

Application of Passive Optical Network Technology in Distribution Network Automation

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As a salient proportion in the social development, the power industry can effectively transmit the power energy, improve the power consumption efficiency in the society and bring greater benefits to the company. In recent years, amid the operation of China's power industry, the PON technology is gradually applied in the distribution network, thus endowing it with prominent advantages and enhancing the quality of the whole power transmission. Based on this, studies in application of PON technology in DNA bear great importance to further boost the application influence of such technology and entitle it with a greater role in reality.

1. Analysis on the DNA

The DNA utilizes a great many current scientific and technological fruits, such as computer technology, information technology (IT), etc. In the synergy of these, the whole performance of the distribution network has been improved and empowered to discover problems in the distribution network, and automatically stops operation and reports to relevant personnel, guaranteeing its normal operation. In common sense, the DNA comprises three proportions. The first is

distribution network master station, which is the core of the whole distribution network and is also responsible for all ongoing events involved in the distribution network while monitoring the operation of distribution network; the second is distribution network sub-station, which is in charge of column switches, switching stations and monitoring of distribution terminals under its control; meanwhile, it offers master station a sound decision basis by transmitting data collected during the monitoring to it; the last is distribution network terminal. Its main job is monitoring the operation of distribution stations and terminal devices by means of the feeder, so as to timely know the power consumption by clients.¹ In the vast internal structures of a DNA system, distribution network communication system plays the most crucial part. To put it into another way, the automation of the whole system is achieved through it by transmissions of uplink data and downlink data. In operation, the distribution network communication system acts as a bridge, connecting the above-mentioned three proportions into one and ensuring fast and accurate

Abstract:For power companies, numerous equipment and devices play important roles in their daily operation. Distribution network serves a quite crucial part, which guarantees its better performance and can better the power transmission. That being the case, automation technology emerges in the distribution network application and hence the distribution network automation (DNA) is formed. Aiming at enhancing yet even more the performance of the distribution network automation, this paper studied the application of passive optical network technology in the distribution network automation technology, hoping to lay a sound foundation for the development of China's power industry.

Key words:Passive optical; Network technique; Distribution network automation; Application

Published on 30th Sept,2017

information communication within the entire system.

2. Introduction to the PON Technology

The PON technology consists of optical network unit and optical line terminal as well as their matching distributors, which

connect these two indirectly. Also, the entire equipment is composed of a passive optical splitter and optical fibers (See Figure 1).

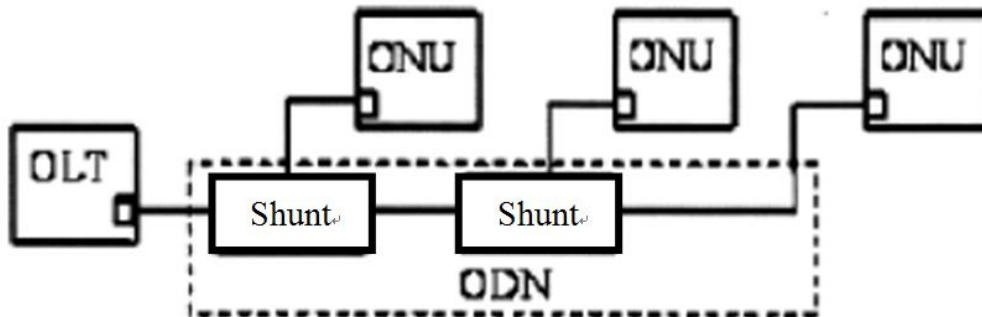


Figure 1. Diagram for the PON

In the whole PON, the optical distributor is a very important part which sends downlink data and manages the uplink data, while, at the same, properly allocating power of the optical distribution signal and reusing the wave length. The optical fiber terminal can serve as an interchanger to exchange uplink and downlink data and present all businesses in the system. It, in addition, also connects with passive optical fibers to better network management and distribute the wideband more reasonably. In the system, no power source is needed in shunt for its operation. Therefore, it can run normally under any complicated weather. Normally, at 2/4 or 8, control the shunt can achieve the multiple-level connection. At user side, a relevant interface can be made available by optical network unit. Finally, the

switchover between uplink and downlink data lays the basis for business operation and ensures its proper implementation².

