[4, 5]. The ratio of the voltage to the voltage of the grounding body (relative to the zero potential) is to the current value of the earth body. There are two kinds of methods in the past:

Using the earth resistance meter (ZC-8)

Grounding resistance meter method is generally applicable to the grounding resistance measurement of transmission line tower, an independent lightning rod, microwave towers, such as small grounding device. In general, the ZC-8 type grounding resistance measuring device is used to measure the grounding resistance. Wiring is shown in Figure 3.

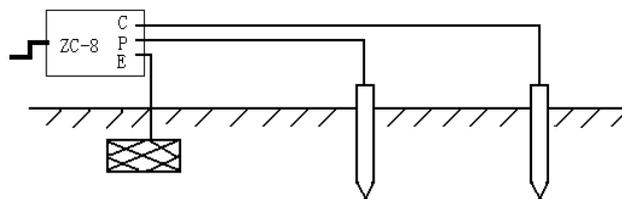


Fig. 3 Connection schematic diagram of ZC-8 type grounding resistance meter

Use a clamp ammeter

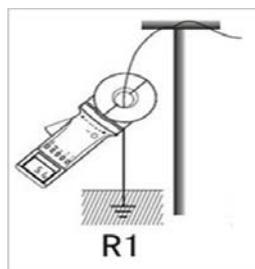


Fig.4 Wiring diagram of clamp ammeter

At present, we usually use two methods, shown in Figure 4, ZC-8 method, the clamp table method, but these two methods generally exist the following drawbacks:

(1)Spend more time and energy.: ZC8 need to disconnect the 4 grounding. A table, only need to open the 3 grounding. Operation is required to disconnect the 3 ground lead off the assembly line, and then parallel. Then connect it with the fourth grounding line in parallel. Because the grounding wire is mostly rusty or die welding phenomenon, it is necessary to use the electric welding machine to break off the ground wire. But most of the towers are in the mountains, carrying electric welder and small generators very difficult, leading to some tower can not be measured.

(2)Low accuracy: the use of ZC - 8 and the clamp table method is another problem. In order to save space, transmission lines in the same direction as the majority, are erected on the same tower. In this case, the current, voltage disturbance is too large, resulting in the test data is not accurate, and even can not be tested.

So we have to develop a new test method, which can test the results accurately and quickly.

Research on the grounding resistance tester without dismantling tower lead line

(1)Constituent parts

In order to solve the above problems, we have developed ground resistance tester without

dismantling the tower downlead. The main testing device is the current coil, which is based on the principle of the Roche coil. The test unit comprises a Rogowski coil and integrator. The apparatus consists of a battery (rechargeable battery pack), a DC inverter unit, a frequency conversion power supply, data sampling and calculation unit, display screen, current coil, and so on. Structure diagram is shown Figure 5.

