RESEARCH ON SINGLE-PHASE GROUND FAULT LOCATING FOR NON-EFFECTIVELY GROUNDED SYSTEM IN SHANGHAI

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ABSTRACT

Grounding through Peterson coil is the most common mode for 10 kV grids in the southwest of Shanghai. Some Peterson coils also have a parallel resistance. The traditional way to find the fault single-phase ground location is mostly relying on manpower to 'test & remove' the feeders and their sub-feeders step by step. This way often costs much manpower, time and material resources. The technology of this paper will change the above status. When single-phase ground fault occurs, the parallel resistance will be switched on and off according to a sequence of orders. The characteristic waveform will be captured by many fault indicators installed on 10kV lines. Then, the data of indicators will be transferred to the master station of fault locating system, and the fault area will flash based on geographical background after analyzing. It is very helpful for the workers to repair quickly. This technology has been applied in actual 10 kV lines.

INTRODUCTION

Because the fault phase current does not change much when a single-phase ground fault occurs in non-effectively grounded system, traditionally it is difficult to determine the fault spot on the power lines. Therefore, the fault locating is one of the difficulties in such system, and also becomes the important research field for us.

CURRENT SITUATION

It is a typical hybrid grid mainly based on over-head lines in the southwest of Shanghai, the neutral point grounding mode is mostly through Peterson coil. Recently, a parallel resistance has been installed with the Peterson coil to increase the rate of selecting fault line. In future, the newly installed Peterson coil will often include a parallel resistance. This way will go on.

However, though we can determine the fault line, we still can not determine where the fault spot on the line is. When a single-phase ground fault occurs, the traditional ways to find the fault spot are often time-consuming and laborious.

Manual search method

When a single-phase ground fault occurs, the workers will remove the feeders one by one to test which the fault line is. If got it, then remove the sub-feeders of this line one by one to continue testing the fault spot, and so on. So, it will cost much time, and also need several persons to cooperate together.

Fault feeder selector

Nowadays, the fault feeder selectors are often installed in substations to select the fault line among the feeders. Sometimes, they are not accurate. Anyway, it can be a reference for manual search method. However, the fault feeder selector can't determine the concrete fault spot too.

Old fault indicator

Old fault indicators have been installed on some over-head power lines. If the indicators detect a large short-circuit current, they will give a sign on the bottom so that the patrol workers can see it. Old fault indicators can only detect the short-circuit faults, they can't detect the single-phase ground faults. But actually, the probability of the latter is much larger than the former.

FAULT LOCATING SYSTEM

Composing

The entire system consists of the following sections:

Monitoring equipments

They include many distributed fault indicators on 10kV lines.

Master station

It receives all kinds of data from monitoring and communicating devices, and determines the fault area after analyzing. Also, it communicates with the Peterson coil control device to switch on and off the parallel resistance according to a serial of orders.

Communications equipments

They include many repeaters and wireless receivers on the communication link, and so on.

Fault locating principle

A new type of fault indicator has been developed, and also a fault locating system has been established, which can determine and locate the single-phase ground fault area of 10 kV over-head power lines, as shown in Figure 1.

