

Research on Improved Active Damping Method Based on Dc Microgrid

Yuting Wang¹, Bo Hong¹, Zhixiong Yang^{2, a}, Liyue Yuan¹, Peng Gu¹,
Shuai Yuan¹, Jun Li¹, Aikun Ma¹

¹State Grid Liaoyang Electric Power Supply Company, Liaoyang 111000, China

²Kunming Institute of Physics, Kunming 650223, China

^axiongmaoer39@126.com

Abstract. In order to solve the system instability caused by a large number of constant power load access in the DC microgrid, an active damping control method based on the DC current feed forward of the grid connected converter is proposed. The mathematical model of DC-AC converter and the control strategy of active damping method suitable for DC-AC converter are studied in this paper, and a small signal mathematical model of DC microgrid is established. Based on the principle of system dominant pole distribution and impedance matching, the adverse effects of constant power load on the stability of the system and the improvement of the active damping method on the stability of the system are analyzed, and the design principle of the active damping parameters is given. Simulation and experimental results show that the proposed active damping method can improve the stability of DC microgrid system with constant power load and high permeability.

1. Introduction

DC microgrid is a small power transmission and distribution network which combines all kinds of distributed power, energy storage and load in the form of DC. It has the characteristics of simple structure, less conversion link and high efficiency of energy utilization, [1, 2]. Compared with the AC microgrid, the DC microgrid does not have the problems of frequency, phase synchronization and reactive circulation, and there are few power electronic converters, which make the control relatively easy, the system reliability is high, and the power quality is good, so [3, 4] has been paid more and more attention at home and abroad.

The general system structure of DC microgrid is shown in Figure 1 as shown in Figure 1, in which the grid connected converter is used as the voltage control unit of the DC microgrid, and the voltage stability of the DC bus is maintained by the constant voltage control mode. In the general case of direct drive wind turbine and photovoltaic power generation, the maximum power point tracking strategy is adopted to achieve maximum utilization of renewable energy. The energy storage unit can adopt constant current (power) to stabilize power fluctuations. [5] At the same time, a large number of power electronic devices with closed-loop load control in DC microgrid can be regarded as constant power loads. The power of the constant power load still keeps constant when the DC voltage fluctuates, and has the characteristic of negative damping. [6, 7] A large number of access may cause the instability of the DC bus voltage and even the system collapse [6]. DC bus voltage is a measure of the power of DC microgrid.



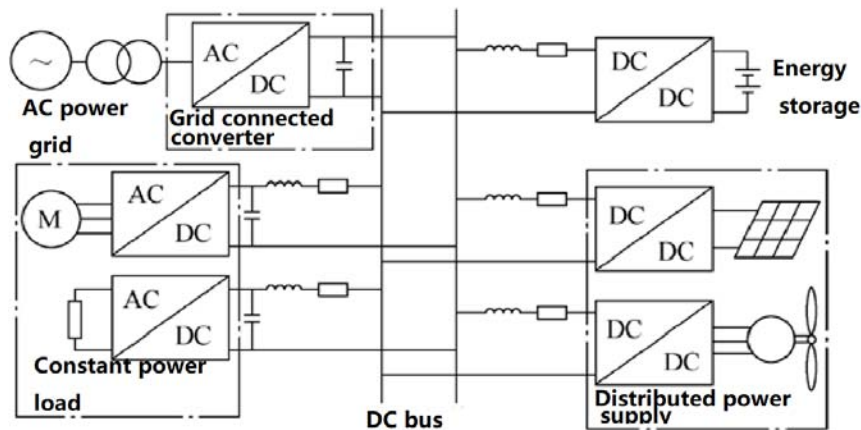


Figure 1. Typical structure of a DC microgrid

Therefore, in view of the stability of the DC microgrid with high permeability with constant power load, this paper first establishes the mathematical model of the DC micro grid connection converter, and puts forward an active damping method for the output current feed forward to the DC-AC converter, so as to establish the small letter of the DC microgrid with a simple and single topology structure. The mechanism of the constant power load is not beneficial to the stability of the system and the effect of the active damping method on the stability of the system. At the same time, the design principle of the parameters of the active damping controller is given. Finally, the effectiveness of the method is verified by simulation and experiment.

2. Design of active damping parameter and stability analysis of DC microgrid

This section will analyze the influence of the active damping method on the bandwidth of the voltage loop and the design principle of the active damping control parameters, as well as the influence of the active damping parameters on the stability of the DC microgrid, and compare the stability of the DC microgrid before and after compensation. In this article, the parameters of DC-AC are shown in Table 1.

