

Study on the Influence of Grounding Conductor Structure on Its Grounding Impedance Spectrum Response

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Abstract

The grounding diagnosis of pole and tower plays an important role, and the tower is characterized by its unique characteristics. It is necessary to develop a new method for the diagnosis of pole and tower. Frequency diagnosis is applied in many aspects, so it is necessary to analyze the frequency response characteristics of pole and tower. The influence of the frequency response of pole and tower on the radius of the pole and the soil resistivity is analyzed under three different grounding structures using CDEGS software, and the differences and similarities of spectral response under different structures are discussed.

Keywords

Spectrum Response, CDEGS, Impedance, Tower Diagnosis

1. Introduction

The state detection of grounding devices is a necessary way to identify hidden dangers and ensure safe operation of grounding devices. So far, various diagnostic methods for measuring grounding conductor have been put forward [1] [2] [3]. The tower grounding has its unique characteristics [4]: the remote location, the grounding electrode is radioactive, long-term corrosion result after the grounding electrode become shorter and fine, for the ultra HVDC transmission system this phenomenon is more obvious, so it is necessary to find a unique grounding corrosion detection method. Frequency diagnosis is applied in many aspects [5] [6]. Therefore, based on the CDEGS software package, three different grounding conductor models are established to simulate the effect of multi fre-

quency current on the earth's impedance. The characteristics of the impedance with the frequency of the grounding conductor under the three injection modes of the single end, middle and dot of the power supply are analyzed, and the breakthrough point is explored for the new method.

2. The Establishment of Three Simulation Models

Horizontal grounding conductor is a typical grounding device. In order to study the influence of conductor structure on its spectrum response characteristics, three typical grounding conductor structure models are set up in this paper, as shown in **Figure 1**.

Figure 1(a) is a single horizontal embedded conductor model, and the current is injected from one end of the conductor. **Figure 1(b)** is a two-root horizontal embedded conductor model. One end of the two conductors is connected to a symmetrical distribution, and the current is injected into the end point connected by the two conductors. **Figure 1(c)** is a conductor model with four horizontally buried conductors. The 4 conductors are evenly distributed across the cross, one end is connected together, and the current is injected from the end point.

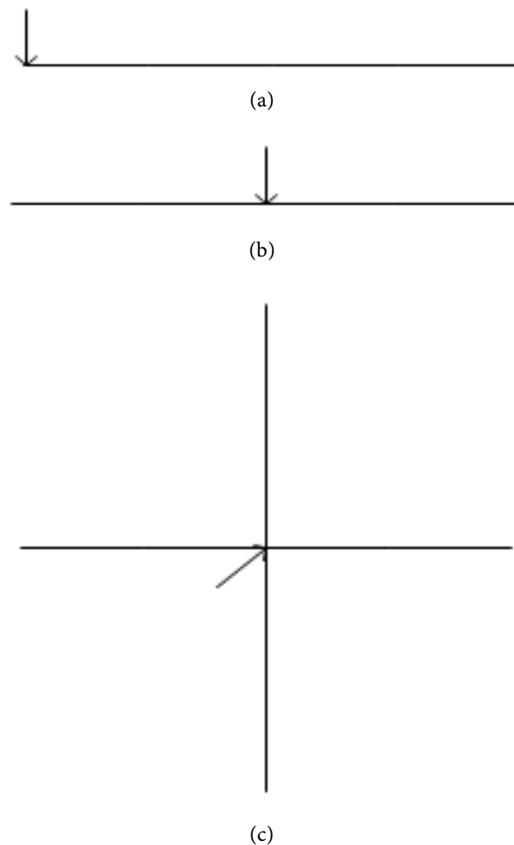


Figure 1. Simulation model diagram. (a) Single end injection modeling diagram of power supply; (b) Modeling diagram of middle end injection of power supply; (c) Modeling diagram of vertical grounding conductor.

