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# Reconstruction Strategy of Distribution Network with DG based on improved binary Particle Swarm Optimization algorithm

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**Abstract:** Distribution network reconfiguration is a complex nonlinear combinatorial optimization problem. In order to overcome the problem that the original particle swarm optimization (pso) algorithm is easy to fall into the local optimal and difficult to jump out, an improved pso algorithm is proposed to solve the distribution network reconfiguration model with distributed power supply (DG).By introducing nonlinear dynamic adjustment of inertia coefficient and direction matrix to guide the update of particle velocity, the particle is moved towards the lowest voltage node, and a large number of infeasible solutions are processed to improve the global search efficiency and convergence speed of binary particle swarm optimization algorithm. Finally, the effectiveness of the algorithm is verified by simulation of IEEE33 node distribution system.
**Keywords:** Distribution network restructuring，BPSO，Nonlinear inertial weight，Direction matrix

## 1. INTRODUCTION

Distribution network reconstruction is to eliminate overload, reduce network loss and improve voltage quality by changing switch combination and network structure under certain constraints. Distribution network reconfiguration is a nonlinear integer combination optimization problem, which is a typical NP hard problem. At present, in solving the problem of distribution network reconfiguration, many literatures have proposed a variety of reconfiguration algorithms, including heuristic algorithm, intelligent optimization algorithm and hybrid algorithm combining them.

Heuristic rules are generally used to reconstruct the distribution network, including branch switching method and optimal flow algorithm. Since most of them adopt approximate and heuristic methods, and few times of power flow calculation, the solution speed is relatively fast, but the accuracy is not high, so it is difficult to find the correct global optimal solution. Intelligent Optimization algorithms, such as ant colony algorithm, genetic algorithm, Particle Swarm Optimization, harmony algorithm, artificial fish Swarm algorithm and hybrid frog hop algorithm, have been widely used in distribution network reconstruction and achieved some achievements. In literature [6], binary particle swarm optimization (BPSO) algorithm based on mixed leapfrog thought was used to search branch groups, and the historical optimal value was grouped for several times. Binary particle swarm optimization (BPSO) algorithm in branch groups was used for intra-group search.

However, this kind of algorithm USES the idea of random search, but still has some blindness, low search efficiency, and requires a lot of time. The hybrid algorithm combines heuristic algorithm and intelligent optimization algorithm. Firstly, the optimal solution obtained by heuristic algorithm is used as the initial solution of intelligent optimization algorithm. Although this method can effectively reduce the calculation amount of intelligent algorithm, it is also simple to add the two without further integration. Moreover, when the difference between the heuristic algorithm and the optimal solution is too large, it restricts the search of intelligent optimization algorithm and makes it difficult to find the accurate optimal solution.

At the same time, with the continuous infiltration of distributed power supply (DG), it has an impact on the power flow, node voltage and network loss of the distribution network, which makes the problem of distribution network reconstruction more complicated. Literature [8] by analyzing access distributed power (DG) in distribution network, using standard artificial fish algorithm and Pareto model, the multi-objective optimization problem into a Pareto efficient solutions for the optimal solution, the introduction of fast non dominated sorting strategy and external elite archiving strategy form the multi-objective artificial fish algorithm, and the selection of distributed power distribution network, artificial fish can be applied to contain distributed power (DG) in distribution network reconfiguration problem. Literature [6] introduces niche sharing technology to update global optimal particles in multi-objective particle swarm optimization algorithm based on the active distribution network with DG access, and obtains a scientific and effective optimal reconstruction scheme according to fuzzy satisfaction evaluation and decision method after solving.

Based on the optimal reconfiguration of distribution network with distributed generation (DG), this paper proposes to construct the objective function of multi-objective distribution network reconfiguration with network loss and voltage offset, normalize the indexes with different dimensions, and convert the multi-

objective function into single-objective function by using the weight coefficient method. At the present stage, most algorithms simply add heuristic algorithm and intelligent algorithm, and deeply integrate heuristic rules and intelligent algorithm. Firstly, the matrix rings are reordered to produce an ordered ring network. The direction matrix is generated in the position of the ordered ring network according to the lowest voltage of the ring network, and the direction matrix is combined with the binary particle swarm optimization algorithm to form the improved binary particle swarm optimization algorithm based on the direction matrix, and the distribution network scene with distributed power supply (DG) is combined. Finally, an IEEE33 example is used to verify the effectiveness of the algorithm.