Table 1. The parameters of DC-AC converter

parameter	numerical value
filter circuit	2
Parasitic resistance of filter inductor	0.1
Busbar capacitance	2000
DC Bus Voltage	100
Voltage amplitude of power grid line	50
Ratio coefficient of current loop	6.32
Integral coefficient of current loop	316
Rated power	4

2.1. Design of voltage loop bandwidth

From table 1, the width of the current loop selected in this paper is 480Hz. Generally, the voltage bandwidth is much lower than that of the current loop.

The bandwidth of the ring is between 18 Hz ~ 32Hz. In this paper, the corresponding bandwidth of $K_{up} = 0.4, 0.6, 0.8$ is 18Hz, 26Hz and 32Hz respectively. It can be seen from formula that k and ω_c have little effect on the bandwidth of the voltage loop due to the smaller multiplying coefficients of k and ω_c . Figure 2 gives the burde diagram of the voltage ring transfer function before and after

compensation and under the bandwidth of different voltage rings. It is known that the bandwidth of the voltage loop is the same in the traditional way and the active damping method, and the active damping method basically does not change the tracking performance of the DC voltage.

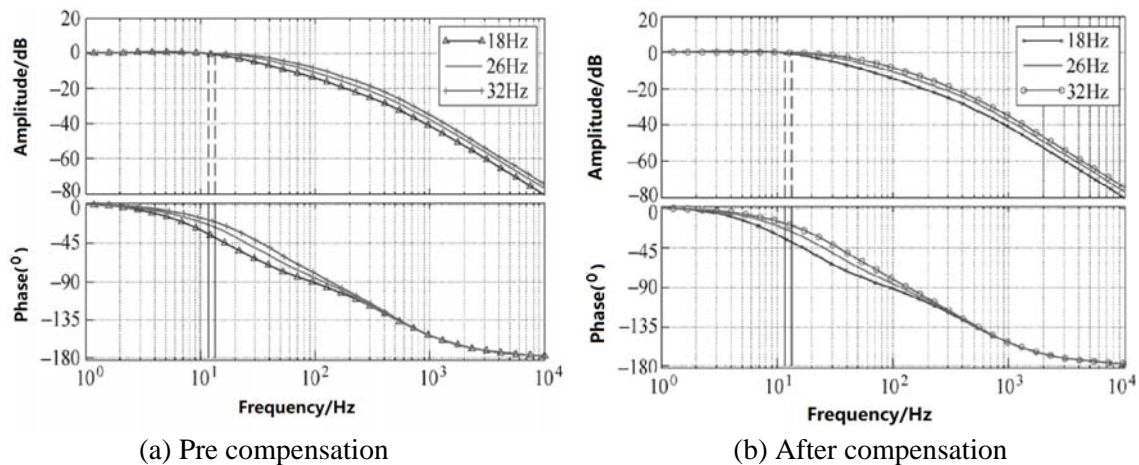


Figure 2. Bode plot of the voltage control-loop transfer function.

Figure 3 gives the equivalent loop gain T_m Nyquist curve before compensation for different voltage loop bandwidth.

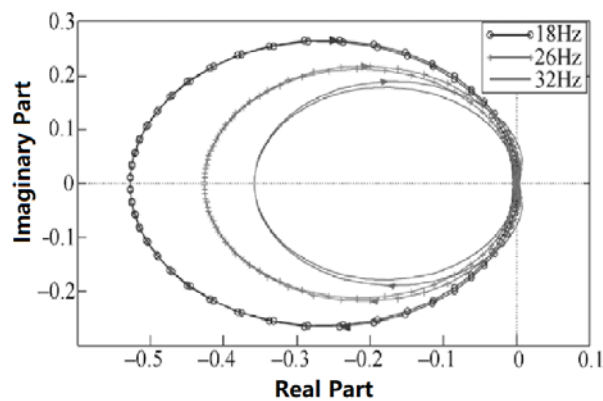


Figure 3. Nyquist plot of minor loop gain T_m with different voltage control-loop bandwidth

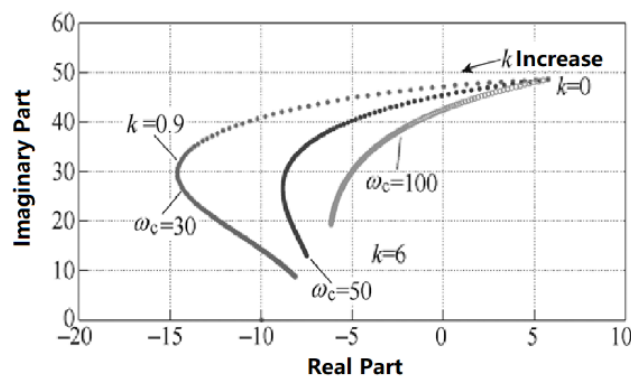


Figure 4. Root locus plot of different damping parameters

As shown in Fig. 3, the larger the bandwidth of the voltage loop is, the farther the Nyquist curve of the equivalent loop gain is (1,0), the greater the stability margin of the system.

