CHAPTER 5

CONCLUSIONS

Today's commonly used power converters have a poor input power factor and rich harmonic current, which deteriorates the power line quality and may interfere with other power electronic equipment. To improve the input power factor of current power converters, stringent input power factor regulations such as IEC 1000 have recently been enacted. Therefore, power factor correction techniques have been very popular topics in recent years' power electronic research. Because the addition power factor converter will increase the cost of the overall system, the integrated single-stage power factor correction techniques become attractive especially in low-power cost-effective applications.

This thesis presents the generalized structure and common necessary condition of the single-stage PFC converters. After that, it focuses on the study and improvement of the CCM CS single-stage PFC converter. Finally, the comparison between the example circuits of CCM two-stage and single-stage PFC converter is done to show the merits, the potential problems and the future research direction of single-stage PFC converters for universal line applications.

The integrated single-stage PFC converter actually combines the PFC stage with the PWM dc/dc converter. Because the control circuit is focusing on the tight regulation of the output voltage, the input current shaping function must be achieved automatically based on the operation principle of the single-stage PFC converters. So far, the dither concept is good enough in explaining the DCM single-stage PFC converter; however it cannot be used to further understand the CCM single-stage PFC converters. In this thesis, a general necessary PFC condition is derived based on the study of the ideal boost PFC converter. This condition is verified by the present integrated single-stage PFC converters. It can be used to understand the present CCM single-stage PFC converters, to give design intuition of the CCM single-stage PFC converters, and to check the possible new single-stage PFC topologies.

The current source single-stage PFC converter is attractive because its CCM input current reduces the EMI filter size and improves the overall efficiency. In this converter, an additional inductor is used to shape the input current in CCM input inductor current mode. The function of this inductor is explained by the necessary PFC condition. Besides, the DCM/CCM conduction angles of the input inductor current during a line cycle also affect the input power factor. The circuit intuitions are given and then the design consideration is presented. It shows that there is an optimal point of the inductance distribution between the input inductor and the additional inductor. At this optimal point, the low input current THD and bus voltage stress can be achieved. However, for universal line application, the CS single-stage PFC has problems as high current distortion and small capacitor voltage margin at high line. To overcome these problems and make the optimal design easy, a low cost, low loss and small size auxiliary switch is introduced to the CS single-stage PFC converter. The experimental verifications show that the improvements of input power factor and efficiency are effective.

The single-stage PFC techniques are attractive because they reduce the total cost and size by saving the PFC switch and controller. However, for universal line applications, the comparison study shows that the wide bus voltage range of the single-stage PFC converters will require larger component ratings compared to the two-stage PFC converters. Therefore, the benefit of saving one PFC switch and PFC controller is only attractive for low power applications. It limits the applications of the single-stage PFC converters. How to reduce the bus capacitor voltage range will be very interesting future work that will improve the overall efficiency and reduce the total cost and size of single-stage PFC converters.