Technology and application of high speed fault location, isolation and self-healing in DC distribution network

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Abstract. With the continuous increase of DC load, the research of DC distribution network has been developed rapidly. Compared with the traditional AC distribution network, DC distribution network has the advantages of less conversion times, high efficiency, low cost, simple control structure, no need to consider the frequency and phase and reactive power compensation equipment. Compared with AC distribution network, DC distribution network has more flexible operation mode and less power supply points However, the more flexible operation mode of DC distribution network also brings the problem of fault location and self-healing. The fault location, isolation and self-healing control strategy of AC distribution network can not be applied to DC distribution network. In this paper, a high-speed fault location, isolation and self-healing method for DC distribution network is proposed. Based on high-speed goose communication, a comprehensive evaluation is carried out according to the fault status of the power grid, and the millisecond level fault location, isolation and self-healing of DC distribution network are completed. The coordinated control equipment based on this method is successfully applied in Tongli integrated energy service center. When the fault occurs in this area, uninterrupted power supply is realized in the non fault area, which verifies the correctness and practicability of this method.

1Introduction

With the development of power electronics technology, distributed generation with DC output characteristics such as photovoltaic and energy storage are connected to the power grid on a large scale, and the DC load is increasing[1]. The DC distribution network is easy to access renewable energy, with high system efficiency, small loss, large power supply radius, high reliability, and broad application prospects. However, the more flexible operation mode of DC distribution network also brings the problem of fault location and self-healing[2].

Typical overhead lines of AC distribution network are shown in Figure 1. The fault location, isolation and self-healing control strategies of AC distribution network generally include distributed control and centralized control[3]. Distributed control is also called distributed FA, which is completed by distribution automation terminal. Centralized control is also called centralized FA, which is completed by master station. Distributed FA can share fault information and other states among terminals in real time, judge fault area and isolate fault area through fault state and direction of upstream and downstream nodes; centralized FA can collect fault state and fault direction of each switch node, make unified comprehensive decision to judge fault area, and carry out fault location, isolation and self-healing[4-5].

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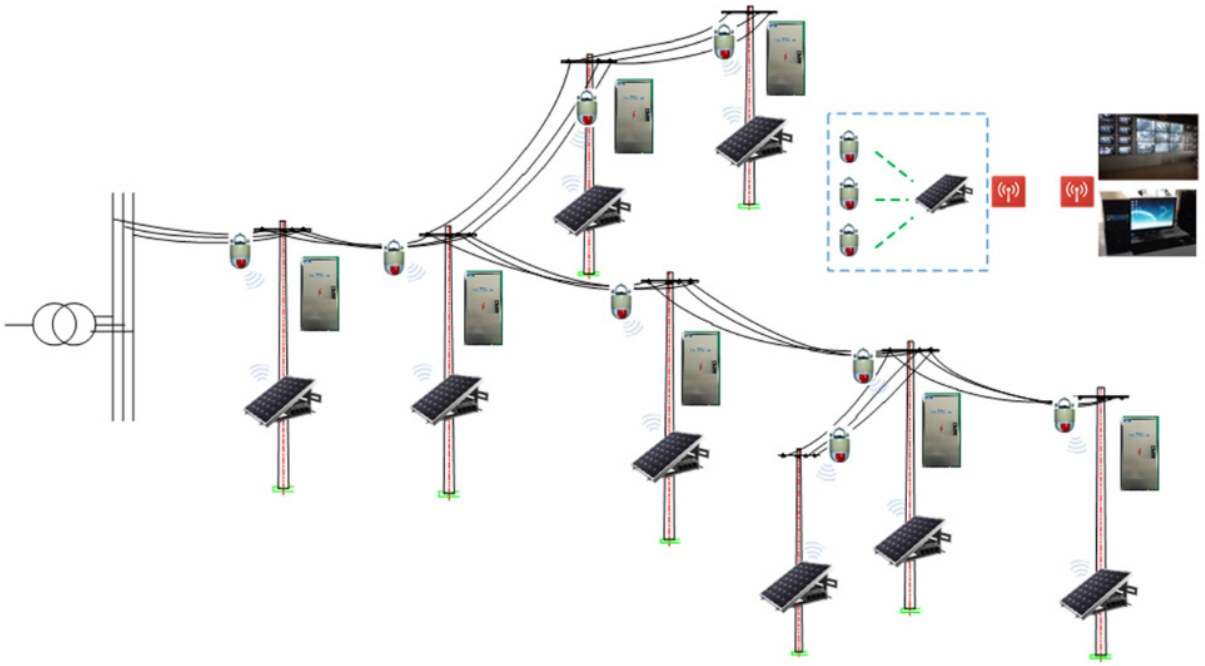

