Research on Application of Distribution Automation Terminal Equipment Based on Smart Grid in Power Distribution Automation

Guohui Yang, Mengde Xu
Department of Electrical Engineering and Automation, Luoyang Institute of Science and Technology, Luoyang, 471023, China

Abstract. With the improvement of people's living standard, people's demand for electricity is also getting higher and higher. Nowadays, distribution automation plays a vital role in smart grid, so strengthening the construction of distribution automation is conducive to promoting the efficient operation of power grid and the sustainable development of power industry. The application of smart grid plays an important role in promoting China's economic recovery and in promoting the upgrading of China's power system and technological progress. Distribution automation is an important part of the construction of a strong smart grid. It is a key means to further improve the quality of power supply and improve the reliability of power supply. This paper discusses the composition of distribution automation terminal equipment and analyses its application in power distribution network. It is hoped that the application technology of terminal equipment in distribution network can be enhanced and the automation level of distribution network can be improved.

1. Introduction
Power distribution network automation system is an important link in power system automation. It uses computer network technology, communication technology and other means to monitor distribution lines and optimize the management technology of distribution network [1]. Since the discovery and application of electric power, the social demand for electric power has been continuously increasing. While people are striving to improve the quality of electric power, they should also consider the relationship between electric power development and the environment. How to achieve energy conservation, emission reduction and environmental protection while developing high-quality electric power [2]. Under the urgent demand of the whole transformation and innovation, the power system, which plays an important role, is placed in a prominent position. The change in the use of resources is closely related to the innovation and construction of smart grid [3]. Distribution automation terminal equipment is used in power distribution network automation, which not only realizes remote control, telemetry and remote signaling functions efficiently, but also plays an important role in maintenance and detection of cable systems [4]. These modes are compatible from low to high, and are combined with each other according to the structure of the distribution network and the importance of the user, and are inherited from low to high with the upgrade of the distribution network structure and user importance [5]. Automating the distribution network will bring huge changes to the power system, with realistic economic and social benefits.

Transforming the utilization mode of electric energy and transforming the traditional thermal power generation mode into a new energy generation mode based on renewable energy will become the mainstream, which is an inevitable way to achieve sustainable development of the electric power
industry [6]. Under the normal operation of the distribution network, the distribution network automation through the construction of the operating conditions of the power distribution network, and optimize the operation mode of the power grid [7]. Distribution automation is an important part of the construction of a strong smart grid, and is a key means to further improve the power quality of distribution networks and improve the reliability of power supply [8]. The automation of power distribution is not only to make the power allocation more efficient and high quality, but also to ensure the safety and reliability of the entire power grid system. When the distribution network is running abnormally, the distribution network automation can quickly detect the fault area and abnormal conditions, thereby quickly isolating the fault area and quickly recovering the normal power supply in the non-faulty area [9]. As far as China's power system is concerned, the level of the distribution network is far behind the transmission grid, both in terms of automation, intelligence, and self-healing and optimization capabilities of the network. Based on the smart grid, this paper analyzes the development history of the smart grid and discusses its development characteristics, and discusses the specific application of the distribution automation system in the whole smart grid.

2. Necessity of Distribution Automation Construction

The so-called smart grid is essentially a form of power grid with certain intellectualization needs, which will be based on high-speed two-way network to consider the application of intelligent system technology. The necessity of the construction of distribution automation is caused by the increasing demand for high-quality power from people's living standards. The man-machine interface circuit is mainly used to maintain equipment configuration, such as displaying the measured voltage, current and power data. It can also detect equipment failure and adjust part of the operation data of the equipment. As the core of distribution automation monitoring and management system, the main station system is mainly responsible for collecting real-time information of distribution substations in various regions, monitoring, control and effective management of the entire distribution network. The reason for most power outages is due to the failure of the power distribution system, and the quality of the power has a very close relationship with the performance of the distribution network. The development of the power industry needs to be carried out scientifically. It is not enough to blindly consume energy to increase the production of electric energy. The construction of distribution automation based on smart grid can improve the operation quality of the grid and enable the grid system to meet more demands.

