Smooth Switching Control Method for Parallel and Off Grid of Distributed Photovoltaic Power Grid Based on Deep Reinforcement Learning

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Abstract. The parallel and off grid switching of distributed photovoltaic power grid will cause sudden changes in voltage and current, which is a key factor affecting its stable operation. Therefore, a research on the parallel and off grid smooth switching control method of distributed photovoltaic power grid based on deep reinforcement learning is proposed. The in-depth reinforcement learning method DQN algorithm is used to build the energy management model of the distributed photovoltaic power grid, explore the characteristics and laws of the distributed photovoltaic power grid, and on this basis, in-depth analysis of the transient phenomenon of the parallel off grid switching of the distributed photovoltaic power grid is carried out. Based on the PQ and VF control principles, the grid connected controller and the off grid controller are designed, and the smooth parallel off grid switching control strategy is formulated, The smooth switching control of the parallel and off grid of the distributed photovoltaic power grid can be achieved by implementing the strategy. The experimental data show that the minimum value of the sudden change coefficient of voltage and current obtained by the proposed method is 0.1 and 0.2, which fully proves that the proposed method has better control effect of parallel and off grid switching.

Keywords: Parallel and Offline Distributed Photovoltaic Power Grid · Smooth Switching · Deeply Strengthen Learning · Control Strategy · Island Detection

1 Introduction

The independent photovoltaic power generation system has a serious problem of day-night imbalance. The photovoltaic array can convert solar energy into electric energy only when there is sunlight in the day, and does not generate any electric energy at night. Photovoltaic power generation is also affected by natural factors such as light and season, and the output power fluctuates sharply [1]. If there is only an independent photovoltaic power generation system in the power supply network of a region, the quality of load power supply in that region is extremely poor, and there is the possibility

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of power failure at any time, which seriously affects work and life; If the independent photovoltaic power generation system is directly integrated into the distribution network, the power quality of the entire distribution network power supply area will be reduced, and even the regional distribution network will collapse, affecting the entire large power grid.

When the distributed photovoltaic power grid is not equipped with energy storage, due to the limitation of the output of the distributed energy itself, the ideal control effect cannot be achieved. The traditional microgrid controller is applied to the distributed photovoltaic power grid. Because it is not designed for the distributed photovoltaic power grid, it cannot adapt to the photovoltaic output characteristics, resulting in the unstable control effect. The voltage and current in the grid change greatly during switching [2]. Reference [3] proposes an improved Gaussian filter based on phase-locked loop (PLL) for power grid monitoring and seamless transmission control, which is used to improve the power quality of microgrid with photovoltaic cell energy storage (PV-BES). Reference [4] controls the connection of multiple PV strings and multiple inverters based on a photovoltaic DC switch topology. After the energy storage is added to the controller of the distributed photovoltaic power grid, the problem of day night imbalance of photovoltaic power generation can be solved by timely charging and discharging. The controller controls the distributed power supply module and energy storage module at the same time. During grid connected operation, the controller based on energy storage needs to keep the output power of the source storage module unchanged. During off grid operation, the controller needs to adjust the output power of the source storage module following the power fluctuation in the network. In addition, the controller needs to complete the state synchronization before and after the switching of the distributed photovoltaic power grid. At this time, if the charging and discharging control of the energy storage device is improper, the controller will still have poor effect. Therefore, the controller of distributed photovoltaic power grid is always considered to be the part prone to problems, and also the key to the parallel off grid switching technology of distributed photovoltaic power grid. Therefore, a research on the parallel off grid smooth switching control method of distributed photovoltaic power grid based on deep reinforcement learning is proposed.

2 Research on Smooth Switching Control Method of PV Grid Parallel and Off Grid

2.1 Establishment of Distributed Photovoltaic Grid Energy Management Model

In order to improve the smoothness of the parallel and off grid switching control of the photovoltaic grid, the first step is to build the energy management model of the distributed photovoltaic grid, explore the characteristics and laws of the distributed photovoltaic grid, and lay a solid foundation for the subsequent transient analysis of the parallel and off grid switching of the distributed photovoltaic grid [5].

