CHAPTER 6
CONCLUSIONS

In this dissertation, first, a time varying d_0 controlled three-phase step up/down AC/DC converter is roughly reviewed. This converter has the high performance characteristic as compared with the existing converters. For example, a single stage structure leads to high efficiency, clean AC line current with unity power factor and with adjustable clean DC output voltage. However, there remain many drawbacks to improve. For example, this converter does not possess bidirectional power flow capability rendering the applications limited to only undirectional power flow situations. Also, as far as practical implementation is concerned, the time varying d_0 control is much more difficult to realize and less robust. In addition, the random switching dynamics make one almost impossible to find a linear time invariant model for controller design use. Hence, based on the generalized zero voltage space vectors concept and motivated by the approximate constant D_0 expression, the author first proposed a seven-active-switch configuration to achieve bidirectional power flow capability in chapter three. Then, the author derived a closed form duty ratio control law by using the familiar state space averaging technique and with the assumption of existence of a constant D_0 control strategy. Luckily, it turns out that the assumption is true and one can obtain the corresponding linear time invariant models. These include the DC model and the small signal model in the forms of both state equations and transfer functions as well as the corresponding equivalent circuit models given in chapter four. The analytical model is rather useful for understanding the converter behavior as well as for simulation and design. It is interesting to find that the proposed converter has one degree of freedom about choosing D_0 for a given output voltage.

In chapter four, the author adopted a distributed D_0 control strategy to assign one half D_0T_S to the beginning and the other half D_0T_S to the end of each switching period T_S. In other words, one half D_0T_S is attributed to V_{70} the space vector and the other half D_0T_S is assigned to V_{07} space vector such that, during both intervals of $\frac{D_0}{2}T_S$, the stored energy of capacitor C can be transferred to the output. Hence, during these two intervals, V_{77} is applied and the three bridge arms are short circuited. Finally, from the derived model it is straightforward to achieve the maximum constant D_0 control, namely $1-2d_m$. An analog implementation of the controller is proposed and some experimental results are presented for demonstrating the validity of the theory.

In order to achieve better efficiency, the author proposed a dead-band control strategy to further improve the maximum constant D_0 control strategy. It is basically based on the observation that, in each time interval during a switching period T_S, the magnitude order of d_1, d_2 and d_3 or d_4, d_5 and d_6 is preserved in the proposed control strategy. As a result, one can choose the minimum duty ratio of d_1, d_2 and d_3 or d_4, d_5 and d_6 during each interval as the maximum constant D_0 control. It is interesting to see that, due to this selection of maximum constant D_0 control, only V_{70} or V_{07} can happen in each interval but not both as that of chapter four. Hence, the final result is rather promising. In other words, the switching number of each active switch of the bridge can be reduced by one sixth and voltage V_C can be further lowered.

Due to limitation of time, some further researches may be suggested as follows. First, although the theoretical basis derived in the dissertation is sound but it does involve much calculation. The analog implementation of chapter four seems not very attractive. Hence, a fully digital implementation is worth developing in the future. Second, the important dynamic model of the proposed converter has been derived in this dissertation. Hence, it may be used for applying many modern control theories to achieve much better transient performance. Also robust control and system integration for a special application is worth exploring. Finally, as far as the power electronics domain is concerned, the similar theory can be applied to other types of converters.