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Research Article

Design and Analysis of an LCL-based Photovoltaic Power Generation System in Low Voltage Grid Through Virtual Impedance Shaping

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Abstract

Grid-connected inverters have an important responsibility in transferring power produced by renewable energy resources to the power grid. Nevertheless, these inverters often produce current harmonics due to high-frequency switching and DC link ripple. To tackle these challenges, different filters, containing the LCL filter, are employed. However, in situations with uncertain network impedance and LCL filter resonance in weak grids, instability can happen. This paper attends the power quality improvement of grid-connected photovoltaic arrays using LCL filters utilizing a current sensor and virtual impedance shaping. The output impedance of the photovoltaic array power optimization system is decomposed into an active and passive element. This paper develops a series and parallel impedance shaping procedure to ensure that the output impedance of the LCL-filtered grid-connected inverter is dissipative up to the Nyquist frequency. The design procedure for both parallel and series virtual impedance is investigated, and the system's sensitivity is thoroughly analyzed. To validate the proposed approach, extensive simulations have been carried out using MATLAB software. Simulation results of the PV power conditioning system illustrate the robust and precise performance of the control system, suitable tracking of the PV array maximum power point, high-quality current injection into the grid, and system's capability to maintain stability, even in a weak grid condition.

Keywords: Grid-connected inverter, Photovoltaic array, LCL filter, Virtual impedance.

Highlights

- The power quality improvement of grid-connected photovoltaic arrays using LCL filters is investigated utilizing a current sensor and virtual impedance shaping.
- The output impedance of the photovoltaic array power optimization system is decomposed into an active and passive element.
- A series and parallel impedance shaping procedure is suggested to ensure that the output impedance of the LCL-filtered grid-connected inverter is dissipative up to the Nyquist frequency.

Citation: [in Persian].