Research on sequence automatic execution technology of substation safety measures

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Abstract. With the increasing complexity of the power grid, in order to ensure the reliability and stability of the power supply system, higher requirements are imposed on the automation level of the power system. Substation security measures are generally performed manually, and maintenance personnel need to cast and withdraw pressure plates one by one based on the automatically generated secondary security measures, and manually verify the results of each step. This paper proposes a technology for the automatic execution of security measures in substations. Based on the generated security measures, it implements automatic sequence control operations and has proofreading functions. This method improves the level of substation automation while ensuring the correct execution results of safety measures, and provides an important guarantee for the safe and stable operation of the power system.

Keywords. Substation overhaul; safety measure ticket; automatic implementation

1. Introduction
With the continuous deepening of power grid construction, the power system has changed from a simple single-end power supply method to a complex multi-end power supply method. It not only improves the reliability of power supply, but also puts forward higher requirements for the automation level of the power system. At present, the country is vigorously carrying out smart grid construction. More and more smart substations are being used in actual projects, which has greatly improved the information level of the power grid and is of great significance for ensuring the safe and stable operation of the power grid [1].

Traditional substation security measures are generally performed manually. Operation and maintenance personnel need to cast and return the corresponding pressure plates one by one on the protective device according to the security measures. The soft pressure plates that support remote control also need to be manually remotely operated in the monitoring system [2]. The above two operation methods must manually confirm whether the operation results of each step are correct and the work efficiency is low; and the lack of effective control over the operation sequence of the safety measures steps, the error of the safety measures operation sequence causes the substation protection device to malfunction or incorrect One of the potential threats to action is that for intelligent substations, frequent plugging and unplugging of optical fibers will reduce fiber life [3].

In view of the above problems, in order to further improve the automation level of the substation, improve the efficiency of the maintenance work of operation and maintenance personnel, and improve the reliability of the secondary maintenance of the substation, this paper proposes a sequential automatic execution technology of substation safety measures [4]. The method realizes the function of
secondary safety measures of manual or automatic “one-button” sequence control operation protection device based on the automatically generated safety measures secondary operations ticket, and has the function of step-by-step anti-correction to realize the operation of the safety measures of secondary safety measures Sequential, batch operation of the protective device soft platen [5].

2. Automated generation of safety measures ticket based on standard safety measures library

On the basis of encoding various interval types, operation task types, operation object types, and security measures, instantiate the operation objects within a certain interval, that is, the specific pressure plate related to security measures in this interval. Identification, such as various types of GOOSE outlet soft pressure plates, reclosing soft pressure plates, longitudinally-connected differential protection soft pressure plates, switch start failure sending soft pressure plates, overhauling hard pressure plates, and corresponding bus protection internal branches SV / GOOSE receives soft platen (or interval receiving soft platen), start failure receiving soft platen, isolation knife gate forcibly closing soft platen, corresponding to intelligent terminal to overhaul hard platen and outlet hard platen, and unit to overhaul hard platen. Most of these types of platens can be automatically identified by the SCD library guide tool and manually associated with those that cannot be identified. For fiber insertion and removal operations, it is handled as a prompt item. After instantiating all types of pressure plates inside the interval, you can find the corresponding security measures coding table according to the equipment security measures mapping table and instantiate the security measures task steps [6].

The general principles of the automatic generation sequence of the security measures strategy are as follows: (1) Traverse all checked maintenance equipment, analyze the isolation point, and exit the SV receiving soft pressure plate of the maintenance equipment in the running equipment; (2) Traverse all checked maintenance equipment, analyze the isolation point, Exit the GOOSE receiving soft pressure plate of the maintenance equipment in the running equipment; (3) Traverse all checked maintenance equipment, analyze the isolation point, exit the GOOSE sending soft pressure plate from the maintenance equipment to the running interval; (4) disconnect the maintenance if necessary Optical fiber circuit between the equipment and the operating equipment; (5) If the primary equipment does not lose power, exit the hard terminal at the interval intelligent terminal exit; (6) Put in the maintenance hard plate for maintenance equipment; (7) If the primary equipment fails, the current loop is disconnected And short-circuited, the voltage loop is disconnected.

