

Chapter 2

Research of Optical Fiber Communication in Relay Protection

Zhan Guo and Zu-ming Xiao

Abstract With the development of large grid, distributed, heterogeneous complex power network, the power grid management is more and more complex and its safety operation is more important. In order to effective control of power systems in normal operating conditions within the shortest possible time, the relay signal must be accurately passed to the communication terminal by the transmission channel. At present, optical fiber protection channel is widely used in many parts in China. It also has some problems, such as leakage of immature technology, lack of synchronous optical transmission signal protection performance indicators. In this paper, the basic content of relay protection is described, the application of optical fiber communication technology, as well as the problems exposed in the practical application in the signal transmission channel is introduced, the development prospect of new technologies and materials for optical fiber communication technology is analyzed.

Keywords Relay protection • Optical fiber communication • Application mode

2.1 Introduction

As a relay signal transmission medium, optical fiber communication has been a preliminary application, and it is the future direction of development of the relay channel. But within the industry to develop relevant standards and norms without

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some special business electricity private network taken into account, only taken into a variety of business in the public communication network. Because of this, the reliability that relay signal is transferred by fiber channel has been questioned. In order to make the fiber protection channel really get a wide range of applications, we must conduct a thorough study of the relay signal performance and fiber-optic application.

2.2 The Overview of Relay Protection

2.2.1 The Content and Basic Functions of Relay Protection

2.2.1.1 The Overview of the Relay Connotation

Power system is consisted by power plants, substations, and the organic whole of the transmission and distribution lines, including many complex high-voltage electrical equipment and protective, regulating, monitoring low-voltage automatic device. Usually power system at run time will inevitably appear short circuit, disconnection, ground fault caused by external factors, such as lightning, birds, and internal factors, such as equipment aging, the artificial and improper operation. Malfunction or abnormal situation, not only will affect the normal use and production of the client, but also damage to the device or even grid overall security breach, irreparable damage to the normal economic production. In order to reduce threats the abnormal situation towards the power system in the actual operation, strict regulation is needed for equipment's procurement, installation, operation and maintenance, the appropriate protection and automation devices should be equipped.

Relay protection device is the protection the power system to install and run, its function is to reflect the fault and abnormal operation. Protection devices for a certain distance away from each other, signal transformation should be valid and correct in order to maintain a synergistic action. Therefore, the relay signal transmission is essential for the normal operation of the power system or other public communication, to solve many technical problems that protection channel exists is the protection of the management and operation of modern long-distance power grid transmission.

2.2.1.2 The Basic Functions of Relay Protection

First, when the power system is failure, the relay protection component quickly and unequivocally sends trip command to recently circuit breaker, so that failure component can be disconnected from the power system in a timely manner, which minimize damage to the power system components and the impact of power supply system. Second, it could detect irregularities in the operation of electrical

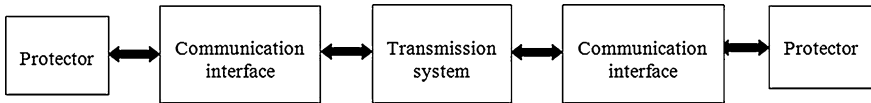


Fig. 2.1 The working principle of the protection device

equipment, and send signals to the management terminal according to the abnormal conditions and equipment maintenance requirements, so that staff can deal with in a timely manner or automatically disconnected electrical equipment which will cause accidents and given a degree of automatic delay.

2.2.1.3 The Signal Transmission Channel of Relay Protection

The relay protection device output the 2 Mbit/s or 64 kbit/s signal through the interface to reach the contra lateral terminal by transmission channel. The work process is shown in Fig. 2.1.

2.2.1.4 The Traditional Signal Transmission Channel

The relay protection signal can be transmitted through a variety of different communication channels, such as traditional power line carrier and microwave.

Power line carrier channel is a specific signal communication in power system. It has the advantages of short input duration, simple device, communication effect, communication lines usually corresponding erect where power lines lay. There are two application forms, specific carrier and reuse carrier, the application of these two forms is not very satisfactory. There is a poor anti-interference and anti-misuse ability.