Figure 1 Typical overhead lines of AC distribution network

However, the existing distributed fault location and isolation control technology and centralized FA control technology are not suitable for DC distribution network

- As shown in the figure above, the centralized fault location and isolation control of AC distribution network can realize the collection of the whole network information through the distribution automation master station, and can realize the fault location, isolation and self-healing control. However, due to the slow speed of the master station to collect the whole network information, it takes several seconds or minutes to complete all the information collection, fault location, isolation and self-healing requirements for uninterrupted power supply in barrier area.
- The distributed fault location and isolation control technology of AC distribution network can identify the fault status of adjacent nodes. As shown in the figure above, the distribution network line is long and far away. The distribution automation terminal can not identify the whole network information, and can only obtain the information of adjacent nodes. Generally, it only considers the rapid fault location and isolation, and does not carry out fault self-healing control. The self-healing control also needs to be confirmed by the master station After fault isolation, the control command of contact switch is issued.
- The distributed fault location and isolation control technology of AC distribution network does not need to consider the operation state of the power supply. However, the diversification of the operation state of DC power supply makes it necessary to cooperate with DC power supply in the process of fault self-healing, so the self-healing control technology of AC distribution network is not suitable for DC distribution network.

In this paper, a high-speed fault location, isolation and self-healing method for DC distribution network is proposed. Based on high-speed goose communication, a comprehensive evaluation is carried out according to the fault status of the power grid, and the millisecond level fault location, isolation and self-healing of DC distribution network are completed. The coordinated control equipment based on this method is successfully applied in Tongli integrated energy service center. When the fault occurs in this area, uninterrupted power supply is realized in the non fault area, which verifies the correctness and practicability of this method.

2Control method

2.1Method for fault location and isolation in DC distribution network

The typical DC distribution network system architecture is shown in Figure 2. Define the positive direction of the system, and confirm the upstream node, downstream node and t node of each tie switch. Along the positive direction of the system, determine the upstream node and downstream node from top to bottom. When multiple tie switches have the same upstream node, they are t nodes. Taking the S1 switch in Figure 2 as an example, S2 and S3 are the downstream nodes of S1. On the contrary, S1 is the upstream nodes of S2 and S3. If S2 and S3 have the same upstream node, S2 and S3 are t nodes.

