CHAPTER 7

Conclusions and Future Work

7.1 Introduction

In previous chapters, three types of PECs are discussed to supply power to AC and DC loads of residential distribution systems (two-stage, single-stage, and hybrid AC/DC systems). This chapter gives conclusions drawn from previous chapters and future work of research work discussed in this thesis.

7.2 Conclusions

Two high gain DC-DC converters (TSHGC and HGIBC) are proposed in this thesis for a two-stage (DC-DC and DC-AC) residential AC system as front-end DC-DC converters. The TSHGC has a high gain operation at a low D with reduced elements as compared to some reported high gain converters. At low values of D, the practical voltage gain of TSHGC is very close to its theoretical voltage gain with reduced conduction losses in the elements of TSHGC. The TSHGC has improved efficiency and power density due to lower values of D and lesser number elements. However, the TSHGC requires a high value of input inductance for achieving input current with low ripple. Also, it has a floating output and has slightly higher voltage stresses on the power semiconductor devices of TSHGC. To take care of these issues, another front-end DC-DC is proposed, namely HGIBC. The HGIBC has two parallelly connected inductors at the input side to achieve continuous input current with less ripple and a lesser number of elements as compared to TSHGC. As the HGIBC has non-floating output, a common-mode voltage problem can be avoided in it. Moreover, the HGIBC is capable of operating in three operating regions which results in achieving three different voltage gains based on two switching logics, 180^{o} phase-shifted and complementary switching. As the HGIBC operates in three regions, the devices experience different current/voltage stresses which leads to cost-effective device selection for a particular application according to the voltage-gain requirement. The performance of proposed TSHGC and HGIBC is being investigated through simulation and experimental studies. Further, the proposed two front-end DC-DC converters are compared to some reported high gain DC-DC converters to show their effectiveness. Hence, the proposed two front-end DC-DC converters can be used for two-stage AC system because of their features as compared

to some reported converters. However, a DC-AC converter is required along with the proposed two DC-DC converters when the low voltage DC sources supply the AC loads/grid.

The additional DC-AC converter along with the two proposed DC-DC converters increases the volume and decreases the reliability of overall system. To take care of these issues, three high gain DC-AC converters as single-stage power conversion for AC residential system, namely Type 1 SLC-ZSI, Type 2 SLC-ZSI and eSLC-ZSI. The three SLC-ZSIs have higher voltage gains at low values of D_{st} with reduced elements as compared to some reported SL based ZSIs. As they operate at low values of D_{st}, M can be operated near to unity which gives power inversion at reduced harmonic distortion. Although the Type 1 and Type 2 SLC-ZSIs have high gain inversion, they have more ripple in the continuous input current and moderate voltage/current stresses on the elements. To overcome these issues, eSLC-ZSI is developed from Type 2 SLC-ZSI. The eSLC-ZSI has reduced energy storage elements. Detailed mathematical modeling of the three SLC-ZSIs is carried out and their characteristics are compared with reported SL based ZSIs to show their effectiveness. The performance of three SLC-ZSIs is verified through simulation and experimental results. It can be concluded from the comparison and verification that the three SLC-ZSIs are advantageous over the cascaded connection of DC-DC and DC-AC converters for a AC residential system.

The three SLC-ZSIs are better choices as single-stage power conversion for AC systems in comparison to two-stage power conversion. However, in recent times, DC loads are gradually increasing along with existing AC loads in modern residential systems which leads to the requirement of hybrid AC/DC system. The proposed converters (TSHGC, HGIBC and three SLC-ZSIs) are not appropriate at their present circuit configuration to supply AC and DC loads with better power density. They have to be connected either in parallel or in a cascaded way to supply the DC and AC loads, which increases the volume and decreases the reliability of the hybrid system. To take care of these issues, a hybrid converter, namely, IHC is proposed to supply AC and DC loads simultaneously through a single power converter. It is developed from the switching concept of HGIBC and SLC-ZSIs. The IHC has two operating conditions ($D + M \leq 1$ and $D + M \geq 1$), unlike CHCs. Due to the two operating conditions, the IHC has wider ranges of D and M which leads to independent control of AC and DC outputs. Further, the IHC has three operating modes for achieving different AC and DC voltage gains in the two operating conditions. As the IHC is in interleaving nature, it uses

low values of inductors to obtain continuous input current with less ripple. Also, it uses low current/voltage rating of devices for high power applications which results in economical prototype design. The performance of IHC is verified through simulation and experimental results. Further, power losses in the elements and efficiency variation of IHC are compared with two CHCs to show its effectiveness. It can be concluded from the comparison and verification that the IHC is a better choice for supplying AC and DC outputs of hybrid AC/DC system.

7.3 Future Work

- By replacing constant input DC source of proposed converters, low voltage DC sources such as solar and fuel cells have to be considered as the main input source for the residential systems.
- Instead of standalone operation, grid integration of proposed converters has to be done. Further, power quality issues during grid integration have to be addressed by designing efficient switching techniques and robust controllers.
- The proposed topologies have to be modified for multi-input and multi-output operations, which have to be carried out further.
- Moreover, a transformerless solar PV based grid system has to be developed by minimizing leakage current.
- Wide bandgap devices have to be used for designing the prototypes of proposed converters to achieve high power density.