Scholar Publishing Group
Distributed Processing System
https://doi.org/10.38007/DPS.2020.010102
ISSN 2790-0916 Vol. 1, Issue 1: 9-16

Distributed Generation on Phase-to-Phase Short Circuit Protection in Distribution Network

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Keywords: Distributed Generation, Distribution Network, Phase-to-Phase Short Circuit, Automatic Reclosing

Abstract: As the distributed generation (DG) is connected to the distribution network, the network structure of the original distribution network will change, and the original phase-to-phase (PTP) short circuit (SC) protection strategy will also change. At this time, the protection devices in the transmission line may make some incorrect action instructions, which will lead to the deviation of the coordination between the PTP protection devices in the distribution network and the instability of the system network structure. In order to ensure the reliability of transmission line power supply in distribution network and fully display the potential of DG, it is necessary to study the PTP short-circuit protection. This paper analyzes the influence of(TIO) DG on PTP short-circuit protection in distribution network from three aspects, that is, the influence of DG on PTP short-circuit protection before and after(BAA) access, and TIO DG on the reliability of PTP short-circuit protection. For the access of DG equipment, it changes the distribution of fault current in distribution system and brings transformation effect to the original distribution network protection configuration, so the PTP short-circuit equipment in distribution network will be affected. Finally, the method of combining automatic reclosing with PTP SC protection strategy of distribution network is proposed, so as to protect the safe operation of distribution network system.

1. Introduction

In order to solve the problem of large demand for electric energy in people's production and life, it is necessary to apply these emerging power generation technologies to people's daily production and life. A large part of these emerging electric energy generation technologies are decentralized and small in volume, which is the so-called DG technology [1-2]. However, integrating these power resources into the power grid, especially in the case of PTP short-circuit faults in the distribution

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network, will have a great impact on the power supply.

The research effect of distributed power generation on PTP short-circuit protection of distribution network is remarkable. For example, a scholar uses neural network technology to detect the voltage wave of short-circuit between phases to determine the type of fault, and to identify the nature of the fault by acquiring transmission line data combined with automatic reclosing [3]. In terms of SC protection of distribution network, some researchers have proposed a channelless protection scheme, which is combined with more traditional definite-time overcurrent protection. Under the support of advanced communication systems, an acceleration unit is configured at the protection installation. When the fault occurs, the fault can be quickly removed, which can quickly and accurately remove the fault, avoid the distributed power supply from running out of operation, and ensure the reliability of the power supply [4]. A scholar introduced an adaptive protection strategy, relying on advanced computer and communication technology, through real-time power flow calculation, a large amount of electrical quantities obtained are stored in the computer, and these electrical quantities are compared and analyzed, according to the comparison with the normal quantity to determine where the fault occurred. The error of this protection scheme is very small, the accuracy is extremely high, and there is almost no possibility of malfunction of the protection device [5]. Nevertheless, it is still necessary to make a lot of improvements to the original protection methods of short-circuit between phases in the distribution network in order to achieve better circuit protection feasibility.

This paper first introduces the development status of distributed power generation, and then proposes the requirements for PTP short-circuit protection. Then, it compares the impact of distributed power generation on PTP short-circuit protection BAA the access of distributed power generation. TIO the terminal on the interphase SC protection, and finally this paper proposes a combination of the post-acceleration mode auto-recloser and the interphase SC protection strategy to protect the transmission line and reduce the frequency of faults in the distribution network.

2. DG and PTP SC Protection

2.1. DG

Distributed power generation is another name for distributed power sources in power systems. This power structure mainly refers to regional small grid power generation systems relative to large-scale power grids, and is generally limited to community-scale power generation systems [6-7]. In order to cope with the sharp reduction of global fossil energy and protect the increasingly fragile ecological environment, the global distributed power generation industry has developed rapidly with the support of various governments. Developed countries actively participate in the development and use of renewable energy. In addition to increasing relevant technical research, they also promulgate some incentive policies to stimulate the market and encourage the development of DG renewable energy [8-9].

2.2. PTP Short-Circuit Protection

In order to more reliably ensure the safety of the power grid system, the requirements for PTP short-circuit protection are: fast response to faults and rapid protection of them, and instantaneous action when the current increases, as the main protection strategy for PTP short-circuit protection of transmission lines [10]. In order to prevent the output short-circuit of the output of the next-level transmission line, causing the malfunction of the current-level transmission line and making it lose its selectivity, it is generally used to prevent short-circuit conditions at the outlet of the next-level transmission line [11]. The setting calculation is shown in formula (1):

$$I = \frac{F_N E_N}{C_N + \alpha C_M} \tag{1}$$

In the formula, C_M is the total resistance of the protected circuit, F_N is the fault type coefficient in the system network, C_N is the total resistance acting on the system network, α is the ratio of the distance between the positions of the protected lines, that is, the current protection The protection range of, the calculation protection range is shown in formula (2).

$$\alpha = \frac{F_N}{F_{rel}^{I}} - \frac{F_{rel}^{I} C_N - F_N C_{N_{\min}}}{F_{rel}^{I} \cdot C_M} \tag{2}$$

In the formula, F_{rel}^{I} represents the current short-circuit protection factor, and the maximum value of the protection range α will not be greater than 1.

