Microcomputer Implementation of a Finite Error Convergence Time Controller for Voltage Source Inverters

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Abstract—In this paper, a voltage source inverter (VSI) with a finite error convergence time controller is presented. A Sliding Mode Control (SMC) has used in many applications due to their robustness, but the convergence of the system states to the equilibrium point is normally asymptotic in infinite time. Recently, terminal sliding mode control (TSMC) not only guarantees the finite error convergence to the manifold from any initial states and the finite error convergence reaching time to the equilibrium point but also reserved the merits of the SMC. With this proposed TSMC parameters design, the inverter output voltage will track the sinusoidal reference voltage within very short time. Thus, the performance of the inverter can be improved. Experimental results are given to verify the theoretical analysis. For comparison purposes, a classic sliding mode controlled VSI is also tested on the same experimental system.

Keywords—Voltage source inverter (VSI), finite error convergence time controller, infinite time, terminal sliding mode control (TSMC), manifold

I. INTRODUCTION

High performance voltage source inverters should supply the output AC voltage to the reference sinusoidal with low total harmonics distortion (THD) and fast dynamic response. To minimize THD, several control schemes have been proposed for voltage source inverters. PID controller is widely used in industry due to their simple control structure and ease of design. But, PID controller can not provide good control performance when the controlled plant is highly nonlinear and uncertain [1], [2]. Deadbeat controllers have been employed, but deadbeat control is highly dependent on the accuracy of the parameters [3], [4]. The repetitive controller (RC) and μ-synthesis controller can overcome parameter uncertainties and load disturbance. However, RC or μ-synthesis controller has implementation difficult and algorithm complexity [5], [6], [7]. Proposed in 1950s, and sliding mode control is being given attention due to its robustness characteristics [8], [9]. Researches have also been conducted to derive various sliding modes to achieve control performance. A number of SMC techniques associated with the inverter system have been reported. Jezernik et al., Chiang et al., and so on utilized classic SMC to control objections, but steady-state errors exist and poor transient response is obtained [10], [11]. Chern et al. proposed the integral variable structure control to reduce the steady-state error [12]. However, this method incurs unsatisfactory dynamic response. As mentioned by [10], [11], [12], linear sliding surface is adopted. Its characteristic is that the system tracking error converges to zero asymptotically. Recently, a new type of SMC technique called terminal sliding mode control (TSMC) was developed and applied for robots and nonlinear systems [13-17]. Compared with linear sliding-surface-based control, terminal sliding mode control can drive the system tracking error to converge to zero in finite time that provides better tracking precision control [18]. Therefore, this paper presents such a controller which introduces a finite error convergence time mechanism to resolve classic SMC problems for special application to VSI. From the point of view in practical inverter application, if the load disturbance is a large step change or an uncertainty or a nonlinear condition, TSMC system will easily achieve a finite error convergence time, reduce the steady-state error, obtain fast dynamic response, and prevent a high THD. Thus in principle, the proposed controller can be used with all TSMC systems, but will be applied below specifically in the context of a single-phase VSI. As will be seen, the presented finite error convergence controller will yield a closed-loop VSI with low THD and fast dynamic response under different types of load. Experimental results are presented to illustrate good performance of TSMC controlled voltage source inverter. While the final performance results of the presented system do not surpass the THD results of recent prior work, the proposed controller robustness, structure and design simplicity are significantly better than the prior studies.

II. DYNAMIC MODELING

The output voltage $v_o$ of the single-phase voltage source inverter, shown in Fig. 1, can be forced to track a sinusoidal reference voltage $v_{rj}$ by applying the TSMC.