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Fuzzy Logic Control of Matrix Converter Based PMSM Drive to Reject Internal Voltage Disturbances

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ABSTRACT
In order to optimize the speed-control performance of the permanent-magnet synchronous motor (PMSM) system with different disturbances and uncertainties, a nonlinear speed-control algorithm for the PMSM servo systems using sliding-mode control and disturbance compensation techniques is developed in this paper. First, a sliding-mode control method based on one novel sliding-mode reaching law (SMRL) is presented. This SMRL can dynamically adapt to the variations of the controlled system, which allows chattering reduction on control input while maintaining high tracking performance of the controller. Then, an ex- tended sliding-mode disturbance observer is proposed to estimate lumped uncertainties directly, to compensate strong disturbances and achieve high servo precisions. A fuzzy sliding mode controller is used to reduce the disturbances during loading. Simulating validity of the proposed control approach.

Index Terms—Disturbance observer, permanent-magnet synchronous motor (PMSM), Sliding-mode control (SMC), sliding- mode reaching law (SMRL), fuzzy logic controller.

I INTRODUCTION

In the permanent-magnet synchronous motor (PMSM) control system, the classical proportional integral (PI) control technique is still popular due to its simple implementation [1]. However, in a practical PMSM system, there are large quantities of the disturbances and uncertainties, which may come internally or externally, e.g., unmodeled dynamics, parameter variation, friction force, and load disturbances. It will be very difficult to limit these disturbances rapidly if adopting linear control methods like PI control algorithm [20].

Therefore, many nonlinear control methods have been adopted to improve the control performances in systems with different disturbances and uncertainties, e.g., robust control [4], [5], sliding-mode control (SMC) [6], [7], [10], [16], adaptive control [8], backstepping control [9], predictive control [11], intelligent control [13], [14], and so on. In these nonlinear control methods, SMC method is well known for its invariant proper- ties to certain internal parameter variations and external disturbances, which can guarantee perfect tracking performance de- spite parameters or model uncertainties. It has been successfully applied in many fields [15], [16]. In [6], the fuzzy sliding-mode approach was applied to a six-phase induction machine. In [7], a hybrid terminal sliding-mode observer was proposed based on the nonsingular terminal sliding mode and the high-order sliding mode for the rotor position and speed estimation in one PMSM control system. In [17], the performance of a sliding-mode controller was studied using a hybrid controller applied to induction motors via sampled closed representations. The results were very conclusive regarding the effectiveness of the sliding-mode approach. A neuron-fuzzy sliding-mode controller applied to induction machine can also be found in [15].

However, the robustness of SMC can only be guaranteed by the selection of large control gains, while

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