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Research on Anti-Islanding Protection Communication Based on IEC 61850 Standard

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Abstract

INTRODUCTION: As a high proportion of distributed power sources are widely connected to the distribution network, they change the topology of the traditional distribution network and the characteristics of electrical quantities, among others.
OBJECTIVES: In order to prevent unplanned islanding from occurring in the distribution network, which affects the power supply quality and personal safety of the distribution network, the distribution network needs to be equipped with anti-islanding protection.
METHODS: In this paper, the typical unplanned islanding scenarios of active distribution networks and the information interaction requirements for anti-islanding protection are analyzed. Based on the analysis of anti-islanding protection information interaction requirements, a SCADA fault detection information model is established based on IEC 61850 standard. A line topology description method based on IEC 61850 SCL is proposed to solve the problem of reduced reliability of anti-islanding protection detection due to line topology changes, inability to accurately determine the boundary of the island, and susceptibility to omission or misjudgement. Meanwhile, a subset of information models for anti-islanding protection has also been refined in conjunction with the functional requirements of typical active distribution network scenarios.
RESULTS: Finally, the effectiveness of this paper's method is verified by examples, and the related results are effectively used in the smart power distribution management system
CONCLUSION: Aiming at the aggregated management challenges of massive medium and small-capacity DERs in low-voltage distribution network station areas, this paper establishes an IEC 61850-compliant universal DER information model, constructs a communication security control logical node, and realizes source-side dynamic conversion of inverter data from Modbus to IEC 61850 protocol.

Keywords: active distribution network; distributed energy resources; Anti-islanding protection; IEC 61850; information model

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1. Introduction

As distributed energy resources (DERs) are increasingly integrated into distribution networks, the topologies of these networks and their electrical behaviors after faults have been greatly transformed [1,2,3]. Consequently, traditional distribution network protection and control strategies are no longer sufficient to meet operational and safety requirements [4,5,6]. To prevent the formation of

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unplanned islands in distribution lines, which can affect the safety of maintenance personnel and power supply quality, it is essential to install anti - islanding protection on networks [7,8, 9].

The current anti-islanding protection detection for distributed energy resources (DERs) can be categorized into local detection methods and remote detection methods based on whether communication is required. Local detection methods, in terms of detection principles and techniques, can be further grouped into active and passive types [10]. Active methods introduce small disturbance signals during normal operation of the distribution network, monitoring these disturbances to determine if an islanding effect has occurred. Common detection methods include frequency/power perturbation methods and impedance methods [11,12,13,14]. Passive methods detect by observing electrical parameters like voltage, frequency, and phase at the DER connection point (PoC), checking whether these values surpass predefined limits. Common detection methods include over/under-voltage (OUV) and over/under-frequency (OUF) methods. Reference [15] proposes an anti-islanding detection method using S-R triggered relays for fault detection, used to identify under-voltage and over-voltage conditions. However, while active methods are highly accurate, they may affect power quality; passive methods, though they do not affect power quality, have difficulty in determining thresholds, thus posing risks of false positives and false negatives. Remote detection methods utilize the communication systems of the distribution network (such as power line communication, SCADA systems) to monitor voltage, frequency, and other parameters in real-time, thereby determining if islanding has occurred [16,17]. Reference [18,19] puts forward an anti-islanding protection strategy relying on power line communication (PLC). Remote detection methods are characterized by fast response times, high reliability, the ability to monitor the entire grid's islanding status without being limited by the scale and capacity of DERs, and they have no impact on the power quality of the distribution network, making them an inevitable trend in the development of digitalized distribution networks. However, both active and passive methods rely on topological information[20,21], and due to the change in access to distributed power sources and the lack of information archives, the topological information of the distribution network is missing, so it is not possible to accurately determine the boundary of the island, which is prone to trigger the risk of omission or misjudgement.

Currently, remote detection methods primarily monitor data collected from monitoring equipment, sensors, and leakage currents to observe distribution network lines and determine if an island has formed. However, due to some manufacturers using proprietary custom data formats at the communication data model level, achieving interoperability between devices is challenging. Therefore, establishing a communication information model with unified semantics is necessary [22,24]. The IEC 61850 standard is widely applied in substations, achieving semantic standardization at the device level [25]. In medium-voltage distribution networks, the IEC 61850 standard has been utilized in scenarios such as feeder automation to establish fault location and isolation information models. The IEC 61850-90-6 standard specifies data models, communication mappings, and engineering configurations for distribution networks, with reference [26] conducts research on the information model for centralized feeder automation based on IEC 61850-90-6, though specific applications for anti-islanding protection are less described.