In order to simplify the calculation, the AC side of the distributed photovoltaic grid is set to consider the photovoltaic power generation system and load. The DC side includes batteries and hydrogen based energy storage system composed of electrolyzers, hydrogen storage devices and fuel cells. The AC side and the DC side are connected through AC/DC converters. The main parameters of various equipment are shown in Table 1.

Table 1. Parameters of Distributed PV Grid Equipment

Equipment	Photovoltaic power generation	Battery	Hydrogen based energy storage
Peak power/kW	200	10	10
service life	20	20	20
Maximum capacity/kW·h	-	20	1500
Efficiency/%	20	90	60

In the distributed photovoltaic power grid, the final energy source is photovoltaic power generation, and its characteristic law conforms to the formula (1):

$$P_{\max} = P_t \times \alpha_z \tag{1}$$

In formula (1), $P_{\max}$ represents the maximum power output of photovoltaic power generation; P_t represents the solar radiation power received by the photovoltaic panel in real time; α_z represents the conversion efficiency of photovoltaic power generation.

The battery is mainly used as short-term energy storage equipment with high charging and discharging efficiency. It is mainly used to maintain the real-time supply and demand balance. Its characteristic law conforms to the formula (2):

$$R_{t+1} = R_t + \int P_c \times \alpha_c \mathrm{d}c - \int P_f \times \alpha_f \mathrm{d}f \tag{2}$$

In Formula (2), R_t and R_{t+1} represent the battery capacity corresponding to t and $t+1$ at time respectively; P_c and P_f represent charging and discharging power; α_c and α_f indicate the charging and discharging efficiency of the battery.

Hydrogen based energy storage is mainly used as long-term energy storage equipment with low charging and discharging efficiency and low peak power. However, it can store energy for a long time through electrolysis, mainly to balance the energy imbalance between seasons. Its characteristic law conforms to Formula (3):

$$\hat{R}_{t+1} = \hat{R}_t + \int \hat{P}_c \times \beta_c \mathrm{d}c - \int \hat{P}_f \times \beta_f \mathrm{d}f \tag{3}$$

In Formula (3), $\hat{R}_t$ and $\hat{R}_{t+1}$ represent the capacity of hydrogen storage device corresponding to t and $t+1$ at time respectively; $\hat{P}_c$ and $\hat{P}_f$ represent the power of electrolyzer and fuel cell; β_c and β_f indicate the efficiency of the electrolyzer and fuel cell.

Since the total load in the distributed photovoltaic grid is small, it is greatly affected by random factors, and the load curve has obvious volatility over time, so it will not be repeated [6].

Based on the above analysis results of the components of the distributed photovoltaic power grid, a distributed photovoltaic power grid energy management model is built by applying the in-depth reinforcement learning method - DQN algorithm, as shown in Fig. 1.

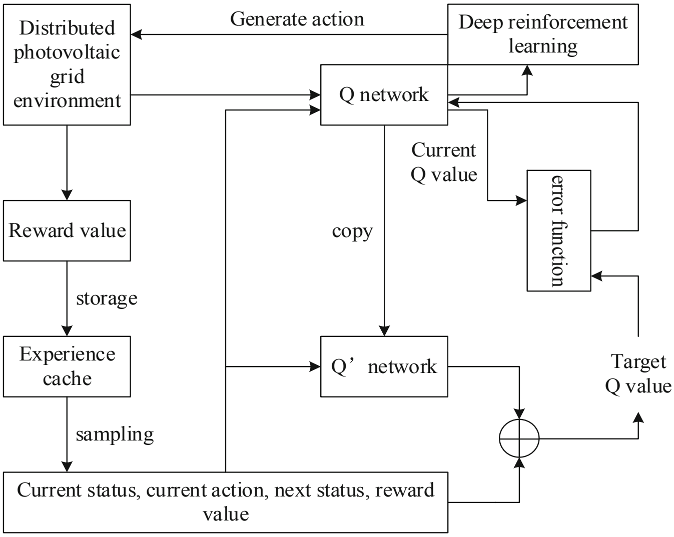

Fig. 1. Schematic diagram of distributed photovoltaic grid energy management model

As shown in Fig. 1, the construction model fully demonstrates the process of data flow and information interaction, which can be mainly divided into data generation, caching and sampling, neural network design and calculation, gradient calculation and parameter update, and action generation and selection [7].

