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IMPROVED INTEGRAL SLIDING MODE CONTROL METHODS FOR SPEED CONTROL OF PMSM SYSTEM

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Abstract. *To improve the disturbance rejection property of permanent magnet synchronous motor (PMSM) speed control system, the integral sliding mode control (ISMC) method is introduced in the control design of speed loop. However, the simulation and implementation results show that it is difficult to balance the chattering and the anti-disturbance capacity. To this end, three kinds of improved ISMC control methods are developed. First, ISMC using linear varying gain is developed. Using this method, the switching gain of ISMC controller can be smaller while still ensuring that the speed state reaches its steady state and the steady state fluctuations can thus be reduced. Moreover, the anti-disturbance capacity of the PMSM system can also be assured. Second, an integral sliding mode control based on extended state observer (ESO) is developed. ESO can estimate both of the states and the disturbances simultaneously. By using ESO, an estimate of the lumped disturbances is obtained, which is employed for the feedforward compensation design of the composite ISMC control law. In this case, the controller may take a smaller value for the switching gain without sacrificing disturbance rejection performance, which helps to reduce large chattering caused by high control gains. Third, an adaptive composite control method combining linear varying gain and ESO is developed to take advantages of both improved methods. These improved methods show advantages in reducing the chattering while ensuring the dynamic and disturbance rejection performance. Both of simulation and experiment results are provided.*

Keywords: PMSM, Integral sliding mode control, Extended state observer, Linear varying gain, Composite control, Speed-regulation

1. **Introduction.** Permanent magnet synchronous motor has gained widespread acceptance in numerical control machine tools, robots, aviation and so on, due to its excellent features such as high power density, torque-to-current ratio and efficiency [1]. Linear control schemes such as proportional-integral (PI) control scheme have been widely used in PMSM servo system because of simple implementation [2]. However, it is very difficult to achieve a satisfactory performance in the entire operating rage by only using linear control methods. The reason is that the PMSM servo system is a nonlinear system with unavoidable and unmeasured disturbances as well as parameters variations [3, 4, 5]. Thus, various methods of nonlinear control methods have been developed for PMSM system, such as adaptive control [6, 7], robust control [8], sliding mode control [9], input-output linearization control [4], backstepping control [10], neural network control [5], fuzzy control [11] and finite-time control [12], etc.

Sliding mode control (SMC) is a very useful nonlinear control method [13, 14, 15] and it has been introduced in AC servo drive systems [16, 17] due to its good robustness for external disturbances and variations of system parameters, fast response and easy