Therefore, this paper first analyzes the information interaction requirements for islanding protection based on the typical scenarios of the active distribution network. Based on the information model of IEC 61850 and combined with the functional requirements of the typical scenarios, it improves the SCADA detection information model and the information model subset for islanding protection. At the same time, it proposes a topology description method based on IEC 61850 SCL to solve the problem of inability to accurately determine the islanding boundary, in order to improve the reliability of islanding protection. Finally, the effectiveness of the method proposed in this paper is verified through a case.

2. Materials and methods

2.1. Demand Analysis for Anti-Islanding Protection in Active Distribution Networks

With the large-scale integration of distributed energy resources, traditional protection and control strategies in distribution networks are significantly impacted. The islanding effect, as a specific fault state, occurs when, during a distribution network feeder fault, DERs are unable to disconnect from the grid immediately and still provide electricity to the local load, resulting in an island that operates independently and uncontrolled by the grid [27]. Based on whether the islanding region is pre-designated, islanding operation can be categorized into two types: planned islanding and unplanned islanding.

Analysis of Typical Unplanned Islanding Scenarios in Active Distribution Networks

To ensure the distribution network operates normally, distributed energy resources (DER) need to be quickly detached from the grid when their ability to exchange current ceases. Erroneous manual operations or feeder faults leading to circuit breaker disconnection can all result in unplanned islanding on the distribution network feeder. To prevent the feeder and connected equipment (loads and DER) from operating under unplanned islanding conditions, which could damage distribution network equipment, cause out-of-phase reclosing, endanger personnel safety, and reduce grid reliability, it is essential to detect such conditions and halt the supply of power to the feeder by the involved DER, that is, it is necessary to be equipped with island-isolation protection.

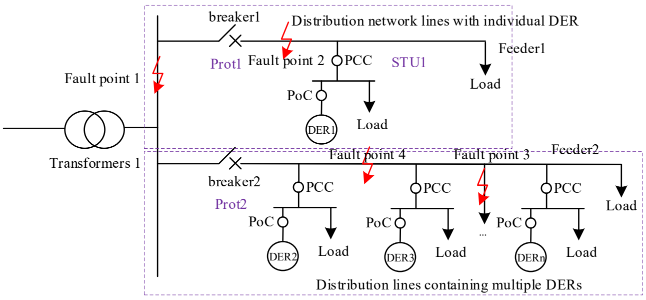

Figure 1. Typical lines of distribution networks with distributed power sources

For the study of unplanned islanding, the location of the fault point on the feeder topology is crucial. There are three typical fault locations on radial feeders as follows:

The fault point is located on the busbar of the distribution network, as shown by fault point 1 in Fig. 1. In this case, feeders 1 and 2 of the distribution network will form an unplanned island.

The fault point is located on feeder 1 of the distribution network, as shown by fault point 2 in Fig. 1. Here, the entire feeder 1 will become an unplanned island.

The location of the fault is on the branch of feeder 2, as shown by fault point 3 in Fig. 1. In this scenario, the branch protection will trip, preventing the formation of an unplanned island.

The location of the fault is on the branch of feeder 2, as shown by fault point 4 in Fig. 1. The upstream protection near this fault will trip the circuit breaker, creating a partial island. DER2 will continue to operate normally, while DER3 will be in an unplanned islanding region.

Analysis of Information Interaction Requirements for Anti-silo Protection

When unplanned islanding occurs, generating and consuming equipment will operate continuously and dangerously for some time, causing damage to equipment and posing a threat to personnel safety. Measures must be taken to detect and prevent unplanned islanding. Without locking the automatic reclosure function of the relay protection device, islanding protection can be achieved by direct transfer tripping (DTT) method of the DER system or by notifying the DER system of the unplanned islanding state to disconnect DER from supplying power to the feeder, thereby preventing out-of-phase reclosing shortly after tripping. Additionally, island detection using local measurements at the grid connection point may not be effective in detecting the island, but it can be enhanced by transmitting the circuit breaker trip information to the DER, thereby improving anti-islanding protection.