(1) Data generation, caching and sampling. Under the state Γ_t at a certain time, when the environment receives an action Ψ_t, according to the Markov decision process, a reward value χ_t will be generated and the next state Γ_{t+1} will be obtained, thus generating the data tuple $(\Gamma_t, \Psi_t, \chi_t, \Gamma_{t+1})$. This group of data is further stored in the experience cache, and the array is randomly extracted from the experience cache when needed, so as to reduce the correlation between the data and facilitate the research of smooth switching control methods for PV grid parallel and off grid;

(2) Design and calculation of neural network. The neural network in the DQN algorithm is the Q network of the calculated value function and the Q' network of the same structure. The Q network accepts the current state and calculates the Q value from the sampled data in the experience buffer and copies it to the Q' network regularly. In this way, the model for calculating the target Q value will be fixed for a period of time, which can reduce the volatility of the model;

(3) Gradient calculation and parameter update [8]. The current R value $Q(\Gamma_t, \Psi_t; \vartheta)$ and target Q' value $\chi_t + \gamma \max Q(\Gamma_{t+1}, \Psi_{t+1}; \vartheta)$ are calculated by Q network and Q' network respectively. Where, ϑ represents the learning rate of the deep reinforcement learning method; γ represents the discount factor of the deep reinforcement learning

method. The gradient is calculated by the mean square error function and the parameters of the Q network are updated to realize the iteration of the Q network;

(4) Action generation and selection. In the DQN algorithm, actions are generated through $\max Q(\Gamma_{t+1}, \Psi_{t+1}; \vartheta)$ calculation. Since the same batch will sample multiple arrays during the sampling process, multiple actions will be calculated. In the action selection process, the depth reinforcement learning strategy is generally used, that is, the best strategy is selected with a greater probability, and the actions are selected randomly with a smaller probability to ensure sufficient exploration.

The main parameters of DQN algorithm, an in-depth reinforcement learning method, are set according to the operation characteristics of the distributed photovoltaic power grid, as shown in Table 2.

Table 2. Main Parameters of DQN Algorithm

Parameter name	Symbol	Numerical value
Iterations	Υ	1000
scale	Ω	32
Cache capacity	O	100000
Greed coefficient	ε	0.0001
Discount factor	γ	0.9
Learning rate	ϑ	0~1

The above process completed the building of the energy management model of the distributed photovoltaic grid, and analyzed the components of the distributed photovoltaic grid, providing support for the subsequent transient analysis of the parallel and off grid switching of the distributed photovoltaic grid.

2.2 Transient Analysis of Parallel and Off Grid Switching of Distributed Photovoltaic Power Grid

Based on the above energy management model of the distributed photovoltaic power grid, in-depth analysis of the transient phenomenon of the parallel off grid switching of the distributed photovoltaic power grid is carried out to make sufficient preparation for the subsequent design of the parallel off grid controller.

In the process of switching the distributed photovoltaic power grid from grid connection to island mode, there are various transient phenomena, mainly the instability of voltage, frequency and power, and the control of the distributed photovoltaic power grid is different due to the difference between the two modes. Therefore, necessary methods must be taken to ensure smooth switching and stable operation.

In the process of switching the distributed photovoltaic power grid from grid connected operation mode to island operation mode, the energy storage controller timely switches from three loop control to double loop operation mode. Since the filtered capacitor voltage loop and the filtered inductor current loop remain unchanged in the two operating modes, it can ensure the smooth and fast mode switching process of the system. When the load changes, it is necessary to further study how to ensure the power balance. As the energy storage device generally uses the battery, the energy density of the battery is high, but the dynamic response, power density and cycle life are far lower than those of the super capacitor [9]. It can be seen that the storage battery is an energy storage device, which is used to supplement the power shortage. The super capacitor has a fast response. In order to reduce the transient phenomenon in the switching process for a short time, the super capacitor uses VF control to quickly support the voltage and frequency of the distributed photovoltaic power grid system. This is very suitable for the switching of distributed photovoltaic power grid from grid connection to island operation mode, that is, during the switching process, the voltage and frequency support are quickly responded by the super capacitor, while the main power supply can be undertaken by the battery when the island operates stably to compensate for the power shortage. This not only avoids the performance defects of using one energy storage alone, but also avoids the additional configuration of power or capacity to achieve smooth switching when using a single energy storage, thus reducing the cost.

