ABSTRACT

Due to the merits of high efficiency, high power density, high torque to inertia ratio and free from maintenance, surface-mounted permanent magnet synchronous motors (SMPMSM) have now been widely adopted for servo drives in various applications such as robotics, manipulators, machine tools and production materials handling. Fast and robust dynamic response as well as efficient steady-state operation is often emphasized on these applications. Therefore, robust field weakening control strategy is the focus of this research for SMPMSM drives. Basically, the major contributions of this dissertation can be summarized as follows. First, the classification of ten operation regions for four-quadrant operations and the partial field weakening concept are proposed. It is seen that consideration of the stator resistance is crucial to achieve the fastest response. Second, a closed form solution of the maximum available torque-producing current is proposed for calculating the corresponding saturation bounds of the speed controller in real time. By combing the closed form solution and a conventional proportional-integral (PI) speed controller, the drive can achieve both fast response and automatic field weakening control. Third, a robust tuner based on the proposed virtual maximum phase voltage amplitude together with a minimum copper loss controller based on the partial field weakening concept is proposed to achieve minimum copper loss over the entire operating range. Moreover, a dc link voltage sensorless control version is also proposed which is very useful in electrical vehicle applications. Due to the application of the robust tuner, the high performance can be preserved in spite of the variations of the dc link voltage and the parameters of the SMPMSM. Fourth, a sliding-mode speed controller with an adaptive lumped uncertainty observer is

also proposed to achieve the robust control aim. A tighter estimation of the lumped uncertainty can be obtained by applying the adaptive lumped uncertainty observer to fully use the maximum torque capacity as well as to reduce the chattering phenomenon. Due to these advantages, the proposed sliding-mode speed controller may be used to replace the existing PI speed controller to achieve high performance operation for the entire operation region in the future.