2.2. Parameter design and analysis of active damping controller

Figure 4 shows the changes of the dominant poles of the DC microgrid system from $K_{up}=0.8$, $K_{ui}=10$ to 0rad/s, 50rad/s, 100rad/s and K from 0 to 6 respectively.

As shown in Figure 8, in the case of the same K value, the dominant pole distance is the farthest from the imaginary axis, and the dominant pole gradually approaches the virtual axis with the increase of ω_c , so the oversize of the ω_c may lead to the instability of the system. Under the same ω_c condition, with the increase of K value, the leading pole of the system is far away from the virtual axis, and then gradually approaching to the virtual axis, so the selection of the K value cannot be too large and too small. In the case of $\omega_c=30\text{rad/s}$, the dominant pole is the farthest from the imaginary axis. Considering the stability margin and damping capacity of the system, we select $\omega_c=30\text{rad/s}$, $K=0.9$.

Figure 5 shows that the dominant pole of a DC load in the case of a constant power load varies with the load power from 0 to 1.1 (PU) (the reference power set to 4kW), in which $\omega_c=30\text{rad/s}$, $K=0.9$, $K_{up}=0.8$, $K_{ui}=10$.

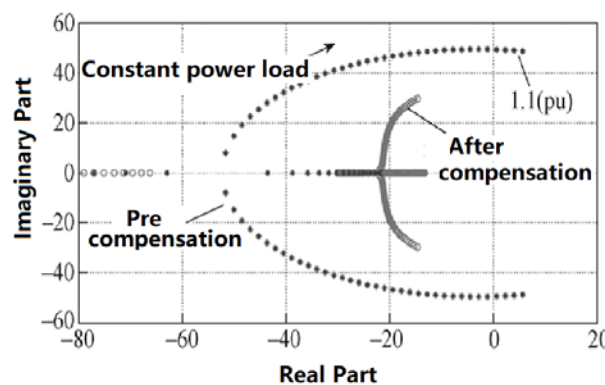


Figure 5. Root locus plot of CPL variation with and without compensation

3. Simulation Analysis and experimental verification

Based on the RT-LAB real-time simulation platform, the DC microgrid simulation system model, and the parameters of Table 1 and the selected active damping parameters are set, then the stability of the DC microgrid under the constant power load disturbance is simulated and analyzed, and the theory is finally pushed through the theory. Further verification is carried out in the guide.

3.1. Simulation analysis

In order to verify the effect of active damping method on the stability of DC micro grid under constant power load disturbance, this paper simulates that the load of DC microgrid is all constant power load, and the total load power change curve is shown in Figure 6. The load power of the simulation setting occurs once every 1s step, the overall trend is successive jump, and the final 8s time is increased from 0.85 (PU) (3.4kW) to 0.96 (PU) (3.84kW) at the end of the time.

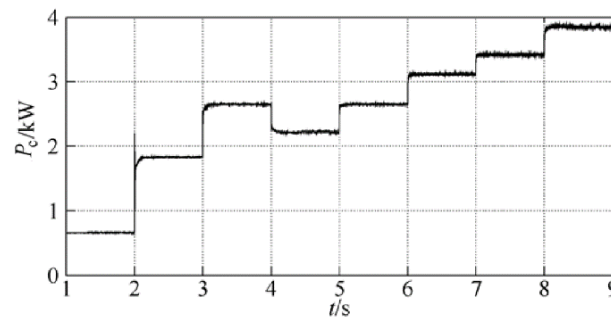
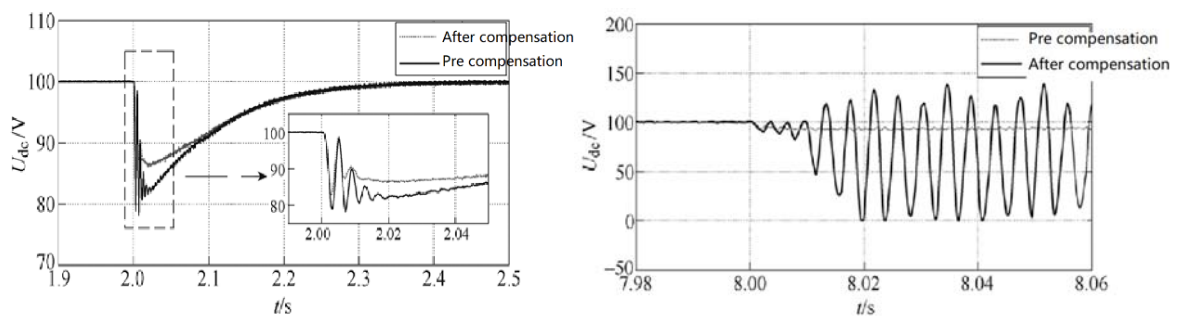


