Article

Research on the Modulation and Control Strategy for a Novel Single-phase Current Source Inverter (Supplementary Material)

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S1. Simulation Results

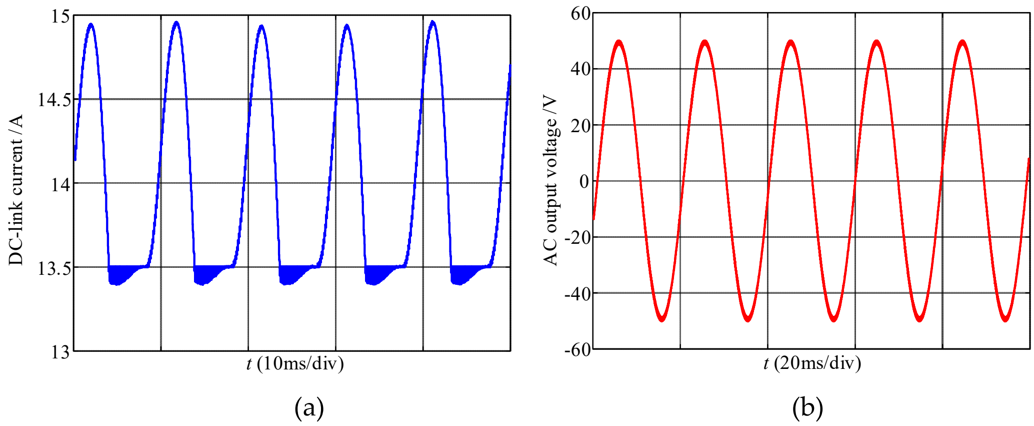

Figure S1. Simulation waveforms in steady state: (a) DC-link current; (b) AC output voltage.

The topology of the proposed single-phase CSI with the modulation and control models are established in the simulation environment of Matlab/Simulink. L_{dc}, C, R, and U_{dc} are set as 4mH, 265μF, 25Ω, and 25V, respectively. The amplitude and frequency of the reference of u_o are 50V and 50Hz. Substituting the above parameters into formula (17), i^*_{dc} > 11.5A is obtained. However, considering factors such as harmonics and tube voltage drop, i^*_{dc} should leave a margin. At present, i^*_{dc} is set to 13.5A. The simulation waveforms of i_{dc} and u_o are shown in Figure S1. The amplitude of u_o is 25V, and i_{dc} is maintained in the range of 13.5A to 14.9A. During several switching periods where the DC-link inductor L_{dc} is discharging ($u_{dc} < u_o$), the value of i_{dc} is clamped at above 13.5A. Thus, the switching mode consists of the energy-supplying mode and magnetizing mode. During several switching periods when the DC-link inductor L_{dc} is charging ($u_{dc} > u_o$), the CSI operates in freewheeling mode and energy-supplying mode alternately. L_{dc} is charged in energy-supplying mode, where i_{dc} increases to 14.9A. In contrast, i_{dc} remains unchanged in freewheeling mode. When $u_{dc}<u_o$, the previous switch mode is maintained until the value of i_{dc} drops to 13.5A.

Suppose the switching tube S0 and diode D0 are removed from the topology in Figure 1. In that case, it will become a traditional single-phase CSI, and i_{dc} will become uncontrollable, which can demonstrate the necessity of improving CSI topology and controlling the DC-link current. Expressly, two cases of initial DC-link current are set up.

In Figure S2, the initial DC-link current is set to a small value. In the steady state, i_{dc} is discontinuous and cannot provide sufficient current to AC load, which results in significant distortion of u_o. If $i_{dc} < i_o$, the duty cycle of the energy-supplying mode reaches 1, and the dwell time of the magnetizing mode will reduce to zero. At this point, L_{dc} cannot be charged, and i_{dc} continuously decreases until i_{dc} becomes zero. In this case, i_{dc} and u_o are all uncontrollable.

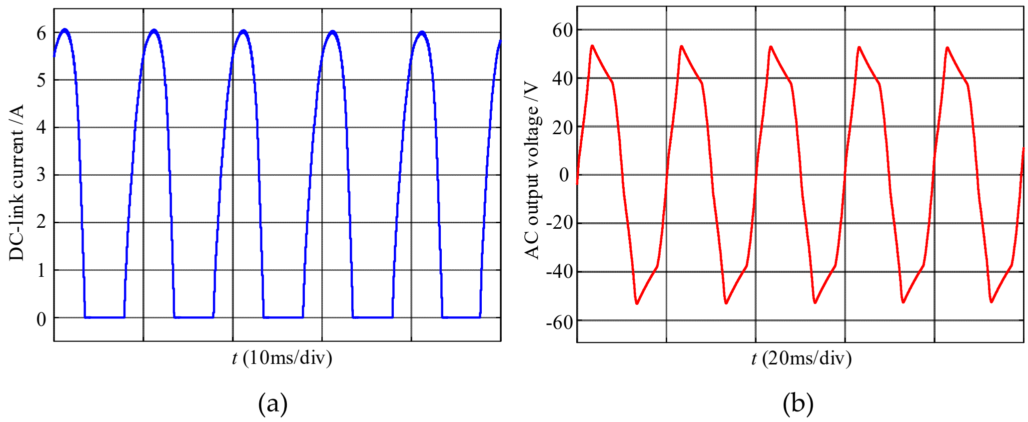

Figure S2. Simulation waveforms on the traditional single-phase CSI when the initial DC-link current is 0A: (a) DC-link current; (b) AC output voltage.

In Figure S3, the initial DC-link current is set to a great value. i_{dc} continuously increases, although u_o is under control. The duty cycle of the energy-supplying mode is small, and the dwell time of the magnetizing mode is great, so L_{dc} is charged for a long time. Therefore, in this case, the relationship between the duty cycle of the energy-supplying mode and the DC-link current is positive feedback and uncontrollable.

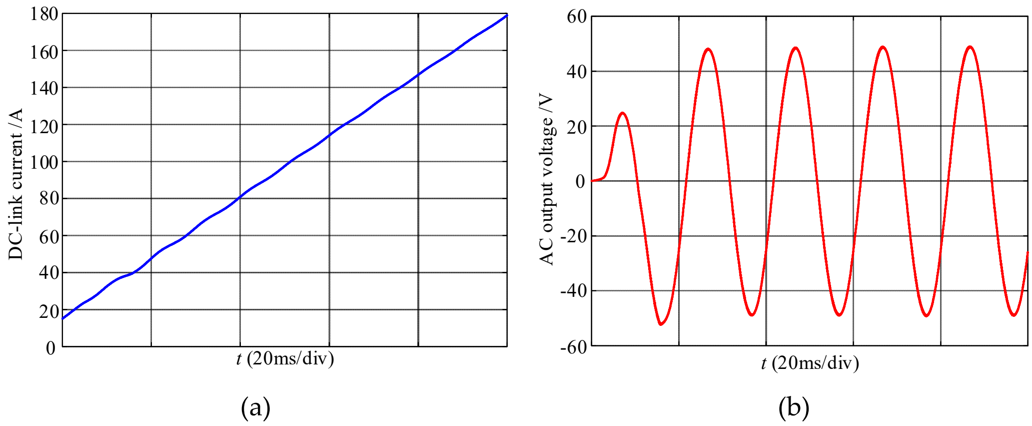

Figure S3. Simulation waveforms on the traditional single-phase CSI when the initial DC-link current is 16A: (a) DC-link current; (b) AC output voltage.