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AUTOMATIC LOADING TRANSFER CONTROL TECHNOLOGY TO ELIMINATE OVERLOAD

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Abstract. *The conventional methods of eliminating the overload are generally based on algorithms to search for load transfer paths, which are a large amount of calculation and low feasibility. When accidents or device faults occur in power grid, the busbar automatic transfer switch (BATS) is used to backup power supply, and ensure the continuity. This paper makes use of thoughts of BATS to eliminate the overload by transferring it to backup power. Due to the complexity of the power grid structure and operation mode, the paper proposed a new BATS auto-generated algorithm, which can automatically search for BATS models in accordance with operation modes of power system. When there is overload, the corresponding BATS models are automatically found out, and then the feasible plan is generated through control technology automatically. The practical analysis proves that this method is feasible and practical.*
Keywords: Intelligent busbar automatic transfer switch (BATS), Overload eliminating, Auto-adapted modeling, Transfer control technology

1. **Introduction.** With the development and expanding scale of power grid, the structure and control technology are more and more complicated. Control measures with manual intervention nowadays, cannot ensure high quality and efficient operation [1], which made power grid develop toward smart power grid. When there is serious equipment overload, dispatcher or operator usually cuts off the load by manual, which reduces operation efficiency, distribution reliability, stability and economy [2-4]. Another method is to adjust the power of each generation according to the sensitivity calculation, but generation jurisdiction to regional power grid is limited. There is another approach of finding out the paths of load transfer [5-7]. However, its calculation is huge, complex, and many of calculated routes are infeasible.

Busbar automatic transfer switch (BATS) can not only transfer loads to the backup power and restore power [8,9], but also can be used to eliminate overload. However, owing to the complexity of power grid structure and diversification of operation modes, the conventional BATS devices still have many problems, such as low performance, poor reliability, and low efficiency.

In this paper, a new BATS auto-generated algorithm is presented, which can automatically search for BATS models in accordance with operation modes of power system. Then we build BATS models, make use of information from energy management system (EMS), and simulate BATS action logics [10], by which we can realize the automatic load transfer control technology. When device overload occurs, the overload can be reduced or

removed from work power to backup power. In this way the algorithm is high real time and adaptive in power grid.

The rest of this paper is organized as follows. The auto-adapted BATS model is presented in Section 2. In Section 3, we describe BATS control technology. The simulation results are analyzed in Section 4. Finally, the conclusion is given in Section 5.

2. Auto-Adapted BATS Model.

In consideration of complex structure and operation modes in power system, the design of BATS models is also complex. This paper comes up with a new auto-adapt modeling algorithm according to the needs and requests of eliminating overload. At first, the basic BATS units are defined, and then with auto-adapted BATS modeling algorithm, BATS models are automatically searched based on the power grid operation modes.

2.1. Definition of BATS model.

Each BATS model includes using state, locked state, action condition, and action sequence, as shown in Figure 1. By the way, using state is symbolized whether BATS has been used or not and the locked state is a sign that BATS cannot act.

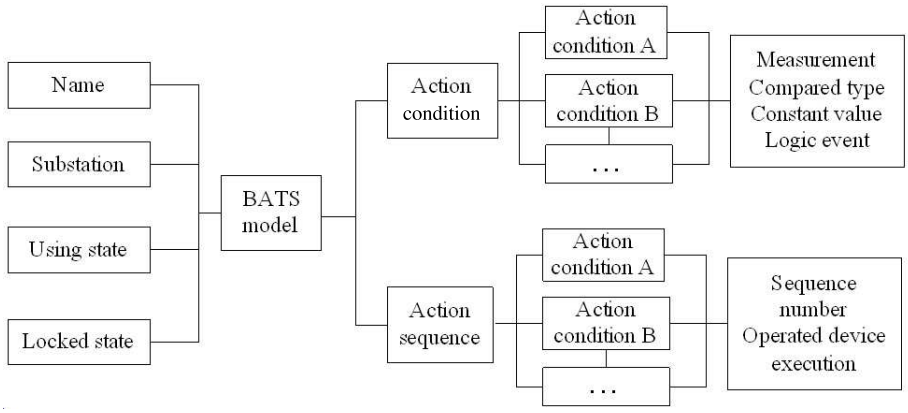

FIGURE 1. Model of busbar automatic transfer switch

On the base of definitions of basic attributions, each BATS model is composed of action condition step and action sequence step. Action condition step is used to judge whether BATS gets to start or not. Action sequence step is made up of operation sequence after action condition judgment.