## 2. DISTRIBUTION NETWORK RECONSTRUCTION MODEL

### 2.1MATHEMATICAL MODEL OF DISTRIBUTION NETWORK RECONFIGURATION

Network active loss of reaction distribution network advantages and disadvantages of economic operation, the network voltage deviation is reactive power distribution network is an important index of power quality, considering the DG has a great influence on injection power on the node voltage, this paper adopts the multi-objective optimal weighting method, will reduce the network loss and reduce the node voltage deviation, as two optimization objectives, gives different weights to each target coefficient weighted sum, get the overall objective function is

$$min\ f(x) = min[\lambda_1 f_1(x) + \lambda_2 f_2(x)] \quad (1)$$

$$f_1(x) = \sum_{i=1}^{n_b} k_i r_i |I_i|^2 \quad (2)$$

$$U_{bias} = \sum_{l=1}^{m} \left| \frac{U_{lN} - U_l}{U_{lN}} \right| \quad (3)$$

where $f_1(x)$, $f_2(x)$ are distribution network loss value and network voltage deviation; $\lambda_1$, $\lambda_2$ Is the respective weight coefficients, $\lambda_1 + \lambda_2 = 1$; $n_b$ Is the number of branches in the distribution network; $k_i$ Is the branch switch state,0 means the switch is off, 1 means the switch is closed; $r_i$ Is the resistance of the branch; $I_i$ Is the load current of the branch; $U_{bias}$ Is the voltage offset of the network; mis the total number of nodes in the network; $U_l$ Is the node voltage at node l; $U_{lN}$ Is the rated node voltage at node l, generally sets as 1.

### 2.2CONSTRAINT CONDITION

(1) Power flow constraint: power flow constraint conditions should be satisfied for distribution network reconstruction.

(2) Branch current constraint: $I_b \le I_{bmax}$, $I_b$, $I_{bmax}$ are respectively the current flowing through the branch and the maximum permissible current.

(3) Nodal voltage constraint: $V_{imin} \le V_i \le V_{imax}$, $V_i$, $V_{imin}$, $V_{imax}$ are respectively the voltage, lower limit and upper limit of the node.

Network topology constraint: $g_k \in G_k$, $g_k$ is On-off state combination, $G_k$ Is a collection of radial switch combinations. In the process of distribution network reconfiguration, network topology constraint is the key .

### 2.3DISTRIBUTED POWER FLOW CALCULATION MODEL

Different types of distributed power supply adopt different processing methods in power flow calculation of distribution network. The asynchronous wind generator can be simplified into PQ node. In power flow calculation, the simplified method is to treat it as "negative load" [9], and treat it as load with opposite power flow direction and equal power, $P_s$, $Q_s$ Are the active and reactive power of the node respectively

$$P = -P_S \quad (4)$$

$$Q = -Q_S \tag{5}$$

Distributed power sources such as internal combustion engine and conventional gas turbine with synchronous generator and voltage-controlled inverter are treated as PV nodes with constant voltage and injected power. When the reactive power of the node is out of bounds, it needs to be converted into PQ node. If the node voltage exceeds the boundary in the subsequent process, it will be converted into PV node again, and so on.

Photovoltaic cells and other power supplies connected to the grid through current inverters can be regarded as PI nodes with constant current and input power, and the corresponding reactive power can be calculated according to the voltage, current amplitude and active power obtained in the last iteration, which can be converted into PQ nodes through equation (6).

$$Q = \sqrt{|I|^2 + |U|^2 - P^2} \tag{6}$$

## 3. IMPROVED BINARY PARTICLE SWARM OPTIMIZATION ALGORITHM BASED ON DIRECTION MATRIX

### 3.1HEURISTIC CRITERION

Literature [11] estimated the network loss change before and after switch switching and concluded that the network loss increment generated by switches on both sides at the lowest point of switching ring network voltage was the minimum, which could effectively reduce the network loss of the system. The actual research also shows that the disconnection switch in the optimal combination of distribution network reconfiguration is usually near the lowest voltage of the loop network, and the closer the disconnection switch is to the lowest voltage of the loop network, the lower the network loss. Therefore, the lowest point of loop network voltage can be used to guide the random search of intelligent algorithm, so that it moves to the lowest point of voltage, and then tends to the global optimal solution.

### 3.2ORDERED RING NETWORK MATRIX AND DIRECTION MATRIX

There is no order in the branches of the basic ring matrix described in literature [7], and there is no direction to speak when using intelligent algorithm to optimize it. The use of random search will cause low search efficiency and easy to fall into the local optimal problem. In this paper, the branches in the ring network are sorted according to the connection order of the distribution network, and one of the branches with the nearest electric distance is put in the first place and the other in the last place. According to the distance between each branch and the lowest voltage node, the direction matrix is formed.