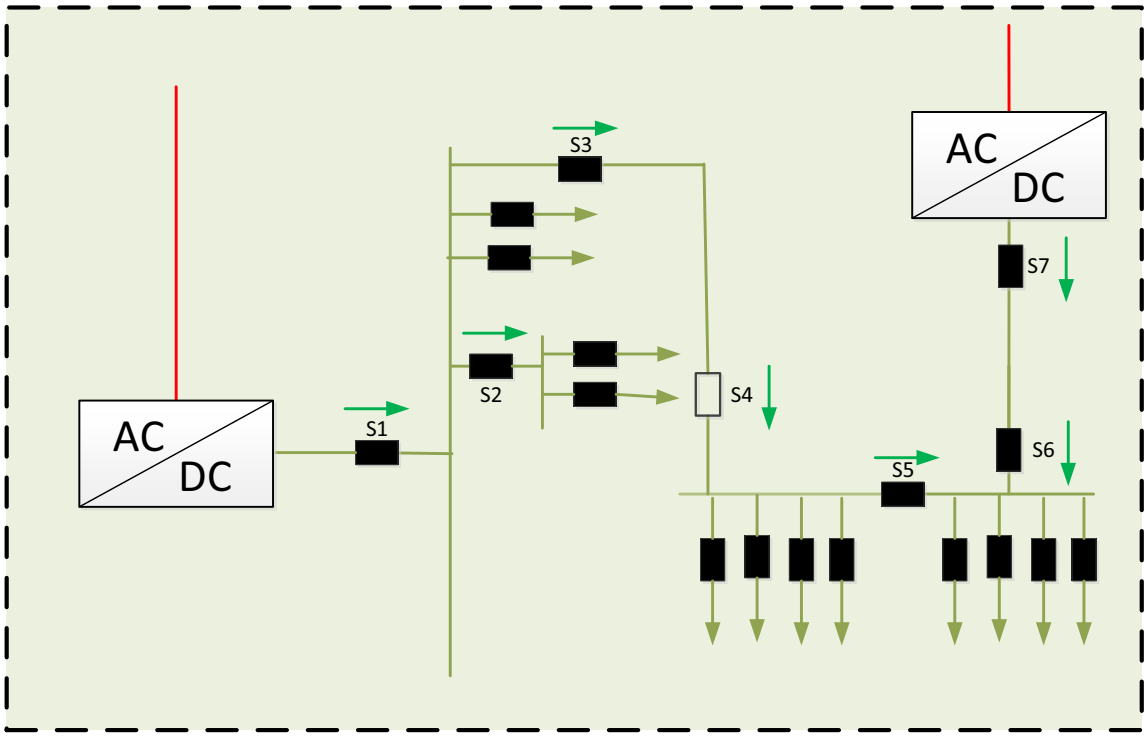

Figure 2 system architecture of typical DC distribution network

Through goose communication protocol, real-time collection of DC power point operation status and contact switch operation status, when received a switch over-current action information, it is positive over-current, then judge whether the downstream node of the node is positive flow, if the downstream node is reverse over-current, then judge the fault between the node and the downstream node, send the node and downstream node tripping and power supply Power block goose command. Similarly, if a node has a reverse over-current, it will determine whether the upstream node or T node of the node is a forward flow. If the node, upstream node, t node trip and power supply lockout goose command are sent. The isolation switch is replaced by the switch on / off switch. The over-current action information is sent by the DC feeder terminal or protection device configured with DC distribution network interconnection switch through goose communication. The control flow of fault isolation is shown in Figure 2

2.2Identification and isolation of transfer switch

Before judging the fault self-healing control, it is necessary to determine the tie switch that can be transferred. First of all, the switch must be divided, and both sides of the switch must be connected with DC power supply, and the tie switch is in normal operation for a period of time (10 seconds). The identification logic of the tie switch is shown in Figure 3.

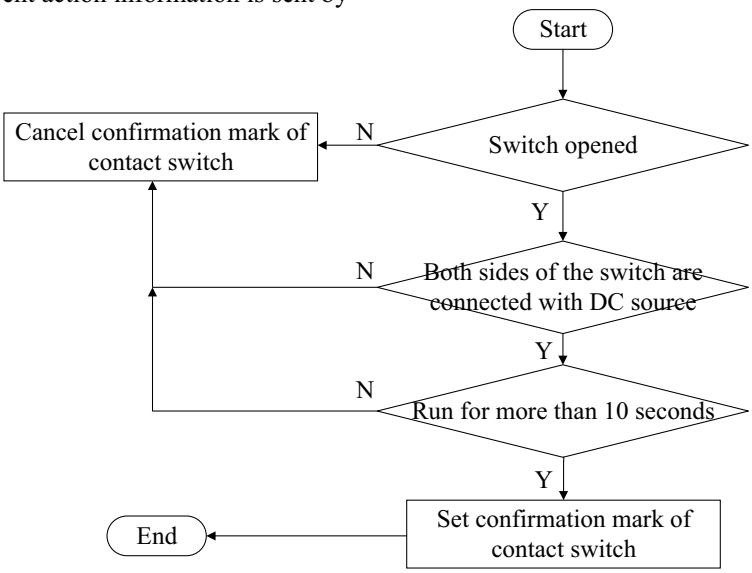

Figure 3 identification logic diagram of tie switch

When the fault isolation is successful, the fault isolation success flag needs to be transferred to each switch node of the power grid step by step. Step 1: after the fault isolation success table is detected, the step-by-step transfer is started, in which the downstream fault isolation success flag is transferred to the upstream node and t node, on the contrary, the upstream fault is transferred to the downstream, no matter whether it is transferred to the upstream or to the downstream If the switch is closed, when it is open, the transfer is terminated. The transfer logic of fault isolation success flag is shown in Figure 4.

