

The Research of Power Secondary Anti-disoperation Function in Dispatching Control Center Based on The Mode of Full Remote Control and Integrated Dispatching and Control

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Abstract. In the dispatching control center, the integration of dispatching control and anti-disoperation is realized. The key technologies include building and displaying the secondary anti-disoperation model, establishing the anti-disoperation model interaction process, and forming the second anti-disoperation judgment logic in the dispatching control center. These research results can ensure the safety of the primary equipment operation to the cold standby, and the safety of the secondary equipment remote control operation, and also enrich the remote monitoring information of unattended substation. It provides a feasible scheme to solve the anti-disoperation risk based on the mode of full remote control and integrated dispatching and control.

1. Introduction

Nowadays, the existing anti-disoperation technologies include mechanical anti-disoperation, electrical anti-disoperation, and microcomputer anti-disoperation. With the rapid development of computer technology, microcomputer anti-disoperation has become a key technology to prevent electrical disoperation.

In recent years, with the spread of the integrated dispatching and control mode of State Grid, the cooperative operation mode between the dispatching control center and substations is more and more popular. Furthermore, following the development trend of unattended substation, some regional power grids gradually promote the primary and secondary remote control operations, and the remote control operations of the power grid equipment from the running status to the cold standby status are further applied when the concept called “the full remote control” in dispatching control center is proposed.

The full remote control mainly includes: remote control operation of the breaker and the disconnector, remote control operation of the power line interval to the cold standby status; remote control operation of the secondary equipment, such as remote resetting of protection signal, rapid turning of protection status, turning of line recloser status, switching of synchronism check and voltage check and so on. Thus, the original anti-disoperation technology and management mode should be changed to eliminate the new risk of disoperation.



2. Status Quo

In recent years, power grid companies have some feasible research and practical application on anti-disoperation to deal with the above changes.

In order to realize remote control operation of primary equipment from running status to cold standby status, Based on the management mode of "large operation" and "large overhaul", the researchers propose a technical scheme of three-layer anti-disoperation structure for the dispatching control center, operation and maintenance station and the controlled station, to solve some disoperation problems [1]. An intelligent anti-disoperation system based on service bus and message bus in the intelligent grid dispatch control system (Hereinafter referred to D5000) is proposed in order to perfect the application of the integrated dispatching and control system and strengthen the security of the remote control operation in the dispatching control center [2]. The paper [3] elaborates the construction of an intelligent operation management system which achieve remote control and anti-disoperation integrated based on D5000 platform, including the modeling of primary anti-disoperation equipment, the formulation of anti-disoperation rules, and the anti-disoperation data interaction agreement between the dispatching control center and substations. Further, the paper [4] introduces the modeling process on integrated remote control and anti-disoperation, and gives the scheme to the generation of anti-disoperation rules in the dispatching control center. The paper [5] proposes the breaker unit model based on intelligent anti-disoperation topology calculation and the loop topology search algorithm, which provides a theoretical basis for regulating the generation of anti-disoperation rules in the dispatching control center. The paper [6] introduces an anti-disoperation data interaction agreement extending from 104 agreement, which has been implemented in the construction of integrated dispatching and control system in Fujian power grid.

3. Problems and Solutions

In 2017, state grid Fujian electric power company put forward new anti-disoperation requirements under the full remote control mode for deepening the full remote control work. The original anti-disoperation system refers to the "five defenses" of the primary equipment, including to: prevent to misoperate on the circuit breaker; prevent to pull the disconnector with the load; prevent to set the grounding wire and close the ground disconnector with the load; prevent to close the disconnector with the ground status; avoid entering charged space. To realize remote control operation to the cold standby status, the intelligent anti-disoperation system in the dispatching control center should be equipped with the functions of preventing to misoperate on the circuit breaker, preventing to pull the disconnector with the load, and preventing to close the disconnector with the ground status. Within the full remote control mode, the new anti-disoperation system adds the secondary anti-disoperation locking function, including that the primary equipment operation restrained by the secondary condition, the secondary equipment operation restrained by the primary condition, and the secondary equipment operation restrained by the secondary condition.

