

Resistance capacitive inverter allocation method based on fast reactive support based on Microgrid

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Abstract. In the low voltage microgrid multi inverters parallel system, the sudden change of load will lead to voltage fluctuation in the microgrid, and the fast reactive power support capability of the inverter is a necessary way to maintain voltage stability. By introducing resistance capacitance virtual complex impedance into inverter output current feedback, a fast reactive power support RC inverter and its parallel power allocation method are proposed in this paper. The equivalent output impedance of the inverter is designed into resistive and capacitive, can be realized in the micro grid support fast reactive power public connection point, so as to keep the system voltage stability, and can inhibit the resonant inverter output impedance and the impedance between, to further reduce the voltage distortion. The effectiveness of the control method is verified by simulation and experiment.

1. Introduction

Parallel control of micro grid connected with network and coordinated control of multi distributed power supply in microgrid. Compared with the external power distribution system connected, the microgrid can be regarded as a virtual generator with unique operation characteristics, and when it is connected to the grid, it will supply power to the external distribution system. Aiming at the control mode and control strategy of microgrid at home and abroad, three control strategies, PV control strategy, PQ control strategy and V/F control strategy are mainly put forward. At the same time, there are three different control modes for the microgrid: the master slave control mode, the peer control model and the multi agent [1] (Agent) based hierarchical control mode. The current power electronic interface technology of distributed generation device mainly uses voltage source control PWM technology, and the core control strategy is power (or frequency) droop control strategy. China has developed an inverter control device in the renewable energy generation system [2], such as photovoltaic grid connected power generation system, wind power grid system and so on. However, the functions of such inverter control devices are very single, which can only be applied to the grid connected control mode of independent distributed generation system, which still has a large distance to the control objectives of the microgrid system. Because the micro grid is the combination of a variety of different energy structure, the power supply and load node in position dispersion on the transmission of electrical energy, [3] with greater volatility and uncertainty, so the requirements of inverter in microgrid can well adapt to the change of these conditions, with strong robustness and speediness, and power requirements to achieve two-way flow of energy and very flexible control. The existing inverter products and technologies are difficult to



form micro grid, which is difficult to meet the needs of microgrid system's stable operation. So far, multi-functional inverter control technology and devices suitable for microgrid are still blank in China.

2. Equivalent modeling of resistance capacitance Inverters

2.1. The unified output power characteristic of different output impedance Inverters

Figure 1 is a simplified diagram of 2 DG connected inverters in parallel, consisting of DG, transmission impedance and load.

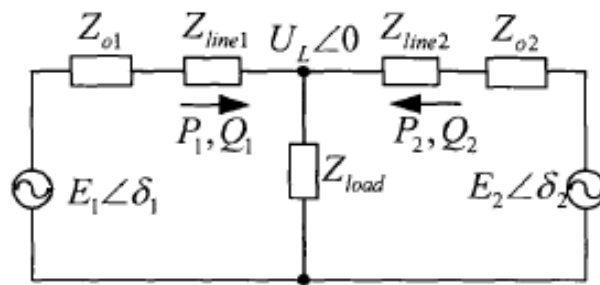


Figure 1 Simplified model of 2 inverters parallel system

In Figure 1, the transmission impedance includes the equivalent output impedance Z_{oi} and Z_{line} line impedance, E_i is the fundamental voltage amplitude of the inverter's no load output; δ_i is the phase difference between the no-load output fundamental voltage e_i and the load voltage. Considering the influence of line impedance, the active power and reactive power transmitted by the i ($i = 1, 2$) inverter are respectively.

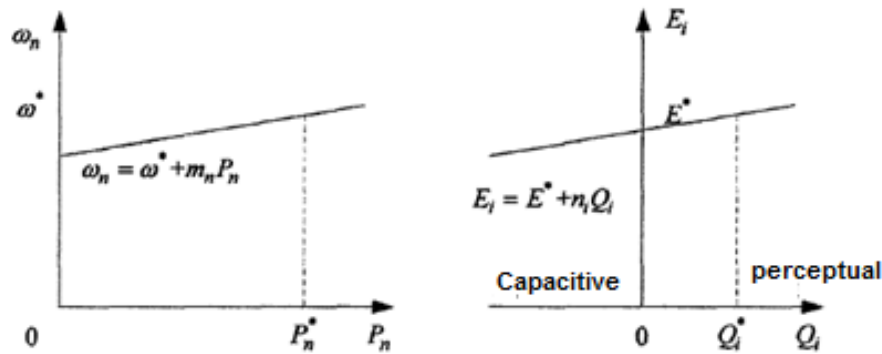
$$\begin{aligned} P_i &= \frac{1}{Z_{oi} + Z_{linei}} [(E_i U_L \cos \delta_i - U_L^2) \cos \phi_i + E_i U_L \sin \delta_i \sin \phi_i] \\ Q_i &= \frac{1}{Z_{oi} + Z_{linei}} [(E_i U_L \cos \delta_i - U_L^2) \sin \phi_i - E_i U_L \sin \delta_i \cos \phi_i] \end{aligned} \quad (1)$$

In the formula (1), ϕ_i is the impedance angle of transmission impedance, line impedance $Z_{linei} = R_{linei} + jX_{linei}$, and the equivalent output impedance $Z_{oi} = R_{oi} + jX_{oi}$ of the inverter. This shows that the active power and reactive power of the output are related to the amplitude and frequency of the output voltage.