3. The Common Points and Differences of the Grounding Frequency Response Characteristics under the Three Structures Affected by Various Factors

3.1. The Influence of the Radius of Each Structure on the Frequency Response

In the range of frequency variation from 2 Hz to 1 MHz, the conductors' radius of three grounding modes vary from 0.005 m to 0.02 m. According to the engineering practice, the excitation source is set as 20 A current source, single segment conductor length is 50m, conductor relative resistivity is 17, relative permeability is 1, soil resistivity is $200\Omega/\text{m}$, and only horizontal conductor radius is changed to simulate. According to the simulation data, the frequency response characteristics of impedance mode value are drawn, as shown in **Figure 2**.

The three condition of the grounding conductor impedance frequency response characteristics of similarities: different radius values of impedance characteristic curve of frequency response is basically the same; in the low frequency stage, the impedance value of different frequency coincident frequency response curve; at high frequencies, the rate of different radius of the impedance frequency response curve with the rise of the different frequency. The greater the conductor radius is, the slower the impedance modulus increases with the frequency. At the high frequency stage, the smaller the conductor radius is, the greater the corresponding impedance modulus is.

What is the difference: the radius of the conductor is still the magnitude of the impedance mode. Single end impedance starting injection conductor is about $7\ \Omega$, The initial impedance of the middle end injecting conductor is about $4\ \Omega$, while the initial impedance of vertical cross conductor is about $2.5\ \Omega$; in the frequency range of 1 MHz, the largest single ended impedance into conductor can reach about $46\ \Omega$, the center conductor of the largest injection impedance can reach about $30\ \Omega$, and maximum impedance of vertical cross conductor is about $21\ \Omega$.

Based on the simulation data, the characteristics of the impedance angle frequency response are drawn, as shown in **Figure 3**.

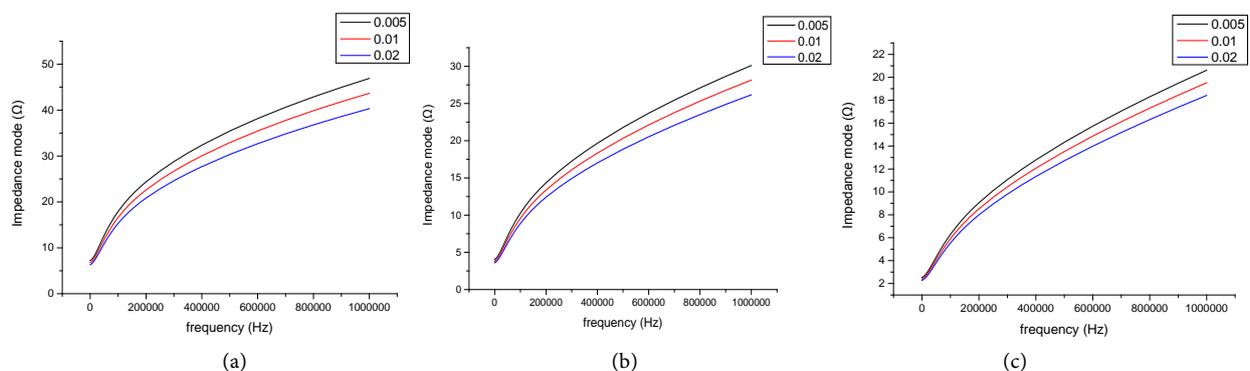


Figure 2. The influence of radius on the characteristic of impedance mode spectrum. (a) Frequency response characteristic curve of single end injection impedance model; (b) Frequency response characteristic curve of middle end injection impedance mode; (c) Frequency response characteristic curve of dot injection impedance mode.

