Simple current controller for grid-connected inverters operating under grid disturbance and fault

Cho, Beomki[1], Do-Hyeon Kim[2], Da-Young Hyeon[3], Yun-Kyung Hwang[4], Woo-Young Choi[5], Jung-Min Kwon[6]

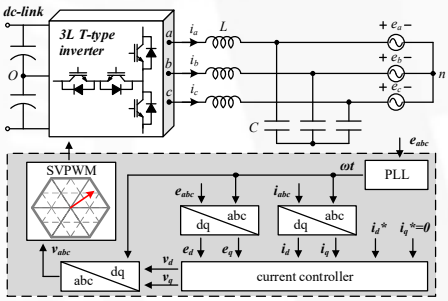
[1-5]Hanbat National University, Korea, Republic of (South Korea)

[2]Jeonbuk National University Jeonju, Republic of Korea

Abstract

Grid-connected inverters must maintain stable current regulation under grid-voltage disturbances such as abrupt voltage variations, phase jumps, and unbalanced conditions. Conventional proportional–integral (PI) current controllers suffer from performance degradation because the integral action accumulates errors from grid-voltage disturbances, leading to integrator saturation, large current overshoots, and fail-safe disconnection. To address this issue, a simple current controller is proposed for grid-connected inverters. By redefining the integral path as a modulation factor applied to the feedforward voltage, the proposed controller decouples the integrator output from the absolute grid-voltage magnitude. The controller is implemented in the synchronous reference frame with space vector modulation while remaining compatible with conventional control structures. Experimental validation is performed using a laboratory prototype of a three level T-type (3L-T-type) inverter under various grid disturbance conditions. The controller maintained balanced three-phase currents, prevented overcurrent during the phaseangle step change, and reduced current THD under harmonic voltage distortion, confirming its effectiveness under adverse grid conditions.

Proposed Controller



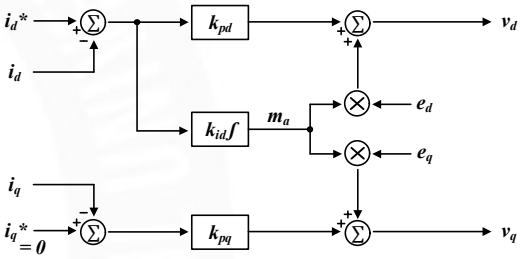
▲ The overall control diagram of the grid-connected 3L-T-type inverter system

$$v_d = k_{pd}(i_d^* - i_d) + k_{id}\int (i_d^* - i_d)\,dt \quad (8)$$

$$v_q = k_{pq}(i_q^* - i_q) + k_{iq}\int (i_q^* - i_q)\,dt \quad (9)$$

$$v_d = k_{pd}(i_d^* - i_d) + m_a e_d \quad (10)$$

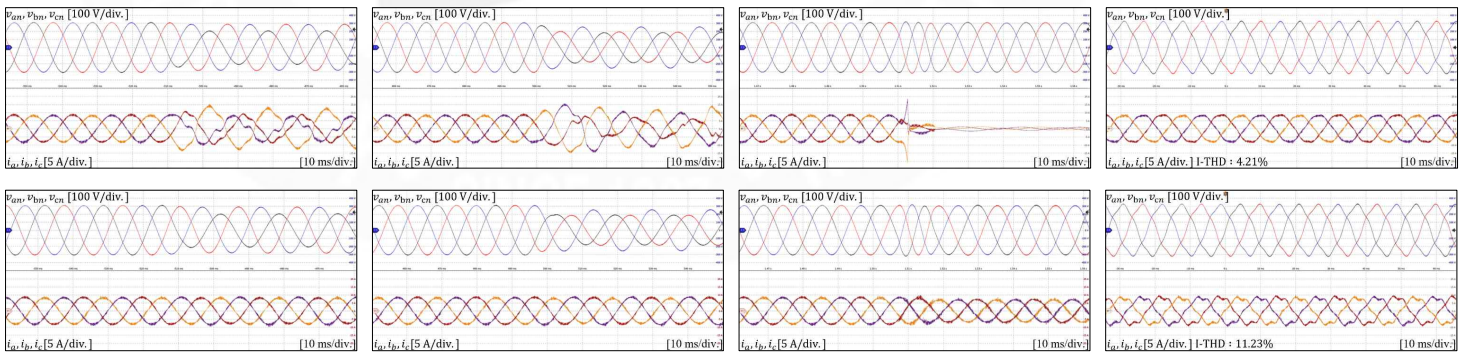
$$v_q = k_{pq}(i_q^* - i_q) + m_a e_q \quad (11)$$



▲ Control algorithm of the Proposed current controller

Results

A 4kW prototype was built to verify the proposed current controller. with full software-based control implemented on a STM32H533. Voltage and current are sampled via 12-bit ADCs, and control was executed every 50 μs.



Conclusion

This paper proposes a simple current controller for grid-connected inverters operating under grid disturbance conditions. By redefining the integrator output as a modulation factor for the grid-voltage feedforward term, the proposed method decouples the integral action from the absolute grid-voltage magnitude and improves transient current regulation. Experimental results obtained from a laboratory prototype verified the effectiveness of the proposed method. Under abrupt single-phase and abrupt double-phase voltage-change conditions, the proposed controller maintained balanced three-phase currents while limiting the peak current within the nominal rating. During a 120° phase jump, the conventional controller triggered fail-safe overcurrent protection, whereas the proposed controller maintained stable operation. In addition, under a distorted grid voltage condition, the current THD is significantly reduced compared with the conventional method.