A MAS and CA Reactive Power Control for Islanded Multi-microgrid

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Abstract: At present, multi-microgrid voltage and reactive power control research is still a bottleneck. Based on this, the paper studied the voltage and reactive power control methodology of multi-microgrid in an island mode, analyzed the current multi-microgrid voltage and reactive power control strategy. The key contribution of this paper is to capture the superiority of Multi-agent systems in collaborating with each sub-microgrid and the advantage of cellular automata model in monitoring solitary erupted inside the microgrid reactive voltage change to propose islanded mode voltage and reactive power control strategy, which is based on a distributed multi-agent coordination model constructed in the paper. Finally, it has verified that this method can solve the multi-microgrid voltage and reactive power control problem in the islanded mode effectively through PSCAD/EMTDC simulation. But in the simulation, an real-time monitoring for micro-cellular source and a large number of experimental data is a must to prove the relationship between the sub-micro-grid, so the task is tough relatively.

Keywords: multi-microgrid; islanded mode; reactive power; multi-agent systems; cellular automata

1. Introduction

Large grid is the main power supply channel. While a series of wide blackout and natural disasters attack happened in recent years, its vulnerability has fully exposed. Several disadvantages such as high costs, operating bump are failing satisfy the ever-increasing security and reliability requirements of users [1]. It’s that these drawbacks cast the large grid as falling object and enable the study of microgrid to progress in the ascendit. In the current state, the study of microgrid in our country is just getting started when compared to the US, Japan and other developed countries. Nowadays China is facing an increasingly prominent challenge of energy bottlenecks. The study of multi-microgrid reactive power control is of great urgency [2].


Stage cellular automata (Cellular Automata, called CA) model is applied to study more traffic, rural land, financial, the application in the power system is just getting started, and it’s even less in microgrid. Document [7] used the combination of multi-agent and CA to simulate urban land expansion method. This strategy can be applied to our grid. Document [8] proposed a Fisher method and CA theory. Based on CA of the basic theory and its application in dynamic simulation of the evolution of the city, document [9] proposed a new spatial distribution of power load forecasting methods. Document [10] proposed an approach based on Fisher and CA, but the message didn’t contain a specific role between cellulars. Document [11] proposed a MAS and CA-based “bottom-up” microgrid distributed coordination control model and microgrid self-approximate-optima strategy. However, the paper didn’t involve CA or MAS model in multi-microgrid.

This paper innovatively built a microgrid distributed coordination control model, and proposed reactive power and voltage control strategy of islanded multi-microgrid based on MAS and CA. On this basis, the simulation proved that this method can effectively regulate the microgrid’ reactive voltage, and maintain the stable operation of the system.

2. Research method

2.1. The system network architecture and reactive power and voltage control of multi-microgrid

The system network architecture of multi-microgrid In this paper, a multi-microgrid system consists of three islanded sub-microgrids. When the switch 1 disconnects, the three sub-microgrids A, B, C turn into a solitary island mode. Switch 2, 3, 4 can control network connection status between sub-microgrids. This multi-microgrid including photo-voltaic generators, wind turbines, fuel cells, micro-turbines, local loads, transformers, circuit breakers (switches), converters, bus, power cables and other elements. Multi-microgrid system structure diagram is shown in Figure 1.
Microgrid island operation reactive voltage characteristics

When microgrid operates in islanded mode, due to the lack of external voltage and frequency from the power grid support, there is some challenges for the microgrid frequency controlling. At this point, all the microgrid load is provided by the distributed power (Distributed Generation, called DG)[1]. This needs to maintain its own internal microgrid electricity supply and demand balance, you also need to ensure a relatively stable voltage and frequency, but their ability to regulate microgrid doesn’t necessarily meet the load requirements. If the load fluctuations, it is difficult to achieve microgrid voltage regulation, voltage collapse may even be the case; if the ability to regulate the microgrid can meet the requirements of load changes, but the load change, particularly reactive load changes are also possible to cause large fluctuations in voltage. So in island mode, load changes and their ability to regulate microgrid need to be considered[2]. When multiple microgrid in a certain sub-microgrid operates in island mode, and it is difficult to achieve a balance between supply and demand of power itself, and whether there is between it and the interaction of other sub-microgrids, how to maintain a stable output bus voltage and frequency, which is still very necessary to be studied in the present.