The paper [3] expands the primary equipment model, such as ground wire and net/cubicle door, to realize the primary anti-disoperation function on the D5000 platform, but it lacks the secondary equipment model to realize the secondary anti-disoperation function. In view of the above problem, this paper studies to expand the secondary equipment models and graphics about the anti-disoperation on the D5000 platform, and form anti-disoperation models and graphics, to realize the secondary anti-disoperation about the full remote control operation in the dispatching control center. The achievements of this research have been put into use in the pilot dispatching control center.

4. Key Technology

4.1. Integrated Remote Control and Anti-disoperation

The integration of remote control and anti-disoperation is shown in two aspects, respectively, model and data sharing. The automatic billing operation and the judgement by anti-disoperation rules are the functions provided by the integrated remote control and anti-disoperation system. The encapsulation of

internal details is achieved through componentization technology on the D5000 platform, and the standard interface is opened to the public [3]. In order to preferably realize the integration of remote control and anti-disoperation system, we unify the grid graph specification file on the D5000 platform, which strictly refers to the IEC61970 standard to realize the integration construction among graphic, library and model [2]. The data and model can be shared for more rationally utilized and effectively configured on the D5000 platform. The paper [7] extends the primary anti-disoperation model based on the former dispatching control model. On the basis of the above research, this paper expands the secondary anti-disoperation model, including the cubicle, protection device, measuring and control device, strap, air switch, change-over switch, secondary signal, etc, to realize the sharing of the secondary anti-disoperation model and data among the modules of the dispatching control center.

4.2. Secondary Anti-disoperation Modeling and Displaying

In this paper, we will extend the secondary anti-disoperation model to establish the correlation between the primary model and the secondary model, in conditions of no affecting the primary anti-disoperation model [3, 4] in the dispatching control center.