3. Expected information comparison and measure status confirmation Implementation plan

The online verification technology of maintenance measures can help operators to verify the implementation of safety measures, graphically display the current state of equipment isolation, effectively improve the accuracy of safety measures, and greatly improve the maintenance of intelligent substation Efficiency of work. The implementation scheme of maintenance safety measures is shown in figure 1.

![Figure 1. Maintenance safety measures implementation plan.](image-url)
By selecting the maintenance interval and maintenance operation tasks, the corresponding instantiated safety measures ticket is automatically called, and at the same time, the system screen will automatically switch to the safety measures visual monitoring interface of the corresponding interval. First, the safety measures ticket will be visually simulated and previewed. During the execution process, the operation steps and sequence are monitored. When an unexpected plate displacement operation occurs, a safety precaution is given, and the desired operation is prompted [7]. After the execution of all security measures is completed, the implementation results of security measures can be checked to ensure that all security measures are in place. And establish a general secondary security measures verification rule base to verify the results of the current security measures execution, the rule base is shown from the table 1 to the table 4.

**Table 1. Operation Type**

| Task status            | Corresponding one time device status | Line protection status | Main transformer protection status | Bus protection status | Intelligent Terminal status |
|------------------------|-------------------------------------|------------------------|-----------------------------------|-----------------------|-----------------------------|
| Line operation         | run                                 | Two sets of inputs     |                                   |                       | Two sets of inputs          |
| Main transformer operation | run (At least one side)            | Two sets of inputs     |                                   |                       | Two sets of inputs on the corresponding side |
| Bus operation          | Operation (at least one connected switch) | Two sets of inputs     | Two sets of inputs for corresponding branches |                       |                             |

**Table 2. Periodic Inspection Type**

| Task status                              | Corresponding one time device status | Line protection status | Main transformer protection status | Bus protection status | Intelligent Terminal status |
|------------------------------------------|-------------------------------------|------------------------|-----------------------------------|-----------------------|-----------------------------|
| Line inspection                          | Cold spare / Overhaul               | Two sets of overhauls  | Two sets of mating two states     | Two sets of overhauls |
| Main transformer final inspection        | Overhaul (three sides)              | Two sets of overhauls  | A set of protection and maintenance | Invest               |
| Bus A set of protection inspection       | Normal operation                    | A set of protection cooperation | A set of protection and maintenance | Invest               |
**TABLE 3. PROTECTION SETTING TYPE**

| Task status | Corresponding one time device status | Line protection status | Main transformer protection status | Bus protection status | Intelligent Terminal status |
|-------------|-------------------------------------|------------------------|-----------------------------------|-----------------------|---------------------------|
| Line main-protection setting | Normal operation | Main-protection setting value state | A set of protection cooperation | Invest |
| Main transformer A set of protection settings | Normal operation | A set of protection and maintenance | A set of protection cooperation | Invest |
| Busbar A set of protection settings | Normal operation | A set of protection and maintenance | A set of protection cooperation | Invest |

**TABLE 4. OUTAGE TYPE**

| Task status | Corresponding one time device status | Line protection status | Main transformer protection status | Bus protection status | Intelligent Terminal status |
|-------------|-------------------------------------|------------------------|-----------------------------------|-----------------------|---------------------------|
| Line outage | Overhaul | Two sets of exits | Two sets of mating two states | Two sets of exits |
| Outage of main transformer | Overhaul (three sides) | Two sets of exits | Two sets of mating two states | Exit on three sides and two sets |
| Bus outage | Operation without any connected switch | Two sets of fit | Two sets of exits | drop out (Corresponding branch) |

Combined with the security measures application, enumeration defines the security measures status of the protection device according to different combinations of the internal pressure plate status of the device (including the protection within the interval, the intelligent terminal, the merging unit, and the external protection connected with security measures across the interval). Establish an anti-correspondence check rule database (an anti-vote corresponds to one state), and perform a state check on the results of anti-voice execution [8].