When unplanned islanding occurs, it is essential to detect the islanding operation accurately and promptly, and to disconnect the distributed energy resources (DER). However, to prevent widespread disconnection of DER from the grid, existing DER systems are equipped with low-voltage ride-through (LVRT) and high-voltage ride-through (HVRT) capabilities to ensure continuous power supply to the grid during disturbances. To this end, the IEEE Std. 1547-2018 explicitly requires that distribution networks must detect islanding within 2 seconds and complete the corresponding protection actions to ensure that fault arcs can be extinguished before reclosing.

As shown in Fig. 2, the use case diagram for island protection prevention is presented. Based on the information exchange process of island protection prevention, island protection prevention can be divided into several key parts such as unplanned island detection, automatic reclosing and blocking, direct trip transfer, and feeder power outage. Among them, the voltage indicator is a device that can display the voltage at the measured point exceeding a certain limit; the DER unit controller is the controller of DER, which has control and data acquisition functions; the substation protection equipment is the substation protection equipment with island protection prevention function, supporting UDP-GOOSE service, and capable of achieving rapid transmission of trip signals; the distribution main station has the topological information of electrical connection points, the operating status of the DER system, and communication methods.

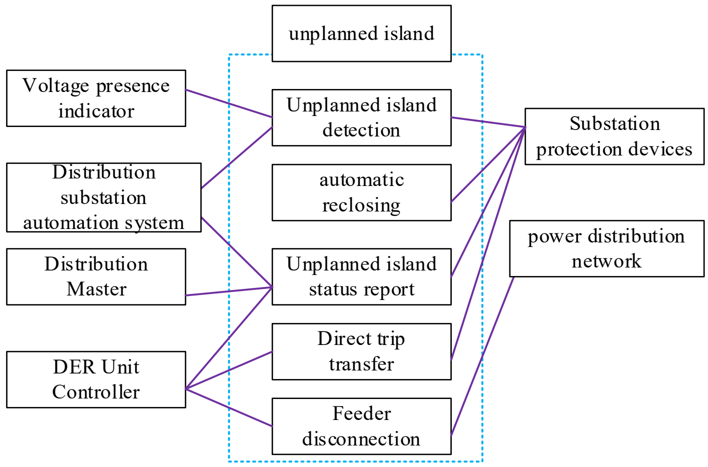

Figure 2. Anti-silo protection - use case decomposition

The voltage indicator continuously monitors the changes in the feeder voltage. If any abnormalities or deviations from the normal operating range occur, the indicator promptly transmits relevant information to the unplanned island detection system to assist in determining whether the system is in an unplanned island state. It provides a voltage data basis for automatic reclosing and unplanned island operation. The DER unit controller cooperates with direct trip transfer and stops operation according to the instructions from the main station to cope with feeder outages.

Island prevention protection requires information interaction objects (i.e. roles) to achieve it through information interaction. The roles involved in implementing island prevention protection include: distribution master station (DMS), distribution substation automation system (SAS), DER unit controller, voltage presence indicator (VPI), substation protection equipment, etc. The sequence diagram of each role participating in implementing island prevention protection is shown in Fig. 3.

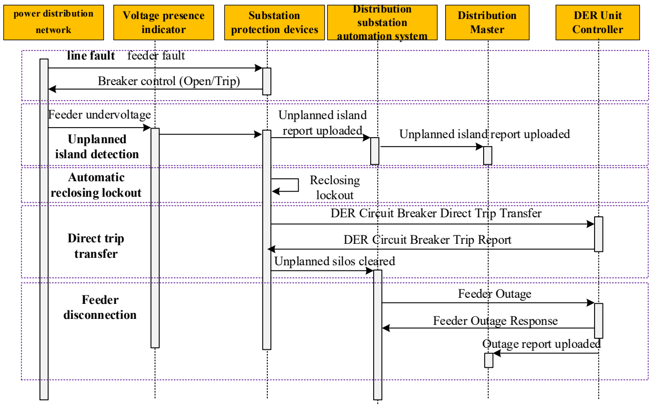

Figure 3. Anti-Islanding protection - sequence diagram

When a fault occurs in the feeder of the distribution network, by detecting the electrical quantities, a non-planned islanding condition is identified. The protection equipment of the substation sends the report of the non-planned islanding to the distribution substation automation system and the distribution master station, and the reclosing function is locked. The distribution master station issues a direct trip transfer command, and the circuit breaker on the DER side directly trips for transfer, and the trip report is sent to the DER unit controller. Thus, the non-planned islanding is cleared, and finally, the power outage report of the feeder is sent.

