Research on Fast Determination of Feeder Fault Based on Intelligent Alarm

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Abstract. According to the present situation that it is difficult for power dispatcher to identify and handle different types of feeder faults in time. This paper analyses the relationship between different types of feeder faults and 10kV bus grounding signal, 10kV bus voltage changes, bus grounding signal frequency, feeder switch trip signal, load change of fault feeder. On this basis, the mathematical calculation model based on the calculation of alarm signal and Telemetry data calculation is established. Then sends out intelligent alarm based on calculation results. It can quickly distinguish all kinds of faults, the accuracy of judgment is over 98%. It greatly improves the accuracy and efficiency of fault judgment and handling, also reduces user outage and risk of personal electric shock.

1. Introduction

All power supply bureaus of Guangdong power grid implement Integration of regulation. It operate mode of dispatching, monitoring and control. Relevant signals such as 10kV and above voltage level switch, bus, transformer, Pt, etc. are uploaded to the monitoring window of dispatching end in a centralized way. The regulator finds problems through monitoring signals; solves problems through remote control operation and adjustment. It greatly improving the cooperative solution ability of problems [1]. The overall access of high voltage level equipment signals in the power grid is convenient to find the existing problems quickly, and the equipment meets the configuration principle of n-1 attribute, which has little impact on users. However, for low voltage level equipment, especially 10KV voltage level equipment and feeder branches of lower voltage level, power is directly supplied to users through the distribution box, with less access signals, or even no access signal [2-3]. It leads to regulation and supervision can not find the fault quickly. It affects the power supply of the user, causes persistent existence risk of personal electric shock. How to quickly realize the judgment and disposal of the different feeder line fault has a certain practical significance [4].

2. Research on low-voltage side bus voltage

Every 220kV, 110kV and 35kV substation is connected with 10kV(or6kV) bus through low-voltage switch of main transformer[5]. The low-voltage side bus supplies power to users successively through feeder switch , feeder branch switch ,distribution box and secondary line, as shown in Figure 1 below,
taking 110kV substation as an example. The 10kV voltage level is used as the low voltage level for description below, and other low voltage levels are the same.

![Diagram](image_url)

**Figure 1.** Power supply path from low voltage side bus to user

The bus voltage at the low voltage side is uploaded to the regulation and monitoring system in three phases. It collects one data every 5 seconds.

When the zero-sequence voltage $3U_0$ exceeds the setting value of the voltage relay by 15V, the kV relay acts, its auxiliary contact is closed, the KS signal relay circuit is on. It triggers the 10kV bus grounding alarm action signal, but when the $3u\_voltageis$ lower than 15V, the voltage relay will return, the normally open auxiliary contact will be disconnected, the KS relay is not charged, triggering the 10kV bus grounding return signal. Under normal circumstances, the zero-sequence voltage is close to 0, far lower than the fixed value of 15V. The zero sequence voltage reflects the voltage of the neutral point. Different types of faults will produce different types of phenomena. The faults of feeder switch are divided into instantaneous faults, intermittent faults and permanent faults. Because the fault types are mainly single-phase faults, and the judgment basis of multi-phase faults is similar to single-phase faults. The following analysis is based on single-phase faults as an example.

2.1. **Analysis of feeder instantaneous fault**

As shown in Figure 1 above, when there are three faults at fault point 1, 2 and 3, and a transient single-phase ground fault occurs, the voltage of the bus ground phase will drop. The closer the fault ground point is to the bus, for example, fault point 1, the more the bus voltage drop. The farther away, the less it drops, for example, fault point 3. However, 10kV bus is non-neutral grounded system, the three-phase voltage is still symmetrical, and the zero-sequence voltage of neutral point is shifted. If phase A is grounded, the voltage of phase a will decrease and the voltage of phase B and phase C will increase. The operation time of overcurrent section I of feeder switch is 0.3s, and that of overcurrent section II is 0.7s. It is far less than the time interval of collecting one data every 5 seconds for the voltage of alarm signal monitoring system. If it is a transient fault, the zero-sequence voltage rises. When it exceeds 15V, 10kV bus ground signal will be triggered. The fault is eliminated in a short time, the 10kV bus grounding signal returns. But the time interval is less than 5 seconds, so it is difficult for regulators to monitor the voltage change.

