Research on Tower Grounding Resistance Detection Technology and System Without Dismantling Grounding Lead

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Abstract

At present, lightning damage has become an important factor affecting the safe operation of transmission lines. Measuring the ground resistance of poles and towers regularly is a measure to ensure the reliable operation of transmission lines. In this paper, the research on detection technology of grounding resistance of poles and towers without detachment grounding leads is carried out. A method and system for measuring the grounding resistance of poles and towers without disconnecting grounding leads is presented. Without disconnecting grounding leads, the grounding resistance of poles and towers can be detected quickly and accurately, the defects of the grounding system can be discovered in time, the grounding system can work normally, and the lightning tripping accidents can be reduced effectively.

Keywords

Tower grounding resistance, Llightning tripping, Non-detachment, Measuring method.

1. Introduction

Transmission network undertakes important transmission tasks. The failure of transmission line mainly comes from the power failure caused by lightning. 40%~70% of trips are caused by lightning, which is an important reason for the interruption of transmission line and is not conducive to the stable operation of the system [1, 2]. The stability of overhead transmission line depends on the lightning protection design, and the tower grounding resistance determines the lightning protection level of the line. Reducing the tower grounding resistance can reduce the equipment voltage to the ground, which is one of the more direct and effective lightning protection measures at present.

Grounding resistance refers to the resistance that is generated when the current is diffused and flowed from the grounding device to the ground and then to another grounding body. The pole tower supports the transmission line, and its grounding device and pole tower together constitute the leakage channel of current. When lightning strikes, the current can be directed to the earth, and the potential of the line to the ground is not high, which will not cause insulation damage [3, 4]. Therefore, regularly measuring the grounding resistance of poles and towers is a measure to ensure the reliable operation of transmission lines and to truly reflect the operation of equipment.

At present, three-pole method and clamp-meter method are the most commonly used methods to measure ground resistance [5, 6]. The three-pole method has high measuring accuracy, but its wiring is relatively complicated and all ground leads of the tower need to be disconnected. The clamp gauge method can measure the ground lead with incomplete disconnection, but there are large errors due to the limitation of measuring principle. The above methods need to be measured manually, with low efficiency and heavy workload. With the development of power grid and the reinforcement of tower downlead, the method of measuring grounding resistance by removing downlead is no longer applicable. Therefore, this paper presents a measurement method and system of tower grounding resistance without grounding lead.

2. Equivalent circuit model of tower

The tower, lightning conductor, conductor and grounding device in the transmission line are connected with each other to form a parallel network. Taking four pins as an example, an equivalent model is established, as shown in Fig. 1.

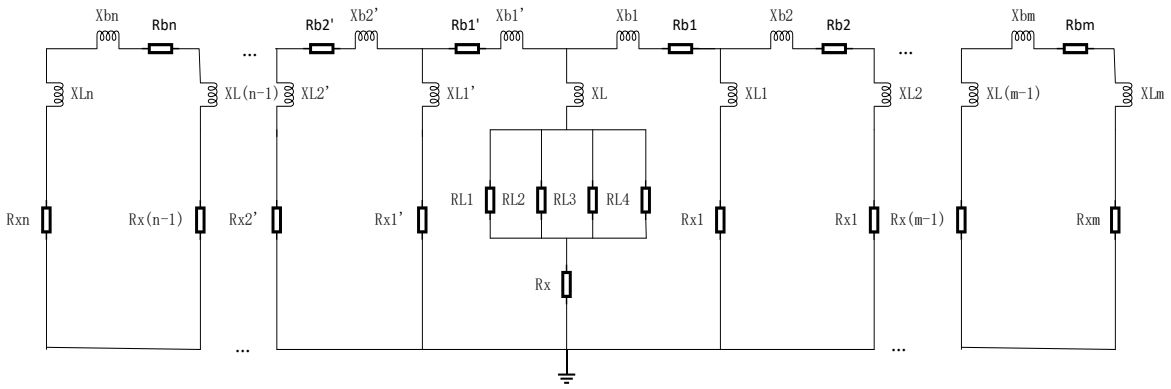

Fig. 1 Equivalent circuit model

Xbn, Rbn, ..., Xb2', Rb2', Xb1', Rb1', Xb1, Rb1, Xb2, Rb2, …, Xbm, Rbm represent the impedance of lightning conductor between towers. XLn, XL(n-1), XL2', XL1', XL, XL1, XL2, XL(m-1), XLm represent the equivalent inductance of the lightning conductor. Rxn, Rx(n-1), Rx2', Rx1', Rx, Rx1, Rx2, Rx(m-1), Rxm represent the grounding resistance of the tower. RL1, RL2, RL3, RL4 represent the resistance of the tower to be tested and its four down conductors. The resistance of other tower downleads is too small to be ignored.

