IOP Conf. Series: Materials Science and Engineering **394** (2018) 042121 doi:10.1088/1757-899X/394/4/042121

Research on Three Times Control of Microgrid Based on Artificial Bee Colony Algorithm

Jigang Bao*, Hengyi Fu, Shixin Zhu and Ying Zhang

College of Technology and Engineering of .LUT, Lanzhou, Gansu, 730050, China

*Corresponding author e-mail: 36508120@qq.com

Abstract. Due to the wide application of the micro grid energy management system and its important has been studied in this paper, artificial bee colony algorithm, based on a control and two control, three times of the control layer energy management system are analyzed, and the algorithm into the three controller, through the algorithm to achieve the maximum power penetration of the micro grid management, the micro grid system is more economical and efficient. Finally, the simulation platform is built, and the effectiveness of the proposed control strategy is proved by the simulation results.

1. Introduction

With the development of Distributed Generation (DG), by reducing energy consumption, improve the stability of power system, being extensive research, but because of distributed generation research cost is higher, strong randomness, the relative control more difficult, and the power that the distribution network receives, etc., have become an important factor restricting the development of distributed generation[1-3]. Therefore, in order to coordinate the distributed generation and distribution network, the microgrid arises at the historic moment, and widely used, the microgrid is made of the distributed generation, energy storage device, the power load and monitoring equipment, the protective devices, and the energy management system, that can provide electricity to the local load and the heat of the small power distribution system. Microgrid is connected to the distribution network as a whole through the Point of Common Coupling (PCC), but it also exists such as power distribution, power quality, system stability and sustainable economy, how to deal with the above issues has become the key [4].

Literature [5] proposed a hierarchical control strategy to allocate power in different time domains and domains, but the communication between DG and DG was limited. Literature [6] with the method of hierarchical control, also the way of network communication link, make contact with the upper control DG, is good enough to enable the lower level data is exchanged, but the goal is not clear between layers. Based on the hierarchical control method, a control for the exchange of data, the secondary control to control deviation value, through the three control is put forward, to manage the micro grid energy, as their top management center, it can be very good for power distribution, troubleshooting and problem analysis, this paper analyzes three control is introduced.

2. Organization of the Text

For distributed control block diagram in figure 1, the first control as the basic control and the second control involves the power quality control, such as a voltage/frequency response, voltage imbalance, harmonic compensation and communication in the grid interconnection is also in the second control scope. The goal of tertiary control includes tidal current regulation and Energy management. Power flow regulation ensures accurate power distribution control in DG units and power exchange between microgrids.

2.1. The first control

The first control is shown in figure 1, its control principle and method are not introduced in detail, and the controller includes positive and negative sequence separator, current and voltage control loop, and active and reactive power droop control loop and virtual impedance loop. The second order generalized integral method is a method for the separation of positive and negative order. The positive and negative sequence is separated by the output end of DG, and the voltage and current component is obtained. The obtained component contains the sinusoidal voltage reference signal through the droop control and reference generation module. Due to unbalance of the PCC point voltage, analyze and compensate can be done through the second control. The generated voltage compensation coefficient compensates for the sinusoidal voltage reference signal. And combined with the virtual voltage drop generated by virtual impedance, the standard reference voltage is obtained. As the standard input voltage, it is controlled by the double loop of voltage and current, and the inverter is controlled by the pulse signal [7].