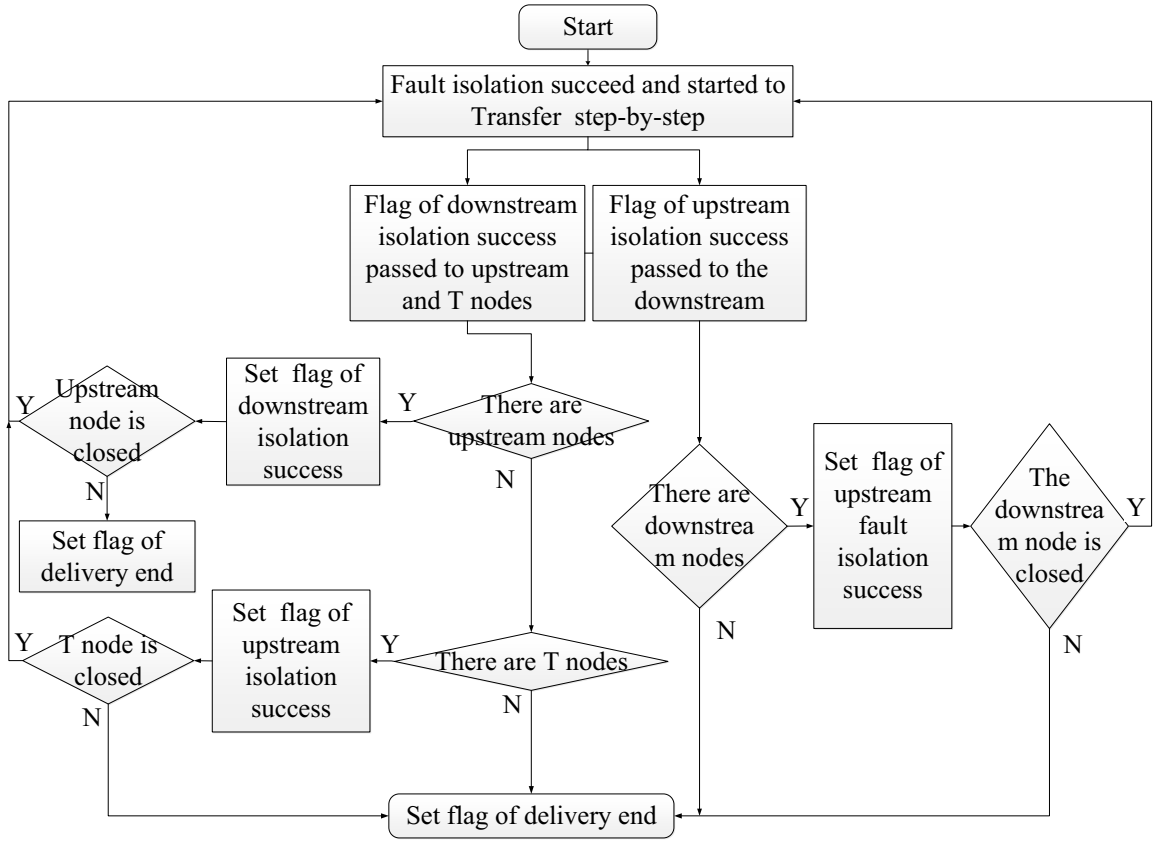

Figure 4 logic diagram of fault isolation success flag transfer

2.3Self healing of faults

When the fault isolation success flag is passed, the fault self-healing control strategy is turned on, and the transfer switch recognizes the fault isolation success flag and the non fault area. If the power supply connected with the non fault area does not operate in the voltage source mode and is not locked, the voltage source of the transfer power supply is sent to start goose to realize the non fault area transfer, and Yuci colleagues send the switch goose closing command After the switch position changes from open position to close position, the self-healing control is realized. The self-healing control logic is shown in Figure 5.

