The Technology for Substation Interlocking Logic Automatic Checking Based on IEC 61850

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Abstract:

This paper presents a positive and negative interlocking logical rules automatically checking scheme based on IEC 61850 SSD (System Specification Description) information model. The mainly technology are presented, such as IEC 61850 SSD information model parsing and checking, the analysis about primary equipment and its topology connection relationship for IEC 61850 SSD information model. Loading and checking for interlocking logical rules file. Automatically arranges different logic combinations by the method of automatically generating positive and negative interlocking logical rules. The relationship between the primary equipment topology and the positive and negative interlocking logic is analyzed. The method of association and matching between topological loop and IEC 61850 SSD model is given. The flow of interlocking logical check for operating equipment such as disconnector, circuit breakers, ground disconnector,earthing switch is designed. Automatically check substation interlocking logic based on IEC61850 SSD information model is realized. Substation typical interlocking logic case is used for verifying the correctness of the method about automatically check interlocking logic.

Keywords:

smart substation, IEC 61850, interlocking logical rules, automatically checking

1. Introduction

Interlocking technology has been made a series of results in the measurement and control devices, the integrated monitoring system for smart substation. Interlocking logical rules for substation level is consistent with the bay level in the smart substation. It is manually configured by the engineer. Interlocking logical rules is manually checked, before substation construction, commissioning and testing. After the approval, interlocking logical rules is used in station-level systems and bay IED(Intelligent Electronic Device). In general, there is a large number of positive and negative logic entries in the substation interlocking logical rules. It is time-consuming and energy-consuming for manual review. Due to human error, there is potential risk for the safe and stable operation of the power grid.

2. Primary equipment and its topology connection relationship IEC 61850 information model

In order to meet the requirement of the interlocking logical checking, this paper defines the arrester, trolley switch according to IEC 61850 modeling idea.

SSD information model details defined in the IEC 61850 is not repeated description. In order to meet the requirement of the interlocking logical checking, this paper defines the arrester, trolley switch according to IEC 61850 modeling idea. According to IEC 61850, arresters and trolley switches are still defined as ConductingEquipment, distinguished by the attribute of type.

The arrester has the type attribute of SAR and the terminals number is one. The type attribute of the car switch is HCT (Handcart), terminals is 2.

Table 1 Substation ConductionEquipment terminal

name	terminals number	type
Arrester	1	SAR
Trolley switches	2	Handcart

SSD information model details defined in the IEC 61850 is descprited as shown:

<ConductingEquipment name="HCT251" desc= "Trolley switches" type="HCT" toppos=" output" >
</ConductingEquipment >
<ConductingEquipment name="SAR 251" desc= "Arrester" type="SAR">
</ConductingEquipment >
<ConductingEquipment name="HCT251" desc= "Trolley switches" type="HCT">
</ConductingEquipment >
<ConductingEquipment name="SAR 251" desc= "Arrester" type="SAR">
</ConductingEquipment >

3. Interlocking logical checking rules

According to the anti-misoperation regulations,

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interlocking logical rules about circuit breakers, disconnectors, ground disconnectors and earthing switch is analyzed.

According to the basic principles of interlocking logic and primary equipment topology, interlocking logic rules checking methods are mainly as follows:

1) Ground disconnectors or earthing switch

There must be disconnectors in all directions of the line extension from the ground disconnectors or earthing switch. Circuit breakers, main transformers and bus equipment in the topology are considered as short circuits.

2) Disconnectors

There is not current in the primary equipment topology, and disconnectors in the substation topology loop connectivity cannot be changed. That is the topological connectivity between the power supply and load, power supply and ground, and power supply and power supply cannot be changed.

3) Circuit breakers

Circuit breaker interlocking rule is generally not need to check.

4. Automatically checking

Automatically checking scheme is shown as below. SSD files and interlocking logic rules files is source data. Verification report is the generated data.

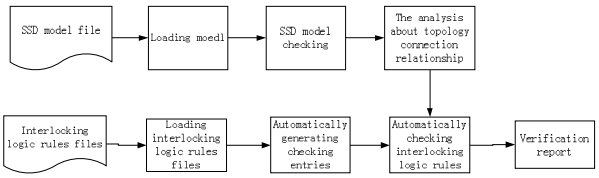

Figure 1 the program flow

4.1 Checking Flow

In this paper, interlocking logic rule is checked based on IEC 61850 SSD. Interlocking logic rule refers <Q/GDW624-2011 the specifications of power system graphic description>.

Automatically checking scheme is shown as below. SSD files and interlocking logic rules files is source data. Verification report is the generated data.

1) Getting substation SSD files and interlocking logic files;
2) Loading SSD topology and interlocking logic separately;
3) SSD model verification;
4) Automatic generation of verification tasks based on interlocking logic rules;
5) Analyze the topological relationship and perform automatic verification of the interlocking logic rules;
6) The logical result is judged and the check conclusion is given.