In this paper, in order to solve this problem, a multi-layered microgrid distributed coordination control model based on MAS and CA is built, for monitoring islanded microgrid and each sub-microgrid voltage and reactive power output, as well as when a sub-microgrid fails. Other sub-microgrid how to make multi-microgrid overall stability.

Mathematical models of microgrid voltage and reactive power

For any more than a micro-network subnet, reactive power balance equations at each node in the sub-microgrid is[12]:

\[
\Delta Q_i = \sum_j B_{ij} (U_j - U_i) + F_i
\]  

(1)

Where: \( B_{ij} \) is mutual admittance nodes i and j; \( U_i \) and \( U_j \) are the two points; \( F_i \) is the influence of other load node voltage; \( \Delta Q_i \) is the load voltage change value; \( U \) is the load voltage change value; \( \Delta Q_i \) is micro-net mutual influence between subnets, so here \( F_i = 0 \).

Using a vector representation of all loads and generators vector interests in the region, and get:

\[
\mathbf{Q} = \begin{bmatrix} Q_L \\ Q_G \end{bmatrix}
\]  

(2)

And

\[
\mathbf{U} = \begin{bmatrix} U_L \\ U_G \end{bmatrix}
\]  

(3)

\[
\mathbf{F} = \begin{bmatrix} F_L \\ F_G \end{bmatrix}
\]  

(4)

Equation (1) can be written as:

\[
\dot{\mathbf{Q}} = \mathbf{D} \dot{\mathbf{U}} + \mathbf{F}
\]  

(5)

Among them,

\[
\mathbf{D} = \begin{bmatrix} D_{LL} & D_{LG} \\ D_{GL} & D_{GG} \end{bmatrix}
\]  

(6)

In (5), \( \mathbf{D} \) is the sensitivity matrix, which is part of trend equation Jacobi matrix voltage and reactive power related, which, DGG is for mutual admittance between micro feeder; DGL and DLG are micro power feed mutual admittance between the feeder and the load; DLL is transmission between load feeders. So linearized system model can be described as the following equation sensitivity (assuming \( \mathbf{F} = 0 \)) [12],

\[
\begin{bmatrix} \Delta Q_L \\ \Delta Q_G \end{bmatrix} = \begin{bmatrix} D_{LL} & D_{LG} \\ D_{GL} & D_{GG} \end{bmatrix} \begin{bmatrix} \Delta U_L \\ \Delta U_G \end{bmatrix}
\]  

(7)

In (6) where: \( \Delta U_L \) is the load voltage change value; \( \Delta U_G \) is micro power supply voltage change value; \( \Delta Q_L \) is the load reactive power variation value; \( \Delta Q_G \) is micro supply reactive power change value.

If \( \begin{bmatrix} \Delta U_L \\ \Delta U_G \end{bmatrix} \), then (6) can be shorted for:

\[
\begin{bmatrix} \Delta U_L \\ \Delta U_G \end{bmatrix} = \mathbf{D} \begin{bmatrix} \Delta U_L \\ \Delta U_G \end{bmatrix}
\]  

(8)

Where: \( C_{UL} \Delta U_G \) is the influence on the load node voltage; \( C_Q \Delta Q_L \) is load node voltage changes in the value of reactive power disturbances. The expression of Agent at this time is the load calculation of voltage deviation.

2.2 Multi double-layer microgrid distributed coordination control model based on MAS and the CA

MAS Description and Construction

MAS is a distributed autonomous system composed by multipleAgent. MAS performance was achieved by the interaction of multiple Agent. Agent is an essential part of MAS. And the Agent have autonomy, communication, coordination and other characteristics. The interdependence between MAS Agent, interaction and mutual influence, on the one hand they complete autonomy according to the operation of mission-specific regulator, on the other hand can share information and tasks between the
communication system with the same level Agent, accept and feedback informations, to achieve the overall coordination system to achieve the maintenance of microgrid voltage level of purpose[12].Four kinds of Agent used in this paper: Grid Agent (PCC Agent); microgrid Agent; Local Control Agent (LC Agent); micro-source Agent.

The main function of PCC Agent is providing the interface for large grid and microgrid, the interface can be achieved through microgrid and large power grids and network operation status and switching microgrid islanding operation state ; while large grid can give orders to microgrid by PCC Agent.

