Research on Automatic Switching Method of Power Supply in Power System based on Artificial Intelligence

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Abstract: In order to better ensure the safe operation of the power system, the automatic switching method of power supply of the power system based on artificial intelligence was proposed. The data of network loss, power flow, voltage, reliability and other related standard parameters in the operation process of the power system were collected, and the simulated annealing algorithm was improved according to the collected parameters. And according to the calculated results of common method of various kinds of power system, power supply automatic cut node types, boils down to PQ node and PV nodes, nodes PI and P - Q (V) for processing, thus power system based on artificial intelligence test under power supply automatic cut method, the simulation experiments show that this algorithm provides effective to avoid the problem of the traditional method, the feasibility is good.

Keywords: Artificial intelligence; Power system; Automatic switching; Simulated annealing

1. Introduction

With more and more attention paid to the utilization and development of clean and renewable energy in the world, the automatic switching method of power supply has been greatly developed. The line loss rate of transmission and distribution system in China has been high for a long time. Because the voltage level of the distribution system is low, and the current flowing through the line is large, the amount of power loss of the distribution system is large. According to statistics, the power loss of distribution network under 10KV accounts for about 60% of the total power loss of the whole power network. Therefore, the energy saving and loss reduction of distribution network is particularly important. In the sense of traditional distribution network, both voltage and reactive power control are based on a central power supply and assume that the current is from the substation bus of middle and high voltage to the direction of low-voltage feeder [1]. This situation is changed by the introduction of automatic switching method of power supply in power system. It changes the power flow at the same time, but also makes the feeder voltage changes, corresponding, also must make the distribution network voltage and reactive power control mode changes. This indicates that after the power system automatic switching method is connected to the distribution network, more effective voltage and reactive power control devices are needed to ensure the voltage control of the distribution system at a reasonable level. The power system automatic switching method usually provides reactive power to establish the magnetic field, so it has no voltage regulation ability. Considering that the generator must absorb some reactive power from the system when it outputs active power, the magnitude of the absorbed reactive power is closely related to the slip rate s and the node voltage U. In order to reduce network loss, the principle of reactive power on-site compensation is generally adopted [2]. The usual practice is to install parallel Banks of capacitors at the generator set. The power factor of the power grid can be guaranteed to meet the requirements through the automatic switching of capacitor Banks.

2. Power System Power Supply Automatic Cutting Method

2.1. Collection of operating parameters in the power system

In the operation and planning of power system, it is necessary to study the steady-state operation of power system and determine the steady-state operation state of power system. The steady-state operation state of a power system is determined by the given network structure, parameters and boundary conditions that determine the operation state of the power system. In mathematics, the automatic switching method of power supply in power system is to solve a group of nonlinear algebraic equations described by power flow equation. Automatic switching method of power supply in power system is the most basic and important part of power system analysis. It is the basis of power system

operation, planning, safety and reliability analysis and optimization, as well as the basis and starting point of various electromagnetic transient and electromechanical transient analysis [3]. The distribution network has many characteristics different from the high voltage transmission network, such as the distribution network has a radial structure, there are single-phase, two-phase or three-phase lines, and a large number of three-phase asymmetric load does not exist, which puts forward some special requirements for the power system automatic switching method. Firstly, the convergence problem will be paid more attention in the power flow algorithm of distribution network. This is because the distribution branch parameter r/X ratio is large, so that the original algorithm that is effective in the high voltage transmission network, such as fast decoupling method, is no longer effective in the distribution network [4]. Therefore, reliable convergence is the primary criterion to evaluate the power flow algorithm of distribution network. Second, due to the existence of a large number of asymmetric load in the power distribution system and single phase and two phase and three-phase hybrid power supply mode, make the distribution of three-phase voltage current no longer symmetrical, thus, the distribution system can not only as three-phase balance system the calculation of single phase, and must be calculated value of three-phase voltage, current and power, the requirement of three-phase power flow calculation. However, as countries around the world pay more and more attention to the utilization and development of clean and renewable energy, the automatic switching method of power supply in power system has been greatly developed [5]. Power system automatic switching method is shown as follows: The automatic switching method of power supply in power system is different from the general load nodes, and it is much more complex, so it is inevitable to introduce new node types in power flow calculation. Therefore, a power flow calculation method that can effectively deal with various power system automatic switching methods should be developed.

After the automatic switching method of power supply in the power system is added, the loop network may appear in the originally radial structure system, so the power flow calculation method formed must have the ability to deal with the loop network. The automatic switching method of power supply is shown in the figure below.