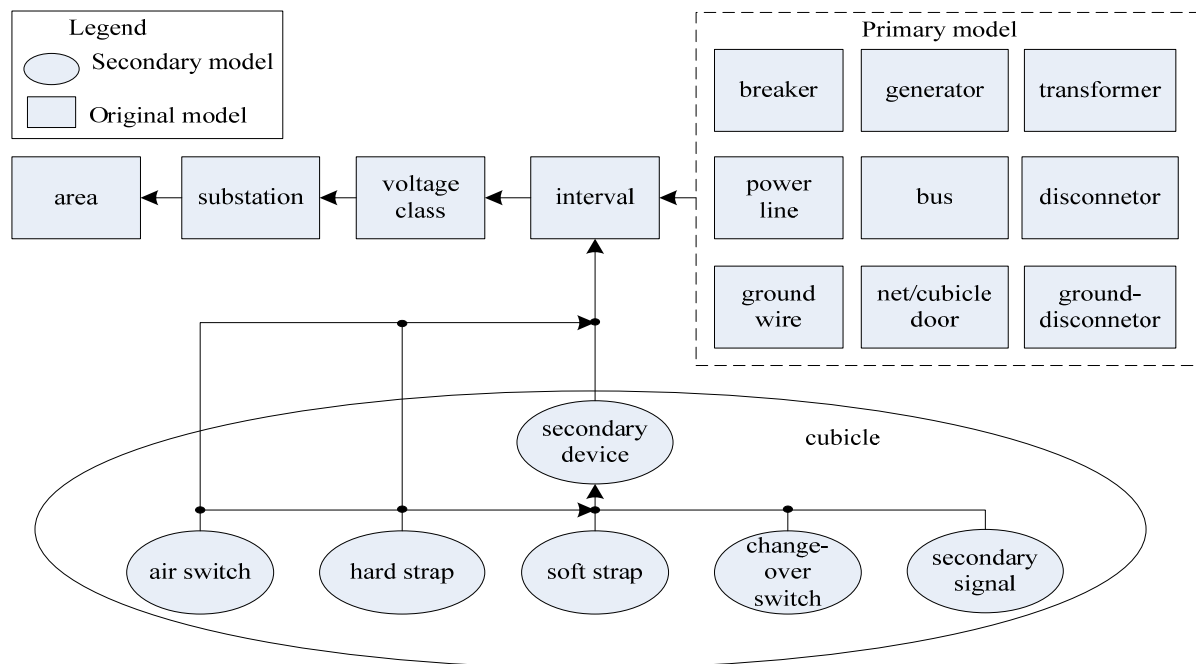


Figure 1. Anti-disoperation Model Extension

Fig. 1 displays the secondary anti-disoperation model extension based on the original model of the dispatching and control system. The square symbol in Fig. 1 represents the existing model information on the D5000 platform, including the dispatching control model and the primary anti-disoperation model, when the ellipse symbol represents the extended secondary anti-disoperation model. Primary models in Fig. 1 are used for remote control operation to cold standby status, including the "net/cubicle door" and "ground wire" models which belong to the anti-disoperation model. These primary models relate to the interval model. The secondary anti-disoperation model's category mainly includes cubicle, secondary device, air switch, hard strap, soft strap, change-over switch and secondary signal, etc. Each category can be further subdivided, as shown in Table 1. The cubicle is used for the centralized installation of power secondary equipment and communication equipment. Secondary devices include protective devices, measurement and control devices, intelligent terminals, merging units, which are used for monitoring, measuring, controlling, protecting and regulating the primary equipment in the power system. Air switch, also known as air circuit breaker, serves as a controllable disconnection point in the

loop of control power supply, motor power supply or device power supply. Hard strap and soft strap are collectively known as the strap, including export strap, function strap, remote control strap, etc. Export strap and function strap are used for a controllable disconnection point in the protection loop, while remote control strap is used for a controllable disconnection point in the remote control loop of the primary equipment. The change-over switch combines the functions of the tap selector and the switch. The secondary signal is used to monitor the operating status of the primary equipment and the secondary equipment.

Table 1. Secondary Anti-disoperation Model Classification.

Number	Category	Type	Function
1	Air switch	Air switch	Device power source
			Remote signal power source
			Breaker control power source
			Breaker motor power source
			Disconnecter control power source
			Disconnecter motor power source
			Voltage acquisition
			
			Tripping export
			Recloser export
2	Hard strap	Export hard strap	Non-three-phase export
			Startup failure export
			
			Overhaul
			Main protection
		Function hard strap	Distance protection
			Zero sequence protection
			Out-of-service recloser
			Non-electric function
			Non-three-phase function
			Backup protection function
			
		Remote control hard strap	Remote control breaker
			Remote control disconnecter
			
		Export soft strap	Tripping export
			Recloser export
			Blocking auto recloser
3	Soft strap	Function soft strap	Blocking self-throw
			
			Main protection
			Distance protection
			Zero sequence protection
			SV receiving
			Failure receiving
			Out-of-service recloser
			
			Remote/local
4	Change-over switch	Change-over switch	Reclosure mode
5	Secondary signal	Secondary signal	
			Blocking signal
			Warning signal
			

There are some principles of building secondary anti-disoperation model, as follows: (1) the secondary anti-disoperation model is associated with the interval model. The relation is shown in Table 2; (2) The cubicle model is established to integrate all the secondary anti-disoperation models and display them intensively, as shown in Fig. 2; (3) In order to meet the requirements of the secondary anti-disoperation in the dispatching control center, the secondary anti-disoperation model is distinguished from the category, type and function; (4) The relationship between the cubicle and the substation is established to manage the secondary anti-disoperation model.

Table 2. Secondary Anti-disoperation Mode Incidence Relation.

Category	Function	Related to
Air switch	Breaker/disconnector motor power source air switch, Breaker/disconnector control power source air switch Protection device/intelligent terminal/merging unit power source air switch, protection voltage air switch	Interval
Hard strap	Export hard strap, function hard strap	Secondary device
Soft strap	Export soft strap, function soft strap	
Change-over switch	Remote/local change-over switch, reclosure mode change-over switch	
Secondary signal	Blocking signal, warning signal	
Secondary device	Protection device, measurement and control device, intelligent terminal, merging unit	Interval

