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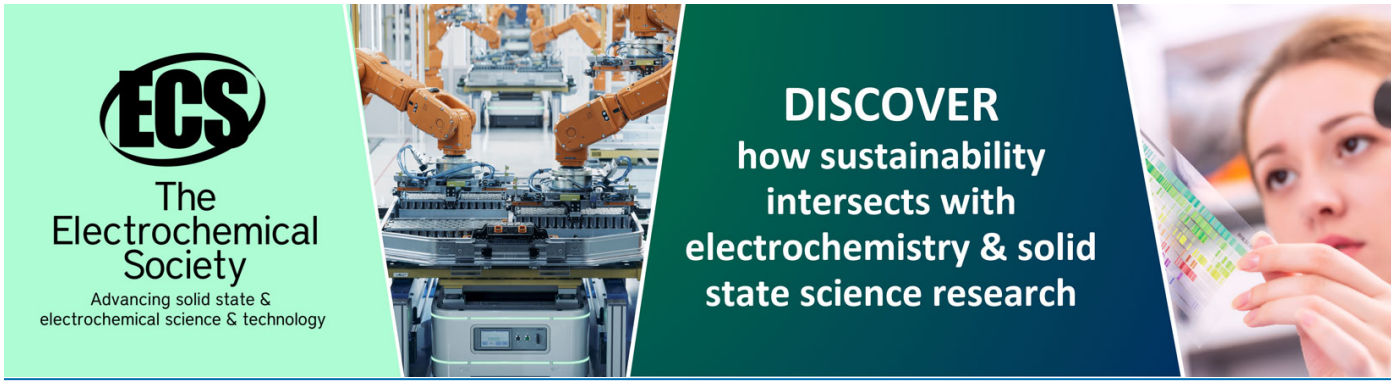

Research and Application of Power Terminal Communication Access System Based on Heterogeneous Network Technology

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Abstract: In recent years, the basic business of power distribution production, such as distribution automation, power consumption information collection and load control, distributed power supply and so on, is growing rapidly, and the demand for power terminal communication access is increasing. Based on the analysis and research of terminal communication access technology, this paper proposes a heterogeneous network combination scheme which integrates multiple terminal communication technologies to solve the problems such as the limitation of existing terminal communication access network technology on the power distribution side. Heterogeneous network networking technology realizes the integration application of wireless private network, low-power wide area network, medium voltage broadband carrier and other channels. It can give full play to the advantages of various communication modes, improve the communication guarantee ability, meet the requirements of full coverage of power terminal communication access network business, provide strong channel support for terminal information return, and provide communication system construction for distribution terminal Useful reference.

1. Introduction

With the improvement of living standards of urban residents in China. The power consumption of residents is increasing rapidly. Residential electricity also shows the characteristics of complex electricity consumption behavior, high comprehensive energy consumption and weak interaction with the grid. It is more and more important to analyze the electricity consumption behavior and two-way interaction. The original smart meter only records the power failure event when the terminal customer loses power, and reports the power failure and power restoration event uniformly after power restoration, so it is unable to carry out the active repair in the first time. Distribution network communication is the guarantee to ensure the automatic operation of distribution network [1]. The traditional optical fiber network has a long construction period and high cost, so it is difficult to solve the "last kilometer" communication problem. The transmission channel of wireless public network is

not transparent and the security cannot be guaranteed. When abnormalities and faults are found, a large amount of manpower and material resources need to be consumed to verify one by one on the site, so as to locate and judge. The operation and maintenance efficiency needs to be improved. It is particularly urgent to highlight the communication demand, but there are still many problems in the application of the existing terminal communication access technology, such as: the lack of overall planning and coordination of business needs; the construction of each business department on demand, without forming a public unified communication access platform; in the face of the wide area distribution of massive terminals, the requirements of various business communication performance are different, and the solutions are different Poor, lack of effective technical system analysis, comparison and integration of construction experience; management mechanism system has not been unified, construction, operation and maintenance management interface is not clear. The existing data resources of power consumption information collection in distribution network are uploaded by GPRS or 4G wireless signals of public network operators, and the failure probability of modules and SIM cards [2]. At the same time, the wireless network access mode of operators can not meet the information upload in remote mountainous areas with poor signal. For this part of users, at present, the popularization of intelligent electricity meter is not available. The collection of electricity information still stays in the original manual meter reading mode, and the traffic in remote mountainous areas is inconvenient, which seriously affects the service quality of power grid companies, so it is urgent to further improve.