According to the automatic switching method of power supply in the figure above, the power flow method of Newton type is selected. Newton method itself has a good convergence ability, can carry out three-phase power flow, and can directly deal with the most node types in various algorithms (PQ node, PV node and equilibrium node), and has a good processing ability for ring network [6]. Therefore, it is very suitable for power flow calculation of power system automatic switching method.

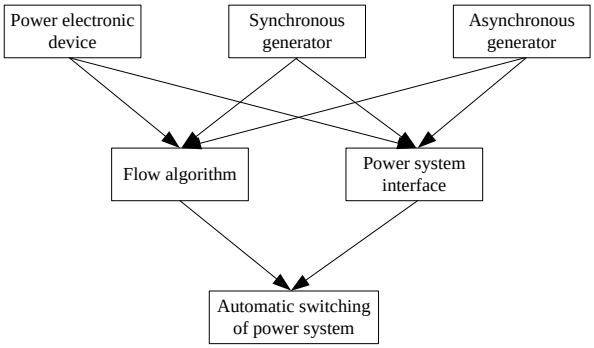

Figure 1. Power automatic switching method

2.2. Automatic switching node parameter division

In the traditional distribution network, there are only two node types: V0 node and PQ node. The outlet bus of substation is usually regarded as V0 node, while other nodes, including load node and intermediate node, are regarded as PQ node. With the addition of various power automatic switching methods to the distribution network, new node types appear in the system, including:

a. PV nodes with constant P and U;

b. PI nodes with constant P and constant current amplitude I;

c. p-q (V) nodes with constant P, indefinite U and Q limited by P and U.

When power flow calculation is carried out, different processing methods must be adopted for different node types. The essence is to convert various types of nodes into PQ nodes or PV nodes that can be processed by traditional methods in each iteration step of power flow calculation. In power flow calculation, the simplified treatment method for automatic switching of power supply in the power system is to treat it as a "negative load" and treat it as a PQ node [7]. For example, the simplified treatment of generator nodes using asynchronous generators is to consider them as PQ nodes, where the active power and reactive power of the generator are constant. According to the wind speed - power curve of the machine, the following formula can be used to calculate the active power of each machine from the wind field under a given wind speed

$$P_{\mathrm{m}} = 0.5\rho AV^3C_p \tag{1}$$

Where, P is the air density (km/m3), V is the wind speed (m/s), A is the swept area (m2) of the machine, and Cp is the wind energy utilization coefficient of the machine. It indicates the proportion of useful wind energy obtained by the wind turbine, which can be obtained from the characteristic curve of machine G given by test data.

Then, the active power of the entire wind farm is calculated. According to the power factor at a given wind farm, the reactive power consumed by the whole wind farm is calculated [8]. This calculation method is extremely simple, but very rough, the theoretical value and the actual value of the deviation may be large. In addition, it can be seen from formula (1) that the theoretical power generated by the motor is directly proportional to the wind area and the third power of the wind speed. The active power output of the generator set is regarded as a function of wind speed. If the wind speed of the wind farm is given, the active power output of the wind farm can be approximated. When calculating the power flow of the distribution network at a certain moment, the output power of the generator set at that moment can be considered as a fixed value determined by the wind speed at that moment.

In the case of inverter, the method of power automatic switching can be modeled by output - limited inverter. Inverter can be divided into current control inverter and voltage control inverter. The current-controlled inverter can be simulated as a PI node with constant active power output and input network current. The corresponding reactive power can be calculated from the voltage, constant current amplitude and active power obtained from the previous iteration:

$$Q_{k+1} = \sqrt{|I|^2 (e_k + f_k)^{k-1} - P_m^2} \qquad (2)$$

Therefore, when power flow calculation is carried out, the reactive power injection amount of PI nodes can be calculated before each iteration, and the PI nodes can be processed into PQ nodes with active and reactive power outputs of P and Q_{k+1} respectively in the k+1 iteration process. After each iteration, the voltage phase Angle and reactive power of the node can be calculated [9]. PI model of distributed power supply also the limit of power output, but can be seen from the type (2), (e_k^2 + f_k^2) of MAO value generally near 1.0, P and I, is the value of the two required to maintain so influence the final calculated Q_{k+1}, value is the PI nodes of a given active power and current amplitude, the P and I if a given reasonable, the calculated reactive power will not be the limit.

In order to overcome the shortcoming of large error when the fan node using asynchronous generator is simply treated as PQ node, a more detailed calculation model should be adopted. Therefore, the wind turbine generator should adopt the p-q (V) model based on the approximate equivalent circuit of the asynchronous generator as shown in figure 2.