2.2. Automatical generation of BATS models.

The purpose of realizing automatical generation of BATS models is that BATS models can automatically change on the basis of complexity and operation mode. At first, the topology information of power grid is analyzed. Secondly the BATS models searched in system are broken into several BATS units based on busbar connected modes. In the end, we analyze action condition and sequence of each BATS unit to realize simulation of action logic shown as Figure 2.

At first, each substation is traversed in power grid, and busbars with the corresponding busbar-connected switch are found out. At the same time, we traverse the connected lines, line switches, backup power and work power, which constitute a BATS unit. Then we get the state of busbar-connected switch to define the type of BATS unit. If the state is open, the lines, the backup power and work power consist of a busbar-connected BATS unit. If the state is close, an incoming-line BATS unit is constituted. At last, lines connected on the same busbar are scanned, which makes up of incoming-line BATS units. The BATS models of transfer are also searched in the same way.

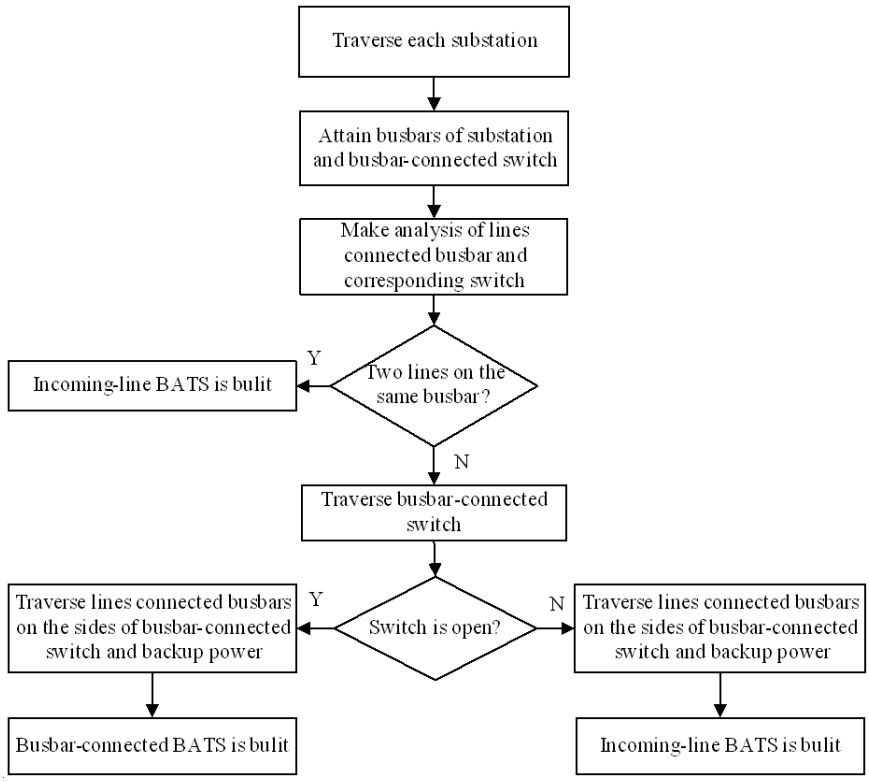

FIGURE 2. Flow chart of automatic generating for automatic switchover model

3. **Control Technology of BATS Modes.** When automatic generation of BATS models has been finished, we establish the BATS models in the BATS control system. After BATS models satisfy the BATS action operation condition, control technology will be given. In the low voltage power system, BATS switch operation has little impact on power grid structure because of radiational structure. On the other hand, in the high voltage system, such as 220kV power system, the structure may be looped network. Switch operation in control technology may change the power flow of the whole power network, and even cause another overload of line or transformer. In this case, BATS control technology is corrected by means of power flow calculation, and the feasible control strategy is finally attained in the end shown as Figure 3.