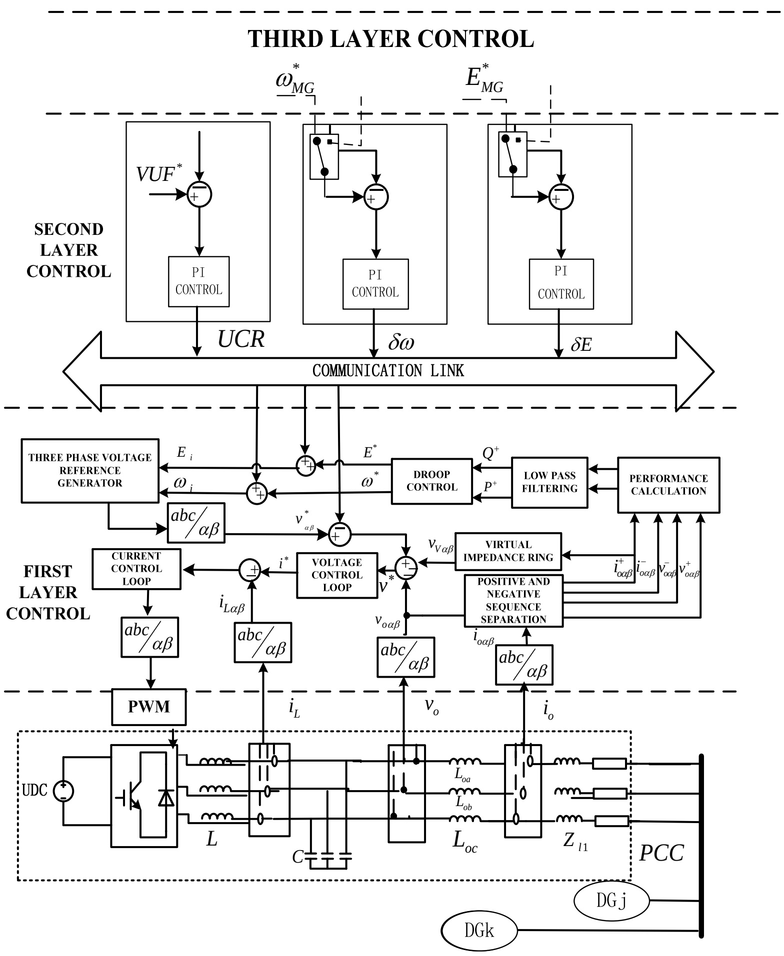

Figure 1. Hierarchical control block diagram.

IOP Conf. Series: Materials Science and Engineering **394** (2018) 042121 doi:10.1088/1757-899X/394/4/042121

2.2. The second control

The secondary control involves power quality control. As shown in the figure, the voltage/frequency deviation, voltage imbalance, harmonic compensation and AC grid connection is mainly controlled. Through the secondary control, the micro grid can be further tracked and adjusted, and the control of hardware data is realized on the basis of the first control [8]. The control principle of this paper is shown in figure 1, and no further introduction.

2.3. The third control

The third controller is installed in the central controller on the basis of first control and second control. According to different operating modes (island and parallel network) requirements, different functions are provided on the micro grid. When the micro grid is in the isolated island mode, the third control can maintain the constant nominal voltage, and the reference frequency is the secondary control cycle, which is the basic requirement for the generated power quality. In the grid connection mode, it manages the micro grid and the large power grid, and the active and reactive power flow is measured and compared in the grid connection point, the frequency and voltage amplitude reference and then the secondary control loop is generated. In this way, the micro grid system through the management of the energy and applies the control algorithm, to control the three times of power allocation, economic operation etc, so as to ultimately realize the maximization of the efficiency and the optimization of energy management of micro power grid [9-10].

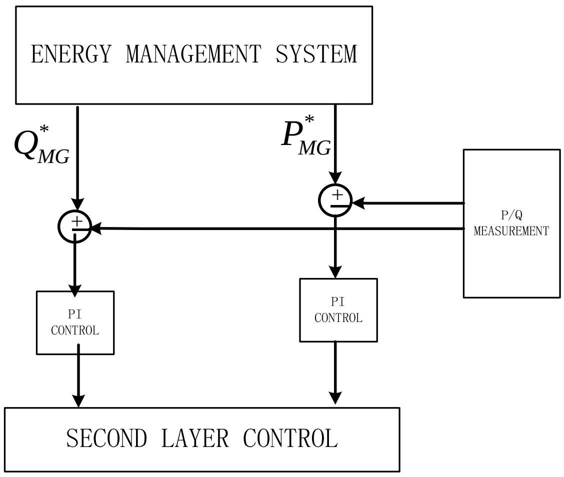

Figure 2. Three control block diagrams.

In this article, three control layer shown in figure 2, with the introduction of artificial swarm algorithm, in the form of energy management system for active power P and reactive power Q biggest osmotic regulation, the realization of the algorithm are described in the following paragraphs. Among them, the maximum active power P^*_{MG} and the collected P are compared, the reactive power of the regulation is compared with the reactive power collected, and finally, the control of the PI deviation is adjusted. In this paper, the third control layer can not only solve the maximum power penetration problem, when in isolated cases, it can maintain the stable frequency f^*_{MG} and voltage E^*_{MG}a for the secondary control layer, and provide the power quality standard voltage imbalance degree VUF^*. When in parallel mode, the three control layer to control the output power, with power grid by collecting the real-time power and compared with the reference power, after compared deviation, eventually produce reference voltage and frequency to the secondary control layer, the energy management system can be optimized using different energy, efforts to achieve economic operation of microgrid.