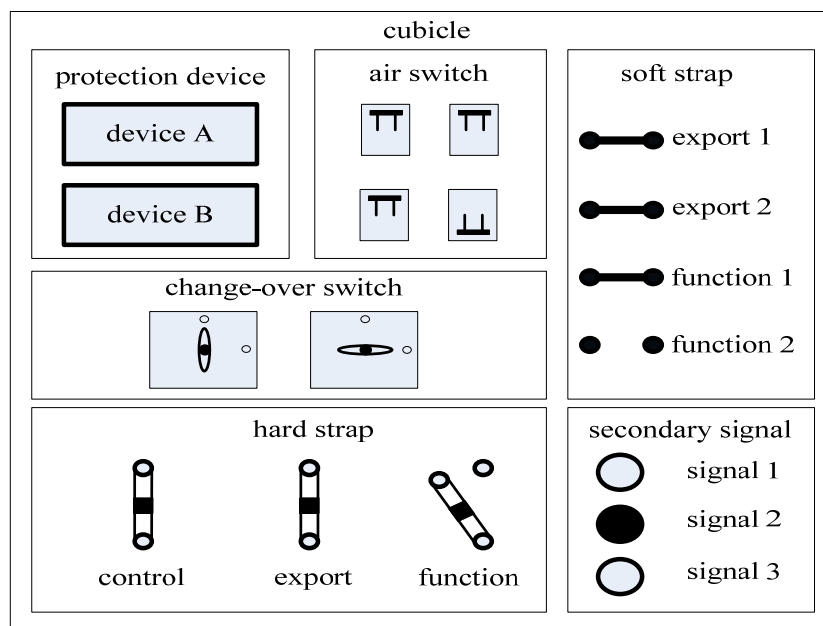


Figure 2. Display Diagram of Cubicle.

The relationship between the secondary anti-disoperation graph elements in Fig. 2 and the status is shown in Table 3.

Table 3. The Relationship Table.

Category	Graph Element	Status Description	Status Value
Change-over switch		The first status	1
		The second status	2
Soft strap		Input status	1
		Exit status	0
Hard strap		Input status	1
		Exit status	0
Air switch		Close status	1
		Separate status	0
Secondary signal		Appear status	1
		Disappear status	0

4.3. The Anti-disoperation Model Interaction Process

The anti-disoperation model interaction process is shown in Fig. 3, as follows: (1) the anti-disoperation substation provides the primary model information and graphic information, mainly including the equipment description of net/cubicle door, ground wire, and the location information of ground piles in the substation. (2) After the dispatching control center gets the primary anti-disoperation equipment information, on the D5000 platform, the net/cubicle door and the ground wire are graphically drawn, and the full model is spliced. (3) The spliced anti-disoperation model is sent to the anti-disoperation substation by message mail. (4) In the anti-disoperation substation, the secondary anti-disoperation model is spliced to the interval model. The complete model is correlated with the anti-disoperation equipment, and added the specific attribute information such as logical formula and communication point number. (5) Generate an anti-disoperation communication point table. (6) The anti-disoperation communication point table is checked and imported to the database in the dispatching control center. (7) According to the anti-disoperation model in the database, the program automatically generates the interval diagram and the cubicle diagram for the screen display.