As far as China's power system is concerned, the level of the distribution network is far behind the transmission grid, both in terms of automation, intelligence, and self-healing and optimization capabilities of the network. The dynamic part of the unified information model mainly stores the message format template of the sensor node collecting data in real time, and parses and updates the real-time collected data according to the template to form data consistent with the storage format of the data service system. The accuracy of the delivery of the filtered power dispatch data, the delivery speed of the power dispatch data, and the safety level detection test data of the power dispatch data are shown in Table 1.

| Project                                    | First time | Second time | Third time |
|-------------------------------------------|------------|-------------|------------|
| Safety Level Detection of Electric Power Dispatching Data | 36%        | 34%         | 38%        |
| Delivery Accuracy of Electric Power Dispatching Data       | 66%        | 62%         | 72%        |
| Data Delivery Time of Electric Power Dispatching           | 6          | 7           | 5          |

Table 1 System sampling analysis map information
Smart grid technology encompasses many areas of technology based on intelligent and automated technologies. In view of the actual operation of the smart grid, it is the process of integrating information and communication technology into the entire power system through certain internal needs and methods. The communication terminal can effectively connect to the communication medium of the control unit and perform communication [10]. The types of communication channels are enclosed as carrier terminals, optical fiber terminals and wireless terminals. The design of automation according to the demand of distribution network can better integrate automation into the work of power production, power transmission, line maintenance and fault emergency repair. As the link between the main station system and the terminal equipment of the distribution network, the communication network must have high stability and reliability. Substations can detect power grid faults within the area by themselves, adjust the voltage, improve the efficiency of the power grid, and reduce the work of the main station to a certain extent.

3. Practical Application of Distribution Automation System in Smart Grid

3.1. Specific Composition of Automation System

For the composition of automation system, it mainly consists of communication interface, system management, monitoring system and main station. In the process of construction of distribution automation, it is clearly stipulated that the construction of distribution automation should be solidified in the production and construction of power grid. For the system management, it mainly takes the monitoring system as its main basic content, adjusts the problems that may arise in each link of management, and promotes the normal operation of equipment to be guaranteed to the greatest extent.

In the system with small resistance grounding mode, the distribution terminal detects the single-phase grounding short circuit by judging whether the zero sequence current exceeds the setting value. In the early stage of power distribution automation system construction, the primary consideration is safety. Only when construction is carried out on the premise of ensuring safety can the construction become meaningful. When the line load is small, the measured current is often close to zero, which will lead to the failure to effectively monitor the change of the load current.

For the function of substation in the whole power distribution automation system, the industrial computer on site can be taken as the basic form to realize its operation, or the substation terminal of embedded system can be taken as the foundation to establish. Verify the transmission delay and its impact on service reliability under the switching state of surround protection. The test results are shown in Table 2. By calculating the difference between the number of packets sent from the source and the number of packets received by the receiver, the number of lost packets is 2486.

Table 2 Delay and packet loss in the switched state

|                | Source end       | Lodging end      | Outsourcing rate |
|----------------|------------------|------------------|------------------|
| Tx Frames      | 87 119 269       | 91 337 165       | Number of packets lost |
| Rx Frames      | 89 334 638       | 87 142 724       | Two thousand four hundred and eighty-six |
| Tx Bytes       | 537 248 317      | 518 323 217      | Conversion time  |
| Rx Bytes       | 526 328 619      | 527 235 648      | 2.36E-03         |

In the distribution network, the high-voltage side impedance of the system is converted to the low-voltage side, and the impedance value becomes small. As the distribution network increases, the negative sequence impedance of the system becomes smaller. The negative sequence impedance of a typical line is hundreds of times the negative sequence impedance of the system. Therefore, there are:

$$\frac{d^2 \omega}{dx^2} - \frac{h \ d \tau}{\alpha^2 EI_0} \ dx = \frac{M}{EI_x}$$

(1)
Since the feeder is generally short, the negative sequence impedance of the load is large, and the negative sequence impedance of the load is much larger than the negative sequence impedance of the feeder:

\[
\frac{d^2 \tau}{dx^2} - \alpha^2 \tau = -\frac{\alpha^2}{h} \left[1 - \frac{EI_0}{EI_{\infty}}\right] V
\]  