Microgrid Agent’s main function is to monitor and manage the local Control Agent. On the one hand, microgrid Agent obtain information from various local control Agent ; on the other hand, microgrid control Agent responsible for the organization and management of local control Agent, accept the commands of large grid.

Local Agent’s main function is to control the local micro-source Agent and load management unit. On the one hand, LC Agent control the micro-source and the load unit management, execution control strategy; on the other hand, it is responsible for receiving microgrid control commands sent to the Agent or to send feedback.

The main function of the micro-source Agent for sources of local micro-managing, storing micro sources ( solar batteries, wind turbines,etc.) related information ( rated power, distributed energy sources,etc.) and power output, and condition monitoring of micro sources, control methods to accept a higher level of local control Agent commands.In the microgrid, interactions between each Agent shown in Figure 2.

About CA CA is a model which using simple local operations to simulate space discrete time and discrete complex phenomena [7]. CA somehow distributed in a regular grid of discrete state in any place, and in the same state update rule, which is formed by a simple dynamic system interaction. CA includes cellular and state, cellular space, neighbors and transformation rules, the model is shown in Figure 3 [8].

Cellular is a basic element of the CA. Under normal circumstances, cellular usually stores two states 0,1 state sets, cellular space is the space in which the mesh collection. CA neighbor effect in the current cellular status.CA Moore dimensional neighbor type, von Neumann type, and extended Moore type. Moore is the common type. Article cellular automata model uses the neighbor using Moore type, which is defined as [8]:

\[ N_{\text{Moore}} = v_i = (v_{i-x}, v_{i-y}), i = 1,2,3, \ldots, 8; \]

Where \( |vix-v0x|, |viy-v0y| \leq 1; (vix, viy) \in Z2; vi for cellular neighbors ; (v0x, v0y) \) coordinates the center of the unit cell ; (vix, viy) for coordinate neighbor unit cells ; Z2 on behalf of two-dimensional cellular space.

The evolution rules of CA is a function which refers to cellular according to the state of the current state of their own or neighbors to determine the next time state. Thus define the cellular automaton model is as follows [8]:

\[ C_{i+1} = f(C_i, C_{i-N}); \]

Where \( f \) — CA evolution rules; \( t \) - time ; CNi — cellular neighbor state combination ; Cti — t time i cellular state; CNI—Cellular neighbor state combination; Cit+1 — t + 1 time i cellular state.

Double coordinated control model based on MAS and the CA In this paper, a two-layer architecture model constructed based on the structure of MAS and CA. It’s a “bottom-up” multi-microgrid distributed coordination control model.

Top model by exchanging information between microgrid Agent to implement microgrid distributed coordination control function; CA based on the underlying model, describes the parameters used to monitor changes in the microgrid micro-sources and loads, as well as island...
2.3. MAS and microgrid based on multiple CA reactive voltage control strategy

Microgrid can be achieved with a large grid interconnection and off states of the switching by PCC Agent, so as long as you can determine the microgrid connection status the next time the power parameter monitoring by the PCC in order to determine whether the microgrid in solitary Presence. Microgrid islanding voltage limits shown in Table 1 [11].

In this paper, referring to characteristics of CA, we abstracted the micro-source and load into cellular, they constitute a set of cellular space, so that you can build with the CA model to simulate the operation of track-source and load operation between sub-microgrids.

Depending on the frequency of changes in the value, and the value of the unit cell voltage and voltage control to determine the current state of the unit cell. Cellular exceed the scope of a fault, this time cellular status value is set to "0" : if within the control range, it has been in a normal operating state or Cellular can return to normal state after trimming, then cellular status value "0." China use the nominal frequency is50Hz, normal operation should be kept within the range of 50 ± 0.2Hz, allows users to offset the supply voltage for 10kV and below the voltage level of ±7%, microgrid power supply voltage from 380V-10kV composition, this model Assuming 380V power supply, so the voltage tolerances shall not exceed 20-25V [13].

Under the lone network mode, the energy source of cellular micro output power and load absorbed power conservation equation [14-15]:

\[ Q = Q_L + \Delta Q \]  \hspace{1cm} (11)

\[ Q = Q_L = 3V_{PCC}^2 \left[ (\omega' L) - \omega' C \right] \]  \hspace{1cm} (12)

Where \( \omega = \omega + \Delta \omega \) is the angular frequency at PCC islanding mode;

\( V_{PCC} \) is phase voltage at PCC;

\( Q \) is active micro-source output and reactive power;

\( QL \) is load absorbed active and reactive power;

\( \Delta Q \) is excess active and reactive power;

\( \omega \) is the angular frequency at PCC;

\( V_{PCC} \) is phase voltage at PCC.