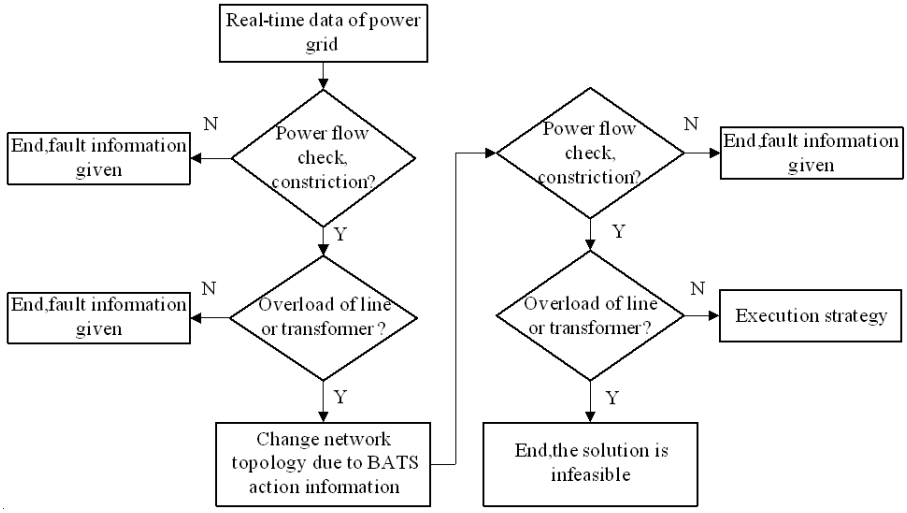

FIGURE 3. Correction of the control technology of BATS system

In the process of correction, we first make power flow calculation to estimate the present operation state. Secondly, the overload of line or transformer is tested. After power grid has changed on account of BATS switch operation, power flow is calculated again to detect the system operation state. We have to detect the overload of power system again. If there is overload, BATS action strategy is corrected. Otherwise, we can directly execute the strategy given by control technology.

4. **System Test.** 220kV substation I has single power and transformer. Line A of substation I is power line and line B is the backup one. On the side of 110kV in substation I, line I and line II are the main loads, and line III is the main power of 110kV substation II. Considering substation II is mainly supplied by another 220kV substation, line III can be the backup power. Besides, line III and corresponding devices can supply the two important loads for power as shown in Figure 4.

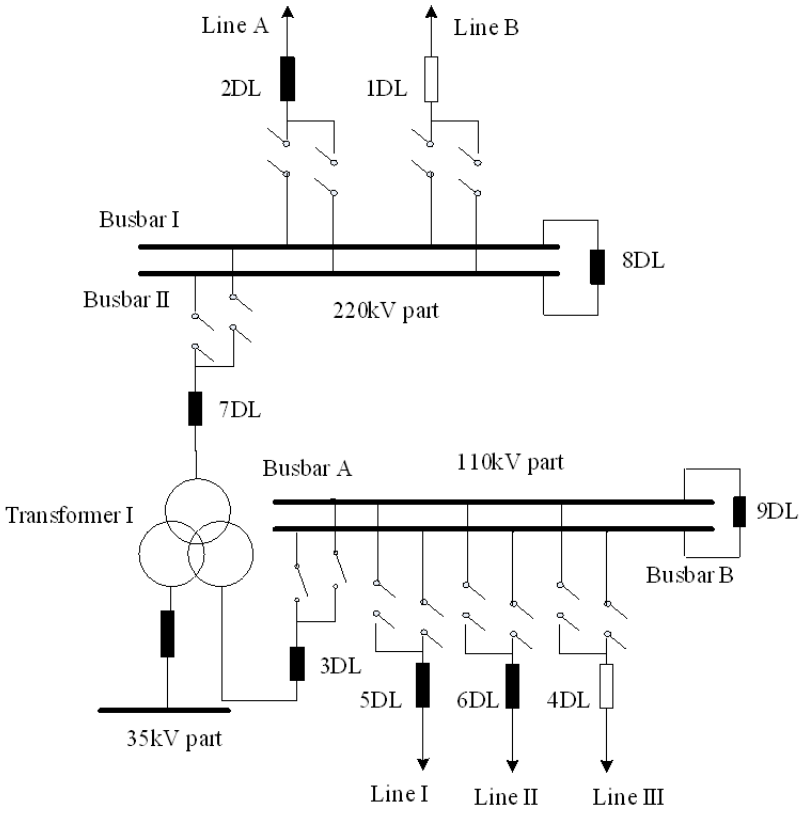

FIGURE 4. Connection diagram of substation I

When line A of substation I overloads, the loads cannot be directly cut off because line I and line II are important loads. In order to transfer the overload, automatic load transfer control technology of BATS is used. Considering there is BATS on the sides of 220kV and 110kV in substation I, BATS of two voltage levels will be discussed as follows.

4.1. **Analysis of 220kV BATS.** The BATS unit, which satisfies line A as work line, is incoming-line BATS of line, and the backup line is line B. Besides, devices connected to line B can bear the loads of transformer I middle-low side. When BATS unit detects line A overload and BATS action condition satisfies, switch 2DL is cut off at first, and then switch 1DL is closed after 2DL having been disconnected as shown in Table 1.