Therefore, it is urgent and necessary to study the communication access network of electric power terminal, break through the "last kilometer" communication "bottleneck, build an integrated public communication access platform to meet the business requirements of electricity information collection, power distribution automation, electric vehicle charging station (stake), distributed power supply, etc., and comprehensively support the construction of strong intelligent distribution grid. In order to meet the new requirements of the above services for the communication access network, and to solve the problems of multiple types of terminals, wide distribution and different communication requirements in the existing terminal communication access network, a design of distribution terminal access with multiple technologies is developed [3], focusing on "network, platform, application" and other aspects, application construction is carried out, and the "last kilometer" information of the terminal communication access network is opened The bottleneck of Shanghai Lianyungang is to realize the seamless link between the electric energy meter, power supply service platform and emergency repair team platform, effectively improve the active service ability, improve the service quality and customer satisfaction, which plays a very important role in the equipment running on the current network, realize the coverage of all users, comprehensively improve the service quality of power supply, and improve the core competitiveness of the grid company.

2. Heterogeneous networking technology

A variety of access technologies complement each other to form heterogeneous access networks and become effective solutions [4]. Through the power terminal communication access network heterogeneous networking technology typical application. It can improve the resource utilization rate of 10kV communication access network and the bandwidth and reliability of 0.4kV communication access network, meet the needs of all kinds of business communication, and open the "last kilometer" communication bottleneck.

2.1 Technology comparison

At present, EPON Technology is the mainstream optical fiber communication technology applied in communication access network. EPON is a point-to-multipoint optical fiber access technology based on Ethernet, and it is a reliable communication mode used to realize power distribution automation [5]. It consists of OLT on the local side, ONU on the user side and ODN. It can provide up and down speed of 1.25gbit/s, and the transmission distance can reach 10-20km. Ethernet passive optical network technology (EPON) is a new type of optical access network technology, which uses point to

multipoint structure, passive optical fiber transmission, and provides a variety of services over Ethernet. It uses PON technology in the physical layer, Ethernet protocol in the link layer, and Ethernet access using PON topology. EPON optical fiber network + medium voltage broadband carrier access can be used as the uplink channel to solve the problem of no signal area underground, and EPON optical fiber network + low power Wan access can be used as the uplink channel to solve the blind spot of wireless coverage on the ground.

Broadband power line carrier communication (PLC) is a kind of communication mode that uses power line as the medium and uses 2-30mhz frequency band for high-speed data transmission. It has the advantages of rapid networking, economic convenience and no need to rewire [6]. According to the different voltage level of power cable, it can be divided into medium voltage and low voltage broadband power line communication. The medium voltage power line carrier communication is a kind of communication mode which uses the medium voltage distribution network power line as the medium to transmit data. According to the different frequency range and bandwidth, it can be divided into broadband technology and narrowband technology. Data access can be realized by medium voltage broadband carrier + low power Wan or medium voltage broadband carrier + wireless private network CPE access.

Low power wide area network (LPWAN) technology is a new type of Internet of things wireless access technology, represented by LoRa and NB-IOT technology, which has the advantages of long distance, low power consumption, low cost, large access capacity, and maximizes the data interconnection of power equipment [7]. It can be used as an extended coverage means of optical fiber, medium voltage carrier and wireless private network, and fundamentally solve the "last kilometer" communication coverage problem of power grid.

2.2 Research contents

In order to meet the different communication needs of various businesses, a terminal communication access network with "optical fiber as the main, broadband carrier as the auxiliary, and wireless extension coverage" is built to support the power supply service command platform.

