CHAPTER 7

CONCLUSION AND SCOPE FOR FUTURE WORK

7.1 CONCLUSION

The matrix converter is an array of $3 \times 3$ bidirectional switches functioning as a direct AC–AC converter. It directly interconnects two independent multi-phase voltage systems at different frequencies. The matrix converter, known for more than thirty years, achieves bi-directional power flow, independent control of the input power factor, buck operation and frequency conversion. Since then it has appeared as an alternative solution for adjustable speed AC drive applications. In the conventional VSI, the multi-phase rectification stage, bulky DC link and the associated input filter add weight and unreliability to the system. The role of the matrix converter as an all silicon solution (except for the need of storage elements for the input current filter), high power density converter and an alternative to conventional AC-to-DC-to-AC converters has attracted researchers to find solutions for problems that prevents it from appearing in the industry. The delay was mainly due to several practical obstacles related to the complex switching methods, problems related to commutation of bi-directional switches and much more to the stability study of the converter along with its input filter.

This thesis presented easier methods for implementing complex switching strategies, studying and mitigating the effects of unbalance, and topological changes to increase the performance indices. The thesis also suggests modulation techniques to eliminate the common mode voltage and a new direct torque control procedure for controlling an induction motor fed by the modified matrix converter topology. In all cases, the direction of the
research work is to focus on the development and analysis of the PWM techniques for different control objectives.

Since the switching strategies play an important role in obtaining the desired performance, this work focused on the details of the PWM techniques. In this regard, a PWM control algorithm has been developed that offers a switching strategy, termed as the Minimum Error Switching Strategy (MESS), suitable for matrix converters operating under high switching frequencies. Its superiority lies in the ease of implementation, simplicity, reduced switching losses and its suitability at high switching frequencies.

The work also introduces a simple carrier based modulation technique, termed as the DIDC PWM technique, as an alternative way of implementing the space vector technique for the matrix converter. Based on the analysis carried out on the original DIDC PWM technique, the thesis proposes a modified control algorithm. This modified algorithm reduces the input current harmonic distortion without affecting the output side performance. The performance of this algorithm has been verified through numerical simulations. An experimental setup of the DIDC PWM technique was developed and tested for the suitability of its implementation.

The thesis also presents techniques to eliminate and reduce the common mode voltage in matrix converter fed induction motor. For eliminating the common mode voltage in the matrix converter, an SVPWM technique based on the rotating space vectors was proposed. Based on the analysis of the technique, the thesis proposed the use of a six-phase matrix converter and a modified rotating space vector technique. These modifications result in the increase of the voltage transfer ratio without introducing the common mode voltage. In addition, the work also brings out the conditions under which the approach fails to eliminate the common mode voltage. The proposed technique and the simulation results portray the usefulness and limitations of the scheme.
Real-time systems are unbalanced to a certain extent and distorted by nonlinear loads. The capability to compensate for input voltage disturbances is a mandatory feature for reliable and efficient control algorithms. For improving the performance of the matrix converter under non-ideal input conditions, a harmonic tracking algorithm based on the oscillations of the Fictitious DC Bus (FDCB) was proposed. Simulation results prove that the tracking control algorithm can successfully cope with the unbalance and the non-sinusoidal input conditions and mitigate the effects of the unbalance at the output. However, the unbalance at the input causes degradation of the input current quality.

The proposed Direct Three-Level Matrix Converter (DTMC) topology with the indirect space vector modulation reduces the THD at the output of the matrix converter. The technique makes available the capacitor neutral point to the load through three additional switches and ensures the reduction of the THD based on the idea of the nearest three-vector selection. In addition, it addresses the problem of neutral current balancing using the concept of virtual vectors. Finally, the analytical loss modeling of the DTMC involves deriving the mathematical relations based on the behavioral model of the semiconductor devices. An experimental setup for the DTMC was developed and tested for the suitability of its implementation.

Finally, the formulation of the Direct Torque Control (DTC), for the DTMC, for reducing the torque ripple in the matrix converter based system is illustrated. The DTC control method for the DTMC uses the phase voltage vectors (short vectors) and the line voltage vectors (long vectors). Using long vectors during the torque transition states and using short vectors during the steady state results in the reduction of torque ripples. However, short vectors result in the serious problem of voltage fluctuations at the input filter capacitance. Because of this, we obtain an output voltage from the DTMC that is asymmetric and having a non-zero average value. An additional voltage hysteresis band reduces the voltage deviation at the neutral point.
during the application of the short vectors and minimizes these fluctuations. Simulation results portray the improved performance of the DTC scheme for the DTMC.

7.2 SCOPE FOR FUTURE WORK

The following specific areas are suggested for further research.

(i) To investigate further the effects of system faults such as single-phase, short-circuit fault etc. on the matrix converter.

(ii) To study and implement the three-phase to single-phase matrix converters for high frequency transformers to bring out the importance of the matrix converter for such applications.

(iii) To further investigate the proposed DTMC configuration for its common mode effects, over modulation operation and study its control capability in closed-loop systems for real-time applications.

(iv) To investigate the application of the matrix converters in the wind energy conversion systems using direct power control methods for the Doubly Fed Induction Generators (DFIG).

(v) To validate in real-time the direct torque control technique by integrating the electric machine, DTMC and the controller. In addition, to investigate and implement Artificial Intelligence (AI) techniques in the vector control of the DTMC based system.

(vi) To investigate the hybrid DTC-SVM technique for DTMC for further improving the performance of torque ripple in the induction motor drives.

(vii) To investigate in details the stability of matrix converters.