CHAPTER 5

CONCLUSIONS

In this dissertation, a novel robust field weakening control strategy for SMPMSM drives is proposed to fully exploit the torque capability as well as achieve minimum copper loss operation. Based on the strategy, a sliding-mode speed controller with an adaptive strategy for the estimation of the lumped uncertainty is proposed to achieve high performance operation. In chapter 2, the mathematical model and constraints for the SMPMSM drives are reviewed briefly. Then, the classification of operation regions for four-quadrant operation and the profound effects resulted from the consideration of the stator resistance are also presented therein. Finally, the zero d-axis current control strategy is adopted for the control strategy of constant torque limit region. Some experiments are performed by using a DSP-based prototype drive. From the experimental results, one can see that the operation range can be extended effectively by the proposed field weakening control strategy.

Based on the constraints of the SMPMSM drives as derived from chapter 2, a beautiful closed form solution of the maximum available torque-producing current is proposed in chapter 3. Based on the closed form solution, a novel field weakening control strategy is proposed to eliminate the gradual adjustment by feedback mechanism so as to achieve faster response and better stability. Also, automatic field weakening control can also be achieved. No region detector is required; therefore the implementation can be highly simplified. For a high performance motor drive system, operation under high drive efficiency is also desirable. Hence, a minimum copper loss controller based on the concept of partial field weakening control is proposed so as to achieve the maximum torque per ampere control. To improve the robustness of the proposed field weakening control strategy, a robust tuner based on the proposed virtual maximum phase voltage amplitude is proposed to obtain more accurate i_{qs} bounds. Also, a proper d-axis current command to achieve robust minimum copper loss is obtained by the combination of the virtual maximum phase voltage amplitude and the minimum copper loss controller. From the results of simulations and experiments, the performance of the proposed field weakening control strategy for both simulations and experiments can be verified.

For a high performance variable speed drive system, good rejection under the lumped uncertainty is also desirable. Hence, a sliding-mode speed controller with an adaptive lumped uncertainty estimator to achieve a robust performance is provided in chapter 4. Due to the proper operation of the proposed adaptive lumped uncertainty estimator, the requirement on the upper bound of the lumped uncertainty can be relaxed. The resultant chattering phenomenon and the additional control energy for the reaching mode condition can be reduced. Therefore, the proposed adaptive sliding-mode speed controller is superior to the conventional PI speed controller. Some distinguished features of the proposed speed controller can be verified through the simulation results. From the observations of these simulation results, one can see that high dynamic response, good rejection performance to lumped uncertainty and minimum copper loss are all achieved. Moreover, due to low chattering and low extra control energy for the reaching condition, the proposed speed controller can also achieve high performance operation even when the drive is operated in the field weakening region.

Finally, several research topics may be recommended in the following for future studies:

1. The dynamic model instead of the steady state model can be used under the consideration of the voltage limitation of dc link and a more smooth transient

operation may be obtained if the time delay effect resulted from a digital controller is considered.

2. The proposed control strategy can be applied to induction motor or interior PMSM drives.
3. Advanced control theory can be applied to SMPMSM drives to achieve more robust and/or less try and error procedure for parameter values in the proposed controller.
4. Other PWM strategies and/or dynamic over-modulation strategies can be applied to improve the transient performance and expand the operation range.