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Adaptive Power Decoupling Strategy for Single-Phase Grid-Connected Converter

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Abstract

This study analyzes the power coupling in the single-phase grid-connected system and designs a novel power decoupling method for restraining the ripple voltage on the dc bus. By introducing a ratio factor between dc-bus capacitors, the decoupling ability in the proposed method can be improved. In order to achieve accurate power decoupling, a neural filter is adopted for clearly identifying the dc-bus voltage level and extracting the ripple voltage on the dc bus. In addition, a total sliding-mode controller is further designed in the control strategy to enhance the system robustness with respect to varied power coupling conditions, e.g., under ideal or distorted power grids.

Research Focus

Decoupling circuit

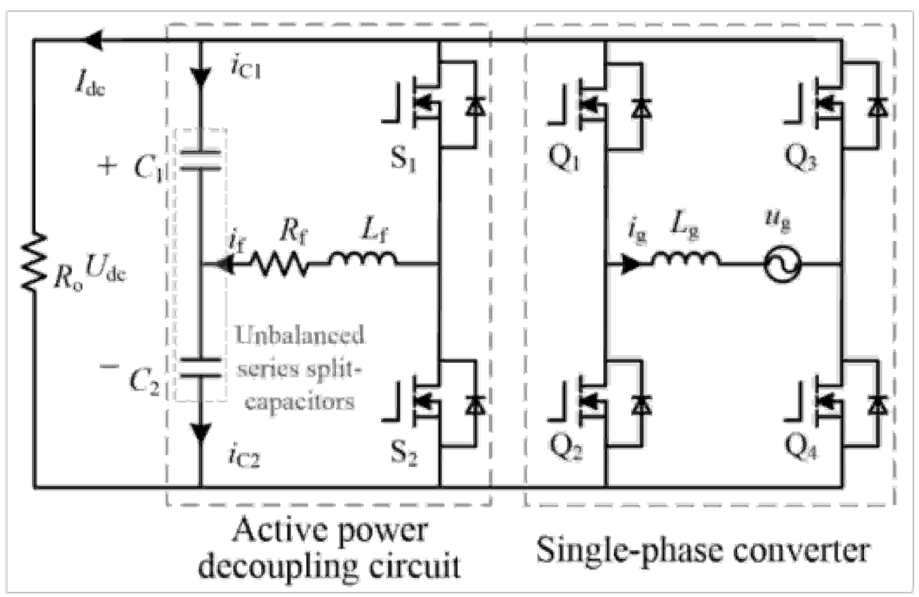


Fig. 1. Circuit framework of single-phase converter with decoupling circuit.

For improving the decoupling ability, this circuit introduces a ratio factor *l* between *C*1 and *C*2. The unbalanced series capacitors (*C*1 and *C*2) are used for the dc-bus capacitors as well as the decoupling capacitors. The inductor (*Lf*) is used to control a buffer current (*if*). By modulating the half-bridge circuit, the average voltage on each of two series capacitors is half of the value of *Udc*.

Decoupling strategy

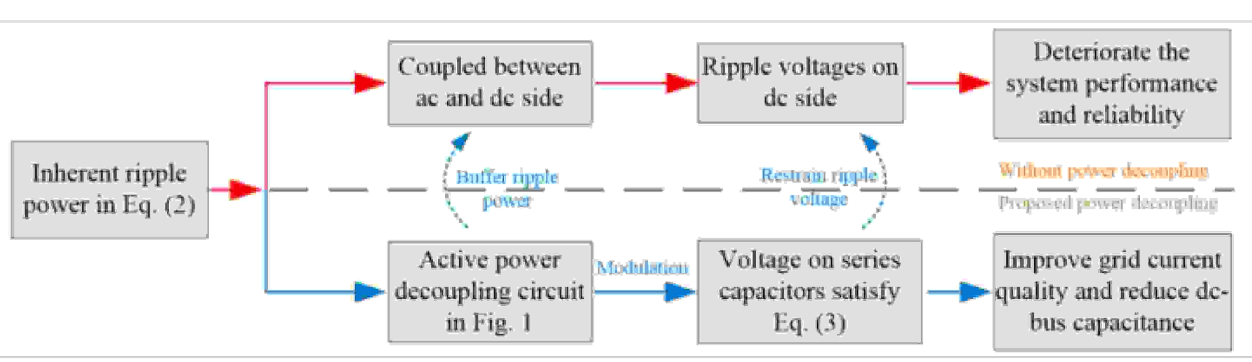


Fig. 2. Implementation flowchart of adaptive power decoupling strategy.