By introducing different virtual impedance, under proper control mode, [5] the equivalent output impedance of inverter has different characteristics, and different output impedance angles determine power droop characteristics. In low voltage lines, the transmission impedance angle is determined mainly by the equivalent output impedance angle because of the line resistance R_{linei} ? X_{linei} . Gives the power expression and droop control equation corresponding to the output impedance type (R, L, C, RL, RC) inverters respectively. ω^* Is the reference value of the no-load angle frequency; E^* is the reference value of the amplitude of the no-load output voltage; [6] m_i and n_i are the droop gain of frequency and voltage, respectively.

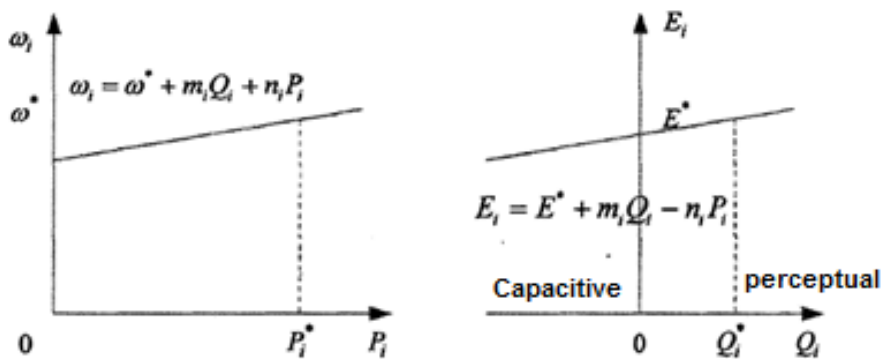
The droop characteristic curves of capacitive inverter and RC inverter are shown in figures 2 and Figure 3, respectively. Obviously, compared with inductive inverters, they exhibit inverse voltage

frequency control characteristics. Compared with other types of inverters, C or RC inverters can significantly improve voltage sags or sags and frequency shifts due to microgrid distribution or load power variation when inductive load is large enough to access microgrid system.



(a) Active power($P-\omega$) droop characteristics (b) reactive power voltage($Q-E$) sag

Figure 2. droop characteristic curve of capacitive inverter



(a) Active power($P-\omega$) droop characteristics (b) reactive power voltage($Q-E$) sag characteristics

Figure 3. droop characteristic curve of resistive capacitance inverter

3. Control modelling of resistance capacitance inverter

The model of a typical inverter parallel control system, as shown in Figure 4, is mainly composed of a power droop control loop, a voltage current loop, and a virtual impedance ring. The actual inverter output voltage u_o , current i_o , no-load line angular frequency reference value ω^* , the no-load output voltage amplitude reference value of E^* as the power droop controller input, calculated by the droop control method of the inverter output reference voltage through the output current feedback is introduced in the virtual impedance loop, reference voltage u_r ; calculation of voltage and current controller is obtained SPWM wave D, so as to control full bridge inverter switch on-off; inverter output voltage u_{inv} through LC filter, the output voltage of the inverter to get the actual u_o .