Combined with the above rules, the improved basic ring matrix and direction matrix are explained in detail by taking distribution network with IEEE33 node as an example as shown in FIG. 1. The branch between the default node 1 and node 2 in literature [7] is branch 1. The basic matrix formed by literature [7] is as follows:

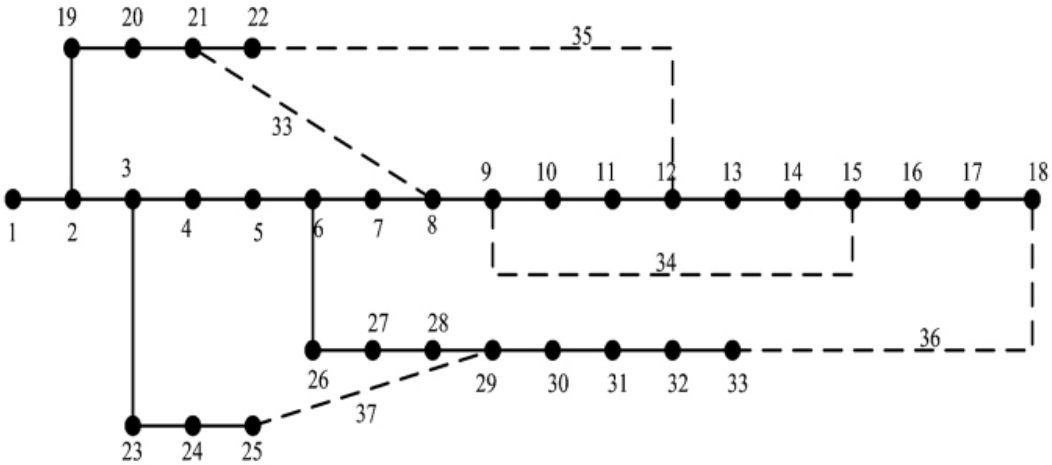



Fig. 1 IEEE33 node distribution system

$$M_0 = \begin{bmatrix} 2 & 3 & 4 & 5 & 6 & 7 & 18 & 19 & 20 & 33 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 9 & 10 & 11 & 12 & 13 & 14 & 34 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 18 & 19 & 20 & 21 & 35 & 0 & 0 & 0 & 0 & 0 & 0 \\ 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 25 & 26 & 27 & 28 & 29 & 30 & 31 & 32 & 36 \\ 3 & 4 & 5 & 22 & 23 & 24 & 25 & 26 & 27 & 28 & 37 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Firstly, the branches in line 1 are sorted according to the connection order of the distribution network. The two branches closest to the electric network are branch 2 and branch 18 respectively. If one of them is put in the first position and the other in the last position, the branches in line 1 of the improved basic ring matrix are {2, 3, 4, 5, 6, 7, 33, 20, 19, 18}.By calculation, the lowest voltage node under this ring network is 8, and branch 7 is the first branch to the left of node 8, so the direction matrix branch is generated.7 corresponds to 1, and branch 33 is the first branch on the right of node 8, so the generated direction matrix branch 33 corresponds to -1.The first behavior of the direction matrix generated according to this rule {6, 5, 4, 3, 2, 1-1-2-3-4}.

By sorting all rows, a new matrix ring is generated, namely, the ordered ring network matrix M is

$$M = \begin{bmatrix} 2 & 3 & 4 & 5 & 6 & 7 & 33 & 20 & 19 & 18 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 9 & 10 & 11 & 12 & 13 & 14 & 34 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 35 & 21 & 20 & 19 & 18 & 0 & 0 & 0 & 0 & 0 & 0 \\ 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 36 & 32 & 31 & 30 & 29 & 28 & 27 & 26 & 25 \\ 3 & 4 & 5 & 25 & 26 & 27 & 28 & 37 & 24 & 23 & 22 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Then, a switch is selected from each row of matrix M to form a switch set, which is a solution of distribution network reconstruction. Close all the contact switches, and through power flow calculation, it can be concluded that the lowest voltage node of each ring network is {8,15,11,32,29}, then the corresponding direction matrix A is:

$$A = \begin{bmatrix} 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 6 & 5 & 4 & 3 & 2 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 9 & 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & -5 & -6 & 0 & 0 & 0 & 0 & 0 & 0 \\ 14 & 13 & 12 & 11 & 10 & 9 & 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & -5 & -6 & -7 \\ 7 & 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

The direction matrix A is determined by the loop network minimum voltage and orderly loop network matrix. When the network load changes, the node minimum voltage changes, and the direction matrix A will also change. Through this mechanism, the corresponding direction matrix A can be generated under different loads.