Extracting ripple voltages

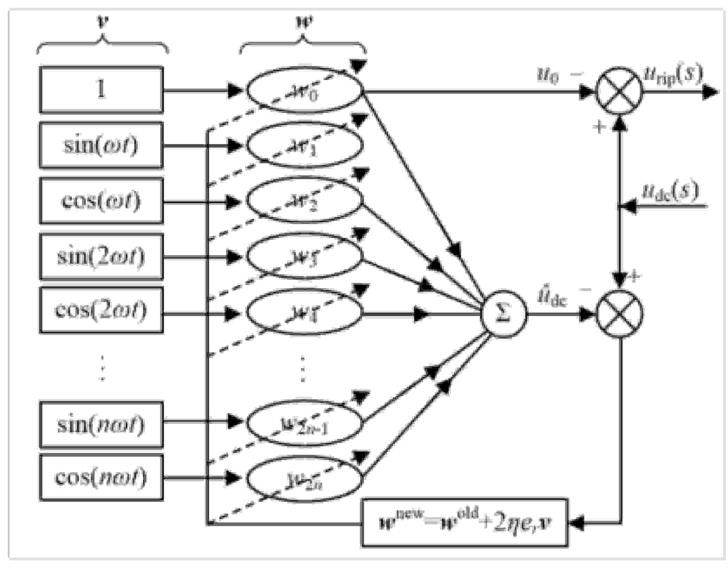


Fig. 3. Structure of neural filter.

For realizing the accurate power decoupling, it is necessary to identify the dc-bus voltage level and extract the ripple voltages on the dc bus first.

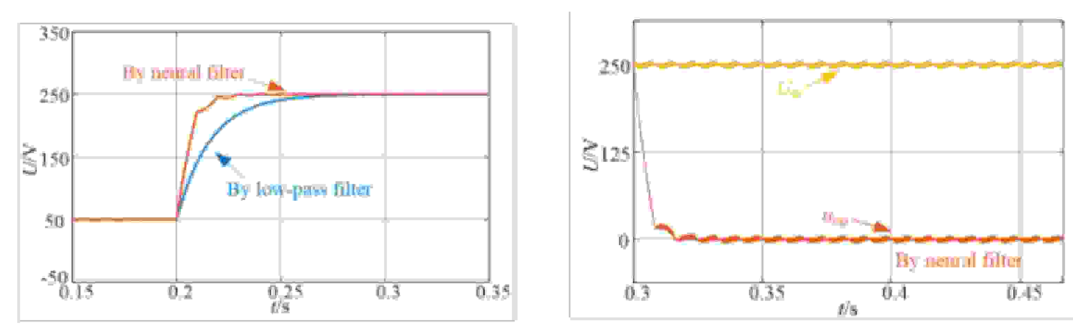


Fig. 4. Numerical simulations of neural filter. (a) Neural filter and first-order low-pass filter at step-change dc voltage. (b) DC-bus voltage and ripple voltage by neural filter

