Chapter 7

Conclusion and future work

7.1 Conclusion

The main focus of this thesis is to investigate alternative solutions for three-phase AC-AC converters, which are necessary for certain applications such as wind energy and AC drive. Matrix converters offer high power densities and variable voltage and frequency operations among various AC-AC converters. The maximum voltage transfer ratio of these converters is limited to 0.866. Integration of a conventional Z source impedance network can improve the voltage transfer ratio > 1. However, it produces a high inrush current at startup; due to this, ZS-USMC cannot achieve soft starting capability, and the discontinuous nature of the input current leads to a large input filter. The quasi Z source and switched boost ultra sparse matrix converters are proposed as the possible solutions to these problems. Furthermore, matrix converter switches are controlled by high-frequency pulse width modulation techniques, which increases the common mode voltage.

- In this thesis, modified SVM techniques are developed to reduce the peak common mode voltage. Auxiliary switches are used in the modified SVM to mitigate the common mode voltage in the conventional USMC. The proposed SVM technique reduces the peak CMV by 42.23% and achieves soft switching at the CSR stage. The proof of concept is validated through simulation studies and laboratory prototypes.

- A new switching strategy for a quasi Z source ultra sparse matrix converter (QZS-

USMC) is proposed to reduce the common mode voltage without affecting the voltage gain. This method also aims to reduce the ripple content in the inductor current. Analysis of the QZS-USMC with the proposed method is derived and validated through simulation studies. A laboratory prototype is built and tested to validate the proof of concept. The proposed method reduces a significant amount of ripple (24%) in the QZS inductor current. In addition, the peak CMV is reduced by 33%.

- By decreasing the number of passive elements in the QZS-UMSC, switched boost (SB) USMC is developed. The SB-USMC achieves voltage gain similar as QZS-USMC but with lower passive components. The analysis of the SB-USMC is derived and verified through both simulation as well as laboratory prototype.

- Three vector space vector modulations (TVSVM-I, TVSVM-II) are proposed to mitigate the CMV in SB-USMC. The TVSVM-I shows better CMV reduction (33%) for low shoot-through periods, whereas TVSVM-II gives better THD in output voltage. The reduction of peak CMV of the TVSVM-II depends on the shoot-through period. For a 0.3 shoot-through duty ratio, TVSVM-II reduces peak CMV by 20%. Simulation and experimental results validate TVSVM-II.

Overall, the SB-USMC offers balanced output voltages under unbalanced input, a wide operating range for output power factor, and constant output frequency with variable input frequency. The switching strategy proposed for QZS-USMC reduces peak CMV and inductor current ripple, whereas the switching strategy proposed for SB-USMC (TVSVM-II) reduces peak CMV and improves the output voltage THD.

7.2 Future work

The proposed converters satisfactorily performed well during experiments. However, a few tasks are yet to be done to develop these converters in product form.

- There is a need to increase the power rating of the laboratory prototype to meet the industry applications. It can be done by designing converters with high-rated semiconductor devices and passive elements.

- Even though proposed switching strategies targeted common mode voltage and inductor current ripple minimization, they can be extended to soft switching. Soft switching is another area to explore when proposed converters are implemented for high frequencies.

- A small change in the duty ratio leads to wide variations in output voltage. So, there is a need to design a closed-loop controller. Designing the proper controller will enhance the converter dynamic performance.

- For fast switching applications, silicon devices can be replaced by SiC and GaN devices.