The following 6 equipment states are defined for the protection device:

1) "Into" state: When this device is operating normally, the soft pressure plate of the secondary circuit of this device and all related operation protection devices (such as differential protection, safety automatic devices, etc.) should be in the corresponding correct state;

2) "Full Retreat" state: The status judgment plate of this device is concentrated in the exit plate of the device, the start failure sending plate, and the related startup protection receiving plate of the operation protection device are in the exit state. It is mainly applicable to the work of eliminating the power failure of the equipment and changing the setting of the protection wheel;

3) "Simple retreat" status: All functional pressure plates and outlet pressure plates of this device are in the same position as the "input" status. Pressure plate (such as 220kV line power failure, only
two sets of line protection start failure sending soft pressure plate and bus protection device failure start receiving pressure plate). It is mainly applicable to a power failure scenario;

(4) "Fully isolated" status: On the basis of the device being "fully retired", in order to avoid sending alarm signals such as "SV link disconnection, goose link disconnection" during the absence process, only all related to it are returned. The SV receiving soft pressure plate of the operation protection device (such as bus differential protection, safety automatic device, etc.) is mainly suitable for the work of the primary equipment without power failure (merging unit, intelligent terminal, protection device, etc.);

(5) "Separate" status: On the basis of the "Simplified withdrawal" of the device, only the SV receiving soft pressure plate of all related operation protection devices (such as bus differential protection, safety automatic device, etc.) is returned to avoid power failure branches. Regular inspection and verification work test voltage and current analog quantities are incorrectly passed into running equipment and cause mis-operation accidents, which are mainly applicable to the primary inspection of equipment power failure protection devices.

4. Technical implementation plan for automatic implementation of security measures in the monitoring system in sequence

At present, the implementation method of substation voting is generally performed manually. The operation and maintenance personnel cast and return the corresponding pressure plate one by one on the protection device [9]. The soft pressure plate that supports remote control can also be operated remotely through the monitoring system. Manual confirmation of the operation results of each step greatly reduces the efficiency, and lacks effective control over the operation sequence of the safety measures. In view of the fact that most of the steps in a typical security measures ticket are for the operation of the soft platen, there are only a few hard platen steps that cannot be remotely controlled. All the secondary security measures that can be automatically generated according to the automatically generated secondary security measures, to achieve manual or automatic "one-click" sequence control operation protection device secondary security measures, with step-by-step anti-correction function, to achieve the secondary security measures operation library Sequential, batch operation of the protective device soft platen [10].

(a) In manual operation, all secondary safety measures are completed manually. The system should judge whether the current step is successful or not based on the currently collected information, and then proceed to the next operation after manual confirmation;

(b) During the automatic operation, the soft pressure plate in the secondary safety measure is implemented remotely by the "one-touch" safety measure function. During the process, the automatic comparison operation is successful. If it is not correct, stop the automatic operation. And when the automatic operation is unsuccessful, it should have the function of turning to manual operation;

(c) For the device to overhaul the hard pressure plate, it can only be thrown in and out manually;

(d) For the hard pressure plate exported to the smart terminal, because the monitoring system cannot collect its position information, it can be constructed as a virtual pressure plate, using manual confirmation.

5. Conclusion

Smart substations have a high degree of integration in the secondary circuit, a large number of optical fibers are used for information transmission, and the equipment outlet lacks obvious electrical disconnection points. Therefore, the safety measures for the maintenance of the secondary circuit have changed greatly compared with traditional substations. At present, the implementation of Ancuo often uses manual execution, and the work efficiency is low. The sequential automatic execution technology proposed in this article can replace manual execution to a certain extent, improve the operational efficiency of Ancuo, and improve the automation level of substations. The operation steps of vote counting are for the opening and closing operations of the soft pressure plate. The automatic execution technology can realize the automatic sequence control operation and provide a powerful auxiliary means for the effective development of the secondary maintenance operation of the intelligent substation.
6. References

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