3. Analysis of TIO Distributed Power Sources On PTP SC in Distribution Networks

3.1. TIO the Distributed Power Supply on the PTP SC of the Distribution Network BAA the Access

Suppose there are two feeders on the power system, namely feeder 1 and feeder 2. There are circuit breakers P1, P2, and P3 on feeder 1, and circuit breakers P4, P5, and P6 on feeder 2. Before the distributed power supply is connected, The action delays of protection P3, P4 and P6 are 0.1s, 0.3s and 0.5s respectively. I1, I2, and I3 are the short-circuit currents of short-circuit points 1, 2, and 3, respectively, which are set as single-phase A-phase short-circuit, and the short-circuit point is located at the end of the line.

Table 1. SC current value of corresponding fault point when distributed power supply is not connected

	Imax	Iset	I1	I2	I3
P1	0.415	0.467	0.124	0.263	0.250
P2	0.372	0.429	0.098	0.134	0.157
P3	0.468	0.495	0.743	0.521	0.524
P4	0.213	0.246	-	0.478	0.783
P5	-0.235	-	-	-	-
P6	0.015	0.017	-	-	0.36

As can be seen from Table 1, before the distributed power supply is not connected, the distribution network is powered by one side. The closer to the system side, the larger the short-circuit current, and the farther from the system side, the smaller the short-circuit current. Therefore, three-stage current protection can be applied to the distribution network. After the distributed power supply is connected, pilot protection is configured between the system and the access point. The maximum load current and the short-circuit current of each set short-circuit point are shown in Table 2.

Table 2. SC current value of corresponding fault point after distributed power supply is connected

	Imax	I1	I2	I3
P1	0.397	0.096	0.125	0.127
P2	0.365	0.074	0.0112	0.0108
P3	0.154	0.622	0.514	0.513
P4	0.136	0.285	0.325	0.178
P5	-0.097	0.372	1.433	-0.241
P6	0.114	-	-	0.61

3.2. TIO the Access Location of Distributed Power Sources on the Distribution Network Current

In addition to its own capacity and type, another important factor affecting the node current of the DG access system is its location in the access system. The beginning of the distribution network is the access point, which is equivalent to incorporating a small power supply into the system. For a general inverter-type distributed power supply, its access to the distribution network is equivalent to access to a controlled current source, and the control quantity is the access point voltage. This situation is equivalent to increasing the total capacity value of the system power supply. It will cause the short-circuit point fault current to increase. But it does not change the direction of the fault current.

In this experiment, the output of each DG is fixed as 50% of the total load capacity, and the DG is connected to the head, middle and end of the distribution network respectively. The simulation results are shown in Figure 1.

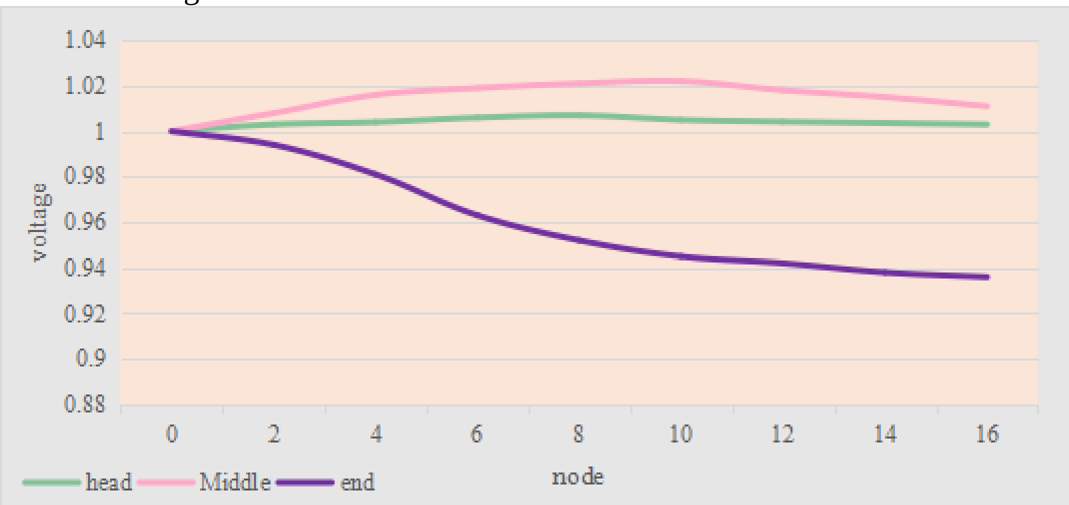

Figure 1. Effect of DG access location on node voltage

It can be seen from Figure 1 that TIO the access to the distributed power supply at different locations in the power system on the current of each node is also different. When the DG is connected to the head end of the distribution network, it has basically no effect on the node current on the transmission line. When the DG is connected to the middle end of the distribution network, it has little effect on the node current. When the location is the end of the distribution network, it has a great influence on the node current.