If the distribution network node 11~20 is reduced by 30%, and the node 23~33 is increased by 30%, the minimum voltage is obtained from the recalculation of power flow and {8,15,10,32,29}. The new direction matrix A 'generated by the above operation is:

$$A' = \begin{bmatrix} 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 6 & 5 & 4 & 3 & 2 & 1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & -5 & -6 & -7 & 0 & 0 & 0 & 0 & 0 & 0 \\ 14 & 13 & 12 & 11 & 10 & 9 & 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & -5 & -6 & -7 \\ 7 & 6 & 5 & 4 & 3 & 2 & 1 & -1 & -2 & -3 & -4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

### 3.3IMPROVED BINARY PARTICLE SWARM OPTIMIZATION

Standard particle swarm optimization (PSO) algorithm, particle swarm optimization, PSO) by Kennedy and others by birds in the process of searching for food, the migration and cluster behavior inspired, and later, they in order to solve the optimization problems of discrete spatial domain, in 1977, put forward the binary

particle swarm optimization (PSO) algorithm (binary particleswarm optimization, BPSO), BPSO in, each particle according to the formula (7) update:

$$V_{id}^{t+1} = \omega \times V_{id}^{t} + c_1 \times r_1 \times (p_{id}^{t} - X_{id}^{t}) + c_2 \times r_2 \times (p_{gd}^{t} - X_{id}^{t}) \quad (7)$$

$V_{id}^{t}$ , $X_{id}^{t}$ Are respectively the velocity and position of individual in d dimension of particle I at the t th iteration; $\omega$ Is the inertia weight coefficient; $c_1$ , $c_2$ are acceleration coefficient; $r_1$ , $r_2$ are random numbers between 0 and 1; $p_{id}^{t}$ Is the optimal position of d dimensional individual at the t th iteration of particle I; $p_{gd}^{k}$ Is the global optimal position of d dimension in the t th iteration of the whole particle swarm.

The position value of each particle in BPSO is only 0 or 1, and the higher the velocity of the particle, the higher the probability of the position value being 1. Particle position update formula is as follows:

$$X_{id}^{t+1} = \begin{cases} 1, r < S(V_{id}^{t}) \\ 0, r \geq S(V_{id}^{t}) \end{cases} \quad (8)$$

Where: r is the random number between 0 and 1 subject to uniform distribution; S(x) is the sigmoid function:

$$S(x) = \frac{1}{1 + e^{-x}} \quad (9)$$

Since distribution network reconstruction is a large scale mixed integer nonlinear programming problem, BPSO is easily trapped in the local optimal domain and cannot jump out in the solution space search process, leading to the convergence of search results to the local optimal rather than the global optimal. In order to overcome this shortcoming, an improved binary particle swarm optimization (pso) algorithm is used to solve the mathematical model of distribution network reconstruction. In order to reasonably balance the global and local search capabilities of BPSO, the inertia weight coefficient omega in equation (7) was improved. After the improvement, the inertia weight coefficient is no longer a constant, but can be continuously nonlinear decline with the search, which helps the algorithm to jump out of the local optimal. The improved inertia weight coefficient formula is:

$$\omega = \omega_{\max} - \frac{\omega_{\max} - \omega_{\min}}{t_{\max}} \times t \quad (10)$$

$t_{\max}$ Is the maximum number of iterations; t is the current iteration number; $\omega_{\max}$ $\omega_{\min}$ Are the maximum and minimum values of respectively, usually set them at 0.9 and 0.4.

At the same time, this paper will improve the basic binary particle swarm optimization algorithm, and use the direction matrix to modify the particle velocity of formula (7) :

$$V_{id}^{t+1} = \omega \times V_{id}^{t} + c_1 \times r_1 \times (p_{id}^{t} - X_{id}^{t}) + c_2 \times r_2 \times (p_{gd}^{t} - X_{id}^{t}) + r_3 \times A_{d,X_{id}^{t}} \quad (11)$$

$r_3$ Is the influence weight of direction matrix on velocity, which is taken on [0,1]; $A_{d,X_{id}^{t}}$ Is the direction matrix, row d, column $X_{id}^{t}$ element.

From the analysis of 2.1 heuristic criteria, it can be seen that switching off near the lowest point of voltage often leads to a reconstruction scheme with low network loss, and the global optimal solution is near the lowest point of voltage. When the direction matrix is closer to the voltage minimum, if $\left|A_{d,X_{id}^{t}}\right|$ smaller, The smaller the influence of direction matrix on particle velocity update, the better the particle swarm optimization can be. When the direction matrix is further away from the lowest voltage, $\left|A_{d,X_{id}^{t}}\right|$ bigger, Then, the greater the influence of the direction matrix on the update of particle velocity is, the better the particle will move towards the optimal solution and jump out of the local optimal. The algorithm flow chart is shown in figure 2.

