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RESEARCH ARTICLE

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Toward a nonlinear control of an AC-DC-PWM converter dedicated to induction heating

Abstract In this paper a nonlinear control strategy applied to an AC-DC-pulse width modulation (PWM) converter is developed and simulated. First a nonlinear system modeling is derived with state variables of the input current and the output voltage by using power balance of the input and output. The system is linearized and decoupled, and then a state feedback law is obtained. For robust control of parameter perturbation, integrators are added to the exact feedback control law. The simulation is provided to verify the validity of the control algorithm.

Keywords DC-DC converter, AC-DC-pulse width modulation (PWM) converter, induction heating, nonlinear control

1 Introduction

In the past few years remarkable progress has been made in development of high power density DC/DC converters using resonant link schemes which utilize high speed devices such as fast recovery transistors and gate turn-off thyristors (GTOs). These new converters not only have high power density but also possess very low switching losses since switching of the devices are made at zero-voltage instants and thus enable the whole system to operate at very high frequencies compared to the conventional DC link transistorized converters. Although these resonant link converters are intended to operate at high power density, almost all the systems presented in the past require self-commutated transistors and have some difficulty performing conversion at very high power levels because of the relatively low voltage and current margins that self-commutated devices such as transistors typically have.

These new converters with high frequencies and high power densities are necessary in induction heating application which leads to the increase of the switching frequency. However, increasing the switching frequency leads to significant switching losses, which will deteriorate the overall system efficiency [1].

In recent years, three-phase voltage-source pulse width modulation (PWM) converters have been increasingly used for applications such as uninterruptible power supply (UPS) systems, electric traction and induction heating. The attractive features of these converters are constant DC bus voltage, low harmonic distortion of the utility currents, bidirectional power flow and controllable power factor [2–4].

In Ref. [5], the design and performance of voltage and current PI controllers have been analyzed, which are composed of an inner current control loop and outer voltage control loop in a cascade structure. In Refs. [6,7], the PWM converter has been modelled in a nonlinear system. In Ref. [8], the nonlinear systems have been analyzed and the controllers have been designed using small signal analysis which is valid only around operating points, on which linear control is based.

In this paper, a nonlinear control technique for a PWM three-phase voltage-source AC-DC converter associated with a power circuit of the passively clamped two switch quasi resonant DC link converter (QRDCL) [9] is investigated. First, it is shown that it is feasible to apply nonlinear multiple input-multiple output (MIMO) feedback linearization technique to such a system that is operated in high frequency regimes. Next, the effect of parameter perturbation on the control performance is investigated. Finally, an integral control is introduced to the exact feedback control law in order to eliminate the steady state error [10,11].

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