2.2. SCADA measurement and topology function information modelling

Currently, the IEC 61850 standard is widely applied in substations to facilitate interconnection and interoperability of devices, and its effectiveness in rapid fault handling for feeder automation in distribution networks has been verified [28]. Implementing islanding prevention using the information model defined by the IEC 61850 standard is advantageous for integrating data within existing distribution automation systems. When establishing the information model based on the IEC 61850 standard using an object-oriented approach, the functionality should be modularly decomposed. Each logical node represents a specific function, and by combining multiple logical nodes, it is possible to achieve protection, measurement, control, and other functions. Therefore, when establishing the information model for islanding prevention, it is essential to clearly define the specific functions in order to select the appropriate logical nodes to meet the operational requirements of the distribution network.

Subset of Information Models for SCADA Functions

In distribution networks, when the logical nodes employed can fulfil functions such as measurement, protection, and alarm, they can easily be adopted for islanding protection, which is beneficial for data integration. If the logical nodes defined by the IEC 61850 standard do not currently meet specific functions, it is necessary to create or extend logical nodes based on the IEC 61850 standard to meet those specific functional requirements. Among these, the SCADA functions for electrical and non-electrical measurements serve as the foundational support for distribution networks, enabling remote control, telemetry, and telecommunication capabilities.

Distribution network terminal devices not only include monitoring terminals that measure electrical quantities (voltage, current, frequency, etc.) and control switches and circuit breakers, but also include sensors such as temperature and humidity sensors that collect data on non-electrical quantities (temperature, smoke, etc.). The IEC 61850 standard has defined a well-developed set of logical nodes related to SCADA, used to implement the ‘three tele’ functions of telemetry, telecommunication, and remote control. Logical nodes for functions such as SCADA and environmental monitoring are all applicable in distribution networks. Telemetry is primarily used for measuring electrical and non-electrical quantities, telecommunication for sending position or status information of switches or circuit breakers, and remote control for controlling switches. Specific details can be referenced in IEC 61850-7-4; this document will not elaborate further.

Configuration of Topology Information

In order to ensure the effective protection of the distribution network, the islanding protection scheme needs to be designed by fully considering the distribution network's environmental conditions (like grid structure and topology) and available resources [16]. The reference [29] proposes the use of communication-based anti-islanding protection, which is limited by the fact that the change of topology information leads to the reduction of reliability, so it is necessary to address the description of topology information of the distribution network.

The real-time topology information of distribution network lines includes static and dynamic topology information, with dynamic topology information being composed of line switches and static topology information [30]. The IEC 61850-6 Ed2.1 can be used to describe the topology of distribution network lines, with the specific description rules as shown in Table 1 below.

Table 1. Line topology information modeling for distribution networks.

Terms	Rules
Substation	Equipment in distribution substations, such as switchboards, distribution boxes, etc.
Equipment	An element within a switchyard, such as a circuit breaker, disconnect switch, etc.
Subequipment	Indicates equipment in one of the three phases.
Process	The type attribute can be used to determine the type of primary equipment for the local network of the distribution network.
Line	The lines of the distribution network, including equipment such as reactive power compensators and voltage/current transformers for the lines, excluding switching elements.
Switch	Used to describe the smart device type.
ConnectivityNode	Connection object that connects different primary devices.
Terminal	An electrical connection point for primary equipment at the electrical wiring level.

It is necessary to determine the switch positions between DER (Distributed Energy Resources) and the distribution network, the switch protection trip signals, and the switch closed states based on the implementation topology information and configuration information, as these decisions will determine whether an islanding situation is formed, as shown in section 1.1. Therefore, the topology model and configuration method in the IEC 61850-6 Ed2.1 version are referenced to represent the key topology information of the distribution network, with specific configuration principles following Table 1. The topology modeling diagram established in section 1.1 is shown in Figure 4. To ensure the uniqueness of the reference, the naming of Line and Substation should be unique throughout the station, and since the Line container cannot describe switches, the Substation container is used for this purpose [25].