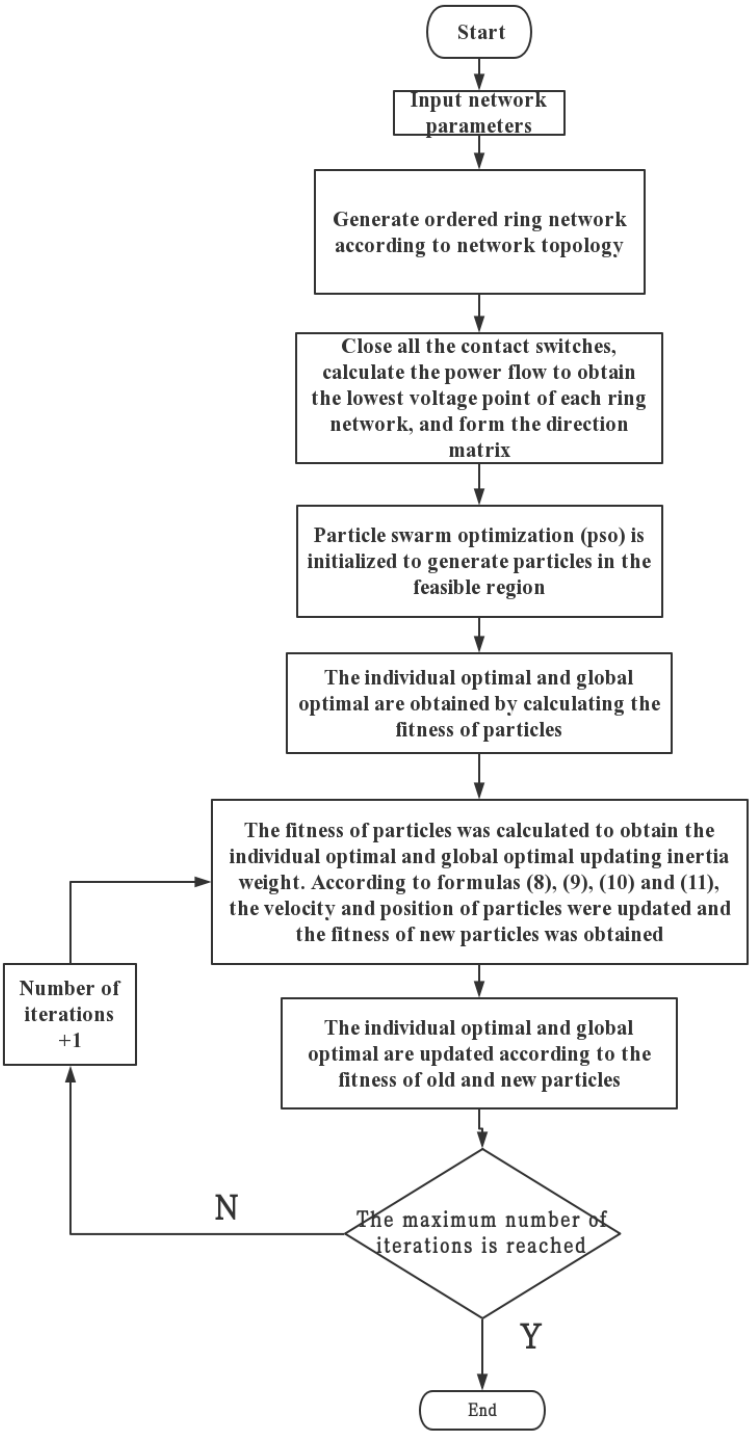



Fig.2 algorithm flow chart

## 4. THE EXAMPLE ANALYSIS

### 4.1 THE INFLUENCE OF OBJECTIVE FUNCTION WEIGHT COEFFICIENT ON OPTIMIZATION RESULTS

Based on IEEE33 distribution network system as an example, the system contains 37 line, including 5 contact branch, five basic ring formation, this article USES the literature [11] before back flow algorithm, and applied the improved particle swarm algorithm, this paper respectively analyzes the distribution network in

Matlab programming without DG and DG access performance of the algorithm, and compared with other reconstruction algorithm. IEEE33 distribution system network parameters and node loads reference [9], in the improved pso parameter design in this paper, the parameters are set as follows:

The size of particle swarm is sizepop=40, the maximum number of iterations $t_{\max}$ =50, the maximum and minimum values of inertia weight coefficient are 0.9 and 0.4 respectively, and the acceleration coefficient $c_1 = c_2 =$ 1.49682. Since the objective function in this paper is a multi-objective optimization model, the normalization method is adopted to transform it into a single-objective optimization problem, and the best reconstruction scheme is obtained. In order to study different weight coefficients of objective function affect optimization results. This paper selects several groups of different weight coefficients for simulation, and the simulation results are shown in table 1.

Table 1 Optimal results under different

| The weight | Network loss/kW | Node minimum voltage/p.u. | Open switch |
|---|---|---|---|
| $\lambda_1 = 0.8$ $\lambda_2 = 0.2$ | | | |
| $\lambda_1 = 0.6$ $\lambda_2 = 0.4$ | 139.551 | 0.9378 | 7-8、9-10、14-15、32-33、25-29 |
| $\lambda_1 = 0.5$ $\lambda_2 = 0.5$ | | | |
| $\lambda_1 = 0.4$ $\lambda_2 = 0.6$ | | | 7-8、9-10、14-15、32-33、25-29 |
| $\lambda_1 = 0.2$ $\lambda_2 = 0.8$ | 139.977 | 0.9413 | |