1) Terminal application analysis

The down communication module of the concentrator is transformed into a broadband carrier module, and the up communication module is transformed into a private network communication module. The smart meter communication module is transformed from the narrowband carrier to the super capacitor wideband carrier module to realize the active report of low-voltage users' power outage and restoration events. The communication modules of other terminals (such as DTU / FTU, charging post) are transformed from wireless public network to private network. Deploy intelligent distribution transformer terminal, realize quasi real-time monitoring of distribution transformer operation status, and improve accurate management and active service level of power outage scope.

2) Channel applicability analysis

For the 10kV communication access network, make full use of the existing optical fiber and carrier communication resources of the substation, power supply business hall and the "three remote" station of distribution automation, take the station as the wireless convergence node, realize the extension coverage of the surrounding business, build the full service access public communication platform for distribution power, and meet the different communication needs of different types of business.

For the 0.4kV communication access network, make full use of 10kV communication access network resources, mainly power line broadband carrier, supplemented by micro power wireless, low-power WAN technology, gradually replace the existing power line narrowband carrier technology, improve the collection frequency of power consumption information collection system, meet the new business requirements of power supply service command system.

2.3 Technology test

1) Medium voltage broadband carrier technology test

The purpose is to complete the test of communication frequency, bandwidth, signal-to-noise ratio performance and joint debugging with Ethernet. Firstly, the carrier machine and coupling capacitor are connected according to the carrier communication network to start the carrier equipment. Test the communication frequency, bandwidth and signal-to-noise ratio of medium voltage carrier. Secondly, carry out the joint commissioning test of medium voltage broadband carrier and Ethernet, start the meter, concentrator, server and micro power wireless equipment in the laboratory, and connect the optical fiber with medium voltage broadband carrier equipment. Finally, manually create a new acquisition task in the master station, and view the acquisition results in the master station platform. The test results are shown in Figure 1.

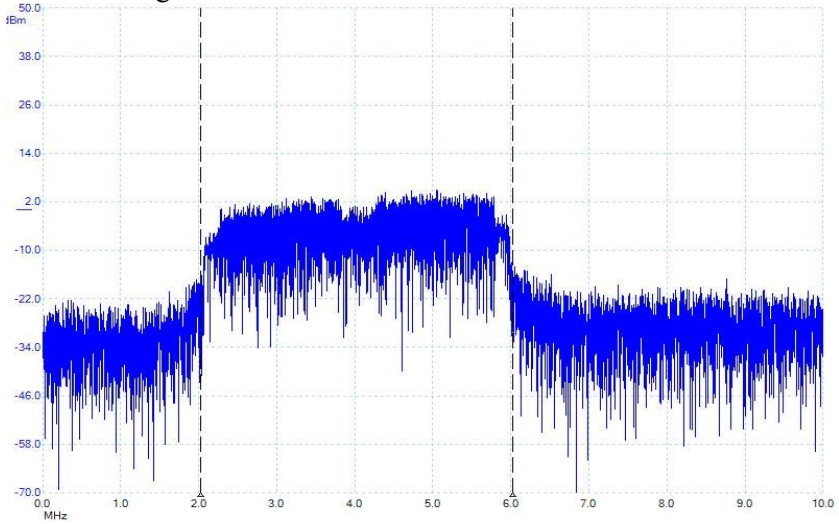

Figure 1. Bandwidth Test Results

2) Low power WAN technology test

The purpose is to complete the performance test experiments of low-power Wan equipment, such as penetration ability and meter reading success rate, and to complete the docking test of low-power Wan equipment and laboratory concentrator. First, according to the set networking requirements, connect the power and communication lines of low-power Wan equipment, start the equipment, and complete the networking of low-power Wan equipment. Secondly, carry out the docking test between the low-power Wan equipment and the laboratory concentrator; start the meter, concentrator, server and low-power Wan equipment in the laboratory, and connect the optical fiber and low-power Wan equipment. Finally, a new acquisition task is created manually in the master station, and the acquisition results are checked in the master station platform. The technical test results are effective and pass the test.