In the distributed photovoltaic power grid, the energy storage unit is composed of energy storage components, rectifier bridge and inverter bridge, and control system. When the distributed photovoltaic grid is connected to the grid, the energy storage unit can absorb excess energy for storage: when the distributed photovoltaic grid is operating in island mode, the dynamic response speed of the distributed photovoltaic grid needs to be improved by controlling the output energy of the energy storage device, which is used to adjust the active and reactive power balance of the distributed photovoltaic grid, and maintain the constant voltage and frequency of the distributed photovoltaic grid, Ensure the stable operation of distributed photovoltaic power grid. PQ control is adopted for micro power supply to make the energy storage device in charging standby state when connected to the grid, and improved VF droop control is adopted for the battery when off grid to ensure power balance, thus maintaining the stability of voltage and frequency in the distributed photovoltaic grid. When the supercapacitor is connected to the grid and turned into an island, the VF control that tracks the grid voltage is used to temporarily provide voltage and frequency reference for the distributed photovoltaic grid.

When the distributed photovoltaic power grid is operating in isolated islands, its voltage will deviate from the voltage of the large power grid due to the droop control effect. If the grid is connected to the grid after direct reclosure, huge impulse current may be caused, causing equipment damage and potential safety hazards. Therefore, before the grid connection of the distributed photovoltaic power grid, certain pre synchronization control measures must be taken to ensure the synchronization of the voltage of the distributed photovoltaic power grid and the voltage of the large power grid.

The pre synchronization unit is used to control the output voltage of the inverter to track the external voltage, so as to reduce the impact of the parallel reclosing process and ensure the smooth completion of the parallel connection. It includes amplitude tracking and phase (frequency) synchronization, also realized by adjusting voltage and frequency [10].

The above process completes the analysis of the transient phenomenon of the parallel and off grid switching of the distributed photovoltaic power grid, and provides a basis for the subsequent design of the parallel and off grid controller.

2.3 Design of Distributed Photovoltaic Grid Parallel and Off Grid Controller

Based on the above transient analysis results of parallel and off grid switching of distributed photovoltaic power grid, the grid connection controller and off grid controller are designed to provide a tool for the implementation of smooth parallel and off grid switching control of distributed photovoltaic power grid.

The essence of PQ control principle applied to grid connected controller is to realize independent control of active and reactive power through coordinate transformation and decoupling control. In the distributed photovoltaic power grid, the PQ control of distributed generation and energy storage can ensure that the active and reactive power transmitted by the distributed photovoltaic power grid remains unchanged.

The PQ control principle is shown in Fig. 2.

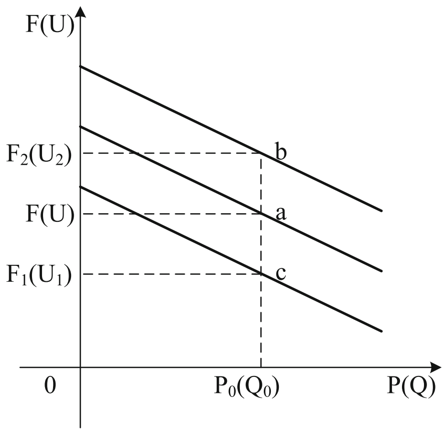

Fig. 2. PQ Control Schematic Diagram

As shown in Fig. 2, assuming that the PQ control is stable at *a* point, the photovoltaic plus energy storage operation is in the set state, that is, the photovoltaic power output P and Q are P_{ref} and Q_{ref} respectively, and remain unchanged. When PQ control is applied to grid connected operation mode, the support voltage and frequency of the system are provided by the large power grid, which will not change arbitrarily, but will only change slightly, and the output P and Q will only change slightly around P_{ref} and Q_{ref} (the area is limited in the figure).

