CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

- As discussed in section 1.3, initial experimental works are needed to analyse the performance of the test motor used in this research. As per the main objective in operating condition (increase in maximum torque capability) of the test motor, performance of the test motor is analysed by taking out its 16 stator terminals as discussed in section 1.4.

- Experimental works done on the test motor under single phase excitation and two phase excitation with different stator magnetic polarities to obtain maximum torque, turn on, turn off angles to obtain maximum torque and simulation works done to obtain dynamic simulation model are detailed in Chapter 2. It is observed that two phase excitation method with type 3 and type 4 winding connections shown in Figures 2.9 and 2.10 are suitable for maximum torque requirements. Efficiency of the test motor with type 4 winding connections is slightly better than that of type 3 winding connections. To obtain maximum torque, the conduction angle and overlap angle have to be maintained at 30 degree and 15 degree respectively. For the simulation work done, speed, torque outputs from the dynamic simulation model are verified with experimental output.
- ANN based speed-torque controller for the test motor based on voltage PWM control technique is designed, developed and implemented on DSP using Vissim version 6.0B software. The merits of the proposed controller are no need of mathematical modeling, easier and faster design steps by the use of Vissim software, flexibility to set different operating conditions and operation of motor under better efficiency. The chopper circuit used is controlled to change the input voltage of the test motor so as to have better efficiency. ANN based speed-torque controller implementation steps discussed in Chapter 3 are applicable for conventional SRMs and the solid rotor SRMs of different geometry.

- Simulation study of ANN based algorithm for rotor position estimation from phase voltage and current of a four phase SRM using Vissim version 6.0B software is discussed in Chapter 4. The simulated motor model is tested with single phase excitation and two phase excitation methods. From the voltage and current signals of the model, flux linkage signals are obtained. Different structures of ANN are trained for phase flux linkage and phase current waveforms as inputs and rotor position as output. Apart from simulation work, real time data are collected using DSP, TMS320F2812 with Vissim working environment. The Hall effect voltage and current sensors are used with signal conditioner circuits to feed the phase voltage, current data to ADC of DSP. The flux linkage-current-position data are collected in data (.dat) files. Because of execution time limitation of the overall system, this approach is tested at low speeds.
• Experimental work to obtain static flux linkage-current-rotor position characteristics of the test motor is clearly detailed in Chapter 5. The execution time of various ANN/ANFIS structure based rotor position estimation algorithms for the test motor, when the algorithms are executed on DSP TMS320F2812 using .C file is detailed and compared. The comparison is done for a specific set of input data. The time needed to execute unipolar and bipolar sigmoid activation functions used in ANN and gbell type input membership function used in ANFIS is detailed for the specific input data. It is concluded that ANN based position estimation technique is superior than ANFIS based position estimation technique with respect to execution time for the same accuracy.

• A novel ANN based rotor position estimation approach is explained to minimise number of voltage and current sensors used. Four different ANNs with 2-5-5-1 structure are used to estimate rotor position within 60 degree. The proposed approach uses only four sensors instead of using eight sensors for the 8/6 SRM. Two phase excitation scheme is followed for the better performance of the test motor. The accuracy of ANN based rotor position estimation method is improved by a factor of 2 by using four different 2-5-5-1 ANNs for 60 degree mechanical instead of using a single ANN for every 30 degree under two phase excitation scheme. The online verification of estimated rotor position by comparing it with actual rotor position under steady state and transient operating conditions proved the validity of the proposed approach in sensorless control applications.
7.2 RECOMMENDATIONS FOR FURTHER RESEARCH

As the test motor is suited for harsh environments in nuclear reactors where rotor has to be immersed in water, efficiency of the motor is sacrificed. This research work contributed in analyzing the maximum torque capability of the motor. Further research works are needed in machine design to increase the efficiency. Eddy current effects at different stator magnetic polarity and at different speed, torque conditions can be analysed.

This research work minimized the number of voltage and current sensors used for rotor position estimation. Accuracy of estimation of the proposed approach can be increased either by using future fast acting processors or by including additional techniques to accurately map the nonlinear data. Additional works are needed to make the test motor sensorless. Sensorless starting of solid rotor SRM can be included with the proposed approach for sensorless operation of the motor. The proposed approach not only encourages the sensorless control of solid rotor SRM but also for conventional laminated rotor SRM with minimum number of voltage and current sensors.