Another microwave transmission phase has characteristic to separate self-fault with the power system fault, which provides a good communication channel to relay signals when failure event occurs. But there are also prone to fading in the actual operation, too many links on the intermediate transfer.

2.2.1.5 Transmission Channel of Optical Fiber Communication

In optical fiber communication system, the light waves' frequency as a carrier is higher than the radio frequency, to consider in terms of the transmission medium, fiber losses are much lower than cable and waveguide. Therefore, the optical fiber as a transmission medium can further improve the safety and reliability of power grid transmission. In actual operation, the optical fiber communication channel has many advantages: First, it has a high rate of the recognition error, and good transmission quality. This transmission characteristic makes the transmission channel have the media rate which the protection devices need. Through fiber

Channel transmission, terminal received information is exactly the same with the original information, there is no lack or change of the information. Second, it has the high anti-interference ability. Due to optical fiber communication media, it can effectively avoid the system-generated electromagnetic interference due to lightning and other natural phenomena. Third, it has characteristics of wide frequency bandwidth, large transmission. Due to the amount of information, and thus it increases the number of pass and make as much as possible to pass information between the originator and the terminal, thereby enhancing the correctness of the signal of protection devices.

2.2.2 *The Application and Problems of Optical Fiber Communication in the Relay Protection*

2.2.2.1 The Application of Optical Fiber Communication

The application of optical fiber communication channel is divided into dedicated connection and reuse connection.

Dedicated connection is connected both ends of the relay by fiber, generally when the distance is greater than 40 km, it is required to amplify the signal by relay equipment for transmission. It is shown in Fig. 2.2.

2 Mbit/s or 64 kbit/s

Multiplexing connection is the protection device connection that sucked terminal speed protection signal is transferred to end through fiber SDH network after multiplexing, and then demultiplexed into a low-speed signal transferred to the right side. General if the protection device interface rate is 64 kbit/s, the signal is needed to reuse by PCM equipment before SDH transmission. If the protection device communication interface output rate is 2 Mbit/s, it doesn't need PCM equipment for reuse. The process is shown in Figs. 2.1, 2.2 and 2.3.

It could be clearly seen from Figs. 2.1 and 2.2, a dedicated fiber connection has been widely used in practice because the transmission link is less and the system constitution is simple. But this connection is defective compared with reuse connections, optical core utilization will reduce, optical connector's change causes mixing increased costs. In addition, the grid structure and other public communications network changes more quickly, the pace of networking is faster and faster, a dedicated fiber connection cannot change with its structure. Compared with the traditional connection, the transmission performance of multiplexing, optical protection channel is better than power line carrier and microwave channel, and multiplexing optical fiber protection channel networks flexible; to meet the

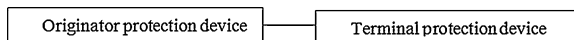


Fig. 2.2 Dedicated fiber connections

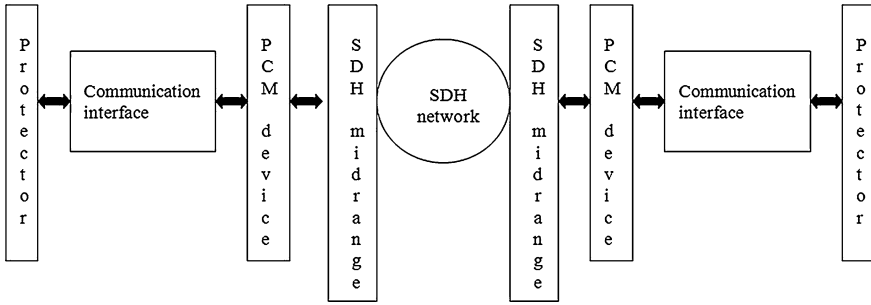


Fig. 2.3 Multiplexing optic fiber connection

rapid changes in the grid structure, also makes full use of resources and cost savings. By the above comparison can be drawn, multiplexed optical fiber protection channel is long-term development direction in the protection channel.

