Automatic Identification of Low Voltage Distribution Network Topology Based on HPLC

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Abstract. With the rapid development of China's national economy and the deepening of reform and opening up, people's demand for electricity is growing. This paper studies the automation of low-voltage distribution network topology based on HPLC power line carrier technology. It is a key technology to effectively extend the communication distance of power line communication network in smart grid. For the power line communication network, we establish the network model of power line carrier layered forwarding tree. Based on the study of the topology and various operation modes of DC distribution network, a new hierarchical coordinated control method is proposed. By coordinating the working mode of each sub module, the power balance and voltage stability of distribution network are maintained under different conditions.

Keywords: HPLC Power Line Carrier Technology, Low Voltage Distribution Network, Distribution Network Communication, Topology Distribution Network

1. Introduction

With the continuous improvement of information technology in our life, it has become indispensable. With the development of embedded power generation in distribution network, as well as the continuous expansion of power consumption for mobile, heating and air conditioning, the load of distribution network is also increasing. Distribution network is a special power transmission network. If you want to use it as a communication network, network traffic will become very complex. The topology of low-voltage distribution network is very complex, and there are great differences in different distribution networks. Different loads leave or input power lines will cause strong channel variability. It is because of these characteristics of low-voltage distribution network that the distribution network is difficult to network and easy to be damaged.

Due to the continuous improvement of science and technology, many experts have studied the topology technology of distribution network. For example, some teams in China have discussed the principle of leakage protector and field trip test conditions, and analyzed the line structure, signal transmission and false trip of leakage protector in low-voltage power line carrier communication.
community. Then, the influence of power line carrier communication and the anti-interference of leakage protector are analyzed theoretically and experimentally. Finally, it is concluded that the trip problem may be caused by anti-interference itself, carrier signal characteristics, equipment insulation capacity and power grid noise, so the carrier signal is only one of the main reasons for the trip problem, and the better solution is to improve the design of leakage protector and enhance the anti-interference ability [1]. Some teams have studied the DC distribution network system, and introduced a simple method to realize power line communication by using switch converter in DC distribution network system. The current ripple at the input end of the converter is used as the signal carrier, and its frequency varies with the transmission data. The frequency modulator can be easily realized by adding a transistor and a resistor to the traditional control circuit. The demodulator is also implemented by a simple analog circuit. Using this method, the converter can transmit data through DC power line [2]. Some experts have studied the current situation of distribution automation system, discussed and analyzed the overall design idea of distribution automation system, and deeply understood the effectiveness of aggressive target positioning strategy determined by different centrality metrics under the condition of limited information state and different network topology. By introducing the utility function based on distance, the modeling of complex social behavior is improved. The reasonable mode suitable for the construction of regional distribution automation system is summarized, and the construction of distribution network automation system is obtained [3]. An expert summed up the voltage sensitivity and got the most needed reactive power compensation node in the distribution network. The concept and calculation method of the comprehensive voltage sensitivity were introduced. The traditional reactive power compensation device was used to adjust the voltage. The performance of the designed carrier unit met the product performance requirements of the State Grid Corporation of China. It can be installed in the experimental Bureau, Further verify the carrier unit in the actual use of the realization of the use of low-voltage power line data stable long-distance high-speed transmission. The voltage fluctuation problem is solved by clustering the voltage and voltage by using the voltage difference matrix. Although the research on low-voltage distribution network topology technology is quite fruitful, there are still some deficiencies in the low-voltage distribution network topology technology.

In order to study the automatic identification technology of low-voltage distribution network topology based on HPLC, this paper studies the power carrier technology of HPLC, and finds the topology calculation formula. The results show that the automatic identification technology of low-voltage distribution network topology based on HPLC is more convenient and practical in power distribution and communication network reconstruction project.