The frequency range of lightning current is 1kHz-20kHz. The grounding device of transmission line tower is a small grounding grid, and its inductive part is far less than the resistance. When the frequency of the measured signal is less than 20kHz, the increase of frequency has little effect on the impedance modulus of the grounding resistance. Therefore, when the frequency of the measured current is different, the influence of the inductive part of the grounding impedance can be ignored.

Except the resistance of the tower to be measured and its four leads and the resistance to ground of the tower to be measured, the rest can be equivalent to Zeq=Req+jXeq. The simplified equivalent model of the tower is shown in Fig. 2.

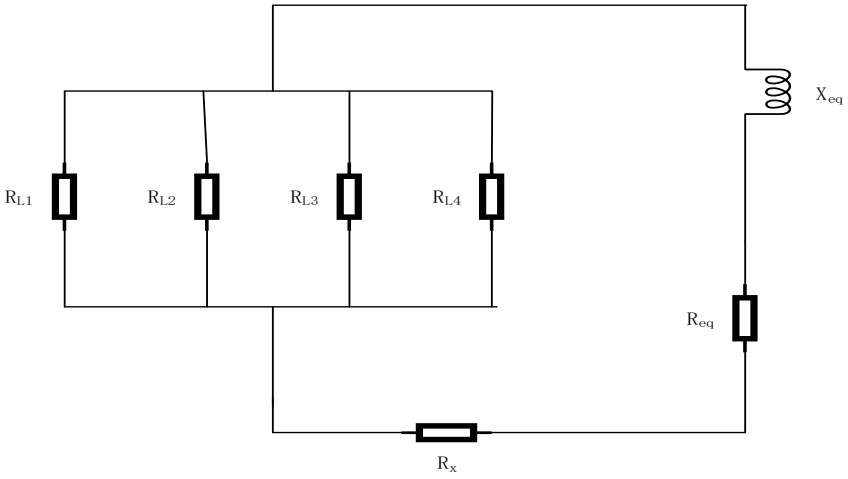

Fig. 2 Simplified equivalent circuit model of tower

3. Measurement method of tower grounding resistance without grounding lead

The detection method of grounding free lead is designed based on Fig. 2. Four voltage transformers and current transformers are connected to four grounding leads respectively, and the generated AC voltage signal is input to the tower through the voltage transformer. The corresponding generated current signal is collected by the current transformer, and the tower grounding resistance can be calculated according to the voltage and current signals. The measurement schematic diagram is shown in Fig. 3.

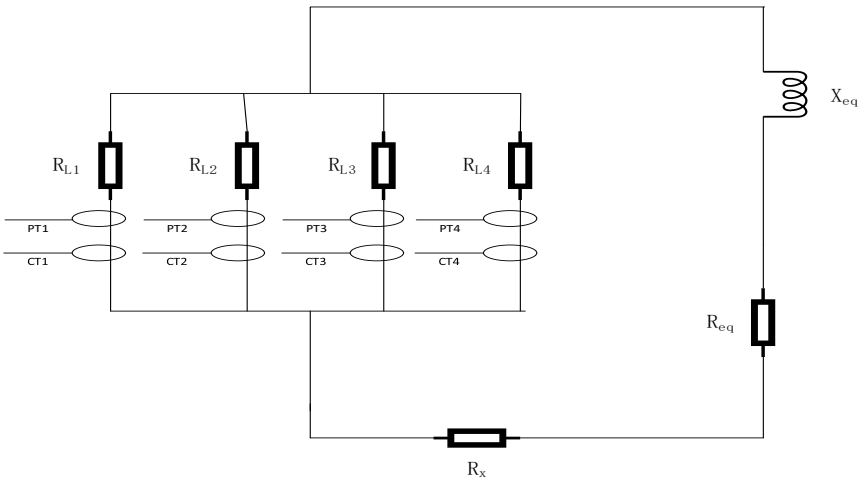

Fig. 3 Schematic diagram of tower grounding resistance measurement

Among them, CT is current transformer, Pt is voltage transformer, and four current transformers and voltage transformers are connected to a measuring device. According to the measurement principle, each lead generates and the corresponding current is , and the calculation model diagram of grounding resistance as shown in Fig. 4 is obtained.