2.3. Realization of automatic switching of power supply

Wen have seen before, automatic cutting algorithm, the general form is: starting from the selected initial solution, diminishing in the use of control parameters f generated when a series of Mapkob chain, generated by a data processing device and acceptance criteria, repeated including "to produce the new calculation Et standard function is poor one judge whether to accept the new one to accept (or leave) the new" the four tasks of experiment, continuously for the current iteration solution, so as to achieve the objective function optimal execution. Therefore, the application of the algorithm should meet the following three requirements:

I. mathematical model, namely a concise formal description of the problem, is composed of solution space, objective function and initial solution.

Solution space. The solution space is the set of all possible (feasible or infeasible) solutions of the problem, which limits the range of initial solution selection and new solution generation. For unconstrained optimization problems, the solution space is the set of all feasible solutions. In many combinatorial optimization problems, a set of constraints must be satisfied in addition to the objective function optimization, so some infeasible solutions may be included in the solution set.

Objective function. Objective function is a mathematical description of the optimization objective of a problem, usually expressed as a sum of several optimization objectives [10]. The selection of objective function must correctly reflect the overall optimization requirements of the problem. Generally, the objective function is not necessarily the optimal objective function value of the problem, but its corresponding relationship is obvious. In addition, the objective function should be easy to calculate, which will be conducive to simplifying the calculation of the difference of the objective function in the optimization process to improve the efficiency of the algorithm.

Initial solution. The initial solution is the starting point of algorithm iteration. The selection of the initial solution should enable the algorithm to derive a better final solution, but a large number of experimental results show that the simulated annealing algorithm is a "robust" algorithm, that is, the final solution of the algorithm is not very dependent on the selection of the initial solution. The automatic switching algorithm is shown in the figure below.

As can be seen from the flowchart above, the generation and acceptance mechanism of the new solution can be divided into the following four steps:

Is produced by a device from the current solution in the solution space to create a data processing, in order to facilitate calculation and accept the following (this is the most time-consuming algorithm), usually choose by the current solution after a simple way to produce the new transformation, such as constitute elements of all or part of the solution for displacement and swaps or inversion, etc. The generation method of the new solution

determines the neighborhood structure of the current solution.

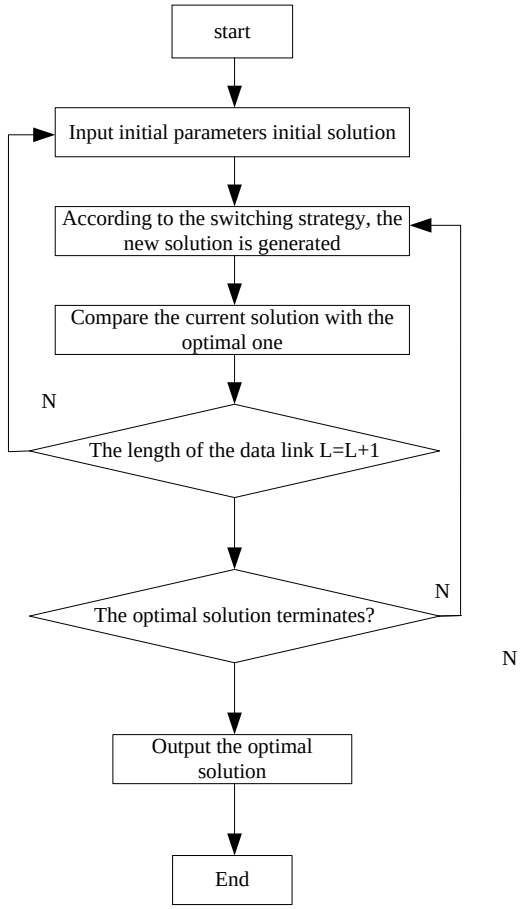

Figure 2. Automatic cutting algorithm process

Calculate the difference between the objective function and the new solution. Since the difference of the objective function is only produced by the transformation part, it is better to calculate the difference of the objective function in increment.

When the new solution is determined to be accepted, replace the current solution with the new solution and modify the value of the objective function. At this point, the current solution implements an iteration. The next round of experiments can be started on this basis. When the new solution is judged to be discarded, the next round of test is continued on the basis of the original current solution.

3. Analysis of Experimental Results

In order to verify the feasibility of the automatic switching method of power supply, a simulation experiment was carried out for the method. The 12.66kv30 bus three-phase unbalance system was used as the basic calculation example. The bus load data and the existence of phase in the line are shown in the following table. The total active load of the system is 4797kW, and the total reactive load is 1599kvar. The baseline value of line voltage UB= 12.66kv, and the upper limit of each line current is 256A.