The high boundary of micro-source/line voltage can determine whether an emergency situation. Specific control strategy as follows [11].

1) When the PCC Agent monitoring phase voltage at PCC large grid voltage exceeds the limit to the islands, PCC Agent disconnect the breaker between large grid, then the multi-microgrid turned into the islanded state.

2) micro-source Agent/load Cellular periodically monitor local changes in the voltage frequency, and the value of real-time transmission to local control Agent.

3) Local Control Agent to determine the load on cellular transmit frequency and voltage variation value is within the scope of failure, if not within the scope of the fault, the local control Agent continues to receive real-time feedback from the load unit cell ; if the failure range, it is determined by adjusting the voltage controller is able to eliminate the limit voltage, and if so, then the command voltage controller to regulate the load voltage, otherwise local control Agent regulator issued a request to the micro network Agent.

4) Microgrid Agent After receiving the request command corresponding micro regulator source Agent / load voltage regulator of cellular to eliminate cross-border.

5) micro-source Agent / load Cellular judge whether self-regulation can be eliminated by cross-border, if it does, the self-adjusting voltage value, otherwise, immediately issued a request to assist in regulating the micro network Agent.

6) Upon receipt of a request microgrid Agent, select the desired source to assist micro regulator Agent / cellular load, if found that the Agent, the process continues ; otherwise, to 9).

7) Micro-source Agent / load to determine whether the regulator would help their cause interference voltage value. Assist in regulating micro source Agent / load after the completion of the task Cellular Network Agent feedback want to micro.

8) After the microgrid Agent receives feedback information to determine whether the elimination of cross-border voltage, if eliminated, then the information is sent to request the assistance of micro-source regulator Agent / load Cellular, skip to 10).

9) Micro Cellular Network Agent in accordance with the load with respect to the importance of microgrid to select required removal of the load, and ordered the appropriate local control Agent disconnected ; after local control Agent receives a command to disconnect the

Table 1 Isolated voltage limits

<table>
<thead>
<tr>
<th>The range of voltage</th>
<th>Short-term voltage</th>
<th>Over voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase voltage/kV</td>
<td>Time limit/s</td>
</tr>
<tr>
<td>The higher limit</td>
<td>0.24-0.26</td>
<td>1</td>
</tr>
<tr>
<td>The lower limit</td>
<td>0.11-0.2</td>
<td>2</td>
</tr>
</tbody>
</table>

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doi:10.12783/jasr.1544-8053/13/7/32

32.4
circuit breaker connection status is set to "0" ("0" represents a disconnected state, "1" represents the connection status), network Agent feedback information to the micro, skip 8).

10) After micro-source Agent / load voltage Cellular receive messages eliminate the limit again detect voltage state, if the voltage returns to normal, it sends a confirmation to assist in regulating the micro source Agent / cellular load, otherwise skip 5).

11) At this time a large grid fault elimination, after 3s, the microgrid Agent sends a command that to re-access to the microgrid to local control Agent which can be cut off load. And the connection state of the circuit breaker is set to "1", reconnected to microgrid.

12) After the elimination of a large grid fault, the fault has been eliminated will send information to the PCC Agent. PCC Agent will let each islanded mode sub-microgrid reconnect the power grid, restore grid state. The system may need to be adjusted at this time, skip 1).

When a sub-microgrid fails, will go off the circuit breaker to ensure the safe operation of the bus of power system and other sub-microgrids. At a time when other sub-microgrids of large grid will take over the task of regulating the bus voltage and frequency. If the bus voltage can not be stable, it must cut unnecessary load to maintain a stable voltage.

3. Results and analysis

3.1 System simulation model

The multi-microgrid in this paper consists of three islanded sub-microgrids. The simulation model contains four types of Agent. Sub-microgrid A which includes MT (micro-turbines) and PV (photo-voltaic battery pack); sub-microgrid B include FC (fuel cell) and WD (wind turbines); sub-microgrid C include PV (photo-voltaic battery pack) and WD (WTG). The simulation model was constructed PSCAD shown in Figure 5 (in this simulation model will not consider the lead resistance and loss during transmission).