3. Implementation of algorithm

Because of the widespread use of distributed energy, new energy has been an important research on the use of utilisation, how to maximize the efficiency of renewable energy, which is mainstream. Therefore, in view of the utilization ratio of new energy sources, it is important to research the permeability of the microgrid when gritting, and the energy utilization rate of the microgrid is greatly increased when the required penetration rate is greater. The traditional existing distribution network has some problems of its own, and its design and planning are not as much as the larger capacity, but it's based on the traditional factors. Therefore, it is necessary to consider the maximum permeability from the study of the microgrid output, and the maximum permeability of the microgrid can address the output power.

In order to further improve the energy utilization ratio and optimize the output power of the microgrid, research on the existing situation is carried out, taking into account the maximum value of the permeation rate of the micro-grid, in this paper, from the objective function of the micro-grid, the maximum active power of the microgrid can be expressed as:

$$\max F_1 = P_m \tag{1}$$

Because the load of distribution network is certain, the objective function can be expressed as:

$$\max F_2 = \lambda \tag{2}$$

$$\min F_3 = 1 - \lambda \tag{3}$$

The permeability of micro grid should reach the target value, and it is considered as the maximum permeability power of the distribution network [11]. When the distribution network is running, it needs to meet certain current balance. At this time, according to the requirements of the node voltage of the distribution network, the voltage of the distribution network needs to be within a certain voltage range. The power of the micro-grid to the distribution network will affect the stability of the distribution network operation, and the output power of the motor needs to be restrained:

(1) Current balance

$$\begin{aligned} P_{m,i} - P_{LD,i} - U_i \sum_{j=1}^{n} U_j (G_{ij} \cos\theta_{ij} + B_{ij} \sin\theta_{ij}) = 0 \\ Q_{m,i} - Q_{LD,i} - U_i \sum_{j=1}^{n} U_j (G_{ij} \sin\theta_{ij} - B_{ij} \cos\theta_{ij}) = 0 \end{aligned} \tag{4}$$

In this case, n is the number of nodes, and i and j are Serial number of nodes in the system. $P_{m,i}$, $Q_{m,i}$ are the active and reactive power of node i, respectively. $P_{LD,i}$ and $Q_{LD,i}$ are the active and reactive power of the load at node i, respectively. U_i and U_j are node voltages[12-14]. G_{ij}, B_{ij} and θ_{ij} are the conductance, susceptance and Phase Angle difference of the voltage between node i and j.

(2) Power balance

$$\sum_{k=1}^{N_g} P_k + P_m = P_{LD} + P_L \tag{5}$$

In this case, N_g is the number of generators, P_k is the power generated by the kTH generator, P_m is the exchange power between the microgrid and the power grid, P_{LD} is the load of the grid, and P_L is the power of loss.

(3) Node voltage constraint

$$V_{\min} \le V_i \le V_{\max} \tag{6}$$

(4) Power constraint

$$P_{g,i}^{\min} \le P_{g,i} \le P_{g,i}^{\max} \tag{7}$$

In this case, $P_{g,i}^{\max}$ and $P_{g,i}^{\min}$ are the maximum and minimum values of the number i generator.

(5) Application of the algorithm

In this paper, the proposed artificial colony algorithm is applied to micro power grid, which to solve the problem of the maximum penetration, and its specific steps are as follows [15]:

Step 1: first, initialize the input distribution network system, and control the algorithm parameters: the population number of the swarm is N, and the maximum number of iterations, the maximum number of iterations and the comparison parameters are carried out for the local maximum limit.

Step 2: the random variable is initially decomput into x_i , and a current calculation and analysis is performed on the electric network.

Step 3: check the node voltage of the power grid through the result of the flow calculation, and see whether the constraint condition is satisfied. If satisfied, proceed to the next step and if no, return step 2 to resume.

Step 4: The results are modified according to the value produced in formula (3-4), and a new solution $x'_{i,new}$ is obtained with the crossover operation, and the current calculation is carried out.

Step 5: check whether the node voltage of the power grid meets the constraint condition according to the results obtained by the power flow calculation. If satisfied, proceed to the next step and if no, return step 4 to resume.

Step 6: select the new solution x_i according to the calculation criteria.

Step 7: the tracking algorithm of each bee was observed, and the honey source search was conducted according to the probability of selection, and the new solution was selected according to the criteria.

