Grid Integration of a Single-Source Switched-Capacitor Multilevel Inverterwith Boosting Capability

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Extended Abstract

Introduction: The presented article deals with the integration of low-voltage renewable sources into higher-voltage power grids. In this regard, the synchronization of the output voltage and the controlling of frequency and current directions are the main issues. Due to the variation of the voltage of capacitors, generating multilevel output voltage in the step-up switched-capacitor inverters requires more consideration. Therefore, desiging a precise voltage level considering the output current, which affects the voltage amplitude, governs the whole procedure. To this end, the structure of the inverter and its design play an important role. Then, the operation of the circuit facing different loading conditions is another factor for investigating its capability for grid-integrated performance.

Materials and Methods: In order to cotrol the deired process, the Proportional-Resonant (PR) controller was applied to the circuit. This controller help regulate the required voltage waveform with regard to the grid voltage. To this end, a PLL was used to detect the zero-corssing point featuring the synchronization of the inverter's output voltage and the grid. Proper control of the inverter depends on the sufficient switching pattern as well as the voltage balance of circuit capacitors . Additionally, the calculation of power loss distribution in the converter in this criterion is a key factor to demonstrate the proper operation of an inverter.

Results: In order to achieve the above-mentioned aims, the control procedure of the circuit structure was simulated in MATLAB software. The simulation results were then compared to those obtained form the expertimental tests. In the test setup, the prototype was controlled with the help of a DSP microcontroller, and sensors fed back data to integrate the inverter into the laboratory grid. Then, the proper voltage balance of the circuit capacitors leading to the gerentation of the desired output waveforms for both standalone and grid-integrated operations were examined. Besides, the steady state of and the dynamic behavior of the converter were also verified.

Discussion and Conclusion: This paper investigated the grid-connection of a single-phase multilevel inverter structure to an existing power grid. The involved voltage-source inverter could generate a near sinusoidal voltage waveform with an amplitude six times the input using a single DC input power supply. A Proportional-Resonant (PR) controller regulated the injected current into the grid, while a PLL was applied to ensure the phase and frequency synchronization of the output voltage with the grid.The grid-connected inverter was simulated in MATLAB software, and its performance was assessed under different loading conditions. Finally, the simulation results were compared with those of the experimental ones. In addition, the standalone behavior of the inverter, supplying a local load, as well as its grid-tied operation with constant and variable current references was evaluated. The correct operation of the inverter in all operating modes, achieving 96.9% efficiency with the inherent voltage balancing of the capacitors, makes it suitable for the grid-integration of low-voltage renewable energy sources.

Keywords: Multi-level inverter, grid-connection, single source, voltage multiplier, switched-capacitor, proportional resonance controller (PR)

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