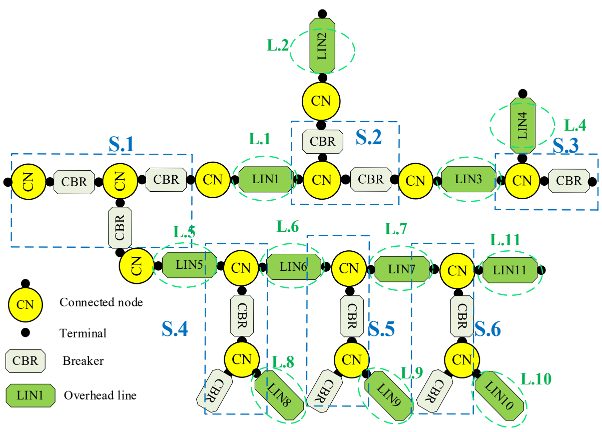

Figure 4. Topological model map

The STU generates a CID file containing topology information according to the configuration. When the topology is updated or partially updated, the master station sends a topology update request to the STU, which uploads the topology result information to the master station, which analyzes the uploaded topology relationship and updates the CID file, thus realizing the application of updating topology information. The specific topology configuration process is shown in Figure 5.

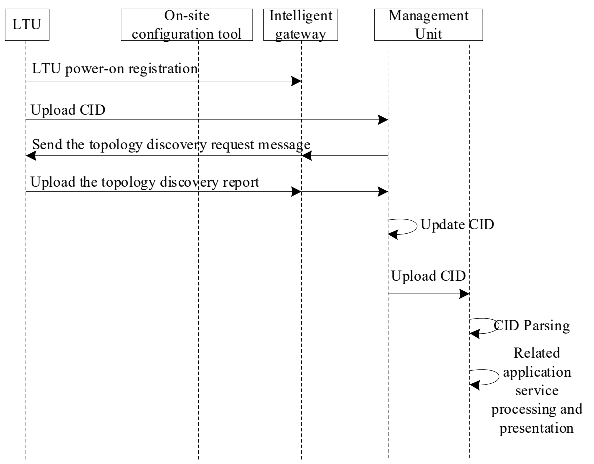

Figure 5. Topology configuration interaction sequence diagram

2.3. Active distribution network anti-islanding protection information modelling

By determining the open or closed states of switches based on the real-time topology information of protection equipment, it is possible to assess whether an unplanned islanding event has occurred. According to the functional requirements outlined in Section 2, the logical nodes defined in the standard are selected to establish a subset of the information model. For functions that are not yet covered, it is necessary to extend and create new logical nodes.

Distribution Network Anti-Islanding Protection Information Interaction

Distribution lines have a wide - ranging presence and operate under complex conditions. When a failure occurs on a feeder, the circuit breakers on both sides of the failure area disconnect, and the isolators close to restore power to the non-faulty area, causing a change in the structure of the distribution network feeder lines, which affects the judgment of unplanned islands. Taking Fig. 1 as an example, when the topology of the line remains unchanged, a fault point 2 on feeder 1 can occur due to human error or a line fault. The protection of circuit breaker 1 is activated, causing circuit breaker 1 to open, and sends a signal to STU1, thereby locking the automatic reclosing function. STU1 opens the local switch and sends the switch status information to the protection of circuit breaker 1, thereby reactivating the automatic reclosing function. When the line topology changes, the linkage relationship of the device data flow on the feeder changes due to the isolators, so the information modeling must describe the linkage relationship of the data flow.

Based on the above analysis of the information interaction process, the information for islanding protection interaction mainly includes the information shown in Table 2.

Table 2. Interactive message.

Information name	Description of information
Voltage presence	Feeder voltage presence.
Trip signal Trip signal	cleared by the protection of the distribution substation to remove faults on the feeder
unplanned island indication	Feeder information to indicate unplanned island state
DTT	Direct trip signal for feeder protection
Cut input feeder command	Substation automation system/DMS prioritizes control over DER management system, cuts off power on the feeder to disconnect it.