According to the parameter range of distributed power, the parameters in this model each micro-cellular source is shown as in Table 2[1].

Table 2 Micro-power parameters table

<table>
<thead>
<tr>
<th>CA of micro-source</th>
<th>Rated power/kW</th>
<th>Active power/kW</th>
<th>Reactive power/kvar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind turbine (WD)</td>
<td>20</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Micro-gas turbine (MT)</td>
<td>65</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Fuel cell (FC)</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>photo-voltaic (PV)</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>

3.2 The simulation analysis study

Reactive power and voltage based on a mathematical model, combined with changes in the value of CA to monitor voltage and frequency. This paper considers the impact of sunlight, wind speed and a sub-microgrid failure between the multi-microgrids and sub-microgrid. In simulation, BRK0 switched off, each sub-microgrid is islanded. Assumed simulation time is 10s.

(a) The impact of light intensity changes on each sub-microgrid At the beginning of the light intensity is 600 W/m², the third scends is increased to 800 W/m², the light intensity restored to 600 W/m² when the sixth seconds, the simulation results are shown in Figure 6 to 8 (when the light intensity changes).
From 6 to 8 can obtain the following conclusions:

(1) When the light intensity was 600W/m², reactive power output of micro-turbine rose to 20kvar, fuel cells reactive power output rose to 10kvar, wind generator reactive power is maintained at 0kvar, photo-voltaic cells reactive power 0kvar; first 3s, the light intensity increased from 600W / m² to 800W/m², photo-voltaic cells reactive power stability in 0kvar. Micro-turbines and fuel cells reactive power output remains unchanged; the first 6s, light intensity back to 600W / m², micro-turbines and fuel cells reactive power remains unchanged, as shown in Figure 6.

(2) from Figures 7 and 8, when the light intensity changes, in the adjustment of sub-microgrid A microturbine, the bus voltage is substantially unchanged; sub-microgrid B in the regulation of the fuel cell, the bus voltage is substantially unchanged; reactive power output of the sub-microgrid C photo-voltaic cells and wind turbines is 0; system frequency has small fluctuations in the light intensity changes, but the frequency change value is still maintained at 50 ± 0.02 within Hz, microgrid to meet operational requirements.

(3) we can see from the above conclusion, the sub-microgrid A miniature gas turbine not only regulate the voltage on its own, but also the sub-microgrid B and C played a good role in the regulation makes multi-microgrid power is overall stable relatively.

(b) The impact of change wind speed on each sub-microgrid

In this paper, stochastic wind experiment. Light intensity is maintained at 800W / m², the simulation time is 10s, the simulation results shown in Figure 9 to 11 (wind speed changes).

From 9 to 11 can be obtained the following conclusions:

(1) can be seen from Figure 9–11, when the wind speed increases, the reactive power output of the wind turbine increases; when the wind speed decreases, the reactive power output of the wind turbine is reduced, and its reactive power output fluctuations in 0kvar. Reactive power microturbine output fluctuations in 23kvar; reactive power output of the fuel cell is about 15kvar fluctuations; reactive power output of photo-voltaic cells fixed to 0kvar. Microgrid more about 1.000pu bus voltage fluctuations, the small-scale fluctuations in the system frequency around 50HZ, meet the minimum system requirements, as shown in Figure 10 and Figure 11.

(2) From the above analysis, in islanding mode, the wind speed changes, in order to maintain the balance of reactive power of multi-microgrid systems, sub-microgrid A regulator in micro-turbines for micro and sub-microgrid Band C played good effect, so that the system bus voltage and frequency balanced relatively.

(c) The impact of sub-microgrid A fail on the multi-microgrid
At the beginning of the experiment, each sub-microgrid network mode in their lone run smoothly, in fifth seconds to swith the BRK1 between sub-microgrid A and bus disconnected, to simulate the gas turbine and photo voltaic battery fault, the simulation time is 10s, the simulation results shown in Figure 12 to 14 (when the gas turbine and photo voltaic cells fail).