3) Function test of heterogeneous networking between optical fiber and medium voltage broadband carrier

Verify the feasibility of heterogeneous networking based on optical fiber and medium voltage broadband carrier (PLC); build test environment, optical fiber and medium voltage broadband carrier networking. First, start the meter, concentrator, server and medium voltage broadband carrier equipment in the laboratory. Secondly, the optical fiber is connected with the medium voltage carrier. The main station manually creates 200, 300 and 400 intelligent meters acquisition tasks; views acquisition time and success rate on the main station platform; adds Gaussian white noise with signal generator; views allowable signal ratio and communication situation; changes communication frequency of medium voltage broadband carrier; views communication rate change; adds external signal interference; views frequency independent selection and anti-interference situation. Finally, a

new acquisition task is created manually in the master station, and the acquisition results are checked in the master station platform. The technical test results are effective and pass the test.

4) Function test of heterogeneous networking between optical fiber and low power Wan equipment

Verify the feasibility of heterogeneous networking based on optical fiber and low-power Wan equipment; build a test environment, optical fiber and low-power Wan equipment networking. First, start the meter, concentrator, server and low-power Wan equipment in the laboratory. Secondly, the optical fiber is connected with the low-power Wan equipment. The master station manually creates 200, 300 and 400 smart meters collection tasks; views the collection results on the master station platform; changes the distance between low-power Wan devices; and views the change of device communication success rate and rate. Finally, a new acquisition task is created manually in the master station, and the acquisition results are checked in the master station platform. The technical test results are good, and the test is passed.

3. Operation status of distribution network

The total area of an urban area is 34 square kilometers, and the power supply density is mainly in A+ and A power supply areas. Now there are 1 220kV substation, 11 66kV substations, 6 power supply business halls, 6 internal units, serving more than 300000 users. There is opmc (optical fiber composite medium voltage cable) on 10kV side. There is OPLC (optical fiber composite low-voltage cable) on the 0.4kV side.

In this area, there are 174 10kV lines with a total length of 504km, 190 ring network cabinets, 281 on column switches, 199 fault indicators, 2896 distribution transformers (1569 public distribution transformers and 1327 special distribution transformers), 236 three remote terminals and 293 two remote terminals. The coverage of distribution automation is 79%. See Table 1 for 10kV business status.

Table 1. 10kV Business Status

Serial number	Equipment distribution	Current quantity (PCs.)	Number of two remote control	Realize the number of three remotes	Coverage rate
1	Ring net cabinet	190	0	96	51%
2	Column switch	281	94	140	83%
3	Fault indicator	199	199	0	100%
Total		670	293	236	79%

The total number of 0.4kV service terminals in this area is 4000, including 889 load control terminals, 426 GPRS meters, 2676 concentrators, 2 distributed power supplies and 7 electric vehicle charging piles. There are 303861 intelligent meters in the area, and the current situation of 0.4kV business is shown in Table 2.

Table 2. 0.4kV Business Status

Serial number	Business name	Quantity (PCs.)	Proportion of communication modes	
			GPRS	230MHzradio station
1	Load control terminal	889	45%	55%
2	GPRS watt hour meter	426	100%	
3	concentrator	2676	100%	
4	Distributed power	2	100%	
5	Electric vehicle	7	100%	

Serial number	Business name	Quantity (PCs.)	Proportion of communication modes	
			GPRS	230MHzradio station
	charging station (pile)			
	Total	4000		

4. Research on terminal communication access system

The wireless private network can meet the requirements of distribution network service transmission [8], providing communication channels for distribution automation "two remote" terminals, acquisition concentrators and load control terminals. The wireless private network covers 10kV and 0.4kV communication networks. In the weak signal and no signal areas of the wireless private network, the broadband carrier and low-power WAN are used to supplement the communication channels. The channel side includes the construction of optical fiber special network, medium voltage broadband carrier and wireless special network. LTE technology system is the best choice for power wireless private network, and lte1800 and lte230 systems have been formed. According to the comparison of spectrum approval, single base station coverage area, tower height, etc., lte230 technology system with relatively easy implementation and higher cost performance is adopted for wireless communication private network [9].

