LYAPUNOV-FUNCTION-BASED CONTROL OPTIONS FOR GRID-CONNECTED INVERTERS

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ABSTRACT

Control methods of grid-interactive inverters are an interesting research topic in power electronics. Various control methods are investigated to control the output current of the inverter and both steady-state and transient response performances are studied. L filters are used to reduce the switching harmonics in inverter output current in initial studies. However, the LCL filter which is third order becomes popular recently because of its advantages such as smaller inductive component sizes, reduced power loses, better attenuation, and lower inverter output current ripple. in inverter output current. Nevertheless, LCL-type filters have the risk of closed-loop instability due to two additional complex-conjugate poles and require resonant damping. Therefore, the design of an appropriate control strategy for an LCL filter-based grid-connected inverter becomes more complex than L-filter-based ones. Although different active and passive damping methods applied to solve the damping issue, these methods either in introduce some additional power loss or increase the control complexity. Therefore, developing a control algorithm which removes the additional active or passive damping requirement is more effective.

The Lyapunov's direct control scheme which employs Lyapunov function was successfully applied to the control of dc–dc converters, three-phase ac–dc converters, single-phase power factor pre-regulators, single- and three-phase shunt active power filters, L-filter-based single-phase grid-connected photovoltaic inverters, switched reluctance motor drive system, and single-phase uninterrupted power supply inverters accomplishing excellent dynamic response and assuring global stability under large signal transients. In this study, various Lyapunov-function-based control (LFBC) schemes proposed for a single-phase grid connected voltage source inverter with LCL filter is introduced. Since the use of LCL filter causes resonance, the conventional (CLFBC) scheme employing the inverter-side current guarantees the asymptotic global stability, but it is not able to damp the resonance. In order to damp the resonant, the Lyapunov-function based control scheme can be extended with capacitor voltage or second current feedback. The analytical equations of the closed-loop poles for each control scheme, the effect of changing controller gains on the loci of closed-loop poles is also discussed. These methods are validated with simulation and experimental studies.