Figures 12-14 can obtain the following conclusions:
(1) can be seen from Figure 12, the 0s-5s, micro-turbines and wind turbines fluctuations, and its reactive power output fluctuations up and down respectively 20kvar and 0kvar. Fuel cells and photo voltaic battery output steady reactive, reactive power fuel cell output fluctuations around 15kvar, reactive power output of photo voltaic cells fixed to 0kvar. Multi piconet bus voltage of about 1 ± 0.005pu fluctuations, small fluctuations in the system frequency of about 50 ± 0.02Hz, meets the minimum system requirements, as shown in Fig.13 and 14.

(2) In the first 5s, the sub-microgrid A bus with large grid connected BRK1 disconnect switch, shows the reactive power output of photo voltaic cells and micro-turbines group constant unchanged from Figure 13, fuel cells and wind turbines reactive power output has been fluctuating 15kvar and 0kvar small range.

(3) From the above analysis, when the child sub-microgrid A miniature gas turbine and photo voltaic battery fails, the fuel cell of sub-microgrid B regulation played a good role, so that the system bus voltage and frequency are very stable.

(4) The impact of sub-micro-network B fail on the multi-microgrid

At the beginning of the experiment, each sub-microgrid network mode in their lone run smoothly, in fifth seconds to swith the BRK2 between sub-microgrid B and bus disconnected, to simulate the fuel cell and wind power generator fault, the simulation time is 10s, the simulation results shown in Figure 15 to 17 (when the fuel cells and wind turbine fail).

Figures 15-17 can obtain the following conclusions:
(1) In Figure 15, the 0s-5s, micro-turbines and wind turbines fluctuations, and its reactive power output fluctuations up and down respectively 20kvar and 0kvar. Fuel cells and photo voltaic battery output steady reactive, reactive power fuel cell output fluctuations around 15kvar, reactive power output of photo voltaic cells fixed to 0kvar. Multi piconet bus voltage of about 1 ± 0.005pu fluctuations, small fluctuations in the system frequency of about 50 ± 0.02Hz, meets the minimum system requirements, as shown in Figs.16 and 17.

(2) In the first 5s, if it will be a sub-microgrid B with large grid connected switch BRK2 off the bus, we can see the reactive power output of the fuel cells and wind turbines constant unchanged from Figure 16, micro-turbines and photo voltaic battery pack reactive power output has been fluctuating around 20kvar and 0kvar respectively.

(3) From the above analysis, the micro gas turbine and photo voltaic battery fails, micro-turbines played a good role in the regulation has the effect of significantly coordinated interaction among sub-microgrid, so that the system bus voltage and frequency is very smooth.
4. Discussion

As it can be seen from the above experimental study, the proposed two-layer model based on MAS and CA for multi-microgrid voltage and reactive power control with good effect.


From the foregoing, MAS and droop voltage control method is more commonly used in the field of power electronics technology and methods, and reactive power and voltage control based on MAS and CA are compared to other micro-grid voltage and reactive power control of the main advantage of the following aspects.

1) Droop control law does not take into account the restoration of the system voltage, so when the microgrid suffered serious interference, voltage quality system may not be guaranteed; single MAS control, although to a certain extent on the case of members of the regulator, but it can not running state detecting various sub-micro-source cellular network can not respond and field solutions; and the proposed MAS and CA-based voltage control method can not only micro cellular source for real-time monitoring, but also reflect the MAS yuan cellular state to respond quickly to the solution, and by implementing the voltage control strategy can achieve the purpose of the system state operation, even in the micro-grid suffered serious disturbances, there are strategies to ensure the quality of the micro-grid voltage.

2) Droop control method only for control between each DG, MAS and CA method is suitable for the micro-grid model for components, elements can be flexibly added to microgrid, and to monitor them.

5. Conclusions

The article’s main contribution is to establish a reactive power and voltage control model of island multi-microgrid which based on MAS and CA. This model proposed a distributed coordinated control strategy of multi-microgrid reactive power voltage which is based on a combination of MAS and CA. And finally, the results show that the strategy of multi-microgrid islanding mode have a good control effect on voltage and reactive power output, system frequency and bus voltage using simulation. The control of multi-microgrid’s reactive power and voltage based on MAS and CA is highly flexible and intelligent. The model proposed in the paper promotes the development of microgrid in control domain.

However, the distributed control strategy without considering the changes of active power of multi-microgrid, the bus voltage in the grid mode or the system frequency control of multi-microgrid. These issues need further study in the future.

Acknowledgements

This work is supported by the scientific research project of Hebei Province Department of Education Fundi(Z2014036).

Reference