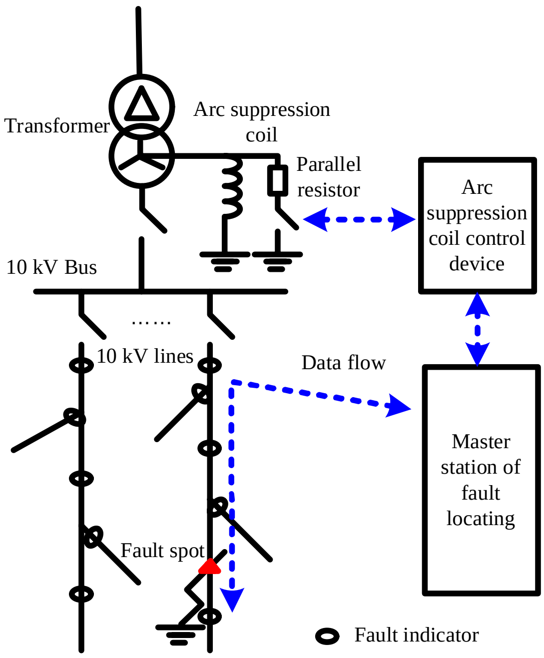

Figure 1 Principle of fault locating system

The basic principle of fault locating system is that, taking full use of the parallel resistance accompanied with the Peterson coil, it will be continually switched on and off several times according to the orders. Then, a characteristic zero sequence incremental current will be produced, it will just go through the ground fault spot on the line to constitute a loop. The indicators before the fault spot will detect the characteristic current, the indicators after the fault spot will not. All the indicators are required to send their data to the master station of fault locating system. After analyzing, the fault location can be determined quickly, and it can also be flashed in Geographic Information System, which is very helpful for the operation and maintenance workers. It will significantly reduce the fault dealing time and the labor bear by the workers.

Characteristics

Locating

Fault locating system can determine and locate the single-phase ground fault area, which will significantly improve the current status of troubleshooting. Also, it can locate short-circuit, disconnection and other faults. It covers wider, and is more practical.

Investment

Taking full use of the existing Peterson coil and parallel resistance, it doesn't require the addition of other devices in substations, thus reduces the investment for equipments and renovation.

Display

Every fault indicator has an ID number, so it can be easily managed to display its status in GIS for judging the fault area.

Self-checking

Fault indicator can check itself periodically, and send the results to the master station. So, the real-time operation status of fault locating system can be monitored online.

Fault indicator

Figure 2 shows the pictures of fault indicators. It is divided into three parts from the appearance. The top is a half part of an electromagnetic induction coil, and can be rotated. The middle part is the main body of the fault indicator. The bottom is a bolt with a hole, it is designed for installation. When we are installing, first we rotate the top half coil 90 degrees, hook the bottom bolt using an operating rod, then lift the fault indicator, hang it on the over-head line, rotate the operating rod to make the top half coil rotate and close. Continuing to rotate the rod can make two parts of the electromagnetic induction coil contact tightly. Thus, the fault indicator can be installed on the over-head line reliably. If we want to remove it, we shall rotate the fault indicator by an operate rod in a reverse direction.

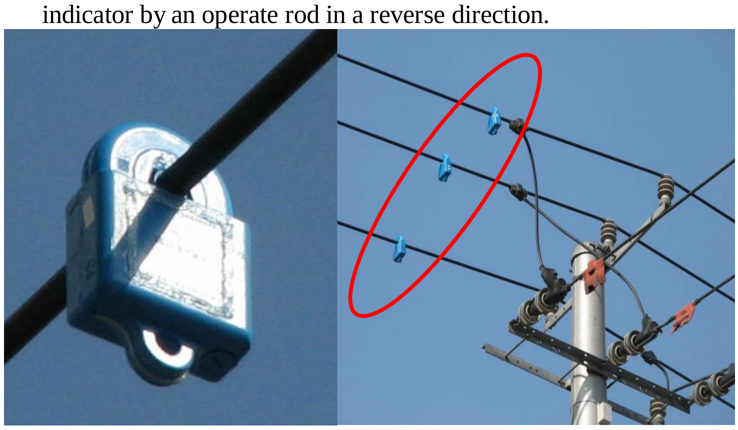

Figure 2 Pictures of fault indicators

Figure 3 shows the principle of fault indicator. It is constructed by fault current sampling, processing, transceiver, and power supply parts. The principle of fault indicator is that, it measures the load current by electromagnetic induction, and converts the analog current to digital data. All the data will be analyzed by micro processor unit (MPU), and be sent to master station by wireless transceiver module. The power unit supplies the energy for all the parts, and charges the battery. The internal clock offers accurate time service for the MPU.