Distribution Network Anti-Islanding Protection Information Model Subset

Based on the analysis of information interaction needs for low-voltage fault detection, the logical nodes mainly include TCTR, TVTR, and MMXU for collecting voltage and current data of the line, XCBR and CSWI for controlling the switches, PTOV and PTUV for detecting line faults, SVPI and SFPI for indicating faults, and IHMI as a human-machine interface, as shown in Table 3. For details, reference can be made to IEC 61850-90-6. To address the issue of overlapping or blank areas at the boundaries of multiple isolated islands in the distribution network, it is necessary to add dynamic boundary synchronization data objects. To this end, the data objects of the DISL logical node based on the IEC 61850 standard are extended. The BounSwSta is added to record the real-time status of the adjacent island boundary switches, and the common data class is SPS, which includes three states: closed, open, and fault.

Table 3. A subset of information models for anti-islanding protection of distribution networks.

Logical node	attributes	function	Applicable Scenarios
PTRC	Str	Start	Feeder Faults
PTRC	Tr	Tripping	Clear fault (trip)
SVPI	Prs	Indication	Voltage presence indication
XCBR	Pos	Position	Manual open operation
MMXU	PhV	Phase Voltage	unplanned islanding detection
RREC	Blk	Latching	Automatic reclosing blocking
PSCH	TxTR	Tripping	Direct transfer tripping
XCBR	Pos	Position	Trip Response
DISL	TxTr	If true, the remote protection direct trip signal is delivered to the other side	Islanding Management
DISL	IsldSt	Reflects islanding status	Islanding Management
IHMI	Loc	Local control	Human Machine Interface
PTOV	Str	Overvoltage monitoring	Overvoltage
CSWI	Pos	Switching of three-phase connection and disconnection	on-off control
TCTR	AmpSv	Current sampling value	Current transformer
PTUC	Str	Undercurrent monitoring	Undercurrent
PTOC	Str	Overcurrent monitoring	Overvoltage
PPAD	Str	Parallel arc monitoring	Parallel arc detection
PASD	Str	Series arc monitoring	Series arc detection
TVTR	VolSv	Voltage sampling	Voltage transformer
PTUV	Str	Undervoltage monitoring	Low voltage protection
SCPI	Abc	Display of missing status	Current presence indication
SFPI	FltInd	Display of fault existence status	Fault indication
PTRC	Tr.general	Trip signal	If true, output trip signal

The Unplanned Orphaned Protection logical node fit mapping diagram is shown in Fig. 6.

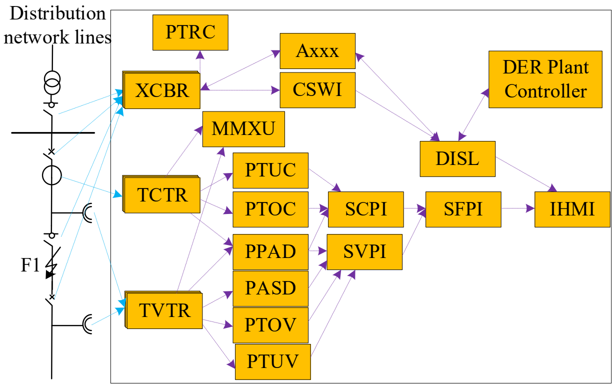

Figure 6. Unplanned silo protection logical node fit mapping map

The monitoring terminal is equipped with logical nodes for anti-islanding protection. The fault indication information it detects is aggregated to SFPI via SCPI or SVPI. The FltInd attribute in SFPI indicates fault information, and the SFPI.Str indicates the fault direction. The master station determines the fault location through information reported by the monitoring terminal. DISL is used to manage the island, MMXU.PhV determines whether it is an unplanned island, and the DISL.IsIdSt attribute reflects the state of the island, thereby disconnecting XCBR through Axxx either manually or using PTRC, to achieve disconnection of DER.

3. Discussion

Taking the implementation of logical nodes and data communication for anti-islanding protection as an example, the configuration of the information model of the system is illustrated in Fig. 7, which is a configuration diagram of the information model in actual engineering. By configuring the topology of the line, the positions and status of the switches on the line can be obtained.