Considering 220kV power system may operate with close loop, the switch operation may have effects on power flow distribution of power grid. The control technology designed in this paper is used to check whether investment of the BATS can eliminate the overload

Table 1. Action of 220kV side

Switch name	Initial state	BATS action strategy
1DL	open	close
2DL	close	open

or not. Simulation proves that the BATS operation can remove the overload and power flow is constricted.

4.2. **Analysis of 110kV BATS.** On the side of 110kV, line III is backup line that supplies power for line I and line II. Because the busbar-connected switch of 110kV is closed, three incoming-line BATS are searched. Line III is backup line and one of line I and line II is the work one. Due to main loads connected to the two lines, this situation cannot satisfy the BATS action condition.

In another way, the switch 3DL can be defined as work switch and switch 4DL is the backup switch. When the line A overloads, BATS unit of 110kV is searched, switch 3DL is cut off and switch 4DL is closed. By the means of the solution, line I and line II are supplied by another power, so that loads of line I and line II is transferred and eliminated shown as in Table 2. Simulation also proves that the BATS operation can remove the overload and power flow is also constricted.

Table 2. Action of 110kV side

Switch name	Initial state	BATS action strategy
3DL	close	open
4DL	open	close

Comparing the two approaches above, the solution of 220kV BATS units can remove overload rapidly. However, because of closed loop operation, the BATS control technology generated must be checked by power flow calculation, which increases computation time and complexity. In a word, 220kV BATS approach is more complex. The method of 110kV BATS can not only ensure power supply for important loads, but also can eliminate line overload of 220kV on the high voltage side. As a consequence, the effect of 110kV BATS approach becomes better. Test shows that BATS system can be exactly executed to eliminate the overload with either solution, and strengthen the reliability of power supply.

5. **Conclusions.** At present, the methods of eliminating overload are not only a large amount of computation and low real-time performance, but also less of requests for continuity and reliability in power system. The technology of using BATS can automatically realize load transfer. Meanwhile, BATS control system corrects the generated control technology, and checks power flow of power grid to judge whether the overload is eliminated or not after BATS action.

The technology of using BATS can not only comprehensively make use of entire information of power grid to realize coordinate work with safe and stable devices, but also reduce maintenance and construction costs of power grid. As the test has been simulated successfully, the use of the technology can be put into practical application.

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REFERENCES

[1] INL Critical Infrastructure Protection/Resilience Center, *Study of Security Attributes of Smart Grid Systems Current Cyber Security Issues*, Department of Energy, China, 2009.

[2] N. Ming, J. D. McCalley, V. Vittal and T. Tayyib, Online risk-based security assessment, *IEEE Trans. Power Syst.*, vol.18, no.1, pp.258-265, 2003.

[3] S. H. Li, M. Shi, L. Dong, L. Yang and G. X. Hou, Causes analysis and control measures on line overload of power network, *Hebei Electric Power*, vol.27, no.4, pp.39-42, 2008.

[4] P. McDaniel and S. McLaughlin, Security and privacy challenges in the smart grid, *IEEE Security and Privacy*, vol.7, no.3, pp.75-77, 2009.

[5] Z. Tian, A. Q. Zhang and Z. H. Li, Bus transfer device based on power stability control platform, *Power System and Automation*, vol.34, no.6, pp.33-35, 2012.

[6] S. Y. Chen, H. P. Song, Y. Wang and D. Pan, Study and application on automatic bus transfer equipment of 220 kV transformer, *Power System Protection and Control*, vol.37, no.7, pp.91-94, 2009.

[7] Y. Q. Su and X. Y. Fu, Study on deactivating strategy of busbar automatic transfer switch for regional power grids, *Power-Supply Network*, vol.29, no.6, pp.33-35, 2012.

[8] S. Q. Li, M. J. Zhang, X. H. Ni, Y. L. Hu and H. M. Wang, Automatic loading transfer control technology to eliminate 330kV transformer overload, *Power System Protection and Control*, vol.37, no.11, pp.106-108, 2009.

[9] Y. L. Zhou, J. W. Sun and J. C. Chen, Spare power automatic switchover for area network and its key test technology, *Automation of Electric Power Systems*, vol.36, no.23, pp.109-113, 2012.

[10] J. W. Yang, W. C. Wu, H. B. Sun, W. W. Tao, B. M. Zhang and W. Jiang, A wide-area automatic switchover system based on EMS, *Automation of Electric Power Systems*, vol.34, no.11, pp.61-66, 2010.