4.2 Verification tasks generated

In this paper, various verification tasks are automatically generated based on the interlocking logic rules. Each task has an operation device, logic operation devices, logical operation value, and logic relationship.

If only the positive logic is given in the Interlocking logic, negative logic is automatically generated. One logic combination generates a check task, and different logic combinations result in different check tasks.

The complete test is a permutation of the checked tasks. The check task expression generated for n logic operations is as follows

$$C_n^0 + C_n^1 + C_n^2 + \cdots + C_n^n = 2^n \quad (4\text{-}1)$$

4.3 GroundDisconnector interlocking logic rules checking

GroundDisconnector interlocking logic rules checking flow:

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1) If the operation type is opened operation, it is not needed to be checked, if the operation type is closed operation the check is performed.
2) Search all disconnector and PT in all directions of the grounding disconnector.
3) Determine whether the position of the disconnector is opening, or the PT is not having volatge, and the conclusion of the check is given.

4.4 Disconnector interlocking logic rules checking

Disconnector interlocking logic rules checking flow:

1) If the operation type is opened operation, it is not needed to be checked, if the operation

type is closed operation the check is performed.

2) Search all ground disconnector and CT in all directions of the disconnector.
3) Determine whether the position of the ground disconnector is opening, or the CT is not having current, and the conclusion of the check is given.

Table 2 disconnector 20013 Positive logic matrix

Positive logic matrix / Operating equipment （220kV line）	I bus disconnector 2011	II bus disconnector 2012	Ground disconnector 20011D	line breaker2001	Ground disconnector 20013D1	Line disconnector 20013	Line Ground disconnector 20113D2
Line disconnector 20013				1	1		0

5、Typical case analysis

Substation typical interlocking logic case is used for verifying the correctness of the method about automatically check interlocking logic.

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The following figure is a typical 220kV double bus line topology wiring diagram, which includes line and the bus bay.

There is 2001 circuit breakers,disconnector 20011, disconnector 20012, disconnector 20013,20011D grounding disconnector, 20013D1 grounding disconnector, 20013D2 grounding disconnector, and other equipment.

The interlocking logic rules configuration for disconnector is as follows:0 in the table indicates the opening state and 1 indicates the closing state. Positive logic barrier states in this article.

Disconnector 20013 topology loop should be ensured no current before and after the interlocking logic operation based on the method studied in this paper,Therefore, the circuit breaker 2001 directly connected to the isolating switch 20013 should be opened.

Ground disconnector 20113D2 and lince gorund disconnector 20013D1 are all closed,so the configuration is wrong.The correct interlocking logic should be opened, that is the logical value is 0.

Using the method studied in this paper, the correctness of the interlocking logic for disconnector can been accurately verified.

6. Conciusion

In this paper, through the study of the technology about automatic interlocking logic based on IEC 61850 SSD model, the logic check efficiency is effectively improved. At the same time, it avoids the potential risk about manually error.

References

[1] Technical specification for preventing electric mal-operation in substation monitoring and control system DL/T 1404-2015
[2] IEC 61850 Communication networks and systems in substations[S].2004.
[3] EPRI. Substation Security and Remote Access Implementation Strategies [R], 20-Dec-2012.http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001024424.
[4] Wang Yi-jun,Zhang Bi-chi,Ni Jun-long.etc. A Design of On-Line Intelligent Lock of Anti-Maloperation System[J] 2011 International Conference on Mechatronic Science, Electric Engineering and Computer, August 19-22, 2011, Jilin, China.367-370.
[5] Schneider, H.,Marsala, R.,Neumeyer, C,etc. X.NSTX protection and interlock systems for coil and powers supply systems[J]，Fusion Engineering, 2009. SOFE 2009. 23rd IEEE/NPSS Symposium on.
[6] Sachdev, M.S., Sask., Canada ,Dhakal, P,etc.A computer-aided technique for generating

substation interlocking schemes[J],Power Delivery,IEEE Transactions on, 2000 Apr (Volume:15,Issue: 2)538–544.
[7] DONG Yuanshuai, CHENG Jian, PENG Bin, et al. A Method of Automatic Generation of Diagram-database-rules-order Based on Bay Model[J].Automation of Electric Power Systems,2015,39(3):84-89.
[8] DUAN Bin,LI Guojing,LIU Yan, et al.Interlocking Implementation Strategy for Multiple Bays Based on Service Tracking and Reservation Logic[J].Automation of Electric Power Systems,2014,38(3):155-160.
[9] Zhao,X.,Ramakrishnan, S.,Lawson, J.,etc. NSTX protection and interlock systems for coil and powers supply systems[J]. 2009 23rd IEEE/NPSS Symposium on Fusion Engineering, SOFE 2009，June 1, 2009 - June 5, 2009.

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