Abstract

In this paper, the design and implementation of a new multiple-input–multiple-output linear control technique based on a theoretically established and experimentally validated small-signal model for the three-phase three-level boost-type ac/dc Vienna converter are presented. Averaging and local linearization techniques are used to derive the dynamic model expressed in the *dqo* reference frame. The resulted transfer functions are discretized for the sake of a digital controller design. Multiple-loop control strategy is adopted and consists of inner current feedback loops, which are based on the straightforward looping technique that neglects interactions between the *dq* components of control inputs and currents, respectively, and of an outer voltage loop, which is designed to ensure dc voltage regulation by adjusting the magnitude of the references for the inner current loops. The output dc voltage unbalance is also controlled in the inner loops. The proposed modeling and control approaches are first simulated and then validated on a 1.5-kW laboratory prototype supported by the DS 1104 digital real-time controller board of dSPACE. The obtained results prove the accuracy of the proposed new small-signal model and, therefore, its reliability for dynamic analysis and control design purposes. It is also proved that a judicious choice of controller parameters, as well as an adequate rating of boost inductors, allows one to meet the IEEE standard requirements in terms of ac line-current total harmonic distortion and power factor. The efficiency of the proposed control technique is maintained in case of disturbances occurring on both source and load sides.

Index Terms—Converter modeling, nonlinear control, real-time control, small-signal modeling, system identification, three-phase rectifier, unity high power factor rectifier, Vienna rectifier.