2.2. **Analysis of feeder permanent fault**

There are two types of feeder permanent faults: one is that the fault feeder can be cut off in time, the other is that the feeder fault cannot be cut off in time.
2.2.1. **Feeder fault can be removed in time.** The feeder has a permanent ground fault, as shown in Figure 1, fault point 1, lasting for 0.3 seconds, the main switch of the feeder trips, triggering the ground signal. After the fault is removed, the bus ground signal returns, at the same time triggering the 701 switch trip signal to the control terminal. If the fault point is on the feeder branch, such as fault point 2 and fault point 3, the 10kV bus grounding signal will be sent, and the protection will cut off the branch switch 711 or the lower switch 301 with correct action [10]. Because the control end does not connect the alarm signal of the branch switch and the lower switch, the switch trip and protection action signal will not be uploaded to the control monitoring end. Because the fault removal time is short, it is far less than 5 seconds. The controller cannot monitor the voltage change due to the time interval of the clock. The phenomenon is the same as that of feeder instantaneous fault.

2.2.2. **Feeder fault cannot be removed in time.** When this type of fault occurs, the fault cannot be removed in time due to the abnormal switch body or the abnormal protection device. The action time is more than 5 seconds. The pcs9000 system at the control and monitoring end can be monitored the change of 10kV bus voltage. The zero-sequence protection of the follow-up grounding transformer cuts off the fault line. Or the dispatching personnel shall arrange the dispatching personnel to rotate the 10kV feeder until the voltage returns to normal and the grounding signal returns.

2.3. **Feeder intermittent ground fault**
The feeder branch has intermittent grounding fault, and each time it is grounded, it will send out grounding signal. Due to the short intermittent time, it does not reach the protection action time, and it returns soon. Some faults continue to developing into permanent faults, waiting for the trip to be removed or the distribution network dispatcher to rotate. If the fault continues to send messages for many times, but does not develop into a permanent fault, it is necessary to inform the patrol service to arrive at the substation for inspection, and power supply sub Bureau to visit the site to eliminate the risk as soon as possible.

2.4. **Comparison of feeder earth fault**
Through the above analysis, we compare various types of faults, as shown in Table 1:

| Fault classification | Bus grounding signal | Frequent bus grounding signal | Feeder switch trip signal | 10kV bus voltage change |
|----------------------|----------------------|-----------------------------|--------------------------|-------------------------|
| Permanent fault      |                      |                             |                          |                         |
|                      | TRUE                 | FALSE                       | TRUE                     | FALSE                   |
|                      | TRUE                 | FALSE                       | FALSE                    | FALSE                   |
|                      | TRUE                 | FALSE                       | FALSE                    | TRUE                    |
| Transient fault      | TRUE                 | FALSE                       | FALSE                    | FALSE                   |
| Intermittent fault   | TRUE                 | TRUE                        | FALSE                    | FALSE                   |

As shown in Table 1, the phenomenon that instantaneous fault and permanent fault can be removed by branch feeder switch is completely the same. But the former has no impact on system operation and does not need be concerned about, while the latter has branch grounding fault and user voltage loss.it needs to be handled in time. According to the characteristics of various types of feeder faults in the table above, a model is established to automatically generate an intelligent analysis alarm signal in the dispatching monitoring system when the corresponding logic is met.
3. Study on fault identification of instantaneous fault and permanent fault cut feeder branch switch

When the transient fault occurs in the power grid, the 10kV bus grounding signal will be triggered. When the branch switch of the cut-off feeder occurs in the power grid, in addition to the trigger bus grounding signal, at the same time, the load current of the fault feeder will decrease due to the cut-off of the branch, so the model is established to study.

However, the load of feeders will fluctuate normally, and it is not clear how much the load of feed forward line is cut by the load of feeder branches. To solve this problem, when a fault occurs, the triggering of 10kV bus grounding alarm signal can be taken as the reference point, and then only the load change after triggering the bus grounding signal for a short period of time can be considered. Load drop value after bus grounding.