2.2.3 The Protection of Optical Fiber Communication Channel

2.2.3.1 Line Current Differential Protection

The basic principle of the line current differential protection is based on the current theorem to achieve protection unit, its principle is simple and not affected by run way, the two protection devices within the system are separate to improve system's reliability. In multiplexed channel application, the synchronization of protection and multiplexing device is essential for the correct operation of the optical fiber differential protection, therefore master and slave timing modes are used to ensure clock synchronization. In addition, the use of 64 kbit/s digital channel, the current differential protection channel not only ensure the current amplitude, but also ensure the synchronous transfer, which tends to affect the accuracy of the BER test, so most of the manufacturers have introduced line current differential protection channel with a 2 Mbit/s digital interface.

2.2.3.2 Fiber Blocking Scheme, Allowing Longitudinal Protection

Fiber blocking scheme, allowing longitudinal protection uses a stable and reliable fibre channel instead of the traditional high-frequency channel, thereby increasing the reliability of the protection action, its structure is developed from the original high-frequency locking structure. The traditional high-frequency locking structure needs regular to exchange of signals to ensure the normal and the sensitivity of the channel, frequency discriminator signal of fiber lockout protection channel eliminates the need for cumbersome inspection procedures by monitoring the fiber

channel protection. In addition, the transformation of the fiber latching only needs to replace the optical transceiver that could access the currently used high-frequency protection, which saves a certain amount of replacement costs.

2.2.3.3 Problems of Optical Fiber Communication Protection Channel

Since the optical fiber communication technology in China starts relatively late, the communication quality is gradually improved, but it needs a full range of coordination and communication among engineer, design, and communications in order to obtain a substantial development.

2.2.3.4 The Lack of Authoritative Requirements and Standards

Optical protection channel is not established technical specifications and industry standards in the initial design and application, so optical fiber communication could only plan and construct accordance with its own characteristics and practices in many areas when the rapid development of optical fiber communication. Due to the lack of uniform standards, optical fiber communication does not meet the requirements to play a protection channel in some areas, which is an adverse impact on the quality of the transmission channel, and thus constitutes the entire power system security risks. Thus, in order for greater integration of resources, reduce duplication building cost, development of uniform standards and norms of the industry is imperative.

2.2.3.5 The Synchronization of Optical Fiber Current

Towards synchronization problem of the vertical flow of the fiber-optic current differential protection devices, the current research manufacturers use GPS synchronization method and data correction method, but both methods have their own application defects. GPS synchronization method is to carry on the GPS-based applications, the sampling synchronization and communication route which could adapt to all forms of communication system that can achieve very high accuracy, and not be affected by grid frequency. But it will be subject to the constraints of the natural and social environment, especially the GPS satellites controlled in wartime.

Data correction method allows the freedom and independent sampling for all protective devices, if the communication route is fixed, after the channel delay measured, when the communication interference or communication interruption, it almost does not affect the sampling synchronization. As long as communication is restored, the protection device according to the received current vector packets can immediately carry out the differential protection algorithm process. The drawback is that each differential protection algorithm process following the data correction process and the comparison of the channel delay parameters. It is not suited to the

traffic routing changes, and the grid frequency changes will also affect its displacement vector result of the amendments.

2.2.4 Application Prospects of Optical Fiber Communication Technology

The optical fiber communication technology has advantages of no crosstalk confidentiality; low loss, long distance relay; frequency bandwidth, large capacity communication; anti-electromagnetic interference in practical applications, so it has good prospects. However, in accordance with the above-described problems, we still need to strengthen research on optical fiber communication. The future optical fiber communication technology in the relay protection should be the direction of ultra-high-speed system; this can increase the bandwidth and take full advantage of reuse. In addition, the optical fiber communication technology should gradually realize optical networking; optical networking could realize large-capacity optical networks and network scalability, reconfigurability, allow the growth of network nodes and business volume. Finally, the fiber material should be adapted to new development and need to develop a new generation fiber, at present, non-zero dispersion of light fiber and no water absorption peak fiber is the main direction of development.

2.3 Conclusion

With the development of communication technology, more and more fiber channels can be chosen for relay protection. At present, the formation of fiber-optic network provides a hardware foundation for relay protection using high-performance channel. How to effectively use it to make it better for the protection services is the crux of the matter. This requires various professional coordination and communication among engineering design, operation, maintenance, communications, protection, needs the accumulation of field practical experience, in the practical application, we should deal with new problems to actively explore, analyze and solve.

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