For photovoltaic power supply, in order to ensure constant output power, when the optical storage output is less than the set power, the energy storage releases electrical energy, and when the optical storage output is greater than the set power, the energy storage absorbs power. For the power module of grid connected distributed photovoltaic power grid, the photovoltaic power supply under PQ control outputs a fixed power.

When the load power in the grid is equal to the set power, the internal load of the grid is balanced and the power is self-sufficient; When the load power in the grid is greater than the set power, there will be a power gap in the grid, and the external distribution network will supply power to the distributed photovoltaic grid; When the load power in the grid is less than the set power, the distributed photovoltaic grid will generate surplus power, which can be transmitted to the external distribution network.

PQ control generally adopts double closed loop control. Measure the three-phase instantaneous voltage U_{abc} and three-phase instantaneous current I_{abc} of the control point, convert the three-phase voltage and current a, b, c into U_d, U_q and I_d, I_q in the d-q coordinate through Park transformation, calculate the output power P and Q of the control point at this time, and provide them to the external loop power control module. The outer loop power control module compares P and Q with the set reference powers P_{ref} and Q_{ref}, and obtains the current reference values I_{dref} and I_{qref} required for the inner loop current control through PI regulation. Compare the difference between I_d, I_q and I_{dref}, I_{qref}, after PI regulation, after coaxial voltage compensation and cross coupling compensation, the inner loop current control gets the voltage control signal U_{sd}, U_{sq}. The U_{sd}, U_{sq} signal is then inverted by Parker to form a three-phase voltage modulated wave signal, which is transmitted to the IGBT control terminal of the converter, thus realizing the control function of the entire controller.

Wherein, the PI module of the outer loop controller uses the power difference to obtain the current reference values I_{dref} and I_{qref} as the formula (4):

$$\begin{cases} I_{dref} = \left(\delta_{pd} + \frac{\delta_{id}}{S}\right)\left(P_{ref} - P\right) \\ I_{qref} = \left(\delta_{pq} + \frac{\delta_{iq}}{S}\right)\left(Q_{ref} - Q\right) \end{cases} \tag{4}$$

In Formula (4), δ_{pd}, δ_{id}, δ_{pq} and δ_{iq} represent the auxiliary coefficients under d-q coordinate respectively; S is the reference standard factor.

The inner loop control link is regulated by PI, the coaxial voltage is compensated, and the cross coupling compensation outputs the voltage control signals U_{sd} and U_{sq}, as shown in Formula (5):

$$\begin{cases} U_{sd} = \left(\delta_{pd} + \frac{\delta_{id}}{S}\right)\left(I_{dref} - I_d\right) + U_d - I_q \\ U_{sq} = \left(\delta_{pq} + \frac{\delta_{iq}}{S}\right)\left(I_{qref} - I_q\right) + U_q - I_d \end{cases} \tag{5}$$

The off grid controller applies the VF control principle, that is, the control strategy that controls the output voltage and frequency of the converter and maintains them at the corresponding reference value. When using this control method, the distributed power supply can change the output power to adapt to the changes in the load power in the system, and the system voltage and frequency are stable near the reference value to maintain the stable operation of the system.

The VF control principle is shown in Fig. 3.

As shown in Fig. 3, VF control operates stably at *a* point. At this time, photovoltaic energy storage operates in the set state, that is, photovoltaic power makes bus voltage and frequency stable near the reference values U_{ref} and F_{ref}, and fluctuates only within the acceptable range. When the internal load power of the power grid fluctuates, the