(2)

3.2. The Role of Automation System

For the whole smart grid, as a key component, the automatic management system and distribution automation take the distribution network geographic information system as the basis for its effective implementation and operation. In the feeder automation system with remote control mode, each distribution terminal detects short-circuit fault information and reports it to the main station of distribution automation. Distribution automation is a very important component of only the power grid. Distribution automation standards are mainly divided into four categories: construction series standards, operation control standards and system and equipment series standards. For the automation system, it regards the distribution network geographic information system as the basic platform for implementing the corresponding input of data information, and effectively combines the distribution network and geographic information. As an important form of inspection automation system, monitoring software will make the final purpose of timely and accurate development of the problem, so as to minimize or reduce losses. Under the joint efforts of all parties, the implementation of distribution network automation will continue to improve and upgrade to standardized and standardized management, which will surely achieve better results and obtain greater social and economic benefits.

4. Conclusion

At present, the technology of distribution automation in China has been well developed, and is moving towards compatibility and openness. The construction of distribution automation based on smart grid is urgently needed in this rapidly developing society. It can effectively improve the quality of power supply and increase people's living needs. This paper studies the application of distribution network automation terminal equipment in distribution network automation, and deeply discusses the composition, function and core technology of related terminal equipment. With the development of smart grid, the start-up of large-scale urban and rural power grid construction and transformation work and the gradual maturity of international and domestic technology and equipment, distribution automation research and application scope is gradually expanding. The establishment of intelligent distribution network system is also inseparable from the optimization of human resources. Only by giving full play to the role of talents and integrating and optimizing human resources can the level of intelligent distribution network be further provided. Under the background of smart grid, advanced distribution automation is a technological revolution. Compared with the traditional equipment, the new intelligent distribution network equipment has stronger advantages, but attention should also be paid to the use of specific intelligent distribution network equipment. We must continuously strengthen and improve the construction of distribution automation to contribute to the economic development of our country.

References

[1] Bush, Stephen F. Network Theory and Smart Grid Distribution Automation[J]. IEEE Journal on Selected Areas in Communications, 2014, 32(7):1451-1459.
[2] Muttaqi K M, Aghaei J, Ganapathy V, et al. Technical challenges for electric power industries with implementation of distribution system automation in smart grids[J]. Renewable and Sustainable Energy Reviews, 2015, 46:129-142.
[3] Fang R, Wang J, Sun W, et al. QoS Model of WSNs Communication in Smart Distribution Grid[J]. International Journal of Distributed Sensor Networks, 2016, 2016(8):1-23.
[4] Wu F F, Varaiya P P, Hui R S Y. Smart Grids with Intelligent Periphery: An Architecture for the Energy Internet[J]. Engineering, 2015, 1(4):436-446.
[5] Asad R, Kazemi A. A novel slack bus-free load flow method for dc microgrids and distribution systems with dc-bus signaling control methods[J]. International Transactions on Electrical Energy Systems, 2015, 25(12):3538-3552.

[6] Mehrasa M, Ebrahim Adabi M, Pouresmaeil E, et al. Direct Lyapunov control (DLC) technique for distributed generation (DG) technology[J]. Electrical Engineering, 2014, 96(4):309-321.

[7] Li K, Tang X, Veeravalli B, et al. Scheduling Precedence Constrained Stochastic Tasks on Heterogeneous Cluster Systems[J]. IEEE Transactions on Computers, 2015, 64(1):191-204.

[8] Zhang T, Cialdea S, Orr J A, et al. Outage avoidance and amelioration using battery energy storage systems[J]. IEEE Transactions on Industry Applications, 2016, 52(1):5-10.

[9] Madani V, Das R, Aminifar F, et al. Distribution Automation Strategies Challenges and Opportunities in a Changing Landscape[J]. IEEE Transactions on Smart Grid, 2015, 6(4):2157-2165.

[10] Heidari S, Fotuhifiruzabad M, Kazemi S. Power Distribution Network Expansion Planning Considering Distribution Automation[J]. IEEE Transactions on Power Systems, 2015, 30(3):1261-1269.