2. Method

2.1. HPLC Power Line Carrier Technology
Power line carrier (PLC) communication makes full use of the laid power line as the transmission medium, without earthwork construction and communication line laying, which can realize rapid construction. Power line carrier communication is an important communication mode grid in intelligent distribution network. Wireless communication technology is a multi-hop network system composed of a large number of carrier nodes installed on the power line. In order to solve the problems of high cost, poor flexibility and difficult installation and maintenance of wired communication technology, wireless communication technology is a multi-hop network system composed of power carrier communication. It is convenient, energy-saving and emission reduction. For low-voltage power carrier network, the instability of network topology requires the consideration of real-time data and network reliability in routing design [4, 5]. Due to the high resistance of low voltage wires or repair wires, the voltage rise of these wires is significant. As far as network operators are concerned, the spatial distribution scenarios of PV installation cannot be specified in advance, because each PV installation is determined by a specific customer. Its application scope is mainly in the range of a transformer for data transmission, it does not need to carry on the intrusive structure to
the user, also does not need the complex communication channel. The advanced numerical model can be used to calculate the fault level of traditional power system with unidirectional current characteristics [6]. Power line carrier includes three parts: low voltage, medium voltage and quotient voltage carrier communication. Medium and high voltage off-line carrier technology has a deeper research on the transmission technology of high-frequency signal on medium and high-voltage lines. In contrast, the problems involved in low-voltage power line carrier technology are more complex than those of medium and high-voltage power line carrier technology. There are many nodes in low-voltage distribution network, complicated access equipment and complex communication system model. The frequent access and cut-out of household appliances in low-voltage distribution network will affect the quality of carrier communication. Affected by the load noise of household appliances and the environmental noise on site, serious electrical interference will be produced, which makes the channel signal more complex.

2.2. Calculation Formula
The contraction device set, boundary point set and topology Island device set formed by topology analysis can be used as the internal system in equivalent calculation. The relationship between node voltage and node injection power is set at any time \( t \), and the node voltage connected with DG measured by voltage measurement device is \( V(T) \), then the difference between the node voltage and the threshold voltage should be calculated firstly:

\[
\Delta V(t) = V(t) - (V_{\text{max}} - \varepsilon)
\]

(1)

Main crystal vibration: \( F_Z \)

(2)

Working frequency: \( F_B = F_Z + 2 \)

(3)

Relative bandwidth: \( B_y = \frac{B_w}{F_c} \times 100\% \)

(4)

In engineering application, the topology island is used as the minimum element in the analysis and calculation of distribution network. However, when the target feeder is too complex, it will lead to a large number of equipment in the topology, which will affect the efficiency of distribution network analysis and calculation. During product design, the data rate and modulation cycle number can be determined according to the needs of practical application, and then the working frequency, crystal oscillator frequency and carrier frequency can be calculated [7].

3. Experience

3.1. Extraction of Experimental Objects
Firstly, a distribution automation communication scheme is constructed. The communication layer of distribution station completes the collection of distribution communication terminals and communicates with the master station through the day / SDFD halo. In order to enhance reliability and safety [8]. Each DSH is connected to these two chains through double FZJ ports, so that the whole network protection of backbone optical fiber, DSD equipment, SFG port, litterer and branch optical cable can be realized. The failure of any DSD, any SFG port, any litterer or any optical cable in the network will not affect the normal use of DSH. The control layer of master station system completes various network management functions such as information extraction, analysis and optimization, and completes the management of communication collection equipment and communication terminal equipment.

3.2. Experimental Design
The office terminal and terminal equipment of the carrier equipment have the same shape. According to the internal burning program, the office terminal and the terminal are distinguished. The SDG label
is the office terminal, and the VDH label is the terminal. The power line between the office terminal and the terminal is no more than a transformer, but it has to go through four air switches. When laying optical cables, the principle of "the position of communication equipment and distribution automation terminal tends to be consistent" must be followed, so as to save construction cost and use the existing pipeline resources of distribution network to lay optical cables. Construction cost analysis. For each additional optical direction of active equipment, a pair of optical modules need to be added. DDS system only needs to replace the low-cost litterer with more optical channels, and reserving the litterer with large splitting ratio can reduce the construction cost of network expansion in the later stage. Analysis of unsafe factors. (1) Illegal access (2) business "embezzlement" (3) denial of service, in view of these three unsafe factors, we need to have efficient and reliable encryption and authentication means to ensure the security of the system. There are two kinds of encryption algorithms: high-level encryption standard algorithm and triple agitation encryption algorithm to protect user information. The triple agitation encryption algorithm is a low-level encryption algorithm, and its security is not enough to meet the user's requirements for high data confidentiality. In contrast, we can use AES encryption algorithm, AES has a long key, composed of 128, 192 and 256 bit keys, which has high security. The network topology uses the substation optical fiber network to the main station, which saves the rental cost. Moreover, the power carrier line and optical fiber line are power private network lines, with high security and good confidentiality [9, 10].