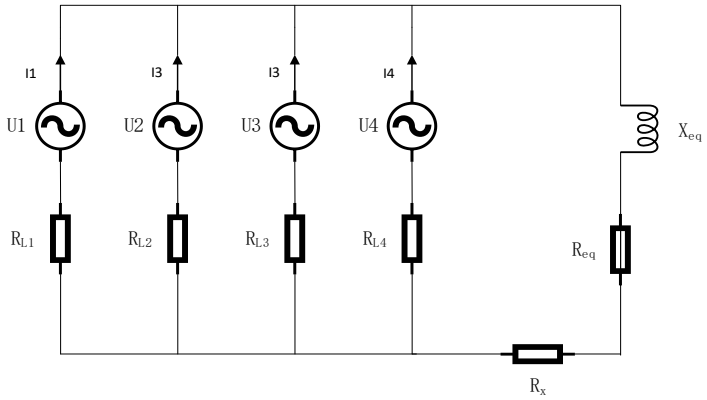

Fig. 4 Calculation model of tower grounding resistance

The input AC sinusoidal voltage signal is injected into the transmission line tower through four voltage transformers, and the four currents generated by the transmission line get the current input device through the current transformer. Thus, not only the tower grounding resistance can be measured, but also the resistance of four down conductors can be measured to detect whether the grounding down conductors have poor contact and other problems.

4. Design of tower grounding resistance measurement system

According to the measurement method of tower grounding resistance introduced above, the hardware circuit is designed. The principle of the measurement method is the same as that of the clamp meter method, and there is no need to disconnect the grounding down lead. During measurement, the four pairs of current transformers and voltage transformers of the system are respectively connected to the four leads of the tower. The voltage transformers and current transformers are connected in the same direction according to the same end, so as to make the magnetic circuit as tight as possible, so as to reduce the error. The device mainly includes: control part, signal generation part, self inspection part, phase measurement part, filtering part, signal conditioning module, communication part and power supply part. The composition diagram is shown in Fig. 5.

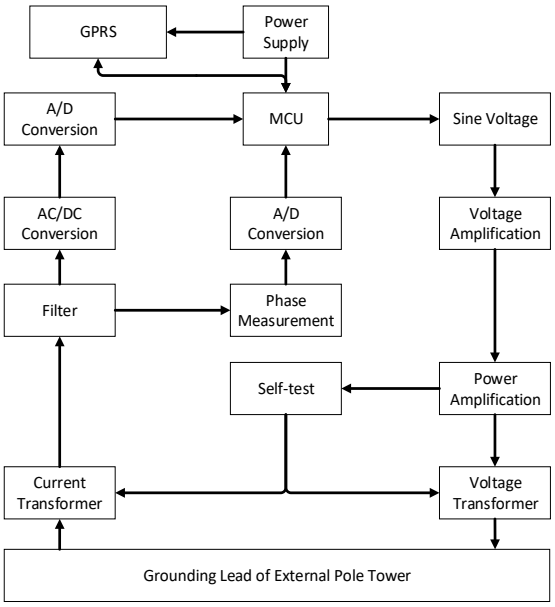

Fig. 5 Overall system design drawing

Modular design is used to facilitate subsequent debugging and expansion. Because the device will be placed outdoors, the environmental conditions are bad, and there are the effects of temperature, rain and snow, etc., the device needs to have strong anti-interference ability, so selecting appropriate modules is the top priority.

MCU is the general controller of the system. The signal generator generates sinusoidal voltage signal, and then outputs four sinusoidal voltage signals through voltage amplification and power amplification module. The voltage signal is injected into the tower grounding down lead through the voltage transformer, so that an induced electromotive force is generated in the circuit and a sinusoidal current signal is generated. The current transformer transmits the current in the tower back to the system, converts the signal into DC signal through the AC / DC conversion module, obtains the phase relationship through the phase measurement module, inputs the signal into MCU again for processing, and then obtains the tower grounding resistance value through the above calculation method.

The function of GPRS in the system is to upload the measured grounding resistance data to the server through GPRS communication module, so as to realize on-line monitoring. From the system structure, four current transformers and four voltage transformers are led out and connected to the tower grounding down lead respectively, and the tower grounding resistance can be measured.

5. Conclusion

In this paper, the detection technology and system of tower grounding resistance without dismantling grounding lead are studied. By simulating the tower equivalent model, a tower grounding resistance measurement method without disconnecting the grounding down lead is proposed. By this method, the tower grounding resistance can be detected quickly and accurately without disconnecting the grounding down lead. The tower grounding resistance measurement system is designed to ensure the normal operation of the grounding system and effectively reduce the occurrence of lightning trip accidents.

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