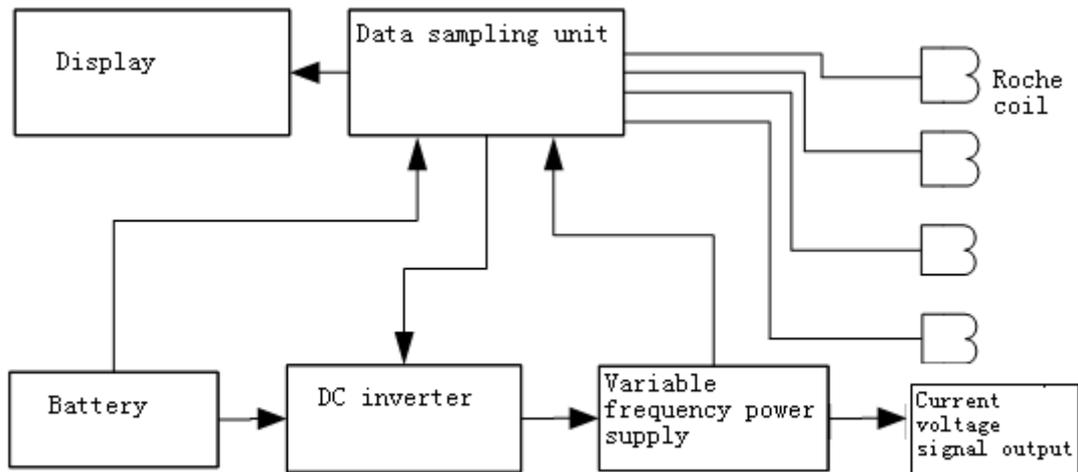


Fig.5 The structure of grounding resistance tester without dismantling tower lead line

Each unit function is as follows:

DC inverter power supply: the battery through the inverter circuit to provide a certain power of AC power supply. It can meet the grounding impedance condition of the ground test of grounding device. Output power is not less than 50VA.

Data sampling and calculating unit: through the digital filter circuit and Fu Liye transform technology, the voltage and current values are obtained under the condition of experimental frequency, and then through the mathematical model, the grounding impedance of the device is obtained.

Current test line: 5 meters per length. Using ampere turns principle, support feet of the tower the wound up to 10 laps, the weak frequency (HF) current signal accurately measured and transferred to the instrument host.

Voltage and current signal output unit: to provide output for the test, the frequency of 45Hz or 55Hz signal.

Rogowski coil: the injected current signal after amplification, sending back to the host, then computing.

(2)Parameter

Test impedance range: $0.01 \Omega \sim 1000 \Omega$, Resolution 0.05Ω .

Test accuracy: $\pm(5\%+5 \text{ Count})$.

Roche coil: Perimeter 5m , Lead length 5m

(3)Test procedure

Voltage and current injection signal line. At 1m from the ground, polished with sandpaper or iron brush grinding, ensure good contact.

Auxiliary grounding. Current line length is 5 times the diagonal of the grounding grid. Voltage line length is 0.618 times current line length.

Connecting the Roche coil. The four coil are respectively sheathed on the tower grounding deflectors.

Field application

With no need to remove the pole downlead resistance tester and zc-8 method and clamp table method, compared to greatly shorten the testing time, saves manpower and material resources. Due

to the outlet of substation (tower 1) interference of voltage and current high, zc-8 type table and clamp table method can not get the test result, but no need to remove the pole downlead grounding resistance testing instrument can accurately test. There is no need to remove the pole downlead grounding resistance measuring instrument accuracy high, test results can be accurate to four decimal places.

Summary

Through on-site verification, there is no need to remove the pole downlead grounding resistance tester, do ground resistance test without disconnecting the tower grounding downlead, saves time and labor. At the same time, the anti-interference ability of the power frequency (50Hz). In particular, zc-8 method is used, the clamp meter method, can't be measured tower (substation outlet and the same pole erected interference larger) value of grounding resistance, the instrument can accurately measure. The measuring range is wide, high resolution, applicable to substation electrical equipment grounding resistance testing, but also applicable to the overhead distribution lines, tower grounding resistance testing. It can be applied in substation power equipment grounding resistance testing, but also applicable to the overhead distribution lines, tower grounding resistance testing. No need to remove the tower deflectors grounding resistance measuring instrument development, lightning evaluation of transmission lines, lightning withstand level calculation provides accurate data, reduce the lightning trip out rate, improve the reliability of power supply and has broad application prospects, with important significance.

Reference

- [1] Zhou Zecun. High voltage technology. China Electric Power Press, 1996
- [2] Chen Huagang. Power equipment preventive test method and diagnostic technology. Science and Technology Press, 2001
- [3] Chen Jiabin. Grounding technology and grounding device. China Electric Power Press, 2010
- [4] Wang Changyu. The safety of grounding technology. China Electric Power Press, 2008
- [5] Cao Dunkui. Transformer oil chromatographic analysis and fault diagnosis. China Electric Power Press, 2011