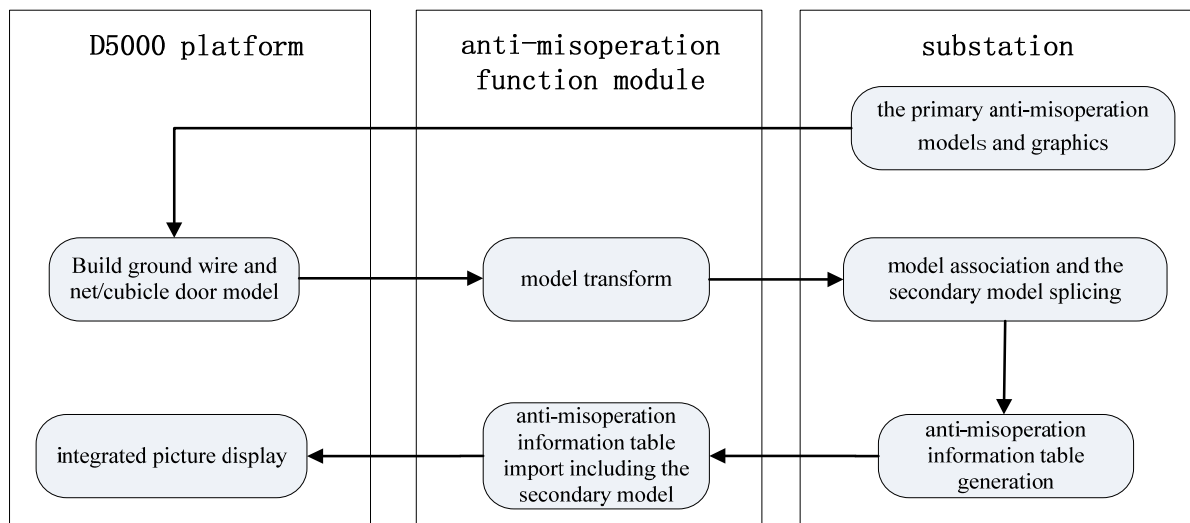


Figure 3. Anti-disoperation model interaction process.

4.4. Secondary anti-disoperation judgment logic

The secondary anti-disoperation judgment logic needs to meet the three universal rules as follows:

(1) The first universal rule is that the primary equipment operation will be restrained by the secondary condition, in order to forbid putting primary equipment into operation without protection.

For example, as shown in Fig. 4, there is a 220kV power line interval with double protection and double bus connection. In this interval, there are a breaker, three disconnectors, three grounddisconnectors, three ground wires and two protection devices.

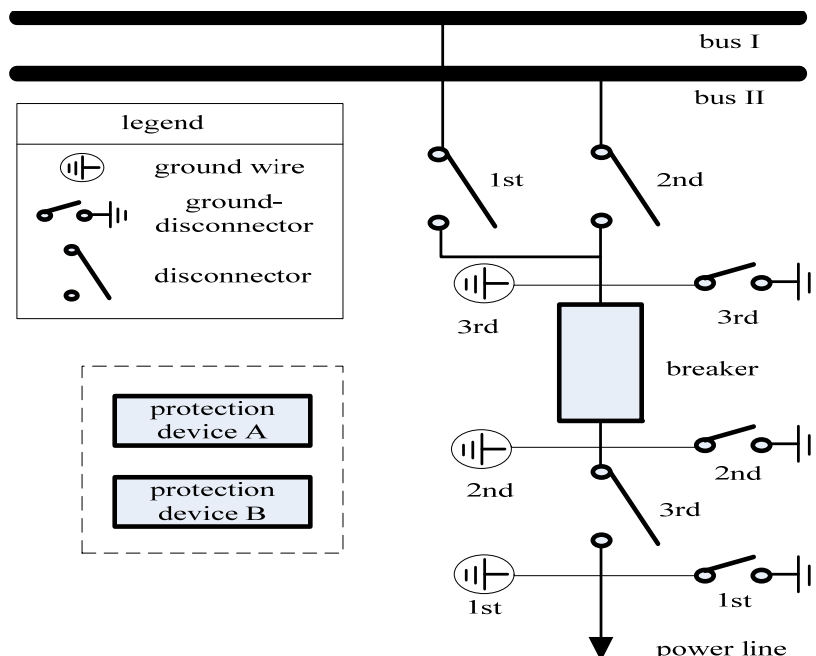


Figure 4. Schematic Diagram of Typical 220kV Power Line Interval.

Without external influence, the power line interval operation from cold standby status to hot standby status, need to meet both the primary anti-disoperation judgement logic of switching operation, and the secondary anti-disoperation judgement logic of the protection status. The primary anti-disoperation

judgement logic of cold standby to hot standby includes two aspects as follows: (I) when the power line interval is in cold standby status, the operator can operate the interval to hot standby status only if all the ground disconnectors are in the separate status and all the ground wires have been removed. (II) Switching operation must follow the sequence of the primary equipment operation, that first close the bus side disconnector, and then close the power line side disconnector.