The statistics are as follows: from January 2017 to June 2019, the bus grounding occurred in Dongguan Power Supply Bureau of Guangdong power grid. 235 cases of feeder branch switch fault removal were found in the final field inspection. The load drop time and load drop proportion are calculated. Table 2 are as follows:

| Proportion of load drop to load before drop | number | Proportion |
|-------------------------------------------|--------|------------|
| 15%to25%                                  | 79     | 33.62%     |
| 25%to35%                                  | 64     | 27.23%     |
| 35%to45%                                  | 56     | 23.83%     |
| 45%to55%                                  | 30     | 12.77%     |
| more than55%                              | 6      | 2.55%      |
| **Avg**                                   | 38.67% |
| **Min**                                   | 17.35% |
| **Max**                                   | 100%   |

It can be found from table 2 and table 3 above that the feeder branch switch can be cut off after the 10kV bus grounding signal is triggered for an average of 0.65 seconds, and the maximum is no more than 3 seconds. At the same time, the load drop accounts for 17.35% to 100% of the load before the drop, and the average load drop is 38.67%.

Because load drop is not more than 3 seconds. For the 235 tripped lines, the maximum load fluctuation of normal operation load in 3 seconds is calculated within one week before and after the time point of fault removal branch switch, excluding manual operation, as shown in Table 3.

| Proportion of the maximum drop value before the drop in 3 seconds when the load is normal | number | Proportion |
|------------------------------------------------------------------------------------------|--------|------------|
| 0%to5%                                                                                   | 185    | 78.72%     |
| 5%to10%                                                                                 | 36     | 15.32%     |
| 10%to15%                                                                                | 10     | 4.26%      |
| 15%to20%                                                                                | 4      | 1.70%      |
| more than20%                                                                            | 0      | 2.55%      |
| **Avg**                                                                                 | 4.21%  |
| **Min**                                                                                 | 0.20%  |
| **Max**                                                                                 | 18.35% |

According to the statistics in Table 3, it can be found that under the normal operation of the above 235 lines with branch tripping of feeders in one week before and after tripping, the average maximum
decline of 3 seconds is 2.21%, the minimum value is 0.19%, and the maximum decline of 98.3% is within 15%.

According to table 3, when the feeder branch trips, the minimum drop is 17.35% of the load before removal. In order to ensure the accuracy of judgment, a reliability factor is added $K_{rat}$, the value is $17.35%/K_{rat}$, $K_{rat}$ take the value between 1.1 and 1.2, so the setting value is 15%.

3 seconds after triggering the bus ground signal, the load of the feeder connected to the bus ground is $P_{after}$, the load of the corresponding feeder when the bus triggers the grounding signal is $P_{before}$.

Then in any feeder, $(P_{after} - P_{before})/P_{before} * 100% < -15\%$, the bus grounding signal is triggered. It is defined that there is a fault in the feeder and the corresponding intelligent alarm is triggered. It is necessary to arrange sub bureaus to patrol the feeder as soon as possible, and patrol maintenance shall focus on the inspection of the feeder to eliminate faults and avoid electric shock accidents and power outage for grid customers.

Using the two fixed values of 3 seconds and 15% will lead to 1.7% possibility of misjudgment. However, feeder lines and branches with permanent faults will not be missed, and the pressure of inspection by branch offices and maintenance personnel will not be increased greatly. So this model function is feasible.

4. Conclusion

(1) This paper analyzes the relationship between different types of feeder fault and bus grounding signal, signal frequency, voltage change, load drop, feeder switch trip signal, and discusses the fast judgment and disposal methods of different faults.

(2) According to the characteristics that it is difficult to distinguish the permanent fault removal and the instantaneous fault of feeder branch. A data module is proposed, which takes the 10kV bus grounding signal as the trigger signal to automatically count the load drop of the corresponding feeder from the time of sending, and more than 15% of the corresponding feeder branch is judged to have fault within 3 seconds.

(3) If the results are not more than 15%, it is judged as instantaneous fault, or there is a fault in the air charging feeder line. It is required that the corresponding branch office focus on the inspection of the air charging line.

(4) According to the alarm signal and telemetry numerical calculation, the model can quickly get different types of faults and trigger intelligent alarm, which has high efficiency and preparation rate, improves the reliability of power supply and reduces the risk of personal electric shock.

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