Research on reporting scheme of grading stop-and-recharge event of low-voltage acquisition terminal

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Abstract. For a long time, power supply companies mainly rely on the power supply service command platform for organization and dispatch of work orders and work orders for low-voltage network power outages. However, the analysis of power outage location, power outage scale, requires personnel strength and repair plan is mainly based on the prejudgment of the phone entered after the user loses power, which is prone to misjudgment of workload or recovery time, low processing efficiency and high cost. There are many security risks. This paper analyzes the problem of stop-and-recharge events, single-user and meter-box stop-and-recharge events, and proposes a reporting plan for the three-level stop-and-return event to solve the problem of immediate reporting of events after power outages. Make full use of the acquisition advantages of the electricity information collection system, and comprehensively improve the customer service response speed and distribution network operation and management level.

1. Introduction

For a long time, power supply companies mainly rely on the power supply service command platform for the troubleshooting of low-voltage network, including organization and dispatch and work orders [1-2] for power outages. However, the analysis of power outage location, power outage scale, requires personnel strength and repair plan is mainly based on the prejudgment of the phone entered after the user loses power, which is prone to misjudgment of workload or recovery time, low processing efficiency, high cost and many security risks [3-5] for follow-up processing on site.

The electricity information acquisition system is connected with the power supply service command platform. By pushing power failure and recovery events of the low-voltage household meter, acquisition unit, main meter of the substation area or concentrator in real time, the electricity information acquisition system is able to assist the power supply service command platform in analyzing and judging the authenticity, location, cause, property and scope [6-8] of a fault comprehensively. This accelerates the troubleshooting response time, reduces the cost and improves the customer satisfaction and system operation index [9-10].

This paper analyzes the problem of power failure and recovery events of the substation area, of monitoring points for key branch and users and of single user and meter box, and proposes a reporting plan for the three-level stop-and-return event. On the basis of the original concentrator, electric energy meter and acquisition unit in the substation area, this scheme is assisted with monitoring devices for
monitoring points and combines the active reporting function of a power outage event with the research and judgment system of the power outage fault acquisition in the main substation to realize the three-level online monitoring of the power supply status from the substation area to the household meter. This solves the problem of immediate reporting of events after power outages.

2. Scheme overview
Currently, there is a relevant metering acquisition device terminal (including a Type I concentrator, Type II concentrator, monitoring and metering terminal for distribution and transformation, load management terminal and data acquisition terminal of station electric energy), electric energy meter (three-phase and single phase electric energy meters) and acquisition unit (Type I and II acquisition units) in the low-voltage network. The application scene can be divided into the following types based on different data acquisition modes:

1. The wireless public network is used between the main substation and the terminal for data communication. RS485 is used between the terminal and the electric energy meter for data communication;
2. The wireless public network is used between the main substation and the terminal for data communication. The low-voltage power line carrier/micropower wireless is used between the terminal and the electric energy meter for data communication;
3. The wireless public network is used between the main substation and the terminal for data communication. The low-voltage power line carrier/micropower wireless is used between the terminal and the acquisition unit for data communication. RS485 is used between the acquisition unit and the electric energy meter for data communication;
4. The wireless public network is used between the main substation and the electric energy meter for data communication;

According to the classification of devices with power failure and recovery events, the events include electric energy meter, acquisition unit and terminal events.

According to the scope of power failure and recovery events, events are classified as follows:
1. Event of single device (such as single electric energy meter, acquisition unit or terminal);
2. Event of multiple devices (such as multiple electric energy meters, acquisition units or terminals);
3. Event of all devices (such as all electric energy meters, acquisition units or terminals);

For the way to inform the main substation in time based on aforementioned different device and scope events, this scheme is confirmed to include the following four aspects:
1. Event sensing. The way for the device to sense a power failure and recovery event correctly;
2. Event reporting. The way for the communication network to support the reporting of a power failure and recovery event;
3. Event researching and judging. The way for the substation to analyze and judge a power failure and recovery event correctly.
4. Event processing. The way for the substation to configure a follow-up processing flow for a power failure and recovery event.

Currently, the relevant event reporting of an electric energy meter is designed based on utilizing the power failure and recovery event before reporting the operation status under the live status. And state grid power companies have complete acquisition schemes for power failure events after the power-on status of a terminal and an electric energy meter. Therefore, this scheme only involves the way to report a power failure event rapidly.

In the communication network, if a node senses a device at the user side has a power failure event, corresponding reporting mechanisms shall be designed to support reporting of events in different coverage scopes.