4.1 Research on wireless private network

The wireless special network is used to cover the intelligent power distribution terminals, providing communication channels for the "two remote" terminals, the use acquisition concentrator and the negative control terminals of the distribution automation. The power wireless private network is mainly composed of core network, base station and network management. The overall architecture is shown in the figure. The core network equipment is responsible for terminal authentication, data encryption, IP address management, mobility management, etc., and communicates with the service master station through SDH transmission network (return network). As the core network element of wireless network, base station equipment provides the main functions of wired wireless protocol conversion, wireless resource management and distribution, terminal access and control. The network management system is used for configuration management, performance management, fault management, software management, etc. of wireless network, and for configuration of interface server with am system. The wireless private network terminal module is responsible for connecting the communication terminal and the power service terminal, and cooperating with the base station system to transmit the up and down data of the power terminal, which can be directly embedded in the corresponding power terminal to reduce the complexity of implementation.

The core network is connected to the aggregation switch through the service uplink port, which isolates the ports of the first / second zone and the third / fourth zone services. The core network is interconnected with the base station through the service lower interface, and two core routers are established between the core network and the optical backbone network to realize the dual channel redundant backup between the wireless core network and the base station.

The return network is responsible for the information return between the base station equipment and the core network equipment. In order to ensure the reliability of the return channel, the power own optical fiber is preferred. Passive optical network and medium voltage broadband carrier technology are used for data transmission. Considering the end-to-end 1 + 1 or 1:1 protection mode, the network needs to provide telecommunication level service support. In case of failure, the service end-to-end switching time is less than 50ms.

4.2 Low voltage broadband carrier

In the area with poor coverage of wireless private network signal, low-voltage broadband carrier and low-power WAN are used to supplement the communication channel to achieve full coverage of all

areas and no blind area for information acquisition. Make full use of 0.4kV low-voltage line, replace the existing power line narrow-band carrier with low-voltage wide-band carrier, support the high-frequency acquisition of power information acquisition system, and meet the new business requirements of power supply service command system.

4.3 System safety protection

The information security of network needs more attention [10]. If the business systems of production control area and information management area use electric LTE wireless communication network or public network to communicate with their terminals, a safe access area shall be set up. The safe access area to the production control area shall include physical isolation components, front-end computer, encryption authentication equipment, etc. The security access area of access information management area shall include security access platform, data exchange system, encryption authentication equipment, etc.

5. System application effect

By means of intelligent power distribution acquisition terminal, integrated hybrid network transmission, intelligent power supply service command system, etc., the intelligent power distribution terminal communication access network constructed by "wired + wireless", "backbone + access", "public network + private network" multi-channel communication technology hybrid network mode can greatly reduce the cost of communication network construction and maintenance, and reduce the average power distribution terminal Price: solve the "last kilometer" access problem of terminal communication access network, realize seamless link between acquisition terminal, power supply service platform and maintenance personnel, reduce failure probability, reduce power outage time, and improve service quality. See Table 3 for the improvement of indicators.

Table 3. Index Improvement

Serial number	Index name	Before implementation	After implementation
1	10kV special network coverage	35.2%	100%
2	0.4kV special network coverage	0	100%
3	Broadband carrier coverage	0	100%
4	Report rate of power outage and restoration events	0	99%
5	Success rate of intelligent table collection	99.2%	100%
6	Success rate of full data and full event collection	20%	>99%
7	Remote cost control success rate	75%	100%
8	Collection frequency of station master table	24 points / day	288 points / day

6. Conclusion

This paper takes the construction of the power Internet of things as the background, takes the broadband network construction demand as the goal, starts from the business demand, carries on the broadband transformation to the business terminal, uses the rich business terminal, pole tower, PLC, optical fiber and other resources. The mixed networking mode of multi-channel communication means is adopted to collect the returned data and deepen the function application of the service platform. The heterogeneous network can be directly extended to the terminal side through a variety of transmission media to realize the function upgrade of the business platform and improve the disadvantages brought by the single access mode. By sensing terminal broadband, network channel diversification and business platform unification, the new generation of intelligent distribution terminal service access network has broadband and ubiquitous features, which improves the resource coordination, rapid response and service management and control ability of "operation, distribution and dispatching",

solves the "last kilometer" problem of power supply and service, and speeds up the communication connection of intelligent distribution terminal It is of great significance to promote the technology.

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