Optimum Design of Line-Start Permanent-Magnet Synchronous Motor Using Mathematical Method

Mousalreza Faramarzi Palangar, PhD Student
College of Science and Engineering, Flinders University

Abstract:

This study presents an analytical method to design an optimum Line-Start Permanent-Magnet Synchronous Motor (LSPMSM). An initial LSPMSM (L0) is designed by combining an induction motor (IM0) and an interior permanent magnet (IPM0) motor. The IM0 and IPM0 are designed analytically from sizing equations. The optimum LSPMSM is developed from IM cage optimization for starting torque and permanent magnet (PM) optimization of the IPM for efficiency. By combining the rotors of the optimised IM and IPM, an optimum hybrid rotor is obtained for the LSPMSM. The optimized motor has better performance in the transient and steady state compared to L0. The proposed optimisation method based on a mathematical model is implemented using a genetic algorithm (GA). An optimization case study is implemented using both the proposed mathematical method and finite-element method (FEM). The optimization results indicate that the optimum design found using the proposed mathematical method is obtained more rapidly and has comparable performance to that found using FEM optimization.

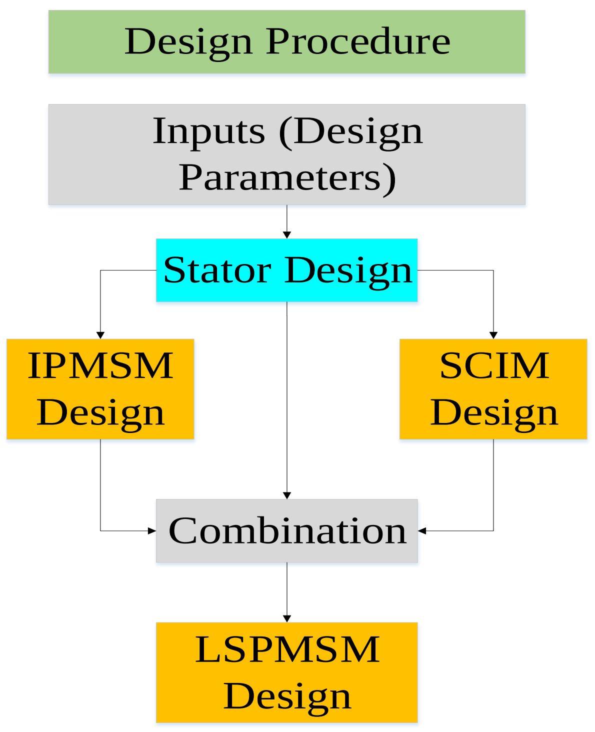
View of commercial IM:


