Conclusions and Suggestions for Future Work

5.1 Introduction

This Chapter summarizes the main contributions and summary of results of present thesis work along with the suggestions for future work. The major and minor contributions are outlined in Section 5.2. The summary of the results presented in the thesis is given in Section 5.3. The Chapter ends with suggestions for future work in Section 5.4.

5.2 Contributions of the Thesis

This thesis deals with a new technique for Design Analysis of the SMPM machines. Starting with the selection of an appropriate method for the analysis of PM machines, the thesis ends with the validation of the proposed analytical method with the experimental and analytical results obtained from the prototypes developed. With a number of analytical and numerical methods reported for the analysis of PM machines, Space Fourier Transform method has been selected and used for the solution of governing field equations involved using MVP. The electromagnetic field distribution and the performance characteristics of the experimental SMPM motor has been reported and validated from the proposed approach. The method is found to have less computational time with better accuracy.

The major contributions of the thesis have been summarized as:

i. Analysis of Surface Mounted Permanent Magnet motors using a two-dimensional analytical and Space Fourier Transform.
ii. Representation of PMs as a continuous current sheet producing same MMF as that of the PMs in real space.

iii. Performance Analysis of the SMPM motor with almost negligible computation time.

iv. The proposed method is able to calculate the electromagnetic field distribution as well as performance characteristics simultaneously.

v. The two-dimensional proposed method for SMPM motors is applicable to both the RFPM and AFPM motors.

vi. The cogging torque can also be determined easily with almost negligible computational time.

vii. A new back-EMF detection method of rotor position sensing .i.e., PM Enhanced Sensing Method which can be used for fault tolerant and safety critical applications.

The minor contributions of the thesis have been summarized as:

i. The application of PM Enhanced sensing scheme as a fault tolerant scheme for the PM motors with each phase supplied from separate POPAMPs.

ii. The proposed method can also be applied for the analysis of fault tolerant motors.

iii. A new method of starting of PM motors is introduced by using an axial flux sheet rotor induction motor on the other side of the axial flux stator.

5.3 Summary of Results

The Chapter 1 presented the salient features of PM machines and their different topologies. Need of modeling of PM machines and detailed literature survey on various methods reported in the literature for analyzing these machines has been discussed. Based on the merits and demerits of different methods present, the motivation and scope of the present work is summarized.

In Chapter 2, a two-dimensional analytical method for the design analysis of SMPM machine has been proposed and investigated. The assumptions made and boundary conditions are discussed. The two variants of the model; *Isotropic* and *Anisotropic* have been discussed for calculation of performance parameters in real and Fourier space. The anisotropic model includes the effect of stator slotting in the performance calculation. Calculation of magnetic field distribution, EMF and electromagnetic torque has been discussed. The computation of cogging torque is also explained using pole by pole model.

The Chapter 3 discussed the development and fabrication of the different prototypes for the validation of analytical method introduced. The RFPM and AFPM motors have been developed for validation of proposed model. Three different variants of AFPM motors have been shown having different number of slots, poles and phases. The PM enhanced sensing with shadow coil scheme has been investigated for the operation of motors. It has been observed that for lesser air gap machine, the PM enhanced scheme with auxiliary motor on same shaft is not suitable owing to the differences in zero crossing due to the armature reaction. The zero crossing detection with shadow coil has no such issues. For AFPM motors, a starting method has been introduced by using an sheet rotor AFIM motor on one active side of axial stator and PM rotor on other side. The sheet rotor induction motor provides starting torque to the AFPM motor and once the motor catches its speed, the AFIM may be switched off.

In Chapter 4, all the results obtained from the different experimental RFPM and AFPM motors and their validation using results obtained from the proposed 2-D analytical method have been completed. The analytical validation using different methods has also been done to prove the effectiveness of the proposed method. The

method has also been used to study the fault tolerant characteristics of the two different 5-phase AFPM motors.

5.4 Suggestions for Future work

The application of proposed method can be extended for the analysis of SIPM and IPM machines. In that case, the PMs have to be replaced by anisotropic layer since the iron, PMs and air gap are present adjacent to each other.

The present method can further be used for the calculation of losses in the PMs and eddy current losses in the rotor iron since the rotor in most of the SMPM machines are solid instead of laminated sheets.

The method is applied to single sided AFPM motor; however its application can be extended to different variants of PM machines like LSPM motor, Doubly salient PM motor, etc.