Chapter 6

Conclusion and future work

6.1 Conclusion

The aim of the thesis is to investigate alternative solutions for AC-AC power converter, which acts as an interface between low voltage permanent magnet generator and high voltage AC load. Integrated Z (impedance) network within matrix converters seems to be a possible solution. However, under extreme situation it requires higher voltage transfer ratio which demands longer shoot through period. Producing a longer shoot through period and to maintain constraint ($m + d_{sh} \leq 1$) results in low modulation index which affects the output power quality. Furthermore integrated impedance source matrix converter require more number of passive elements and is unable to produce balanced output with unbalanced input voltage. The SC-USMC, SB-USMC converters are proposed as the possible solutions to encounter these problems.

The proposed converter integrates the ultra sparse matrix converter with switched capacitor network which is allowed to boost the intermediate DC link voltage with lesser number of passive elements. The switched capacitor network arrangement is such that it requires lower current ratings of devices in an inverter section to deliver higher voltage at the output terminal. Interestingly, SC-USMC provides balanced output voltage with unbalanced input voltage.

Another proposition made in this thesis is switched boost ultra sparse matrix converter. This converter requires one inductor and one capacitor to boost the intermediate DC link voltage by a factor of $\frac{1}{1-2d_{sh}}$. The proposed converter is immune EMI issues due to presence of switched inductor. Three vector modulation scheme is applied to the proposed converter with advantage of reduction in inductor current ripple.

Steady state analysis of the proposed converters i.e SC-USMC and SB-USMC, is derived and supported by simulations studies. To validate the proof of concept, a lab prototype is built and tested. In addition, a dedicated modulation technique is developed for each proposed converters to enhance its operating range in terms of voltage gain, inductor current ripple, more linear operating region and wider range of load power factor.

The converters SC-USMC and SB-USMC exhibit two level voltage at the output terminals, which require considerable filter size making the system bulkier, as power rating increases. In order to address this issue, three level Z source based ultra sparse matrix converters is proposed in this thesis which characterises the high gain along with minimum number of power devices. A modulation technique based on SVM was developed to generate the switching signals to achieve the desired output. An experimental test rig was built and tested, to validate the converter behaviour. Without output filter the proposed converters, exhibit 40% THD at output voltage compared to 90% by the two level converter, thereby making the system compact.

Overall proposed converters discussed in this thesis are mainly for high gain AC-AC conversion, where each converter has its own merit over the other. From the three proposed converters, SC-USMC converter produces higher gain than others, on the other side SB-USMC and three level Z source-USMC are immune to the EMI issues and also requires less number of passive elements. Three level Z source-USMC requires compact output filter than others. Due to the topological advantage of SC-USMC, it produces balanced output with unbalanced input voltage.

6.2 Future work

The proposed converters performed satisfactorily during experiments. However, there are few task yet to be done for the development of these converters in product form. Designing of PCB with proper arrangement of gate driving circuits, transducers, signal conditioning circuits and switching devices are to be taken care.

By observing the switching pattern of proposed converters, there is a need of higher speed switching devices in inverter section compared to rectifier section. This can be achieved by realising inverter section with SiC devices and rectifier section with Si devices for an optimal thermal management and compact structure. For higher power levels, proposed converters can be realised by paralleling either rectifier section or inverter section.

Even though the proposed converters are targeted for wind energy system applications, it can be extended to variable frequency electric drives application. Common mode voltage reduction is another area to explore when proposed converters are implemented for drives application.

Closed loop control action is required for the proposed converters to stabilise the operating point within certain limits. Therefore it is important to choose appropriate type of controller which will enhance the dynamic performance of the converter.