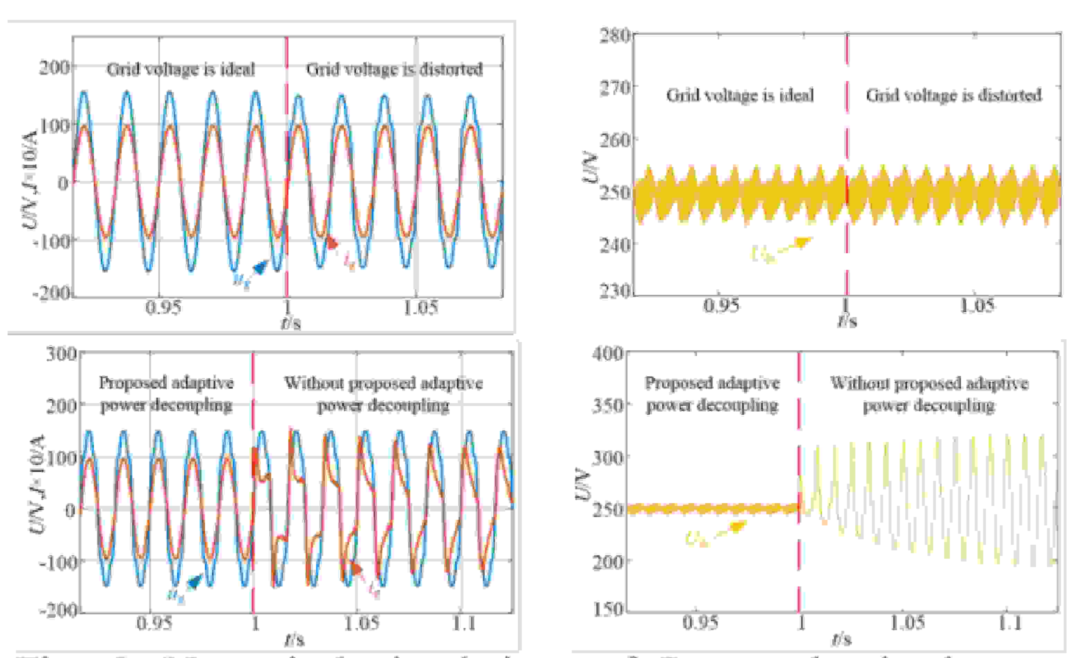
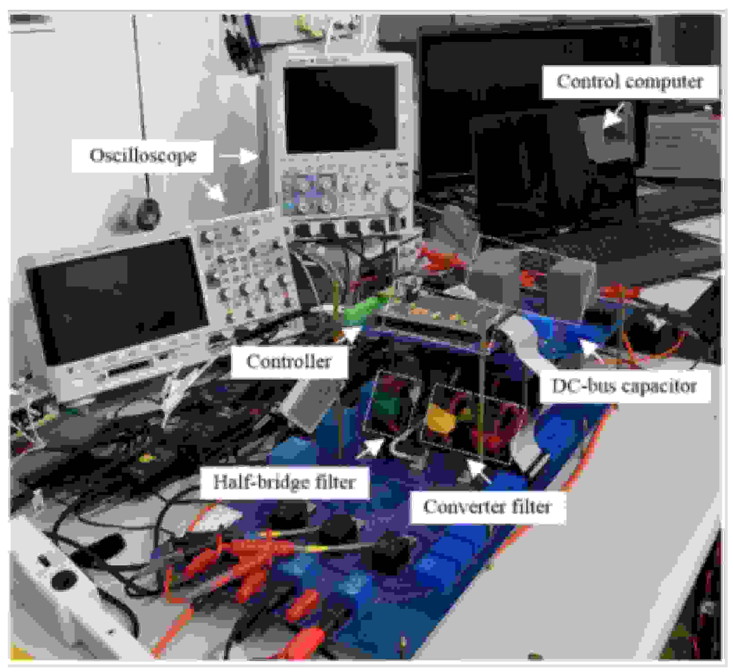


Fig. 5. Numerical simulations of Proposed adaptive power decoupling method. (a) Under varied power grid condition. (b) DC-bus voltage. (c) With and without adaptive power decoupling method under distorted power grid. (d) DC-bus voltage.

Experimental prototype



Experimental results

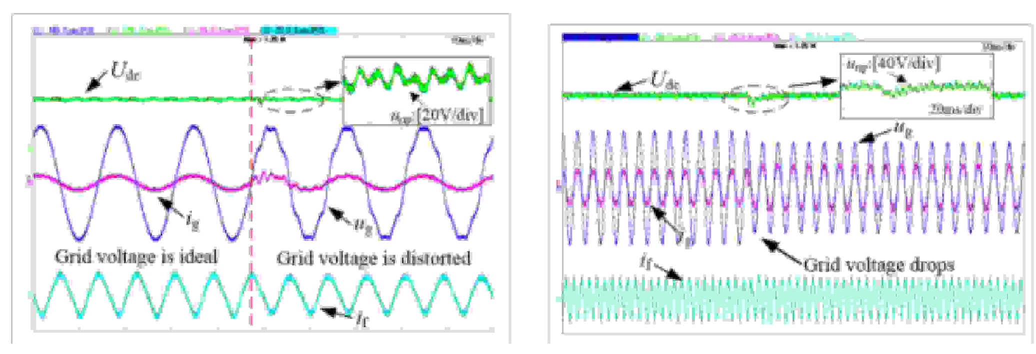


Fig. 6. Experimental results of adaptive power decoupling method. (a) Under ideal and distorted power grid condition. (b) Under grid voltage.

For realizing the accurate power decoupling, a neural filter is adopted for adaptively extracting the ripple voltage for the utilization of later decoupling control. Moreover, a total sliding-mode controller (TSMC) can ensure the system to have robustness performance and be adaptive on different conditions of the power coupling.

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