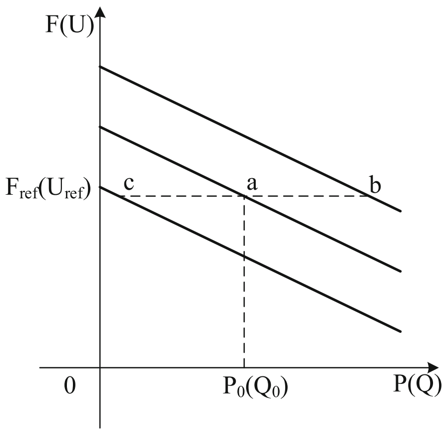

Fig. 3. Schematic Diagram of VF Control

VF control operates away from the *a* point. Assuming that the load power inside the power grid increases, the voltage and frequency inside the power grid decrease. The VF controller maintains stable operation at the *b* point by increasing the power supply power, so that the voltage and frequency inside the power grid remain unchanged. In the off grid operation mode of the power grid, the main control power supply is generally controlled by VF, which is equivalent to the balance node of the traditional distribution network system [11].

VF control adopts double closed loop control as PQ control, and the inner loop current control mode is the same. Finally, U_{sd} and U_{sq} signals are obtained. After signal conditioning, the control of the entire controller is realized. The difference is that the outer loop control link obtains the current reference values I_{dref} and I_{qref} through voltage instead of power. Therefore, it is called outer loop voltage control.

The PI module of the outer loop controller uses the voltage difference to calculate the current reference values I_{dref} and I_{qref}, as shown in Formula (6):

$$\begin{cases} I_{dref} = \left(\delta_{pd} + \frac{\delta_{id}}{S}\right)\left(U_{dref} - U_d\right) \\ I_{qref} = \left(\delta_{pq} + \frac{\delta_{iq}}{S}\right)\left(U_{qref} - U_q\right) \end{cases} \tag{6}$$

The above process completed the design of grid connected controller and off grid controller, and elaborated its control principle in detail, providing support for the subsequent experiment of smooth switching control of parallel and off grid of distributed photovoltaic power grid.

2.4 Smooth Switching Control of Parallel and Off Grid of Distributed Photovoltaic Power Grid

With the above designed grid connected controller and off grid controller as tools, develop a smooth switching control strategy for the parallel and off grid of distributed photovoltaic power grid, and implement the strategy to achieve smooth switching control for the parallel and off grid of distributed photovoltaic power grid.

The switching of two operation states of distributed photovoltaic power grid has always been the focus and difficulty of the research on key technologies of distributed photovoltaic power grid. Based on the problems of parallel and off grid switching, a dual mode switching strategy of parallel and off grid is proposed. The strategy adds a state pre synchronization link. By selecting the switch control, it synchronizes the control signal measurement state, which can suppress the sudden change of voltage and current when switching between parallel and off grid, and achieve smooth switching function.

Difficulties in parallel and off grid switching of distributed photovoltaic power grid can be considered from two aspects: grid connection switching to off grid switching and off grid switching to grid connection. Problems that are easy to occur under the two switching modes can be analyzed, and whether this problem will lead to the decline of power supply quality or grid collapse of distributed photovoltaic power grid and distribution network [12].

It can be seen that if the output frequency, voltage amplitude and phase of the controller are not completely consistent, then impulse current will be generated during grid connection. Therefore, before grid connection, the control system needs to take measures to eliminate the impact of the above factors and achieve stable grid connection. For the problem of switching from off grid to grid connected, the state pre synchronization method can be used to adjust the voltage amplitude and phase angle of the main control power supply system of the distributed photovoltaic power grid to synchronize with the distribution network through the controller. Because the main control power supply system of the distributed photovoltaic power grid contains energy storage devices, and the control of the energy storage devices is simpler and more effective than the control of the photovoltaic array, the state of the main control power supply system can be pre synchronized by using the energy storage devices and the reference voltage and phase angle of the nodes.

According to the above description, a smooth switching control strategy for parallel and off grid of distributed photovoltaic power grid is developed, as shown in Fig. 4.

As shown in Fig. 4, the proposed switching control strategy has two characteristics. One is that two sets of internal loop current control PI, PQ control and VF control are equipped with one set of internal loop control PI respectively. Although one set of internal loop control PI is used more, it can prevent the actual current output value from continuously decreasing during switching, resulting in a smaller port voltage, and maintain the continuity of reference current; The second is to add the state pre synchronization link between the grid connected PQ control and the off grid VF control, which can conduct the state pre synchronization before the switching, so that the switching can proceed smoothly.