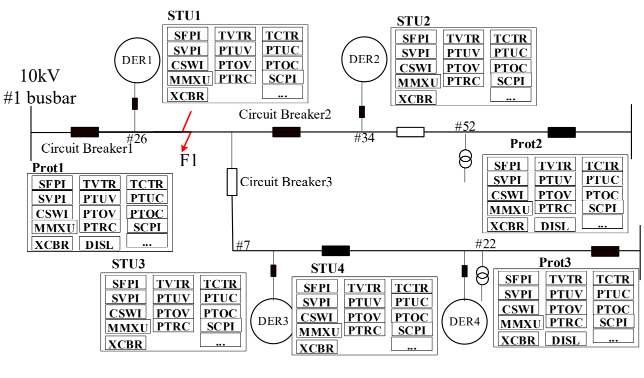

Figure 7. Information model configuration for project

When a fault occurs at point F1 on the feeder, the PTRC. Tr and XCBR.Pos of protection 1 undergo a non-OR logical operation, automatically locking the reclosing function, and DISL. IsIdSt indicates an unplanned island state. DISL.TxTr is set to true, and this signal is communicated via GOOSE to all STUs subscribed to this signal. STU1 and STU2 receive the signal and trip their local circuit breakers, returning the corresponding XCBR.Pos values to protection 1, and changing the DISL.IsIdSt state to Waiting for Grid Connection, while unlocking the automatic reclosing function. When the topology changes and circuit breaker 2 disconnects while circuit breaker 3 closes, a fault at F1 will cause signals from protection 1 to be received by STU1 and STU3, which will simultaneously trip their circuit breakers, returning the corresponding XCBR.Pos values to protection 1, changing the DISL.IsIdSt state to Waiting for Grid Connection, and unlocking the automatic reclosing function.

When this model is applied in the intelligent power distribution and utilization management system, an artificial fault is set at point F1, and the positions and states of each switch are shown in Figure 7. Using the traditional fixed topology method, the average total isolation time of the fault is 172.766 ms. Among them, the average time from overcurrent activation to the writing of protection information into the terminal log is 17 ms, the average time from STU receiving the remote control command to issuing the remote control command to the switch is 19 ms, and the average time from STU sending the remote control command to STU detecting the switch being disconnected is 86 ms. When the topology in the line changes and circuit breaker 2 and circuit breaker 4 are disconnected while circuit breaker 3 is closed, using the fixed topology method, this signal is sent to STU1 and STU2. STU1 and STU2 receive the signal and trip the local circuit breakers, and return the corresponding XCBR.Pos values to protection 1. STU3 does not receive this subscription information, resulting in an unplanned island phenomenon. Using the method in this paper, when the topology changes, the master station sends a topology update request to STU, and STU sends the topology result information to the master station. The master station analyzes the sent topology relationship and updates the CID file. When a fault occurs at F1, the signal of protection 1 will be received by subscribed STU1 and STU3, and the circuit breakers will be disconnected simultaneously, and the corresponding XCBR.Pos values will be returned to protection 1. The master station simultaneously issues a command to STU4 to close circuit breaker 4 and restore power to the non-fault area, thereby avoiding the occurrence of an unplanned island. When an unplanned island occurs, the master station can precisely determine the island area located within the monitoring area of STU3 by combining the CID file and XCBR.Pos values sent by STU, reducing the non-monitored area by 75%. At the same time, the accurate island boundary can be obtained based on the topology information in the CID.

At present, anti-islanding protection mainly detects whether voltage, frequency, phase and other electrical quantities cross the line, so as to determine whether the islanding effect occurs. For example, in Figure 6, each STU sends voltage, frequency and other information to the master station through PTUV, PTUC and other logical nodes, and the master station judges the sent information to determine whether unplanned islanding occurs. However, due to the constraints of topological information, the traditional protection scheme cannot know the boundary of the islanding. By the method of this paper, the master station can query the CID information to determine the equipment connection information of the feeder, mainly to determine the state information of the switch. Based on this, the boundary information can be accurately identified, and thus can accurately determine the information of the STU that needs to be subscribed, thus realizing the judgment of the fault. For example, when breaker 2 is disconnected, the signal of protection 1 will be received by subscribed STU1 and STU3 instead of STU1 and STU2.