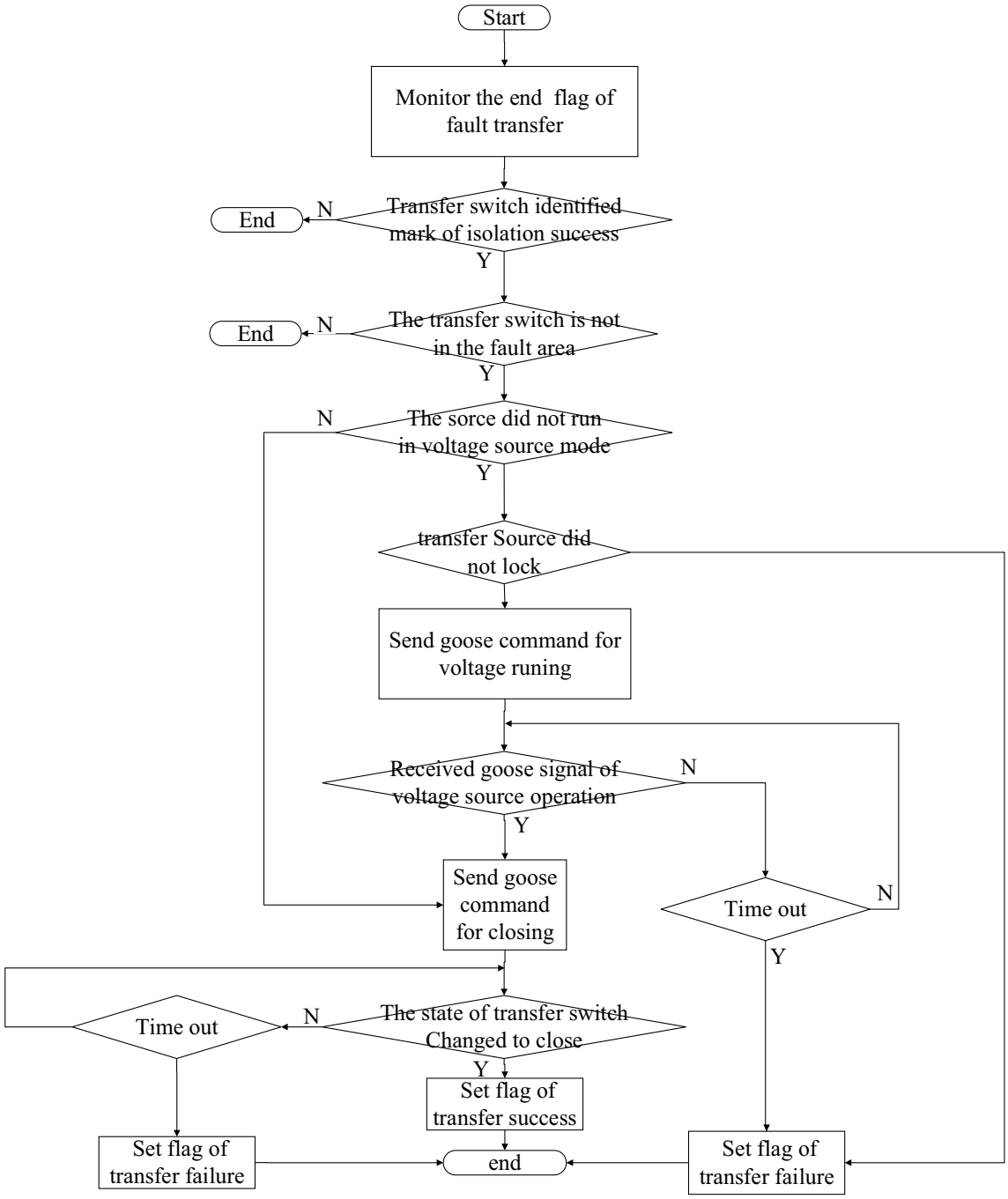

Figure 5 logic diagram of self healing control

3Application of achievements in technical advantages

3.1Project introduction and system scheme

Tongli integrated energy service center is a new type of regional energy Internet, which forms a green low-carbon Park in Jiangnan Water Town integrating energy production, service, exhibition, R & D and office. Taking the four port microgrid router as the center, the main power supply points are its four ports of 10kV, ± 375v, 380V and ± 750V. schematic diagram of system architecture is shown in Figure 6.