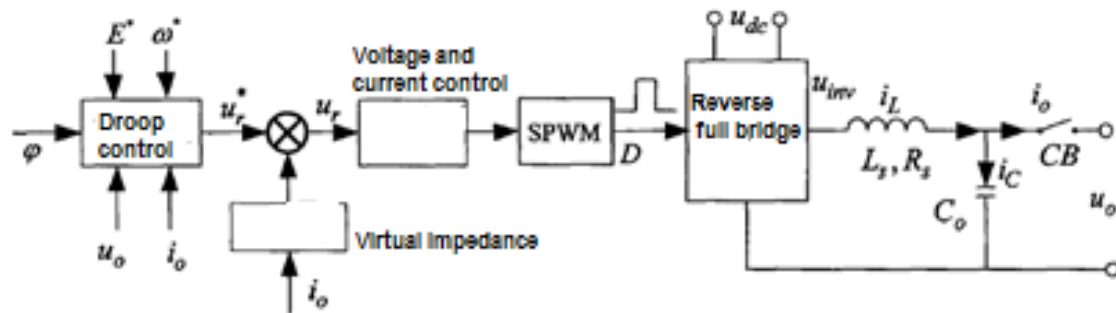


Figure 4 Control modeling of parallel inverter

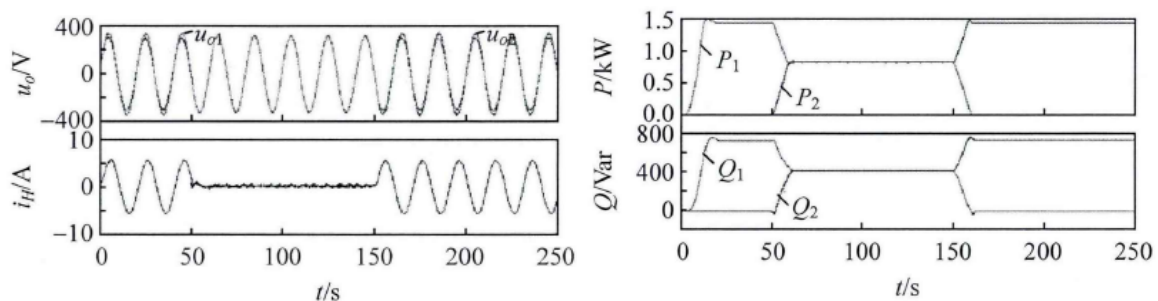
4. Simulation and Experiment

2 parallel models of RC inverter are built by Psim6.0 simulation software. The rated capacity of the inverter is 2.2KVA 12.8kHz, and the carrier frequency is different from the output filter parameter and the connection line impedance of each inverter. The specific system parameters are shown in table 1.

Table 1. Parameter table of parallel resistance inverter parallel system

Control parameters	numerical value	Control parameters	numerical value
k_{pc}	2	τ	1.2
$E^*(V)$	233	$U_{dc}(V)$	400
$\omega^*(rad/s)$	314.5	$Z_{line1}(\Omega)$	$0.036+j0.012$
m	0.00026	$Z_{line2}(\Omega)$	$0.079+j0.032$
n	0.0013	$/$	$/$

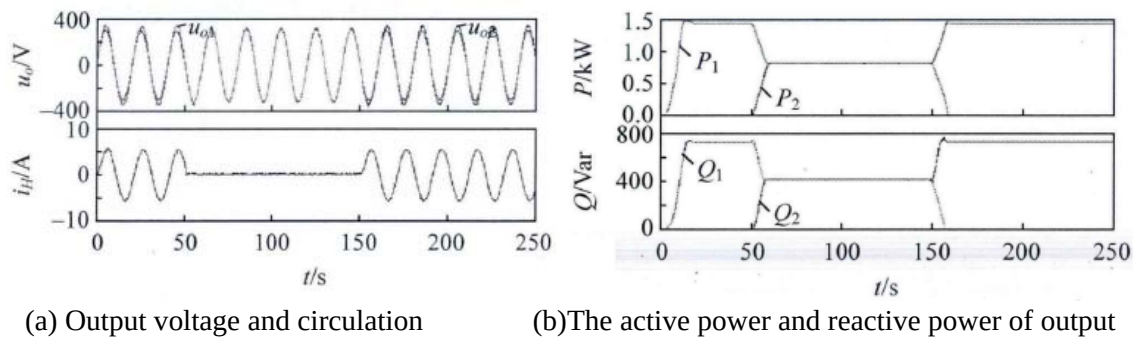
The simulation process is as follows: at $t=0$ time, first inverters operate separately; $t=0.05s$ time, second inverters access; $t=0.15s$ time, first inverters exit. The inductive load with a load of 1.8kVA, of which the inductive reactive power is 760Var. In order to improve the contrast test of RC inverter on voltage quality, figure 5 shows the inverter experiment waveform 1 and 2 are made of L type parallel inverter droop control; figure 6 gives the inverter 1 and 2 simulation waveforms with capacitance in parallel RC type inverter improved droop control resistance.



(a) Output voltage and circulation

(b) The active power and reactive power of output

Figure 5. 2 simulation results (inductive load) of parallel connection of L inverter



(a) Output voltage and circulation

(b) The active power and reactive power of output

Figure 6. 2 simulation results (inductive load) of parallel connection of RC inverter

From the output voltage waveform in Figure 5 and figure 6 and reactive power output waveform shows that compared to the traditional L type inverter, RC inverter with dynamic compensation performance of reactive power compensator, when access to the inductive load, capacitive type RC inverter makes the reactive power compensation of dynamic response time is shorter and the steady circulation amplitude smaller load the power sharing accuracy is improved obviously.

5. Conclusion

In this paper, a capacitive RC type inverter and its parallel power distribution method are proposed. The output impedance of the inverter is designed as a resistance capacitance. It can achieve fast reactive power support at the common connection point of microgrid, thus maintaining system voltage stability, and suppressing the resonance between inverter output impedance and grid impedance, reducing voltage distortion. The multi loop power accurate allocation method of parallel RC inverter is presented, including the power droop control outer ring, the virtual impedance middle ring and the output voltage control inner loop. The effect of the virtual complex impedance parameters on the parallel circulation is analyzed, and the appropriate control parameters are selected. The simulation and experiment verify the effectiveness of the proposed RC inverter for improving the voltage quality of the microgrid, and can be extended to the micro grid parallel system.

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