The information models for anti-islanding protection, topology identification, SCADA, etc., are established based on the IEC 61850 standard and successfully applied to the smart distribution and power management system. Combined with the fault identification algorithm for anti-islanding protection, it can accurately identify short-circuit faults, leakage faults, and determine fault locations. It can promptly issue alarms for faults, thereby improving the reliability of anti-islanding protection.

The comparison of methods between this paper and other literatures is shown in Table 4. This paper improves the subset of the island protection information model based on the IEC 61850 standard, avoiding the redundancy of the general model, enhancing the accuracy of information interaction, and reducing the workload of operation and maintenance personnel. Compared with emerging protection systems such as CPC (Coordinated Protection Control) and VPAC (Virtual Protection Area Control), the innovative IEC 61850 SCL line topology description method combined in this paper can dynamically adapt to changes in the distribution network topology and directly solve the problem of reliability decline caused by topology changes. Compared with technologies such as SDN (Software-Defined Network) and PDP (Policy Decision Point) that focus on communication architecture or security policies, in the complex distribution network scenarios with distributed power sources, this paper not only implements semantic consistency based on the IEC 61850 standard, but also makes up for the deficiencies of pure communication technologies in the customization of protection functions and dynamic adaptation of topology.

Table 4. Comparative analysis of methods.

	Information model	Topology	Reliability	Applicable scenarios
Res[31]	Based on IEC 61850-7-420, establish a data object monitoring model for microgrid.	Monitor the status of electrical connection points to update the microgrid structure.	The influence of communication delay on the topology structure and real-time performance of island detection has not been fully considered.	Island detection for microgrids with distributed power sources.
Res[32]	Unclear specific information model	No topological description involved	Not fully considering the impact of topological changes	Photovoltaic and other large-scale power stations and gas/steam turbine plants
Res[33]	Realization of adaptive overcurrent protection information interaction through information such as circuit breaker status signals	Does not involve line topology description methods	Depends on communication to change protection settings	Applicable to island protection and fault detection in radial AC microgrids
Res[34]	Based on IEC 61850, an information model and function model covering photovoltaic power stations have been established.	This does not involve line topolog.	does not fully consider the impact of topology changes	It is used for monitoring and islanding protection of photovoltaic power stations.
Res[35]	Based on the ratio of the detection signal to the amplitude of the power frequency voltage, a mathematical model for islanding protection is established.	This model does not consider topological changes.	It does not fully take into account the impact of topological changes.	It is used for islanding protection detection in the case of multiple distributed power sources being connected.
This paper	Based on IEC 61850 "criteria" to improve the subset of the islanding prevention information model	Propose a line topology description method based on IEC 61850 SCL	The next stage needs to improve the islanding protection for low-voltage distribution networks	Applicable to distribution networks with distributed power sources and topology changes for islanding protection

4. Conclusion

To prevent unplanned islanding from occurring in distribution networks, which affects the quality of power supply and personal safety. This paper analyzes the information interaction requirements for anti-islanding protection and improves the information model subset of anti-islanding protection. Meanwhile, in order to solve the problem of reduced reliability due to the limitation of anti-islanding protection by topology information change, a topology description method based on IEC 61850 SCL is proposed. This paper's method is conducive to cooperate with the existing information model of MV distribution network based on IEC 61850 standard to realize the fault processing of MV distribution network, and at the same time, it realizes the description of topology information, which solves the problem of reduced reliability of detecting the anti-islanding protection due to the change of topology. As the proportion of DER connected to the low-voltage distribution network increases, it has changed the topological structure of the low-voltage distribution network, resulting in unclear boundaries for island-avoidance protection. In the next step, we will conduct exploration on island-avoidance protection for the low-voltage distribution network.

Appendix A. The first appendix

Table A. Comparative analysis of methods.

acronyms	**full title**
DERs	distributed energy resources
PoC	DER connection point
OUV	over/under-voltage
OUF	over/under-frequency
PLC	power line communication
DTT	direct transfer tripping
SCADA	supervisory control and data acquisition
SCL	substation configuration description language
LVRT	low-voltage ride-through
HVRT	high-voltage ride-through
STU	Smart terminal unit
CID	configured IED description
DMS	distribution master station
SAS	distribution substation automation system
VPI	voltage presence indicator
CPC	Coordinated Protection Control
VPAC	Virtual Protection Area Control
SDN	Software-Defined Network
PDP	Policy Decision Point

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