On the basis of the primary anti-disoperation judgement logic, this paper puts forward the secondary anti-disoperation judgement logic. If none of two protection devices is in normal running status, switching operation from the cold standby to hot standby will be locked by the secondary anti-disoperation judgement logic. Assuming without the secondary anti-disoperation judgement logic, it could happen that the two protection devices are not in running status when the power line interval is in operating status. Once a ground fault occurs in the operating power line interval, the connection between the fault point and the operating power grid cannot be removed in time, resulting in large current grounding of the power grid, loss of a large amount of load, reduction of power grid frequency, impact on the stability of the power system, and huge economic losses.

The existing substations are classified of traditional substations and intelligent substations. Different from the traditional substation, the intelligent substation realizes the intelligent equipment and communication network, and adopts IEC61850 communication protocol. The two classes of substations have the same anti-disoperation principle, but the information of the second anti-disoperation judgment logic is slightly different. Table 4 shows the signal status of 220kV power line protection in the traditional substation, while Table 5 shows the signal status of 220kV power line protection in the intelligent substation. In the two Tables “status value” reflect the normal running status of 220kV power line protection.

Table 4. The Signal Status of 220kV Power Line Protection in the Traditional Substation.

Secondary anti-disoperation model	Status value	Secondary anti-disoperation model	Status value
Tripping export hard strap	1	Out-of-service recloser hard strap	0
Startup failure export hard strap	1	Out-of-service recloser soft strap	0
Main protection hard strap	1	Recloser export hard strap	1
Main protection soft strap	1	Overhaul function hard strap	0
Distance protection hard strap	1	Device power source	1
Distance protection soft strap	1	Protection voltage air switch	1
Zero sequence protection hard strap	1	Device blocking signal	0
Zero sequence protection soft strap	1	Device warning signal	0

Table 5. The Signal Status of 220kV Power Line Protection in the Intelligent Substation.

Secondary anti-disoperation model	Status value	Secondary anti-disoperation model	Status value
Tripping export hard strap	1	Out-of-service recloser soft strap	0
Main protection soft strap	1	SV receiving soft strap	1
Distance protection soft strap	1	Recloser export soft strap	1
Zero sequence protection soft strap	1	Recloser export hard strap	1
Startup failure export soft strap	1	Tripping export soft strap	1
Blocking auto recloser export soft strap	1	Protection device overhaul function hard strap	0
Intelligent terminal overhaul function hard strap	0	Merging unit overhaul function hard strap	0
Protection device power source air switch	1	Intelligent terminal power source air switch	1
Merging unit power source air switch	1	Device blocking signal	0
		Device warning signal	0

(2) The second universal rule is that the secondary equipment operation will be restrained by the secondary condition, in order to prevent the operation equipment risk from the misoperating of the secondary equipment.

For example, as shown in Fig. 4, there is a 220kV power line interval with double protection and double bus connection. The signal status related to the protection function is shown in Table 4 or Table 5. Before putting in the main protection soft strap of protection device A, it is necessary to judge whether the blocking signal of protection device A appears, so as to prevent the signal of protection action from being sent to the dispatching control center by mistake without actual action, which affects the normal monitoring.

(3) The third universal rule is that the secondary equipment operation will be restrained by the primary condition, in order to forbid shutting down protection when the primary equipment is in operating status.

For example, as shown in Fig. 4, there is a 220kV power line interval with double protection and double bus connection. The signal status related to the protection function is shown in Table 4 or Table 5. When the power line interval is in operating status or hot standby status, before exiting the main protection soft strap of protection device a, it is necessary to judge whether protection device B is in normal running status, so as to prevent the abnormal status of both protection devices resulting in the risk of the primary equipment's unprotected operation.

5. Conclusion

In this paper, based on the mode of full remote control and integrated dispatching and control, we research the risk of switching operation to the cold standby, and the risk of remote control of the secondary equipment, and the method of realizing secondary anti-disoperation in the dispatching control center. The research results have been preliminarily tested on the D5000 platform in the dispatching control center of State Grid Fuzhou electric power Supply Company. Trial results show that, these key technologies proposed in this paper can ensure the safety of the primary equipment operation to the cold standby in the dispatching control center, and the safety of the secondary equipment remote control operation, and also enrich the remote monitoring information of unattended substation. The research in this paper provides a feasible scheme to solve the anti-disoperation risk under the mode of full remote control and integrated dispatching and control.

Acknowledgments

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