Distribution network with distributed power protection setting policy

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Abstract: When Distributed Generation (DG) is connected to the distribution network, the original network structure will change, leading to various distribution grid protection deviation, the instability of the network appears. In order to guarantee the reliability and economy of power distribution grid, distributed power and full of potential, so access to protection for distributed power grid feature is the need for research. In-depth discussion on the relay protection setting strategy when distributed power sources are connected to the distribution network, and launch a new current protection scheme. Simulated using simulation software PSCAD / EMTDC. To verify its reliability, quick-movement, selectivity and sensitivity, it has strong application significance in practical engineering.

1. Introduction

The power industry is the support of economic development and the foundation of social existence and people's lives. Therefore, vigorously developing renewable energy power generation technologies such as wind power, solar power, tidal power, and biological power generation can alleviate and solve most of the problem of primary energy depletion. Countries around the world also advocate power liberalization, and are actively encouraging power reform. Incorporated in the distributed power distribution network can be increased when the power and flexibility of operation, reliability. This mode of operation of the grid is being recognized by many workers in the power industry operates.

Power distribution network is a network in the most important part, the safety and reliability of the distribution network with the socio-economic development and people's normal life are closely related, and the normal operation of the relay protection of the distribution network is an important part of the safe operation of the distribution network. [1].

When distributed power sources are incorporated into the distribution network, there are many factors that affect the stability of the network. For example, the type of distributed power supply, the size of installed capacity, and the location of the grid will have many different effects on the relay protection devices in the existing power operation network [2-4]; also need to make coordination and planning distribution network under the multi-scene, programming grid DG access to distribution under uncertainty; the impact on the grid voltage surges and power flow distribution characteristics; also because of the way the grid diversification in the course of the study should build different models for analysis. Distributed power sources are divided into inverter-type distributed power sources and non-inverter-type distributed power sources [5]. This article focuses on the research of inverter-type distributed power sources integrated into the power grid.
2. Existing protection configuration strategy for distribution network

The main difference between the distribution network and the transmission grid is that the distribution network is a single-ended power supply system, and its current and power directions are constant. Therefore, the configuration of the relay protection is also designed based on the single-ended power supply system. Based on the pertinence of the research in this paper, a brief introduction to the configuration protection strategy in the existing distribution network relay protection.

2.1 Traditional three-stage current protection

The original three-current protection is a basic configuration of the distribution network protection, namely current protection, limit current quick break protection and definite time overcurrent protection. Current quick-break protection cannot protect the entire length of the line, because it is set according to the method of avoiding the maximum three-phase short-circuit current generated at the end of the line; The operating current value of the current quick-break protection of the adjacent components is set; the definite over-current protection can protect the entire length of the adjacent line. It is set according to the current that avoids the maximum load running on the line, and it is also set at the same time. Remote backup protection for line protection.

2.2 Pilot protection

Pilot protection is the main protection line, by taking it switch state quantity on both sides of the line, when a failure occurs, the appropriate protection operation can be made fast and accurate. However, when distributed power sources are integrated into the operation of power grid lines, it may cause errors in the line-side discrimination, which may cause the protection to fail to operate in time. Therefore, the new type of current protection studied in this paper adopts the idea of pilot protection, which is The three-stage current protection of the company has been better expanded, so that the distributed power supply is more stable and reliable when it is integrated into the power grid.

3. Equivalent circuit model

When the capacity of the distributed power supply is different, the output short-circuit current is different, and the impact on the protection is also different. The following is a specific analysis.

(1) In the upstream stage of the distributed power supply, a short-circuit fault occurs at the protection point 1. The distributed power supply and the system simultaneously inject short-circuit current into the short-circuit point. Suppose the system potential is $E_1$, The electric potential of the distributed power supply is $E_2$, The line impedance from the system to the short-circuit point is $Z_1$, The line impedance from the distributed power source to the short-circuit point is $Z_2$. If a short-circuit fault occurs in the middle of the line, the entire network can be equivalent to the circuit shown in Figure 1.

![Fig.1 Upstream fault equivalent circuit diagram](image)

According to the equivalent circuit in the above figure, the short-circuit current injected by the distributed power supply into the short-circuit point is as shown in equation (1):

$$I_2 = \frac{E_2}{Z_2 + Z_g}$$

(1)

The short-circuit current provided by the distributed power supply will flow through the protection.
2. When there is no directional element installed on the protection 2, and the short-circuit current exceeds the setting value of the protection 2, it may cause the protection 2 to malfunction. That is: when, \( I_2 \geq I_{SET} \), it will cause the malfunction of the protection. Substituting into the above formula (2):

\[
\frac{E_2}{Z_2 + Z_g} \geq I_{SET}
\]

The result:

\[
E_2 \geq Z_2I_{SET} + Z_gI_{SET}
\]

(3) A short-circuit fault occurs downstream of the distributed power supply

In the downstream stage of the distributed power supply, a short-circuit fault occurs at the protection 2 location. Install the distributed power supply on bus B. Set the system power supply to \( E_1 \), the distributed power supply is \( E_2 \), and the line impedance between the system power supply and the distributed power supply is \( Z_1 \), distributed power supply \( Z_2 \). The impedance of the line between and the fault point is \( Z_g \), and the impedance of the distributed power supply can be simplified to the circuit shown in Figure 2.