The data transmission occurring in the PON system adopts many methods, such as time division multiple access/time division multiplexing method, wavelength division multiple access, wavelength multiplexing, code division multiplexing/code division multiple access, etc. Among all these, their applications are subject to actual situation but the first one is the most commonly used.³ Figure 2 shows the two diagrams of the data transmission in a PON system, which clearly showcases the first method is used for data transmission in a PON system. In the first diagram, the data transmission is conducted via time division multiplexing where the

downlink data is sent through optical fibers by broadcasting. The optical distributor gradually divides all information into different information streams and channels them to corresponding optical network units. Then, it utilizes preset parameters to screen and select useful information. The second diagram displays the transmission of downlink data which is mainly achieved by time division multiple access. It will suddenly transmit data to the optical network unit at the corresponding time. In the meantime, these data can be converted in the optical distributor into related light source signals which is also achieved by time division multiple access, thus making illuminating signals appear in the system. Once finishing transmitting, all data will be

processed in different ways according to relevant protocols. In addition, in a topological structure comprised by the PON system, it is hence unnecessary to place node devices in branch points. An

optical distributor will be enough to guarantee the operation of the whole system. This will decrease the use of optical cables and maximize the value of broadband in the system. It, at the same time,

also provides safety guarantee to system operation, thus accelerating network building and boasting high cost performance.

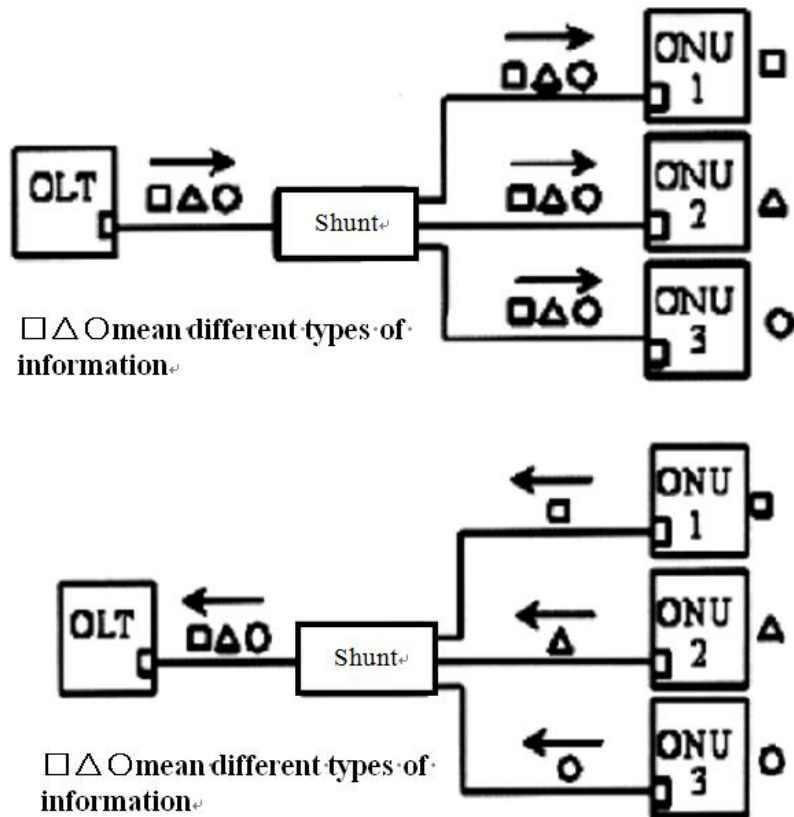


Figure 2. Diagram for PON Data Transmission

3. Application of Passive Optical Network Technology in Distribution Network Automation

3.1 Merging of the PON Technology and DNA Communication System

Since communication system takes an important place in the DNA, in order to lift up the system performance, its merging with PON technology seems inevitable. The merging will result in the stronger performance due to optimization

provided by the PON technology.⁴ During the merging process, a full analysis on PON technology should be conducted for understanding its features, which will help to maximize its effect. But for merging purposes, followings requirements should be met by the DNA: (1) Driven by the strong economic momentum, China's power system has been improved in an overall manner, witnessing an increasing coverage of distribution network system over both favorable environment in cities and

