CHAPTER 9

CONCLUSIONS AND SUGGESTIONS
FOR FUTURE WORK

9.1 CONCLUSIONS

The summary of the research work carried out in different power converter topologies for Direct Drive Wind Energy Conversion (DDWECS) system is presented here. In this research work different types of generators such as induction generator, synchronous generator and permanent magnet generator are considered for DDWECS applications. From the detailed comparative analysis made, the radial flux and axial flux permanent magnet generators are found to be more suitable for DDWECS. Among these two types of generators the radial flux PMG stands out because of its simple construction and reliable operation. A PMG of 1kW, 415V, 200rpm, 16 rotor pole surface mounted Neodeniom iron Boron (NeFeB) magnet with radial flux is used for this research work which is capable of generating near rated voltage in the speed range of 50rpm to 116 rpm. Two types of power converters such as Z-Source Inverter (ZSI) and Z-Source Matrix Converter (ZSMC) are proposed in this research work and are used to get a constant 415V, 50Hz supply to load or grid from the continuously varying Wind conditions.

With the introduction of ZSI the number of power conversion stages is reduced in the DDWECS. Carrier based third harmonic injection PWM scheme and Modified Space Vector PWM scheme are used to predict
the performance of ZSI. The third harmonic injection PWM scheme offers maximum boost but placement of shoot through has limited range and also its dc link voltage, and inductor current are exhibiting ripples. These ripples lead to increase in Total Harmonic Distortion (THD) and switching voltage stress and current stress. The modified SVPWM offers simple shoot through placement under varying input voltage conditions. The ripples are low and so also the switching stresses.

The ZSI is a single-stage DC-AC converter with low switching stress. The output voltage of ZSI is maintained constant irrespective of the fluctuating input condition by suitably adjusting the boost factor. The dc link voltage control strategy of ZSI ensures better stability of DDWECS.

To further reduce power conversion stages in DDWECS, Z-source matrix converter (ZSMC) is proposed. The ZSMC produces an output voltage that is greater than the input generated voltage. The unique impedance network and shoot through distribution of the ZSMC ensures desired sinusoidal input and output voltages. With only three additional switches, the ZSMC has the buck boost function which increases the reliability of the DDWECS. The simulation results very well coincide with the experimental results.

The inherent buck boost capability and shoot through adjustment with respect to the PM generator voltage variations, make the ZSI and ZSMC more suitable for a power conditioner in DDWECS. The output voltage and current waveforms of ZS-MC are almost sinusoidal when compared with conventional PWM inverters.

From the comparative analysis between ZSI and ZSMC, the modified SVPWM of ZSMC requires more number of shoot through pulses for half cycle; whereas it is lesser in the case of modified SVPWM ZSI. The
shoot through insertion and distribution in ZSMC is eight pulses in one sampling period whereas it is six pulses in ZSI for a wind velocity of 6m/s. Hence, ZSMC has more switching losses with the variation in wind velocity. Also the insertion of shoot through period is complicated in ZSMC. The value of modulation index in ZSMC is lower than that of ZSI. As a result the switching voltage stress across the power switches in ZSMC also increases. The limited advantages of ZS-MC based DDWECS is its better input harmonic profile.

The output THD of ZSI and ZSMC at full load is quite low. In addition the waveforms are not distorted in both cases. The dead time in the conventional PWM inverter results in poor power quality. But for RL load applications the duration of dead time is still higher. As a result poor power quality induced torque pulsation noise is produced in the terminal load of the conventional PWM inverter. The output THD of the proposed ZSI based DDWECS is lower than that of conventional DDWECS. The ZSMC based DDWECS yields sinusoidal output voltage as against the conventional system and hence the size of the filter requirement is less in the proposed systems. The overall efficiency of the proposed ZSI based system is improved by 8.1% over the conventional system.

In this proposed novel research work a MPPT algorithm for DDWECS has been implemented on a grid connected system. The cubic optimal power curve between the generated power and machine speed is used. The ZSI shoot through period which regulates the machine speed is adjusted to obtain the maximum power. The current speed of the generator obtained by using a smart and simple speed sensorless scheme has been devised for the salient pole generator. The novelty of this scheme is that the zero crossing of the cyclic phase voltage depends on the speed and rotor poles of the generator.
which ensures higher control efficiency and faster tracking under rapidly changing wind conditions.

9.2 SUGGESTIONS FOR FUTURE WORK

Investigations can be carried out on the radial and axial flux PMG further by increasing the number of permanent magnet poles for low wind speed and high power applications. In such a case the application of permanent magnet generator for low wind speed at remote areas shall be analyzed.

The air gap flux optimization and flux distribution are analyzed by using Finite Element Method for higher pole numbers that will enhance the performance of PMG for high power applications. The armature reaction effects in Permanent Magnet Generator for different loading conditions are to be considered for further investigations.

The placement of shoot through period in ZSMC for intermediate values like 13 Hz, 21 Hz is very difficult. Hence further investigations are needed to improve the performance of ZSMC based DDWECS.

The Z-source multilevel inverter and multilevel matrix converter may also be investigated for further enhancing the energy capture to improve the performance of DDWECS.