As can be seen from table 1, when the weight coefficient of network loss is ≥50%, a group of optimization results are obtained, and the network loss value is relatively small. When the weight coefficient of the voltage deviation value is greater than 50%, a set of optimization results are obtained, and the lowest voltage of the node is larger and the voltage deviation value is smaller. After considering the distribution network reconfiguration is the normal operation of the power distribution network, rather than the state of failure or maintenance, and distribution network reconfiguration single objective optimization, the only optimization objective function for active network loss, so considering the above factors, the optimization of distribution network reconfiguration objectives under the condition of the technical performance of give attention to two or morethings focus more on economic indicators, so later for weight coefficient selecting two child objective function $\lambda_1 = 0.8 \quad \lambda_2 = 0.2$.

### 4.2 PERFORMANCE ANALYSIS OF IMPROVED RECONSTRUCTION ALGORITHM WITHOUT DG CONNECTION

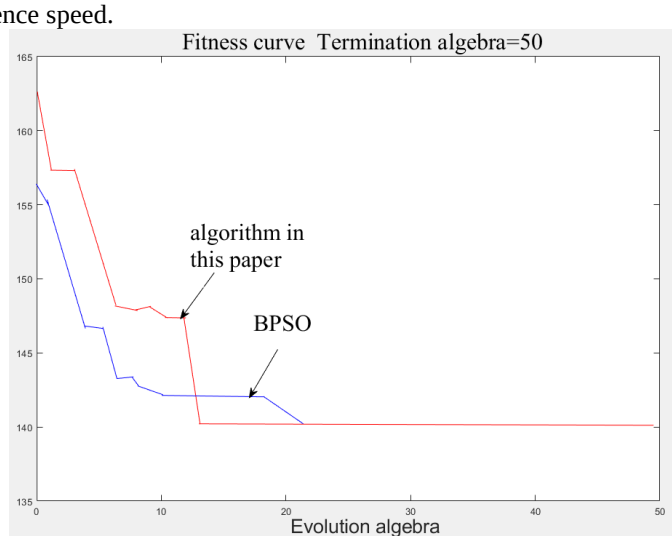
When the distribution system is not connected to DG, the results obtained by applying the reconstruction algorithm in this paper are shown in table 2.

Table 2 Result of reconfiguration and optimization without DG

| Algorithm | Network loss/kW | Node minimum voltage/p.u. | Open switch |
|---|---|---|---|
| initial | 202. 677 | 0. 9131 | 7-20、8-14、11-21、17-32、24-28 |
| Literature [14] | 140. 48 | 0. 9108 | 6-7、13-14、8-9、31-32、24-28 |
| Algorithm In this paper | 139. 551 | 0. 9378 | 7-8、9-10、14-15、32-33、25-29 |

As can be seen from table 2, the minimum network loss value of the reconstruction scheme obtained by adopting the method proposed in this paper decreases by more than 30% compared with the initial value, and is smaller compared with the results in literature [14]. The deviation value of the lowest voltage node decreases from 0.0892 to 0.0622, indicating that the algorithm has good optimization ability. It shows that this algorithm has some advantages in reducing network loss and voltage deviation. The convergence curve of the algorithm is shown in figure 3.

It can be seen from figure 3 that the general BPSO algorithm reaches the extreme value in the 20th iteration, while the improved algorithm proposed in this paper reaches the optimal value in the 12th iteration, and the iteration speed is significantly increased. It shows that the improved algorithm has good searching ability and fast convergence speed.




**4.3 INFLUENCE OF DG ACCESS ON DISTRIBUTION RECONFIGURATION**

In this paper, the installation position of DG in literature [15] is used to access DG at 18, 31 and 32 nodes, DG power factor cosφ=0.8, active power output is 200kW, reactive power output is 150kvar, further analysis of the influence of DG access to distribution network on network reconstruction and the performance of the improved algorithm proposed in this paper. The reconstructed network topology based on the algorithm in this paper is shown in figure 4.

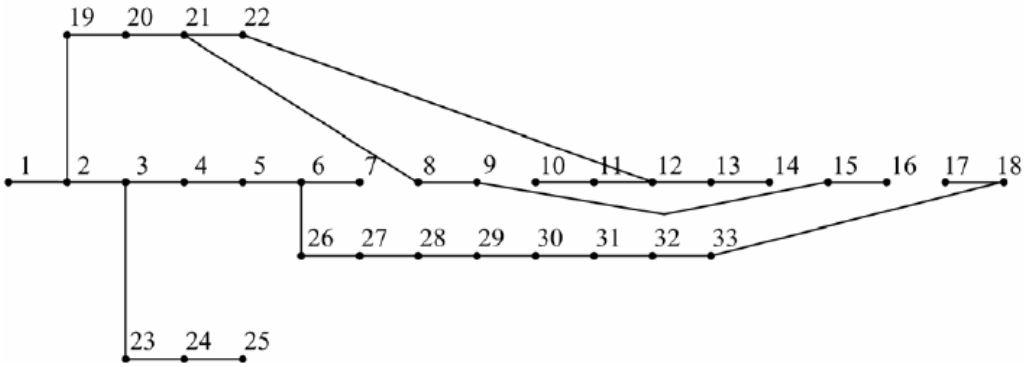



Fig. 4 Topology after DG connected reconfiguration

The algorithm in this paper has also been verified after accessing DG. FIG. 5 shows the fitness curves of BPSO, the algorithm in this paper without adding nonlinear inertia coefficient, and the algorithm in this paper with adding nonlinear inertia coefficient.