1. Active reporting mechanism
   Reporting of single node event in the communication network requires the active reporting mechanism. After receiving a power failure event (such as communication address of a node with a
power failure) from the node with a power failure, adjacent nodes without a power failure transmit and report the power failure event to the local communication module of the terminal by grade under the data acquisition or free status of the current terminal and the local communication module of the terminal reports it to the terminal before the terminal reporting it to the main substation ultimately.

(2) Conflict detection/collision avoidance mechanism

Reporting of a multiple-node event in the communication network requires the conflict detection/collision avoidance mechanism. Limited by the bandwidth of the communication channel, it is inevitable to lose an event reporting if plenty of nodes conduct the event reporting simultaneously. Adding the conflict detection/collision avoidance mechanism can reduce the probability of mutual conflicts among event reporting signals and improve the success rate of the event reporting.

3. Reporting scheme of three-level power failure and recovery events

According to different power failure scenes, power failure events are divided into three major categories: power failure and recovery of the substation area, of monitoring points for key branch and users and of single user and meter box.

3.1. Power failure and recovery of substation area

Power failure of the entire substation area caused by the distribution and transformation and line faults influences the production, livelihood and personal safety greatly. Occupying the top grade in reporting of the three-level power failure and recovery event, it is the most urgent power failure status for repairing. Realizing the reporting of a power failure and recovery event of the substation area will turn "passive repair" to "active operation and maintenance", which is crucial for enhancing the power supply reliability, reducing user complaints and improving the power supply service quality.

According to its causes, power failure and recovery of the substation area can be divided into the following types.

![Image](image_url)

Figure 1. Power failure and recovery of substation area caused by 10kV line fault

3.1.1. Power failure and recovery of substation area caused by 10kV line fault. The high-voltage data acquisition unit is installed to 10kV high-voltage line. The concentrator/ intelligent operation terminal is used to acquire the operation working condition of the acquisition unit in real time via the wireless channel. After sending 10kV power failure event, the concentrator/ intelligent operation terminal reports the power failure event of substation area to the main system substation as shown in Figure 1.
3.1.2. Power failure and recovery of substation area caused by low voltage branch switch abnormality. The branch monitoring device with the super capacitor is installed at the output end of the low-voltage branch switch in the power distribution room to acquire the status and trip causes of the low-voltage switch in real time. In the event of power failure, it is reported to the concentrator/intelligent operation and inspection terminal via the carrier/wireless channel and the concentrator/intelligent operation terminal reports it to the main system substation as shown in Figure 2.

![Figure 2. Power failure and recovery of substation area caused by low voltage branch switch abnormality](image)

3.1.3. Power failure and recovery of substation area caused by transformer fault. Under the circumstance of a normal operation at 10kV side and trip-free branch switch at the transformer side, a transformer fault can also cause a power failure of the substation area. In this case, the concentrator/
intelligent operation monitoring terminal will have a power failure. Therefore, the local communication module with the super capacitor shall be provided. In the event of a power failure, communication between the local channel and the electric energy meter at the user end or the acquisition unit is used for verifying a real power failure event before reporting it to the main system substation as shown in Figure 3.

3.1.4. Realization flow. Conduct software upgrading of the concentrator and the main substation after adding the super capacitor or operation and inspection device to the concentrator communication module and adding the auxiliary device for power failure operation and inspection, built-in super capacitor and built-in communication module with carrier/ micropower channels to the main branch of the substation area. The flow in Figure 4 is followed for reporting.

3.2. Power failure and recovery of monitoring points for key branch and users

The monitoring device with the super capacitor is installed for key monitoring points, which can be an acquisition unit, an electric energy meter or a special device to generate a power failure event after a
power failure of the monitoring point. The local communication module of the terminal is configured with the super capacitor. After a power failure, it conducts communication with the monitoring device to obtain and report the power failure event to the main system substation as shown in Fig. 5.

3.3. Power failure and recovery of single user and meter box

(1) The carrier, micropower dual-channel and super capacitor are equipped in the concentrator carrier module and electric energy meter communication module. After a power failure, it can maintain the communication power for 60s.

(2) According to the fact whether the zero-cross signal loses judging a power failure and recovery, the electric energy meter communication module judges the occurrence of a power failure and
recovery event via the communication between the electrical level of a module ELV pin and an electric energy meter.

(3) The local communication channel has the collision avoidance mechanism. The electric energy meter communication module reports a power failure and recovery event to the concentrator directly or via adjacent nodes.