3.3. Influence on the Reliability of Interphase Protection SC in Distribution Network

DG can be used as a backup power supply to ensure uninterrupted power supply during load peaks and valleys to meet the different requirements of users, which not only ensures the reliability of power supply, but also reduces the expenditures of users [12].

When a large-scale power system fails and a large-scale power outage occurs, the distributed power supply can be withdrawn from the large power grid in time. At this time, the distributed power supply can supply power to a small-scale power grid, so as not to further expand the power outage range, which effectively improves the Safety and stability of power system operation [13].

4. Automatic Reclosing and PTP Short-Circuit Protection Strategy of Distribution Network

Most short-circuit faults in the distribution network system network occur instantaneously in a short period of time. In order to improve the reliability and safety of the distribution network system network supplying power to the load, it is necessary to have special requirements for PTP short-circuit protection strategies. The method currently used is an organic combination of automatic reclosing and PTP short-circuit protection strategies in the distribution network system network.

Automatic reclosing means that when the power system fails, the circuit breaker performs reclosing after operation, so that the transmission line recloses within a short time limit [14]. If it is determined that the fault cannot be repaired in a short time, such as a broken cable, the faulty transmission line will be shut down. This operation is to ensure the safety of the load at the end of the transmission line and the continuity of the power supply [15]. In order to use automatic reclosing to quickly cut off faults in the transmission line, the cooperation mode between the PTP short-circuit protection strategy of the distribution network and the automatic reclosing is divided into the front acceleration mode and the rear acceleration mode [16].

As shown in Figure 2, the wiring diagram of the acceleration mode before the automatic reclosing, AAR means that the automatic reclosing is configured at the protection device. If a fault occurs at point K1, the protection strategy should immediately disconnect the QF1 configured with automatic reclosing, and reclose the automatic reclosing once, if the reclosing is successful, the system will run normally; The circuit breakers QF1 and QF2 should selectively trip the circuit breaker body step by step. In this way, the protection device does not selectively remove the fault first, and then uses the automatic reclosing to cooperate with this mode without selective action, which is called the front acceleration mode [17-18]. In this way, the faults of the lines at all levels can be quickly removed, and the permanent fault lines can be selectively tripped after the automatic reclosing action. The advantage of the pre-acceleration mode is that it uses less equipment. Generally, only one set of reclosing device needs to be configured in the transmission line, and it can be cut off in time when the transient fault develops into a permanent fault, thereby increasing the success rate of automatic reclosing [19]]. The disadvantage of the front acceleration mode is that the automatic reclosing circuit breaker mechanism is installed, the number of actions will increase, and accidents may occur that may cause damage to the mechanism [20].

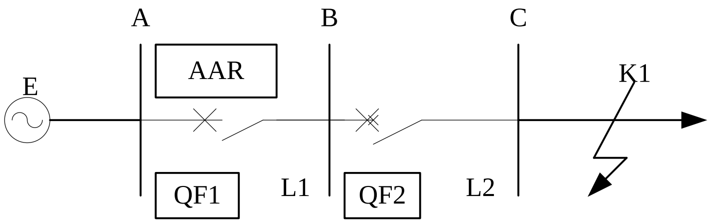

Figure 2. Connection diagram of acceleration mode before auto-reclosing

As shown in Figure 3, automatic reclosing devices are configured at both QF1 and QF2. The difference between the rear acceleration mode and the front acceleration mode is that when a fault occurs in the transmission line, the rear acceleration mode will first operate selectively and then relapsing operation.

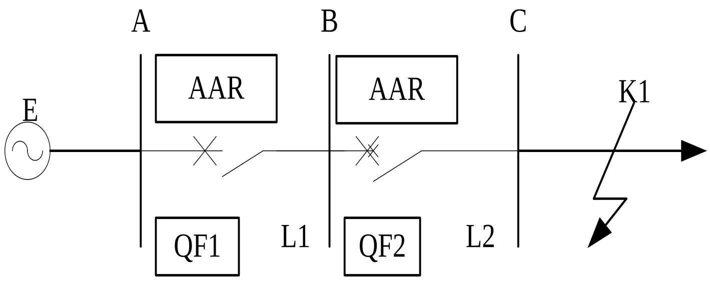

Figure 3. Connection diagram of acceleration mode before auto-reclosing

The post-acceleration method is mainly used for some important power transmission lines. selectivity [21]. The disadvantage of the post-acceleration method is that each circuit breaker is equipped with a set of automatic reclosers, which not only cannot achieve economical efficiency, especially when it is close to the power supply, when the first fault occurs, there will be a relatively short period of time short delay.

5. Conclusion

As a new type of power generation technology, distributed power generation technology has brought revolutionary changes to the power system, but also has an impact on the control and operation of the power system. One of the most significant is the impact of the access of distributed power sources on the PTP short-circuit protection of the distribution network. Therefore, it is necessary to change the original protection setting rules and formulate improved strategies to deal with the large-scale access of distributed power sources. This paper analyzes TIO distributed power sources on the PTP short-circuit protection of the distribution network from different angles, and presents a distribution network protection scheme combining automatic reclosing and PTP short-circuit protection strategies, in order to improve the power supply reliability of the distribution network.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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