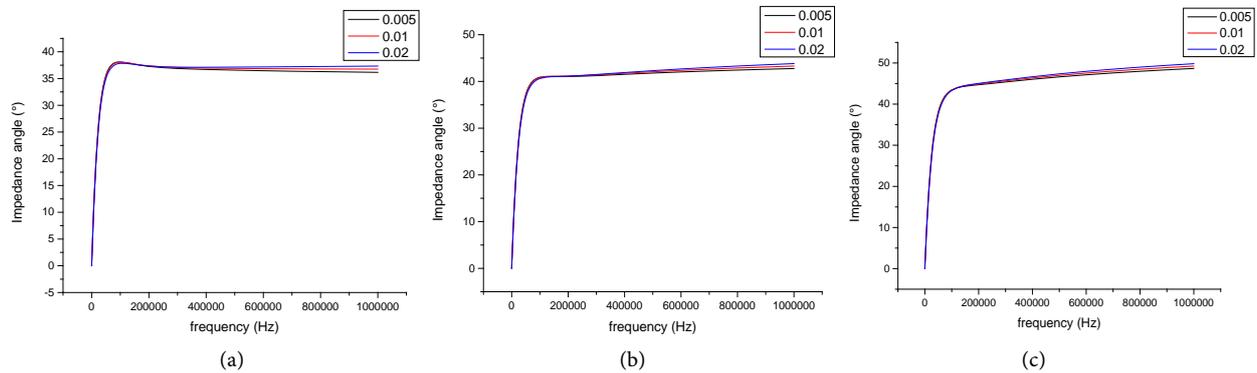


Figure 3. The influence of radius on the characteristic of impedance angle spectrum. (a) Characteristic curve of single end injection impedance angle frequency response; (b) Frequency response characteristic curve of medium injection impedance angle; (c) Characteristic curve of vertical cross impedance angle frequency response.

As can be seen from the above pictures, the characteristics of the impedance angle characteristic curves are different from the different grounding methods, and the variation of the parameters is too small to be observed. Therefore, the characteristic of the impedance angle frequency response is not suitable for judging whether the radius of the conductor is changed.

3.2. Influence of Soil Resistivity on Frequency Response Characteristics under Various Structures

When the signal is injected, the soil resistivity varies from 20 Ω/m to 5000 Ω/m under the range of frequency variation from 2 Hz to 1 MHz. According to the engineering practice, the excitation source is 20 A current source, The length of the single section conductor is 50 meters, conductor radius is 0.005 meters, relative resistivity is 17, relative permeability is 1, only horizontal soil resistivity is changed to simulate. The frequency response characteristic curve of the impedance mode value is drawn as shown in **Figure 4**.

From the above, we can see that the impedance mode frequency response characteristic of the conductor under different grounding modes is similar: in the smooth section of the low frequency, the impedance modulus follows a strict multiplier relation, and the multiple is consistent with the multiple of the soil resistivity. In the high frequency rise stage, the multiple relation of soil resistivity is no longer strictly observed, but the impedance modulus of the conductor with large soil resistivity is large.

The difference: the impedance modulus of the conductor in different grounding modes is different in the same soil resistivity. In the low-frequency smooth section, with 5000 Ω/m of soil resistivity as an example, under the single port injection condition, the impedance module is 179.35 Ω , and the impedance module is 101 Ω at the middle end injection condition, and the impedance module is 63 Ω under vertical intersection condition. The impedance mode slightly presents the multiple relation of the parallel. According to the condition of conductor grounding, considering the existence of simulation error and other