Table 1. Bus load data and line phase conditions

Bus No.	A phase		B phase		Phase C	
	P/kW	Q/kvar	P/kW	Q/kvar	P/kW	Q/kvar
1	0	0	0	0	0	0
2	465	155	0	0	174	58
3	0	0	0	0	0	0
4	0	0	0	0	96	32
5	0	0	32	11	63	21

It is assumed that the system has been equipped with 4 sets of shunt capacitor Banks. Table 1 shows the installation location, unit capacity and unit number of each shunt capacitor bank. The number of units is 1. After the addition of PI node, the power supply automatic switching method in 30 system access position. The experimental results are shown in the figure below.

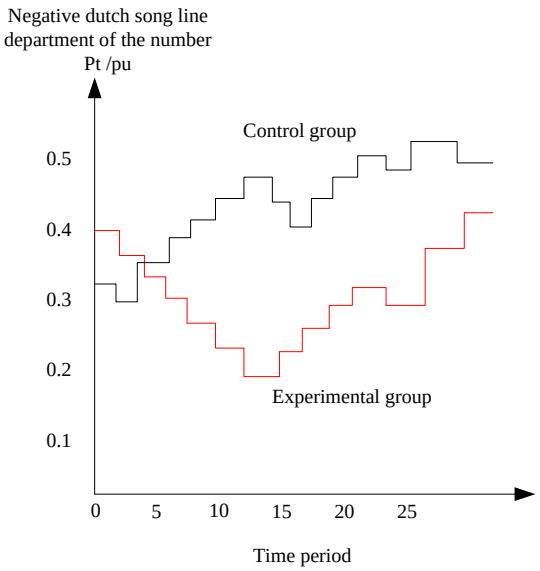

Figure 3. Experimental results

It can be seen from the experimental results in FIG. 3 that the load coefficient of the power supply system significantly decreases and the system energy loss is greatly reduced after the automatic power supply switching method is used, indicating that this method is effective. With the addition of PV power automatic switching method, the system network loss changes

obviously. It has little effect on system network loss and is feasible.

4. Conclusion

Continuous development of power system, increasing the scale of power grid, the load to the rapid growth of the power supply automatic cut method is to decrease network loss, improve voltage quality and important measures to ensure safe and economic operation system, the traditional network loss, low reliability problems cutting method, with the continuous development of artificial intelligence technology, based on the power system power supply automatic cutting method of artificial intelligence, the simulation experiments show that this method can effectively reduce the energy loss of the system and higher reliability.

References

[1] Li Weijie, Wei Hemin, Li Zhibo, et al. Key technology scheme for realizing online group-by-group nuclear capacity of multiple parallel battery groups in communication and dispatching machine room. New Technologies and New Products in China. 2017, 13(4), 10-12.

[2] Wang Xiaoya, Cui Jiang, Tang Junxiang, et al. Research on fault diagnosis technology of aviation rotating rectifier based on extreme learning machine. Mechanical Manufacturing and Automation. 2017, 32(5), 219-222.

[3] Li Yang, Wei Gang, Ma Yu, et al. Dynamic reconfiguration of active distribution network with electric vehicles and distributed generation. Power System Automation. 2018, 42(5), 102-110.

[4] Mao Yuhan, Zhang Yan, Su yun. Optimal configuration method of automatic switching device for backup power supply in multi-voltage distribution network. Power Automation Equipment. 2018, 38 (6)， 77-83+91.

[5] Anonymous. Modular multilevel converter capacitance reduction method with reactive sub-modules switched by sections. Power System Automation. 2018, 42(19), 96-103.

[6] Liu Yihua, Gu Haoliang, Xu Weidong, et al. Improvement measures of automatic switching link circuit in three main transformers and four subsection substations. Electrical Technology. 2018, 19(1), 106-109.

[7] Xu Qiaoyun, Wang Shuojun, Han Bing, et al. Research on zero-crossing detection method of capacitor switching based on recursive correlation operation. Manufacturing Automation. 2017, 39(12), 101-105.

[8] Anonymous. Research on fast switching of power supply in distribution network based on model diagnosis. Computer Applications And Software. 2018, 35(10), 287-291.

[9] Fu Yingjie, Wang Feng, Tan Yanghong. Reactive power optimization of distribution network with distributed generation based on pareto optimal solution. Power System and Its Acta Automaticasinica. 2017, 29(1), 18-23.