(4) The concentrator reports a power failure and recovery event to the main acquisition substation via GPRS.

3.3.1. Power failure of carrier meter. Modification scheme 1: as shown in Figure 8, add the super capacitor and conduct software upgrading for the communication module; conduct software upgrading for the concentrator communication module; conduct software upgrading for the main substation.

Modification scheme 2: as shown in Figure 9, add the wireless dual-channel module with carrier-micropower; add the super capacitor design to the communication module; conduct software upgrading of the communication module; conduct software upgrading of the concentrator communication module; conduct software upgrading of the main substation.

3.3.2. Power failure of RS485 meter under acquisition unit. Modification scheme: Type I acquisition unit communication module/Type II acquisition unit are changed to three-phase power supply and equipped with the super capacitor; software upgrading of acquisition unit communication chip, acquisition unit, concentrator communication module, concentrator and main substation.
3.3.3. Power failure of RS485 meter under concentrator. At the moment of power outage of the electric energy meter, only basic operations such as display and button are maintained and its own power failure status cannot be reported automatically. Therefore, only the concentrator for electric energy meter polling can be relied on to diagnose a power failure. But this mode may have a mis-reporting caused by 485 line fault. As a result, an error-free reporting of a power failure event can be realized by installing the communication module to the electric energy meter or adding the device which can conduct communication under power outage to the meter end.

![Figure 9. Scheme 1 on power failure of carrier meter](image)

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Modification scheme: add the super capacitor to the concentrator communication module or add the operation and inspection device; install the auxiliary operation and inspection device for a power failure to each ammeter phase; the operation and inspection device has the built-in super capacitor and
the built-in communication module with the carrier/micropower channels; software upgrading of the concentrator and main substation.

4. Conclusion
This paper proposes a reporting plan for the three-level power failure and recovery event. On the basis of the original concentrator, electric energy meter and acquisition unit in the substation area, this scheme is assisted with monitoring devices for monitoring points and combines the active reporting function of a power outage event with the research and judgment system of power outage fault acquisition in the main substation to realize the three-level online monitoring for the power supply status from the substation area to the household meter and reporting a power failure and recovery event. This solves the problem of immediate reporting of events after power outages. It makes full use of the acquisition advantages of the electricity information acquisition system and combines with the power supply service command platform deeply to turn the "passive repair" to "active operation and maintenance" to further solves the problem of "the last one kilometer" of the power supply service. It comprehensively improves the customer service response speed and distribution network operation and management level.

References
[1] Lishan B, Chen L, Bo F, et al 2016 J Function Design and Application of Fault Repair and Command Platform for Intelligent Distribution Network Distribution & Utilization 33(12) pp 29-33.
[2] ChangguoZ, Xiaoshu H, Jianbin Y, et al 2016 J Marketing-distribution-dispatch Management Model Optimization for Country Grid Automation of Electric Power Systems 33(12) pp 29-33.
[3] Canming Z, Zhuhong L, Lei T, et al 2016 J Fault localization for electric power communication network based on fault propagation model and supervised learning Journal of Computer Application 36(4) pp 905-908.
[4] Weikang R, Jihua H, Zhihao L, et al 2012 J Research on Intelligent Fault Identification System in Low Voltage Power Distribution Network Low Voltage Apparatus 12 pp 37-39.
[5] Jiangyi H, Engo Z, Xingang D, et al 2014 J Application Status and Development Trend of Power Consumption Information Collection System Automation of Electric Power Systems pp 131-135.
[6] Chuangxin G, Haibo L, Bin Y, et al 2013 J A Survey of Research on Security Risk Assessment of Secondary System Power System Technology 37(1) pp 112-118.
[7] Bo L, Quanyi B, Minghai Y, et al 2015 J Analysis and Coping Strategy of Low Voltage Remote Cost-based Control on the Electricity Service Interruption/Recovery Problem Distribution & Utilization 32(12) pp 61-67.
[8] Haifan H 2012 J Research of Distribution Network Dispatching Fault Rapid Restoration Support System China Electric Power (Technology Edition) pp 22-24.
[9] Yin Z J Study on Event Records Function of Smart Meters Electrical Measurement & Instrumentation.
[10] Yunlong H, Shusheng Z, Wen C, et al 2016 J Study on Testing Method for Power Fails of Smart Electricity Meter and Outage/Power-on Events of Concentrator 44 (3) pp 71-76.