Abstract

CONTROLLING OF PV INTEGRATED GRID-TIED CONVERTERS: REDUCED DC-LINK CAPACITOR AND REDUCED SENSORS

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Solar photovoltaic (PV) systems are integral in harnessing solar energy, and their integration with the utility grid is increasingly prevalent. Power electronic interfaces, such as converters, play a crucial role in facilitating power transfer from PV sources to the grid. This research focuses on the analysis, modeling, simulation, and implementation of solar PV-integrated grid-tied neutral point clamped (NPC) converters interfaced with the grid through an *LCL* filter. The introduction of resonance in the grid current due to the *LCL* filter can lead to system instability. The investigation emphasizes mainly enhancing control strategies, minimizing complexity, and improving reliability and harmonic content in the implementation.

Extensive loss analysis is carried out between NPC and T-Type three-level converter for different semiconductor devices based on Si, SiC, and GaN comprehensively. This facilitates the selection of the best three-level converter for the grid-tied converter. The three-level NPC is chosen for interfacing solar PV with the grid. To ensure compliance with grid codes and standards that limit harmonic distortion, along with enhanced system stability, a cascaded control for the *LCL* filter-based grid-connected NPC inverter is proposed. Multiple loop control strategies are generally preferred to achieve better system stability.

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However, the multiple loop control technique utilizes numerous sensors, which increases weight and cost and decreases the system's reliability. A novel cascaded control scheme that considerably reduces grid-side current and capacitor-side voltage sensors is implemented. Only two inverter-side current sensors are required. The proposed estimation algorithm implements the sensing point. Estimating the grid-side current and the capacitor voltage is carried out through the sensed inverter side current. Another less sensor-based scheme is proposed that is based on sensing capacitor side voltage for the *LCL* filter-based grid-connected NPC inverter.

The robust and stable control technique utilizing fewer sensors is a significant concern in *LCL* filter-based grid-connected converters for the weak grid that requires considerable research attention. This research work incorporates a Trilateral control scheme for an *LCL* filter-based system with a single grid current sensor in the weak grid. This work implements a novel control scheme utilizing a single sensor to sense the grid current. This technique reduces many current and voltage sensors. The α axis of the grid current is proportional to the sense 'a' phase grid current. The β current in the utility grid is acquired by employing the controller reference quantities of the grid current. The computation of another variable, i.e., the current in the inverter side inductor and the voltage across the capacitor, is executed by an estimation algorithm. The proposed technique provides the feature of reducing implementation financial value and weight, which reduces the complexity and size of hardware.

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In order to enhance the reliability, lifetime expectancy, improved efficiency, and reduced cost of the system, an effective reduction in the capacitor size of the DC-bus of a conventional three-phase NPC inverter-based grid-integrated single-stage solar photovoltaic (PV) system is also integrated into the research work. It also retains the feature of minimal oscillations during the change in irradiation.

A twelve insulated gate bipolar transistor (K40H603) with their appropriate drivers and six diodes (FFPF30UA60S) based experimental set-up is developed in the laboratory. Texas instruments-based DSP TMS320F28335 digital controller is utilized to run the set-up. The system performance is observed using a MATLAB version simulation model and authenticated through the experimental results obtained from the laboratory prototype.