As can be seen from figure 5, the number of iterations of BPSO algorithm reaching the optimal solution is 40 times, and the optimal solution is 73.923kw. Without the inertia weight factor of the algorithm in the iteration is 30 or so to get the optimal solution and the optimal solution for the 74 k W, this algorithm to achieve the optimal solution of the number of iterations in 12 times, the optimal solution for the 73.412 kW so in this paper, the improved particle swarm algorithm is compared with BPSO algorithm and did not join the nonlinear inertia weight factor of the algorithm has better optimization results, faster convergence speed, after join the mutation operator of algorithm has better global search ability, and the performance of the algorithm is further improved.

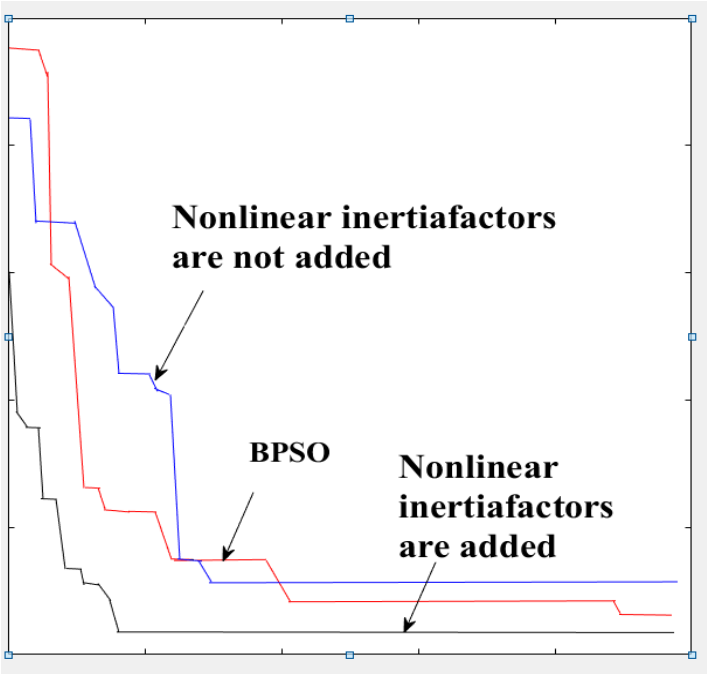



FIG. 6 shows the voltage curve of each node after distribution network reconstruction using the improved binary particle swarm optimization algorithm with direction matrix.

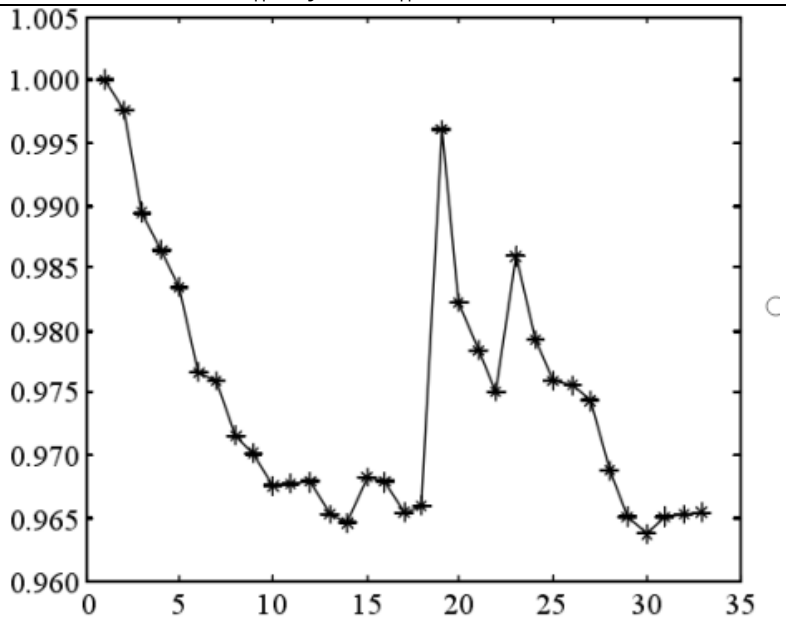



Fig. 6 Node voltage curve

As can be seen from figure 6, in the algorithm optimization results of this paper, the lowest node voltage value is 0.9648p.u., and the voltage value of each node does not exceed the limit. It shows that selecting reasonable access capacity of DG can optimize the operation of the system. When accessing DG, in order to make up for the voltage instability caused by the absence of reactive power, an appropriate reactive power compensation device can be introduced. In addition, this paper also applies the improved binary particle swarm optimization (pso) algorithm to reconstruct the distributed generation when it is connected to the distribution network output as an adjustable device. Table 3 shows the reconstruction optimization results under different output conditions.