The switching process of the parallel off network switching strategy can be described from three switching modes: planned grid connection, planned off network and unplanned off network. When the grid is connected to the grid for stable operation, PQ control strategy is adopted for grid control. The distributed photovoltaic grid controller based on energy storage receives *PWMa* signals and outputs constant power. When the power grid operates stably off the grid, the distributed photovoltaic power grid control adopts VF control strategy. The distributed photovoltaic power grid controller based on energy storage receives *PWMa* signals and outputs constant voltage amplitude

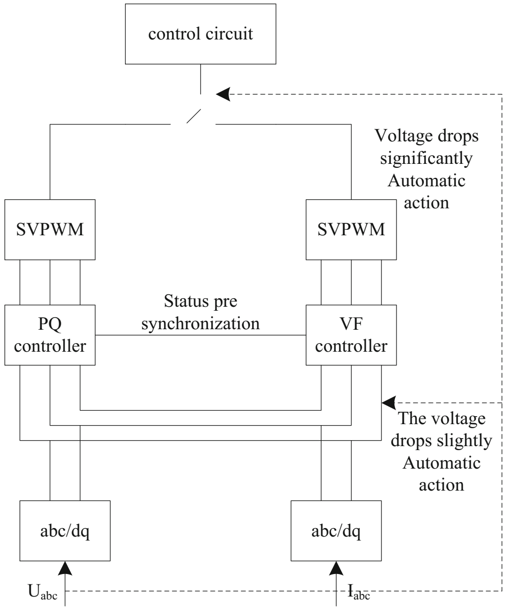

Fig. 4. Schematic diagram of smooth switching control strategy for parallel and off grid of distributed photovoltaic power grid

and frequency. When the distributed photovoltaic power grid is planned to be connected to the grid, make the PQ control link of the distributed photovoltaic power grid controller act first, and conduct the state pre synchronization control to complete the state pre synchronization. When the distributed photovoltaic grid is planned to be off grid, the VF control link of the distributed photovoltaic grid controller will be activated first. When the distributed photovoltaic grid is unplanned off grid (fault off grid) and the voltage is detected to drop slightly, the VF control link is preheated at this time. If the voltage remains stable and does not drop continuously to the critical voltage, the temporarily closed switch is disconnected.

The above process completes the formulation of smooth switching control strategy for parallel and off grid of distributed photovoltaic power grid. The smooth switching control for parallel and off grid can be achieved by implementing the formulated strategy, which can provide more effective help for the stable operation of distributed photovoltaic power grid.

3 Experiment and Result Analysis

3.1 Experiment Preparation Stage

In order to verify the effectiveness of the proposed parallel and off grid switching control method, a simulation model of parallel and off grid switching control is established based on MATLAB/Simulink simulation platform. The total simulation time is set as 4 s, and the load power in the grid is 50 kW. At 1 s, the distributed photovoltaic power grid switches from grid connected operation to off grid operation, and at 3 s, the distributed photovoltaic power grid starts to be connected from off grid operation.

At the same time, the proposed method applies the deep reinforcement learning DQN algorithm, and the learning rate parameter ϑ directly affects the control efficiency of the parallel off network switching. Therefore, it is necessary to determine the optimal value of the learning rate parameter ϑ before the experiment.

The relationship between the learning rate parameter ϑ and the control efficiency of parallel and off network switching obtained through the test is shown in Fig. 5.

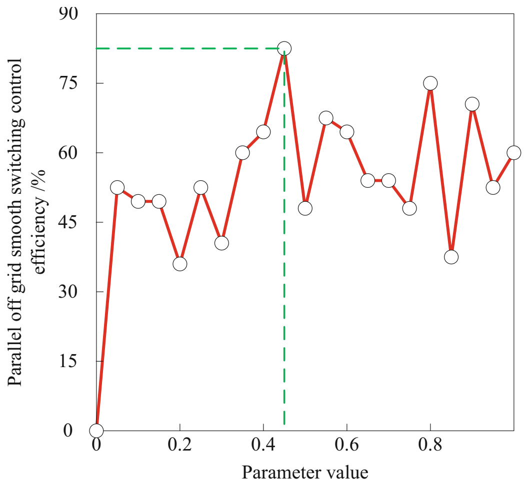

Fig. 5. Relation between learning rate parameter ϑ and control efficiency of parallel and offline switching

As shown in Fig. 5, when the learning rate parameter ϑ is 0.46, the control efficiency of parallel off network switching reaches the maximum value of 82.5%. Therefore, the best value of learning rate parameter ϑ is determined to be 0.46.