complex surroundings such as mountainous forests, basins, etc. Therefore, the application of PON must be ensured to its full operation in any conditions without being interrupted by external elements which may hamper its natural functions; (2) In order to adapt the PON into various environments, during system topology design for the distribution network, the feature of flexibility should be ensured in hope of enabling the system to change automatically based on actual

external environment to meet different business requirements; (3) While safeguarding smooth operation of the whole distribution network, terminals should be used to collect information rapidly and accurately before effective transmission to the master station; meanwhile, as the master station receives the information, it will work out the best command based on the fed information and send it to terminals, realizing the whole joining up of the system with good dispersibility. By this, bidirectional receiving and transmitting can be realized based on the information receiving and transmitting; (4) Devices should be ensured with good performance, making its installation and maintenance easier while merging with PON; (5) Human and material resources necessary in analyzing the merging of PON and DNA should be fully prepared based on the characteristics of the PON technology in a manner of strengthening communication quality and enhancing the capability of the entire distribution network communication system in conducting operational business⁵.

3.2 Application in Topology Structure

In the whole distribution network, topology structure also serves as an important proportion. Through the topology structure, all stations can be interconnected and their structural relations can hence be reflected, which is normally the

first step of building the computer network, and the foundation of realizing various network protocols. Therefore, it influences gravely on network performance, system reliability and communication fees.⁶ During the application of PON technology in the topology structure, the following two structures are mainly adopted:

3.2.1 Chain Structure

It means to connect all optical fibers by chains within the structure to accomplish multi-level beam split. In connection, the master station should be configured along the direction of optical cable (normally at the location of the nearest station). Then the shunt should be used to split the beam, namely, using single-core optical fiber to connect the device in one line; as for the other line, the connection should be realized along other optical network units. Repeat in this manner for overall connection. For devices isolated from these points, they can be directly connected to ensure flat management in the distribution network system. Such structure in the distribution network will decrease effectively the dependence on optical fibers and maximize the functions of limited fiber resources during the distribution network operation.

3.2.2 Star-Type Structure

This structure requires one single-core optical fiber between the master station and each

sub-station. The optical fiber terminal is equipped in the machine room for the master station. The shunt can be installed not only in the machine room, but also, depending on actual situation, in corresponding service hall. To connect it with the terminal via single-core optical fiber can reduce the use of fibers. Corresponding optical network unit terminal should be installed in all stations. Via these optical network units, devices in the sub-stations can be connected with those in the master station. A number of network ports exist in the optical network units. Their priority levels and bandwidth frequencies can be properly configured to meet the actual needs in situations. Moreover, relative virtual networks will also be divided. In all, application of such structure in the distribution network can build a premium network environment while guaranteeing multi-access of the businesses.

3.3 Analysis on the Application Case

In management of DNA, relative platform will often be used as a medium whose operation can control the overall situation. This paper chose a distribution network of one power plant in our city as the study target. During the establishment of communication business, Ethernet was applied to build relative communication network structure; a loop network transmitting by light was adopted

between the power supply station and the master station to effectively run communications, gather all information in the distribution network and connect all information stored in the master station, thus accomplishing real-time monitoring.⁷ This distribution network demonstrated with high security, and integrated many modules into one. Therefore, high success rate was guaranteed (normally reaching 100%) when communication activities were conducted within the master station and effective display was also achieved. In power supply station automation, one of the most components was distribution transformer monitoring terminal. Its operation automatically accomplished the monitoring, effectively gathered parameters such as current, voltage, etc. and displayed such information for operators in an economic operational mode.⁸ In addition, it could monitor the entire distribution network system, ensure relatively high security and provide access from the terminal server for distribution network automation data while passing through the RS232 optical fiber terminal in the power supply station. Such connection ensured an interlinking within the local area network via terminal servers. In the end, data exchange served the master station in the wide area network, ensuring a scientific and reasonable use of information.⁹

4.Summary

In conclusion, social progress propels economic growth, which in turn levels up the requirements of the society for power industry. Against such background, previous management method on the power grid falls behind the current demands. As an important way of managing power grid, DNA will strengthen the functions and contributions of distribution network to the society and provide endless power energy to fuel the social development if it is kept on a continuous development.¹⁰ The PON has high security and high bandwidth, which make it a suitable candidate for application in the distribution network system. But in actual practice, it should be used with cautions so as to make the best of it.

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