Motor

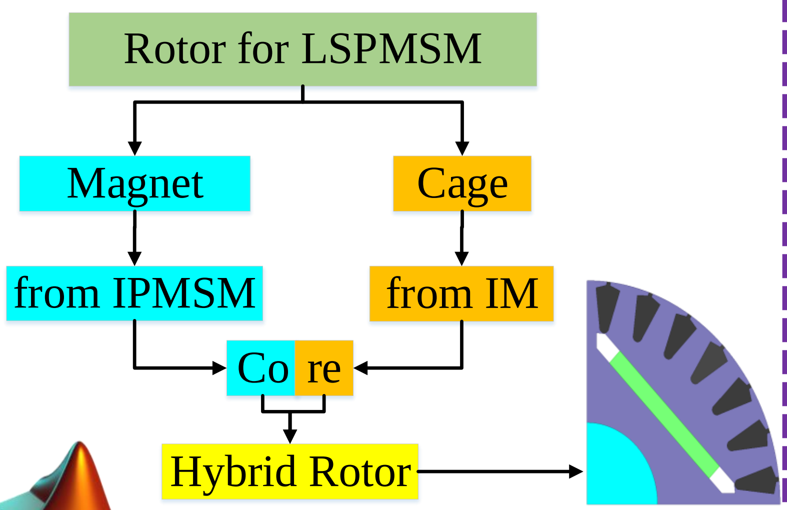

Stator


Rotor

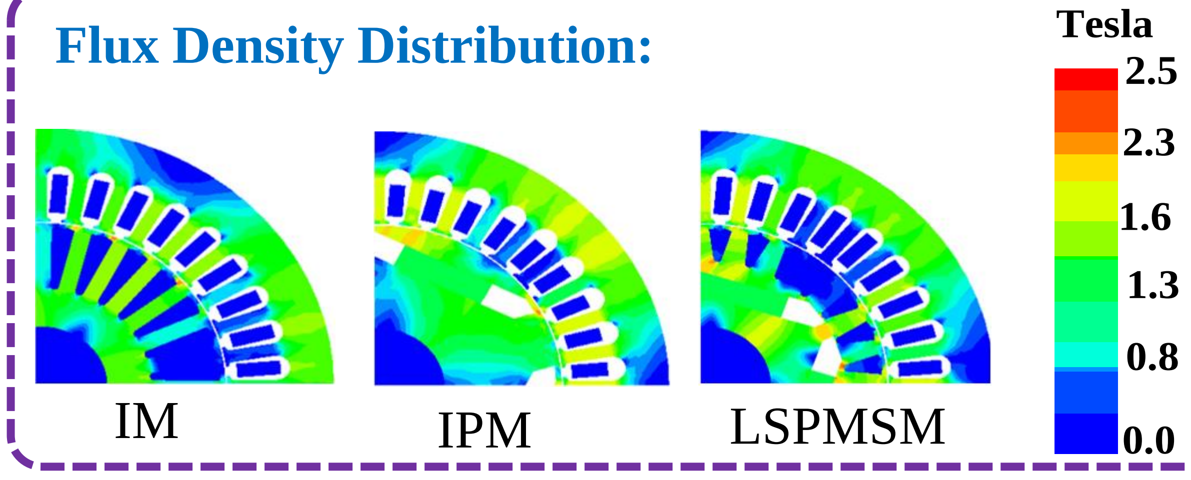
LSPMSM Design Procedure:



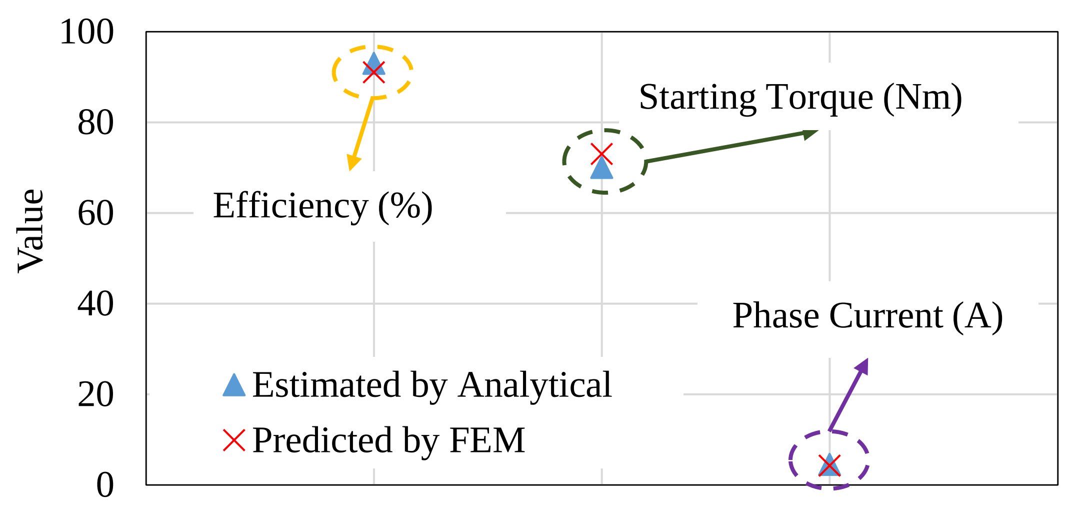
Hybrid Rotor Design Procedure:



Flux Density Distribution:

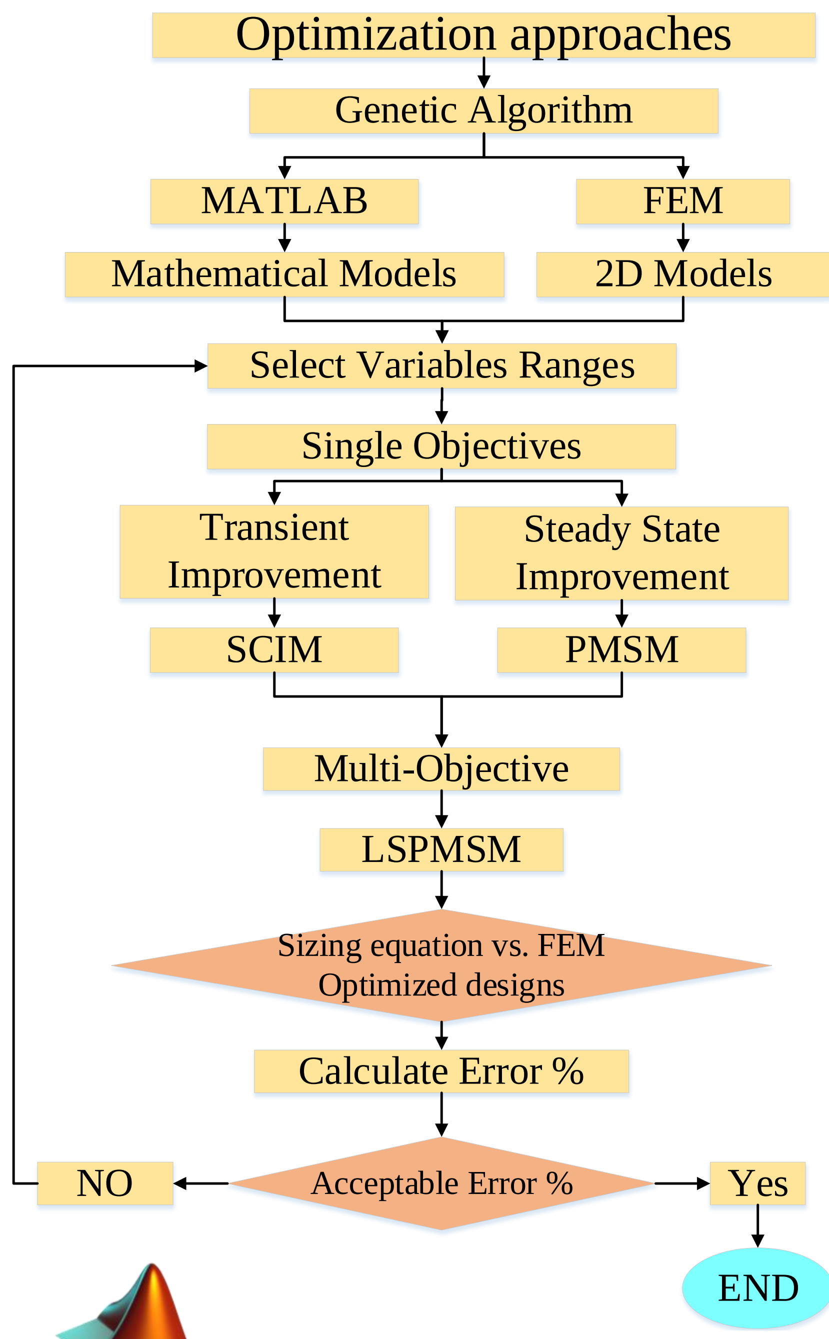


The Proposed Method vs. FEM



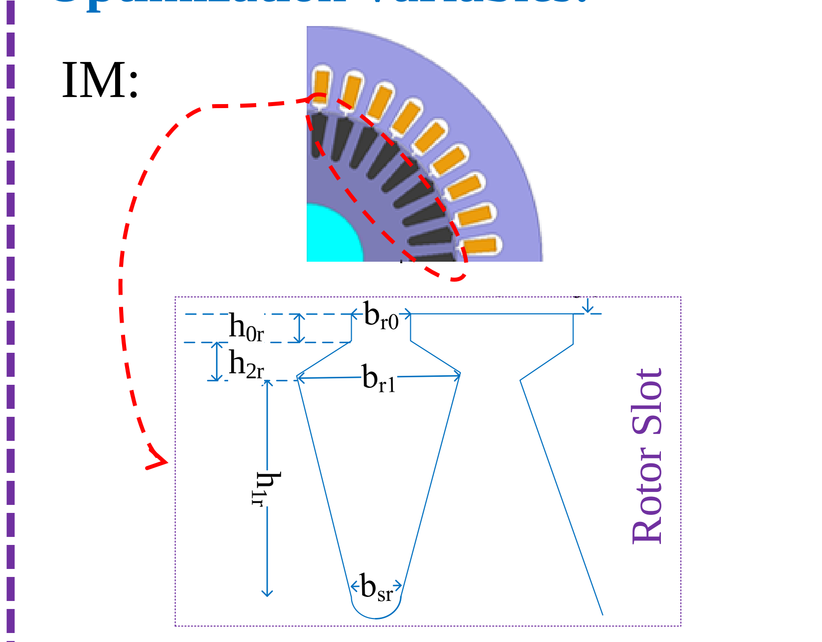
Parameters	Anal	FEM	Error%
Efficiency (%)	93	92	1
Starting Torque (Nm)	70	73	4
Phase Current (A)	4.4	4.2	4.7