The above process has completed the task of experiment preparation, providing convenience for the smooth implementation of the subsequent experiment.

3.2 Analysis of Experimental Results

In order to clearly display the application performance of the proposed method, the mutation coefficient of voltage and current during the smooth switching process of parallel and off grid is selected as the evaluation index. The specific experimental results are analyzed as follows:

The sudden change coefficient of voltage and current can directly display the smoothness of parallel off grid switching of distributed photovoltaic power grid, and the value range is 0–1. The closer the mutation coefficient is to 0, the smoother the parallel off grid switching of distributed photovoltaic power grid is.

The method based on voltage feedback in reference [8] and the grid connected photovoltaic system design with controllable total harmonic distortion and three maximum power point tracking in reference [9] are selected as comparison methods 1 and 2. The abrupt coefficients of voltage and current obtained through experiments are shown in Fig. 6.

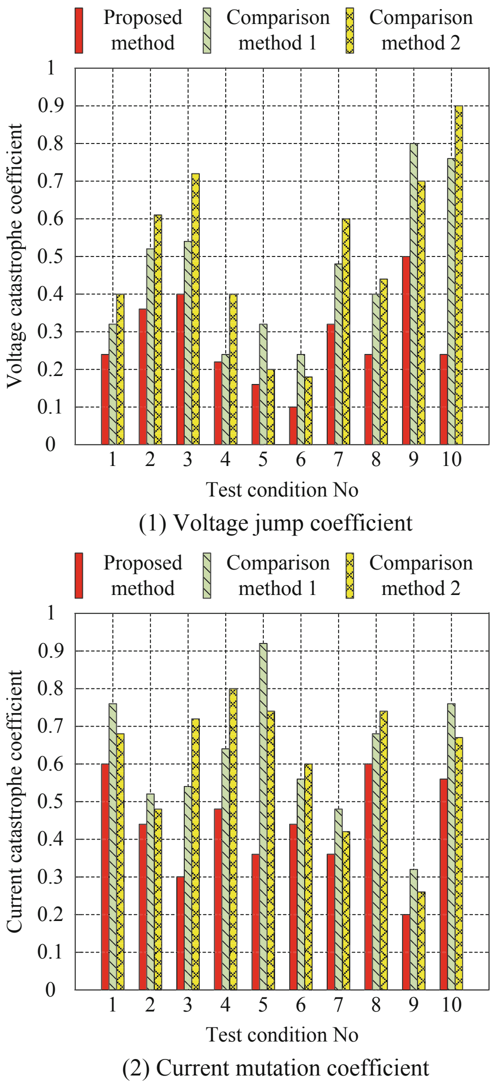

Fig. 6. Schematic Diagram of Sudden Change Coefficient of Voltage and Current

As shown in the data in Fig. 6, compared with comparison method 1 and comparison method 2, the voltage and current mutation coefficients obtained by the proposed method are smaller, with the minimum values of 0.1 and 0.2 respectively, which fully proves that the proposed method has better control effect of parallel and off grid switching.

4 Conclusion

This study introduces deep reinforcement learning and proposes a new control method for parallel and off-grid smooth switching of distributed photovoltaic power grid. Based on the construction of distributed photovoltaic power grid energy management model, the transient situation of off-grid switching is analyzed. Design a distributed PV grid parallel and off-grid controller to achieve smooth switching control. The experimental results show that this method can effectively reduces the sudden change coefficient of voltage and current during the parallel and off grid smooth switching process, provides more effective method support for the parallel and off grid switching control, and also provides reference and reference for the related research on parallel and off grid switching.

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