Design and Application Analysis of Intelligent Technology for Smart Grid Metering Based on HPLC

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Abstract. In order to solve the problem of slow transmission efficiency, small amount of information, short coverage distance, easy to be disturbed, and easy packet loss in the transmission process of traditional narrowband modules, based on HPLC, this paper designed and applied the intelligent technical scheme of smart grid measurement operation.

Keywords: HPLC, Smart grid, Scheme Design, Application

1. Introduction

With the rapid development of artificial intelligence, Internet of Things, and communication technology, the shape of the power grid has also changed[1]. Building an energy Internet is a fundamental way to conform to the trend of the fusion and development of the energy revolution and the digital revolution. In order to improve the customer's satisfaction with quality service, you can timely understand the customer's electricity consumption and demand, State Grid Shanxi Electric Power Company puts forward higher requirements for smart meter functions. At this time, the HPLC communication module came into being. This type of module has a certain improvement in communication rate and stability compared to the power line narrowband module[2]. Not only play a major role in real-time reporting of smart meters when they are powered off, low-voltage customer voltage and current monitoring, station topology information, station phase recognition, station identification, and communication module ID management, but also support the deepening of smart meter non-metering functions in distribution networks. Play an important role in equipment monitoring, fault research and judgment command, operation and maintenance management and control, etc. Fully tap the value of smart meter data assets, further solve the "last mile" problem of power supply services, and comprehensively improve customer service response speed and distribution network operation management level.

2. Basic overview of HPLC
HPLC is a high-speed power line carrier, also known as broadband power line carrier, which is a broadband power line carrier technology for data transmission on low-voltage power lines. The broadband power line carrier communication network uses the power line as the communication medium to realize the convergence, transmission and interaction of low-voltage power users' electricity consumption information. The broadband power line carrier mainly adopts orthogonal frequency division multiplexing (OFDM) technology, and the frequency band uses 2MHz-12MHz. Compared with the traditional low-speed narrow-band power line carrier technology, HPLC technology has large bandwidth and high transmission rate, which can meet the higher demand of low-voltage power line carrier communication.

2.1. Design of real-time reporting function for low-voltage customer table power failure

Based on the high-speed communication mechanism of HPLC communication, after the power meter is powered off, the smart power meter carrier module reports the power failure fault information within a specified time. The smart energy meter carrier module needs to be equipped with a super capacitor. When a power failure occurs, the communication module is in a standby state, and the backup power supply can maintain the power supply for not less than 30–60 s. Through the HPLC communication carrier module to report the outage fault information within the specified time, gradually realize the application of the function of actively reporting the outage event of low-voltage customers. After the low-voltage customer meter is powered off, the specific process of reporting is shown in Figure 1.

![Diagram of low-voltage customer meter reporting process when power is turned off](image)

**Figure 1.** Low-voltage customer meter reporting process when power is turned off

2.2. Design of high-frequency acquisition and monitoring of voltage and current of low-voltage customers

Using THE advantages of wide frequency band and fast speed of HPLC communication technology, the frozen data collection of voltage, current and electric quantity can be realized in 15 min. High-frequency acquisition and monitoring of voltage and current of low-voltage customers support distribution network low voltage, distribution transformer overload and three-phase
unbalanced monitoring, and other work, accurate treatment of low-voltage customers, heavy overload distribution transformer area, three-phase load unbalanced distribution transformer area. In order to give full play to the utility of smart energy meter data assets and further support the improvement of the operation and maintenance management level of the distribution network. Fast and accurate positioning of customers suspected of "power breach, power theft". At the same time, establish and improve the closed-loop management mechanism, comb the core business process, standardize the diagnosis scheme, early warning and response mechanism, work order circulation, site investigation, review and processing, archive and report, etc., so as to achieve the closed-loop management mechanism with accurate positioning, timely response and effective filing. To achieve the goal of "prevention first, real-time monitoring, rapid processing and combined prevention and control", and comprehensively improve the comprehensive anti-power theft capability of Shaanxi Electric Power Company of State Grid.

2.3. Design of Intelligent Recognition Function of “relationship between users and transformers areas”

The relationship of "concentrator and intelligent electricity meter" in the carrier platform area is utilized to realize automatic intelligent identification of distribution transformer and customer electricity meter relationship files and phases, which can support customers' accurate geographical location, accurate repair report, power supply quality research and judgment, three-phase load imbalance analysis and other services. The concentrator carrier table search function is used to analyze the similarity of voltage variation characteristics of customers, intelligently identify and correct the household variable relationship. For other communication network areas, voltage variation characteristics of household table can be compared with those of the main table, realize the identification of household variable relationship. Transform the front server of the main station, improve the supporting functions of the main station, collect the main station to intelligently confirm the relationship between households and changes and compare it with the marketing files, and feed back the inconsistent relationship between households and changes to the marketing. In the normal networking and meter reading process of the HPLC-based communication module, the centralized local module can obtain the network information of the smart energy meter carrier module, and the concentrator obtains the logical topology of the smart energy meter carrier module (electric energy meter) Logical topology information. The master station extends the protocol so that the terminal can acquire the topology of the station, and the master station extension has the function of displaying the topology of the station. HPLC communication module, based on classified big data analysis, utilizes the characteristics of different platforms and loads that lead to different ac phase shifts and voltage fluctuations, and synchronously obtains data such as ac zero-crossing phase shifts and voltage fluctuations. The analysis can accurately determine the power supply station area of the collector, give accurate and reliable station attribution, effectively assist the power supply enterprise in the management of the measurement automation system file, and provide an accurate basis for line loss management and load balancing in the station area.