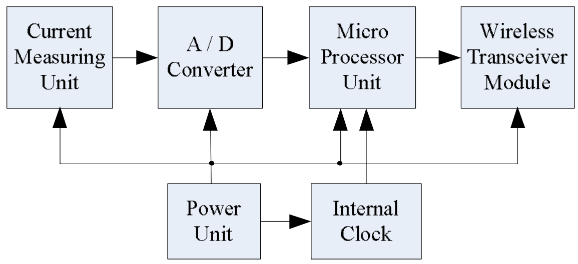

Figure 3 Principle of fault indicator

Master station

In order to achieve the real-time monitoring, fault locating and management, it is necessary to set up some servers for data collection, application and database. Data collection server is mainly responsible for collecting and transmitting data from the fault indicators. Application server is responsible for analysis of fault information, location judgments, alarm display and other applications. Database server is responsible for data storage and management of sampling data, alarm information, history data, et al.

The master station also needs to communicate with Peterson coil control device, so as to make the parallel resistance switch on and off several times, get the action result and time information for analyzing current data from all the fault indicators in time to locate the fault spot. In the master station, we can also know the operation status of all fault indicators online, such as the load currents of feeders and sub-feeders, uniform clock, and the battery voltage of fault indicators, etc. We can also initialize the configuration of fault indicators (e.g. threshold current, clock, various parameters, etc.), and achieve the integration with GIS, DSCADA and other system for sharing the real-time data resource of over-head lines.

Communication Equipments

Because there are so many fault indicators distributed on a large scale, we shall take full consideration of construction and operation costs of communication system. If we use GPRS technology, the operation costs will be great. We finally chose the low-power RF technology. It is cheaper and permitted by Radio Management Committee in selection of free wireless band, such as ISM 433, 868 and 915 MHz. So it can be used widely.

Fault indicators send the data by their wireless transceiver modules to wireless repeaters nearby. Wireless repeats are important data transmission equipments, they are always installed evenly on trunk line, and on every branch line joint spot. High-power battery pack with solar power supplying are configured in wireless repeat, it can work for 3 to 5 years continually according to design. The effective transmission distance of wireless repeater is about 1 km. Each repeat has a unique ID code, the transmission and control of data are achieved by the address coding and internal mechanisms.

Wireless transceiver is responsible for data transmission between wireless repeaters and the data collection server of master station. In order to achieve multi-point, multi-level communication and management, the RF signals are transformed into RS-232 signals by wireless transceiver, and transformed into digital signals by network switches. So, they can easily be transmitted by TCP/IP communications protocols. A wireless transceiver can communicate with many wireless repeaters, its communication capacity depends on baud rate, protocols and the number of communication equipments.

ACTUAL APPLICATION

The fault locating system has been applied to two 10 kV over-head lines in Shanghai Jinshan district. The two lines both have many branches and cross-cables. We have installed 54 fault indicators, 20 wireless repeaters altogether. The installation and test was ended in January 2010.

During the operation period, we find the load currents of the two lines are small. The minimum load current is only 3 to 5 A, it is enough for current measurement, but it is unable to maintain the energy supply for fault indicators for long time running. So we have to improve the energy supply and consumption design of fault indicators. The new type of fault indicator is suitable for different load currents, the measurement and fault determination is more accurate, timely and reliable. It can meet the needs of the actual production process.

CONCLUSIONS

With the development of communication and information technology, the searching ways of single-phase ground faults also need to be improved. Based on the existing equipments, the fault locating system in this paper is a new solution for single-phase ground fault locating. Its feasibility is verified on actual 10 kV over-head lines. In the future, we will still improve its performance, and integrate with other application services to meet the needs of smart grid.

REFERENCES

[1] Xiaobo Zhou, Weibin Wang, Junmin Zhang, 2009, "neutral point grounding modes for 10kV grids in Shanghai area", *Proceedings of 20th International Conference on Electricity Distribution.*

[2]Huannian Yao, Yuemei Cao, 2000, *Resonance Grounding of Power System*, China Electric Power Publishing House, Beijing, China, 122-140

[3] Jian Liu, Zhao'an Wang. 2000, "a new approach to identify faulty sections in distribution system". *Journal of Xi'an Jiaotong University*. vol.34, 7-10

[4] Shanghai Municipal Electric Power Company, 2004, *Provisions of Several Technical Principles in Shanghai Power Grid*, 31-37

Biography

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