4. Discussion

4.1. Determination of Installation Position of Traditional Reactive Power Compensation Device

In order to study the effectiveness of comprehensive voltage sensitivity to determine the installation position of reactive power compensation device, this section uses uaaa15 node medium voltage distribution network system for verification. The voltage level of the system is 5kV, and the reference voltage and capacity are set to be 20.42kv and 250mva respectively. The change of distribution network structure leads to the limitation of the traditional method of power flow calculation in distribution network. The topology of low-voltage distribution network is very complex, and there are great differences in different distribution networks. Different loads leave or input power lines will cause strong channel variability. With the popularity of distributed generation, more and more distributed generation units are connected to the power grid. They destroy the traditional power flow model and change the fault level of the system. Using the improved Newton Ideographs method to calculate the distribution network, the network loss caused by connecting SD at node 1 and node 16 is the minimum. Therefore, in this paper, the active power output of node 1 and node 16 is 3MW, and the active power voltage sensitivity of each node is shown in Table 1.

Table 1. Summary of active voltage sensitivity and comprehensive voltage sensitivity

| Node 2  | Sensitivity node | Node 1  | Node 3  | Node 4  | Node 5  | Node 6  | Node 7  |
|---------|------------------|---------|---------|---------|---------|---------|---------|
| 21.3214 | Meritorious      | 12.4546 | 12.2444 | 14.5432 | 16.2435 | 18.4352 | 15.6756 |
| 43.6912 | Comprehensive   | 32.4132 | 65.8434 | 54.5385 | 47.6432 | 23.6435 | 56.6537 |
It can be seen from the figure that the active voltage sensitivity of node 3 is lower than that of comprehensive voltage sensitivity, and that of node 3 is the highest; that of node 7 is higher than that of node 1; and that of node 2 is the highest. The specific results are shown in Table 2.

Table 2. Summary of reactive power voltage sensitivity and comprehensive voltage sensitivity

| Sensitivity node | Node 8 | Node 9 | Node 10 | Node 11 | Node 12 | Node 13 | Node 14 |
|------------------|--------|--------|---------|---------|---------|---------|---------|
| Meritorious       | 21.6435| 12.7867| 15.5717 | 18.6586 | 16.7389 | 20.4873 | 16.7850 |
| Comprehensive    | 53.5346| 62.6527| 56.8954 | 62.7286 | 64.6284 | 43.6743 | 45.7358 |

It can be seen from the figure that the active voltage sensitivity of node 8 is the highest, that of node 2 is the lowest, that of node 14 is higher than that of node 12; that of node 12 is the highest, that of node 13 is the lowest, and that of node 11 is higher than that of node 9.

4.2. Application of Distributed Storage Management of Topology Information in Fault Self-healing

The distributed storage and management of topology information can be used in power flow calculation, load forecasting, fault self-healing, state estimation and so on. Based on the distributed storage and management method of topology information, a typical distribution network is taken as an example to analyze and verify the application of distributed storage and management method of topology information in fault self-healing. The distributed "node branch" topology information is
generated from the actual physical structure of the distribution network, and the generated topology information is applied to the fault self-healing system of the distribution network, which is generally stored in dust and can be called directly; Is landing detection involves fast transmission of switch position state information in local network, while power supply recovery involves a wider range of topological structure judgment and electrical quantity calculation, which is suitable to be completed by means of mutual information between proxy nodes.

5. Conclusion
The unreliability of power line carrier communication in low voltage distribution network limits the application range of carrier communication. Based on the analysis of the topology of low-voltage distribution network, two algorithms, advanced encryption standard algorithm and triple agitation encryption algorithm, are proposed. These two algorithms can find the optimal solution in the dynamic range. After the optimal solution of each population is exchanged regularly, the whole local solution search space can be enlarged. Therefore, it reduces the possibility that the algorithm is easy to fall into local optimum, and finally the global optimal solution is found. The simulation results show that the algorithm can quickly adapt to the dynamic changes of low-voltage power line network, improve the global convergence and robustness. Intelligent message repeats multiple interconnection networks of remote nodes, it uses the remote node polling process performed by the master node, which is executed by sending polling messages to all remote nodes associated with the master node. When each remote node receives the polling message of general addressing, it responds by using polling response information message and polling message to flood the network in sequence.

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