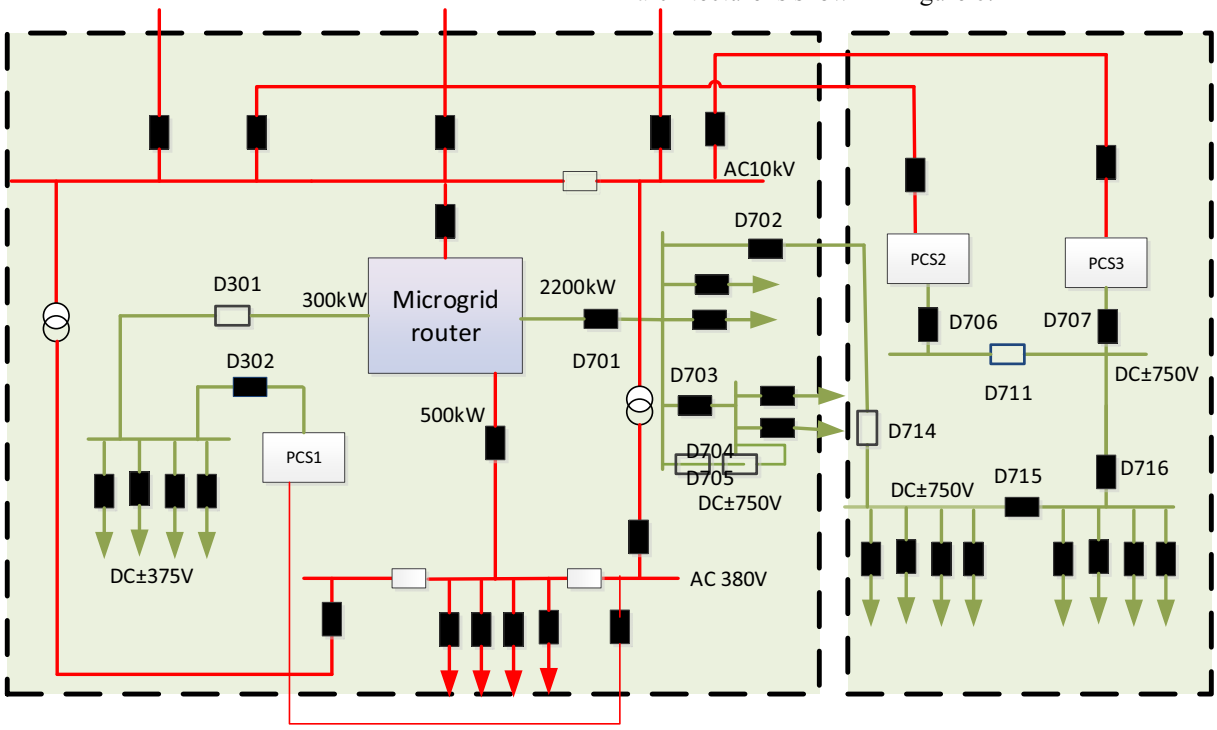

Figure 6 schematic diagram of system architecture

In the normal operation state of the system, when pcs1 fails (10kV system failure, power loss, PCS itself failure) and its incoming line failure, the load is transferred to the microgrid router power supply, pcs1 locks and jumps off d302, and puts into D301 power supply; if the bus fails, pcs1 is off the grid, and after the fault is recovered, it returns to the normal operation state through dispatching operation; if the branch line fails, Pcs1 locks and trips d302. After the branch fault is removed, D301 power supply is put into operation. After the fault is recovered, all operation states will be restored to normal state by human intervention.

3.2Achievement advantage

This paper proposes a high-speed fault location, isolation and self-healing method for DC distribution network, which has the following advantages: the method obtains the status information of each node in DC distribution network area based on goose high-speed communication mechanism, and all information collection can be completed within 5ms, which provides guarantee for the rapidity of subsequent fault location, isolation and self-healing, and meets the requirements of uninterrupted power supply in non fault areas According to the fault status and direction of each node in the DC distribution network area, the fault area is determined and isolated by integrating the upstream and downstream relationship of nodes, and self-healing control is carried out; In the process of self-healing, according to the operation characteristics of DC power supply, this method controls the tie switch and DC power supply, and solves the problem that the self-healing control technology of AC distribution network does not adapt to DC distribution network.

4conclusion

In this paper, a high-speed fault location, isolation and self-healing method for DC distribution network is proposed. According to the fault status of the power grid, a comprehensive evaluation is carried out to complete the millisecond level fault location, isolation and self-healing of DC distribution network. The coordinated control equipment based on this method is successfully applied in Tongli integrated energy service center. When the fault occurs in this area, uninterrupted power supply is realized in the non fault area, which verifies the correctness and practicability of this method.

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