Step 8: according to the local test, checking whether the Limit is reached. If reached, it will give up this solution and jump to step 2. Otherwise, proceed to the next step.

Step 9: the optimal solution is obtained by comparison.

Step 10: the maximum number of iterations was detected to see if the expected value was reached. If satisfied, the program ended. Otherwise, jump to step 4.

4. Results operation analysis

This experiment platform built three DG micro grid system, through the three general controllers work together, control of micro grid is studied, and analyze the cause of micro grid fault. The simulation figures are shown below.

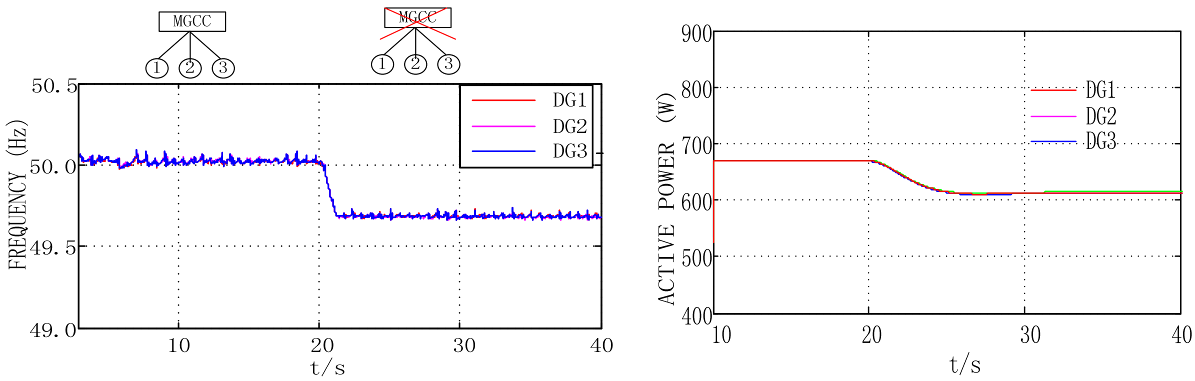

Figure 3. MGCC fault simulation analysis diagram.

Figure 3 shows the response of the system under fault conditions. The figure shows the active power and frequency of the system in the case of MGCC failure or communication failure. It can be seen from the figure that, in 20s, the MGCC system fails, and the frequency of the system drops to 49.7HZ, but the power distribution is still guaranteed. This is because the system's MGCC malfunctioned, and the second control of the system has lost contact with three control, so the frequency of the secondary control has not been adjusted for secondary control, and the frequency has dropped. The active power of the system also fails to accept three control adjustments due to the disconnection of communication. However, due to the effect of droop control, the power of the system is still distributed according to the distribution of droop control, which is equally divided according to 1:1.

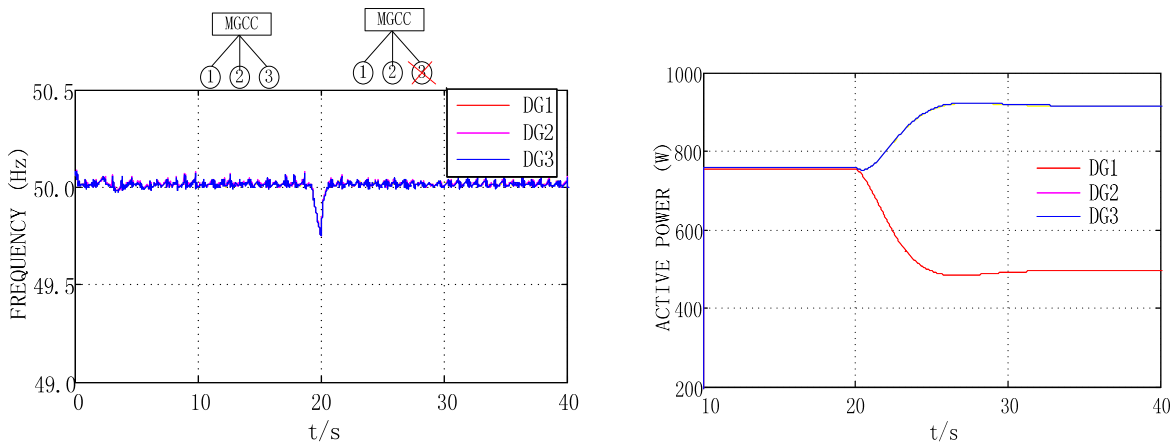

Figure 4. DG3 fault simulation analysis diagram.