Table 3 Result of reconfiguration and optimization with DG

| DG adjustable | Power loss/kW | Node minimum voltage/p.u. | Open switch |
|---|---|---|---|
| 100% | 72. 412 | 0. 9648 | 7-8、9-10、14-15、16-17、25-29 |
| 75% | 91. 168 | 0. 9572 | 7-8、9-10、14-15、17-18、25-29 |
| 50% | 139. 551 | 0. 9378 | 7-8、9-10、14-15 32-33、25-29 |

## 5. CONCLUSION

The multi-objective function is composed of the active power loss and voltage offset of the distribution network, and the multi-objective function is converted into a single-objective function according to the normalization and weighted sum of the multi-objective functions according to the initial state of the network. The nonlinear dynamically adjusted inertia weight coefficient and direction matrix are introduced into binary particle swarm optimization (pso) to improve its global search efficiency and convergence speed. The simulation results show that the proposed method can effectively reconstruct the distribution network, reduce the active power loss and voltage deviation of the system, improve the economy and reliability of the distribution network operation, and improve the automation level of the distribution network.

## 6. REFERENCES

[1]. Civanlar S, Grainger J J, Yin H, et al. Distribution feeder reconfiguration for loss reduction[J]. IEEE Trans on Power Delivery, 1988, 3(3): 1217-1223.

[2]. Bi Pengxiang, Liu Jian, Zhang Wenyuan. A refined branch-exchange algorithm for distribution networks reconfiguration [J]. Proceedings of the CSEE, 2001, 21(8): 98-103.

[3]. Baran M E, Wu F F. Network reconfiguration in distribution systems for loss reduction and load balancing [J]. IEEE Trans on Power Delivery, 1989; 4(2): 1401-1407.

[4]. TIANHao, LÜ Lin, GAO Hongjun, et al. Dynamic reconfiguration of distribution network considering power gridoperation characteristic [J]. Power System Protection and Control, 2015, 43(1): 9-14

[5]. Li Zhenkun, Chen Xingying,Yu Kun, et al. Hybrid particleswarm optimization of distribution network reconfiguration[J]. Proceedings of CSEE, 2008, 28(31): 35-41.

[6]. Ma Caoyuan,Sun Zhanzhan,Liu Jianhua,Li Chunxiao.Distribution Network Reconfiguration based on double Hybrid Particle Swarm Optimization[J].Proceedings of the CSEE,2016,31(11):120-128.

[7]. Chen Chun, Wang Feng, Liu Bei, et al. Network Reconfiguration Based on Basic Ring Matrix and Improved Harmony Search Algorithm [J]. Automation of Electric Power Systems, 2014; 38(6): 55-60.

[8]. Xie Pengyu. Research on Multi-objective Optimization and Reconstruction of Distribution Network with distributed Power supply based on artificial Fish Swarm algorithm [D]. Guangxi:Guangxi University,2018

[9]. WANG Jiajia, LÜ Lin, LIU Junyong, et al. Reconfiguration of distribution network containing distribution generation units based on improved layered forward-backward sweep method [J]. Power System Technology, 2010, 34(9): 60-64.

[10]. KENNEDY J, EBERHART R. A discrete binary version of the particle swarm algorithm[C] // Proceeding of IEEE International Conference on Systems, Man, and Cybernetice, Orlando, USA, 1997.

[11]. Han Xuejun, Chen Peng, Guo infeng, et l. A Power Flow Based Reconfiguration Method of Distribution Networks [J]. Power System echnology, 2007; 31(17): 60-63.

[12]. SUN Jun. Particle swarm optimization with particles having quantum [D]. Wuxi: Jiangnan University, 2009.

[13]. ZHENG ai. Studies n modified uantum-behaved article swarm optimization algorithm for reactive power optimization in power system [D]. Chengdu: Southwest Jiaotong University, 2010.

[14]. HU Wei, HUANG Chun, SUN Yanguang, et al. Distribution network reconfiguration based on artificially propagated hybrids [J]. Electric Power Automation Equipment, 2014, 34(9): 106-111.

[15]. ESMAEILIAN H R, FADAEINEDJAD R. Energy loss inimization in distribution systems utilizing an enhanced reconfiguration method integrating distributed generation[ J]. IEEE Systems Journal, 2015, 9(4): 1430-1439.