Optimization Procedure Flowchart:

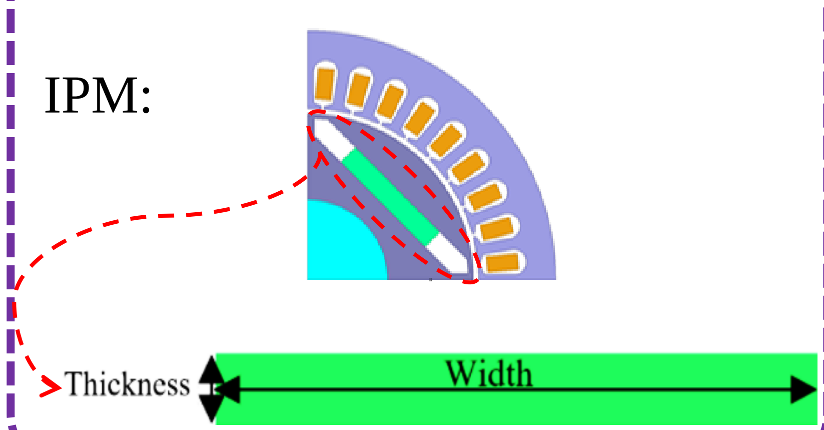


Optimization Variables:

IM:

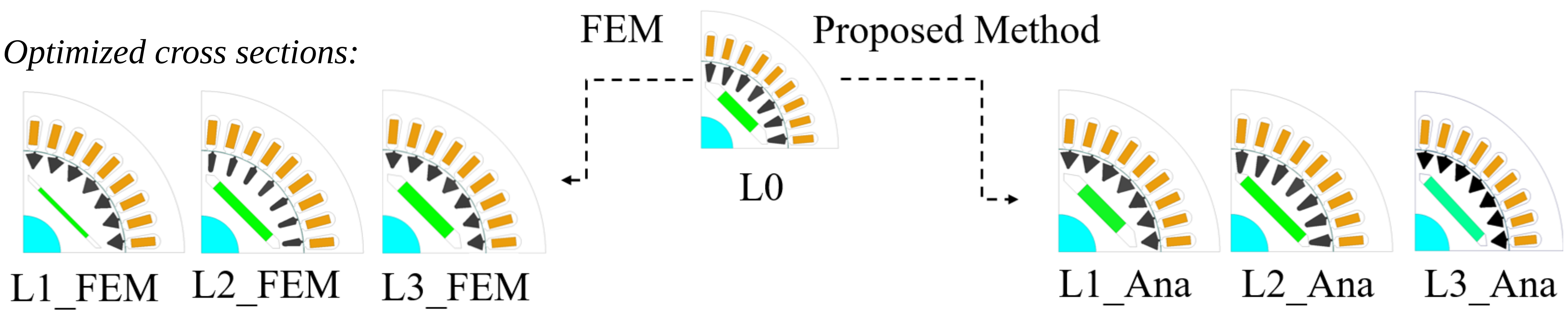


IPM:



Optimization Results:

Optimized cross sections:



Optimum values of the objectives and optimization time spent by two methods:

Motor Type	Optimum values of objectives		Error (%)	Optimisation time
	Starting torque (Nm)	Efficiency (%)		
L1_Ana	82.60	Not included	0.4	4sec
L1_FEM	82.20			6hrs
L2_Ana	Not included	93.25	0.9	5 sec
L2_FEM		92.40		9hrs
L3_Ana	79	92	3.6	9 sec
L3_FEM	82	90	2	12hrs

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