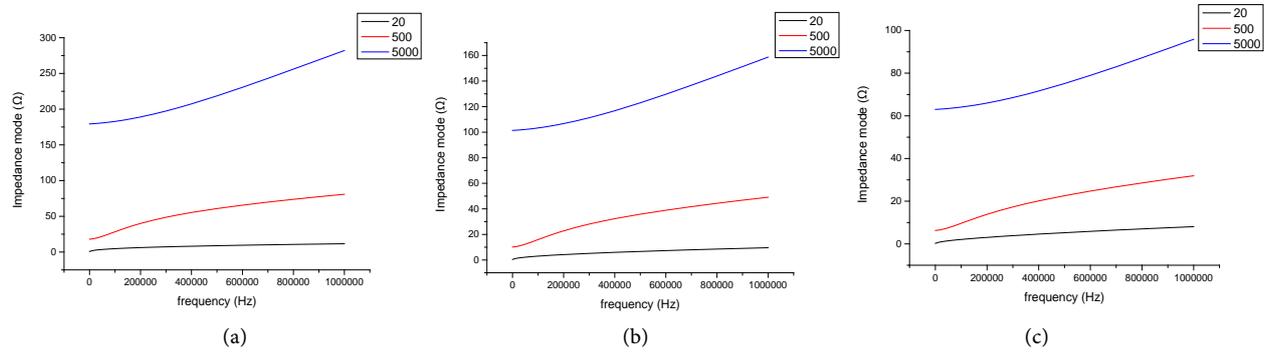


Figure 4. Influence of soil resistivity on the characteristics of impedance mode spectrum. (a) Frequency response characteristic curve of single end injection impedance mode; (b) Frequency response characteristic curve of middle end injection impedance mode; (c) Frequency response characteristic curve of vertical cross impedance mode.

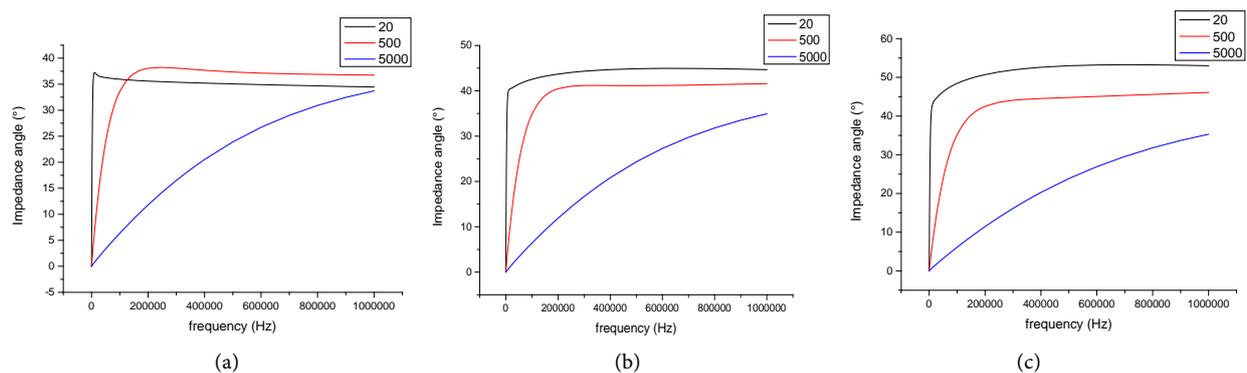


Figure 5. The influence of soil resistivity on the characteristic of impedance angle spectrum. (a) Characteristic curve of single end injection impedance angle frequency response; (b) Frequency response characteristic curve of medium injection impedance angle; (c) Characteristic curve of vertical cross impedance angle frequency response.

factors, it is preliminarily considered that under the same parameters, there is a parallel multiplier relationship between the three ways of grounding.

According to the simulation data, the characteristic diagram of the impedance angle frequency response is drawn, as shown in **Figure 5**.

It is shown from the above figure that the impedance angle frequency response characteristics of the grounding conductor in the three conditions have the following similarity: The basic rising trend of the characteristic curve of the impedance angle frequency response under different grounding modes is constant.

The difference: like the characteristic curve of the impedance mode frequency response, the characteristic curve of the impedance angle frequency response is still affected by the length of the conductor in the amplitude of the curve. In the case of single port injection, the high frequency smooth section of the impedance angle is basically around 34 degrees, and the impedance angle of the high-frequency smooth section injected at the middle end is about 45 degrees, while the high frequency smooth section of the impedance angle reaches 53 degrees at the vertical intersection. At 1 MHz, the terminal angle of the central point injection and the vertical cross connection mode is the rising state, while

the single ended injection is the falling state. So the higher the resistivity of the soil is, the larger the impedance angle is.

4. Conclusion

Based on the above analysis, the frequency response characteristics of different parameters under different grounding modes do have certain rules, which provide a reference value for subsequent research on the frequency response characteristics of corrosion.

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