2.4. courts customer Aspects recognition function design

Through technical means, the acquisition master station can automatically identify the power supply phase of low-voltage customers in the platform area, providing support for abnormal positioning,
three-phase unbalanced treatment and other business applications. The concentrator determines the phase of the household meter according to the communication link, transforms the front server of the main station, and improves the supporting functions of the main station. In other networking methods, the phase of the household meter is determined by the acquaintance between the characteristics of the voltage of the household meter and the split-phase voltage of the station meter. The HPLC communication module is equipped with a zero-crossing detection circuit, which can realize the intelligent identification of the phase of the energy meter (collector) in the process of normal human network and meter reading, and can identify the reverse connection of the L/N of the single-phase energy meter and the three-phase energy meter. Reverse phase order. The concentrator carrier module is used to obtain the relevant information, and the master station conducts the call and test of the relevant information. By accurately identifying the phase, the number of electricity meters on each line can be counted, and the power supply, power consumption and power loss on each line can be calculated and counted, providing an accurate basis for the control of phase loss and optimization of power supply line.

2.5. Courts Topological intelligent identification function design

For the electricity information collection system, the HPLC communication network will generally form a tree network with CCO as the center and PCO as the relay agent to connect all STAs with multi-level association. In the normal networking and meter reading process of the HPLC communication module, the centralized local module can obtain the network information of the smart energy meter carrier module, and the concentrator obtains the logical topology information of the smart energy meter carrier module (electric energy meter) Logical topology information. Further improve the quality of data collection, improve the management of courts archive data, deepen the application level of the collection system, and reduce management and operation and maintenance costs.

2.6. Courts HPLC communication module ID management design

At present, the communication module is not included in the full life cycle management, but is managed as part of the energy meter or the collection terminal. However, the actual inventory and operation of the metering communication module cannot be tracked for a long time, and the situation of idle or wasted resources is serious. In order to realize the whole life cycle management of metering communication module and the whole process control from demand declaration to asset scrapping, the whole life cycle management based on communication module ID came into being. The concentrator periodically reads theCHIP ID of the HPLC communication module and stores it. When a change in the ID of the communication module is found, the alarm shall be reported, and the change in the ID of the newly installed module shall not be reported. Where, The interaction process between the concentrator and the HPLC communication module is shown in Figure 2.
3. Application case analysis

This paper takes a new high-rise residential area in Taiyuan city, Shanxi Province as an example to carry out empirical research. There are 2 power supply courts in the community. A total of 1100 smart energy meters are installed in the 2 courts. All of them are replaced by HPLC communication modules. The data collection channels are connected to the power consumption information collection master station via the concentrator 4G module. Field test data is shown in Table 1.

| Test site | The function point | Child                  | The test results |
|-----------|--------------------|-----------------------|------------------|
|           | Success rate of    | Daily freezing success | 100%             |
|           | meter reading      | rate                  |                  |
|           |                    | Point copy success    | 100%             |
|           |                    | rate                  |                  |
|           |                    | Success rate of fee   | 100%             |
|           |                    | control               |                  |
It can be found that, through the daily frozen data from the main call test site Courts, the success rate of one acquisition reached 100%. During the test, there was strong crosstalk between the two stations. In the environment of strong crosstalk, several transformer schemes operated normally. Each Courts could complete a round of four data sets within 2-3 min, and the success rate of meter reading reached 100%. Voltage monitoring, blackout reporting, phase identification and other non-metering functions have good application results. This fully shows that THE HPLC communication scheme can effectively solve the cross-talk problem of multiple regions through the multi-network coordination mechanism.

4. Conclusion

In general, the design and application analysis of smart grid metering technology based on HPLC was carried out in this paper, aiming to improve the supporting role of smart meters and provide timely and accurate information data for power supply reliability, distribution network repair platform and other relevant business systems. At the same time, it also improves the response speed to customers, reduces
customers' complaints, improves the service ability, further improves the overall power supply service level, actively performs social responsibilities, and establishes the high-quality service brand of State Grid Shanxi Electric Power Company. In addition, also provides data basis for power supply fault judgment, which is conducive to improving the timeliness of fault repair, building a harmonious relationship between power supply and consumption, facilitating customers, enhancing the company's image, and improving customer satisfaction.

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References

[1] Guo qing-lai, wang bo-hong, tian nian-feng, sun hong-bin, wen bai-jian. Energy Internet data trading: architecture and key technologies [J]. Journal of electrical technology,2020,35(11):2285-2295.

[2] Xu wentao. Improvement analysis of intelligent electricity meter based on HPLC communication module [J]. Microcomputer application,2019,35(11):156-158.