![Figure 2](image)

Fig.2  Downstream fault equivalent circuit diagram

After the distributed power supply is installed, the current flowing through protection 2 is \( I'_2 \), as shown in formula (4):

\[
I'_2 = \frac{E_1}{Z_{\text{min}} + Z_1 + Z_2} \cdot \frac{Z_g}{Z_2 + Z_g} + \frac{E_2}{Z_{\text{min}} + Z_g + Z_1 / Z_g} \cdot \frac{Z_1}{Z_1 + Z_2}
\]

(4)

Suppose that before the distributed power supply is connected, when a short-circuit fault occurs downstream of the distributed power supply, the fault current flowing through protection 2 is \( I_2 \), as shown in formula (5):

\[
I_2 = \frac{E_1}{Z_{\text{min}} + Z_1 + Z_2}
\]

(5)

Make the difference between the two and get formula (6):

\[
I'_2 - I_2 = \frac{E_1}{Z_{\text{min}} + Z_1 + Z_2 / Z_g} \cdot \frac{Z_g}{Z_2 + Z_g} + \frac{E_2}{Z_{\text{min}} + Z_2 / Z_g} \cdot \frac{Z_1}{Z_1 + Z_2} - \frac{E_1}{Z_{\text{min}} + Z_1 + Z_2}
\]

(6)

After finishing: \( I'_2 - I_2 \geq 0 \). It can be seen that the short-circuit current flowing through the protection 2 increases, and the sensitivity of the protection will increase. It will cause the protection scope of protection 2 to extend to protection 3, making it impossible to cooperate between the protections.
4. Materials and Methods
Action module description: original protection module: input the direct jump function judgment, receive the direct jump signal judgment, obtain the three-phase current function, judge the action of the total starting element, judge the overcurrent protection action in the direction of section I, and judge the overcurrent protection in the direction of section II. Judgment, overcurrent protection action judgment in section III direction, trip command function, section II delay function, section III delay function, reclosing judgment and reclosing function are enabled. Through the above module judgment and function, the existing three-stage overcurrent protection action and automatic reclosing function are realized.

The newly added modules are: send a trip command to block protection 120ms function, start the block function judgment, start the sender A to send a 120ms block signal function, after a delay of 8ms, receive 8ms block signal continuously, start the sender B to send a 120ms straight jump signal features.

Using the original protection module, set by the setting value, the overcurrent protection of traditional three-configuration program. Utilize the original protection module and the newly added module to realize the overcurrent protection scheme of the distribution network with DG. The specific process is as follows:

When a short-circuit fault occurs on the line, the communication module A sends out a blocking signal, and the related protection is blocked. At this time, the protection downstream of the DG included in the line may have an action command. The original setting value of the protection is less than the fault short-circuit current on the line. The protection close to the fault point will send a protection lock signal to the protection far away from the fault point. After a delay of 8ms for the first and second stages of the protection, test whether the 8ms blocking signal can be received, if not, the protection sends an action command; if the blocking signal is received, the protection that may malfunction is immediately blocked.

5. Results & Discussion
In the simulation process of this article, according to a certain 10kV line, the model of inverter-type DG is simulated and analyzed, and the simulation data is compared with the original setting value of each protection. The verification simulation model is shown in Figure 3.

![Simulation model of 10kV distribution network with DG](image-url)
The parameter settings are shown in Table 1:

| Tab.1  | The simulation model set parameters |
|-------|-----------------------------------|
| The reference voltage | 10.5kV |
| Base capacity | 100MW |
| Load 1 | 3+j1.57Ω |
| Load 2 | 10+j15.7Ω |

It can be seen from Figure 4 that in the original current protection, both protections 2 and 3 are active, which expands the power outage range, in the new current protection, protection 2 is subject to the blocking signal sent by protection 3, protection 2 will not operate, and protection 3 will operate. The simulation verifies the new current protection scheme.

6. Conclusion

This article aims at the change from the original single-side radial power supply mode of the distribution network to the multi-terminal power supply mode, which will cause the unidirectionality of the power flow in the distribution network to change, and the current size, flow direction, distribution, etc. will be greater during faults. The changes have affected the correct operation of the original relay protection and the removal of faults in the distribution network. Through calculation and analysis of DG different grid-connected control methods, types of distributed power sources, and faults The type, access capacity, and installation location have important theoretical value and engineering significance for the influence methods of the relay protection of the distribution network, and then to propose a protection scheme against the above influences.

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