FIG. 4 shows the failure state of the response unit when the system communication link or a DG is lost. It can be seen that in 20s, the system fails, the communication link between DG3 and MGCC is lost, DG3 stops the load power, but DG1 and DG2 can support the system and maintain the frequency nominal value, and the power is equally divided according to the system requirements. This proves that the three control is good for the distribution and regulation of power, which is that the micro-grid system can handle and recover the faults in a very short time interval.

5. Conclusion

In this paper, the energy control system of micro grid is studied and analyzed, and the hierarchical control strategy is put forward, and the basic parameter adjustment and data control of micro grid are controlled by the first layer in the control system. The parameter deviation of the first layer control can be regulated in the second layer control, which is on the basis of control of the first layer, and makes the system precision. In the third layer of control, the algorithm is added to optimize the energy management of the system, so that the three-layer control system can achieve the maximum permeability. Finally, this paper analyzes the simulation judgment of system failure, and proves the necessity and rationality of the control strategy proposed in this paper.

Acknowledgments
This work was financially supported by scientific research projects in Colleges and universities of Gansu province (2016A-158).

Author: BAO jigang, male, Lanzhou, Gansu, engineer, master, research direction for distributed generation and micro grid operation and control.

TELEPHONE: 13893260219

References

[1] Zeng zheng, Zhao rongxiang, Yang huan. Dynamic phase model and simulation of micro grid with inverter [J]. Journal of Chinese electrical engineering, 2012, 32 (10): 65-71.

[2] J. M. Guerrero, J. C. Vasquez, J. Matas, L. G. de Vicuna, and M. Castilla,“Hierarchical control of droop-controlled ac and dcmicrogrids—Ageneral approach toward standardization,” IEEE Trans. Ind. Electron, 2012, 58 (1): 158–172.

[3] LexuanMeng, Member. "Flexible System Integration and AdvancedHierarchical Control Architectures in the MicrogridResearch Laboratory of Aalborg University [J]. IEEET ransactions on Industry Applications, 2016, 52 (2): 1736-1749.

[4] Wu yu, Pan wenxia, et al. Power control strategy of micro-grid based on hybrid energy storage [J]. Power system and automation journal ,2013, 25 (2): 109-158.

[5] Lu zhipeng, Luo an, jiang wenqian, etc. Study on the high performance grid control of the four-bridge arm microgrid inverter [J]. Journal of Chinese electrical engineering,2012, 32 (6): 1-9.

[6] Lu zhenyu, Wu zai jun, Dou xiaobo et al. Adaptive droop control of isolated dc micro grid based on discrete consistency [J]. Journal of Chinese electrical engineering, 2015, 35 (17): 4397-4407.

[7] Wang chengshan, Li xialin, Guo li. Coordinated control of two-stage converter based on power balance in time delay compensation [J]. Journal of Chinese electrical engineering, 2012, 32 (25): 109-117.

[8] S. Buso and T. Caldognetto, “Rapid prototyping of digital controllers formicrogrid inverters,” IEEE J. Emerg.Sel. Topics Power Electron.Jun. 2015, 3 (2): 440–450.

[9] Wu lizhen, Yang xusheng, hao xiaohong. Compensation strategy for unbalanced voltage of micro grid based on secondary control [J]. Power electronics technology, 2017, 51 (5): 42-45.

[10] Jinpeng, Aixin, Xu jiajia et al. Economic operation model of isolated micro-grid based on sequential operation theory [J]. Journal of China electrical engineering engineering,

[11] Shafiee Q, Guerrero J M, Vasquez J C. Distributedsecondary control for islanded microgrids: a novelapproach [J]. IEEE Transactions on Power Electronics, 2014, 29 (2): 1018-1031.

[12] Hirase Y, Noro O, Sugimoto K, et al. Effects ofsuppressing frequency fluctuations by parallel operation ofvirtual synchronous generator in microgrids [C]//Proceedings of 2015 IEEE Energy Conversion Congressand Exposition (ECCE). Montreal, QC: IEEE, 2015: 3694-3701.

[13] Ren ling, Li shunfu, Yang xusheng. Research on control methods of micro-grid system [J]. Automation and instrumentation, 2017: 14-19.

[14] Liu zhiwei. Research on multi-objective optimization of micro grid under high permeability [D]. Power system automation, 2016.

[15] Zhao rui, Zhang leiqi, xin huanhai, et al. Decentralized self-optimizing control strategy for isolated island operation [J]. Power system automation, 2015, 39 (21): 30-36.