Figure 6. Load power curve of the DC microgrid



(a) 2S disturbance time bus voltage waveform (b) 8s disturbance time bus voltage waveform

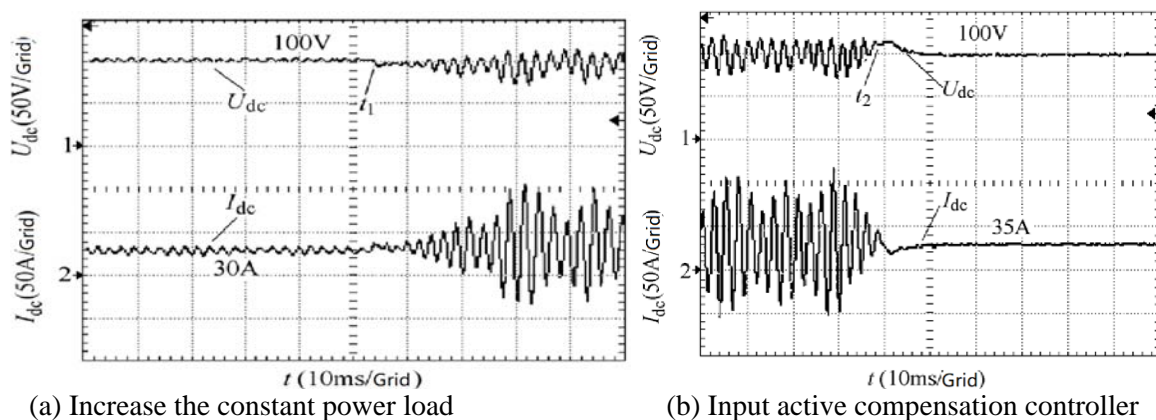
Figure 7. Simulation results of the DC microgrid with and without compensation

Figure 7a and figure 7b are the detailed comparison of DC bus voltage waveforms before and after compensation at 2S and 8s load disturbances.

After the disturbance at 2S time, the voltage sag of the compensated DC bus decreases, and the oscillation in the transient process is prior to the compensation.

3.2. Experimental verification

In order to verify the feasibility of the proposed control strategy in the actual system, a simple DC microgrid, is set up in the laboratory. The parameters of the experimental system are the same as that of Table 1. The load is constant power load, and the constant power load is simulated by the 1.5 resistor after the Buck circuit. The results of the experiment are shown in Figure 8.



(a) Increase the constant power load

(b) Input active compensation controller

Figure 8. Experimental results of the DC microgrid

The top down waveform in Figure 8a is DC bus voltage waveform and DC-AC output current waveform respectively. At the time of T1, the end voltage of the Buck circuit is increased from 68V to 73V, that is, the constant power load is increased from 3kW to 3.5kW, and the amplitude of the DC bus voltage is about 40V oscillation, and the system is in a critical stable state. It is verified that the constant power load is too large to cause instability of DC microgrid system.

In the T2 moment shown in Figure 8b, the active damping controller designed in this paper is designed, the DC voltage and the DC current are rapidly stabilized at 100V and 35A, and the system is restored to the stable state. It is verified that the active damping method proposed in this paper can improve the stability of DC microgrid system.

4. Conclusion

In this paper, an active damping control method of output current feed forward is proposed for the shunt converter of DC micro grid, and the mechanism of the constant power load is not beneficial to the stability of the system, and the design process of the damping parameter is given. The theoretical derivation, simulation and experimental results show that the stability margin of the system is reduced and the system becomes unstable. The active damping method proposed in this paper can effectively improve the stability of the DC bus voltage under the high constant power load and high permeability, and weaken the constant power load on the DC microgrid system. The negative damping effect of the system.

References

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