Automatic Optimization Design Tool for Three-phase Motor Drive to Achieve High Power Density

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INTRODUCTION:

- In recent years, there has been a huge technology transition because of various factors such as electrification of transportation due to environmental concerns and semiconductor device advancements by the development of wide band gap devices (SiC, GaN) Etc [1].
- The challenge in these emerging applications is achieving high power efficiency and density. For this, the engineer has to design and optimize Ac-Ac motor drive calculations with multiple iterations, which is highly time-consuming.
- At UTK, we have developed and continuously upgraded the comprehensive design tool that integrates the state of art design algorithms, models and component database with commercially available devices with a motto to reduce the paper design efforts for the user.
- The three-phase Ac-Ac motor drive design involves topology selection for the rectifier and inverter, device selection, Thermal management system design, bus capacitor selection and mitigation of EMI noise that is more evident due to high switching capabilities.
- The design components are highly interdependent, and design iterations are normally required to achieve a best-optimized design.
- A case study shows the advantage of using the optimized design tool and its working.

DESIGN TOOL PARAMETERS AND ARCHITECTURE

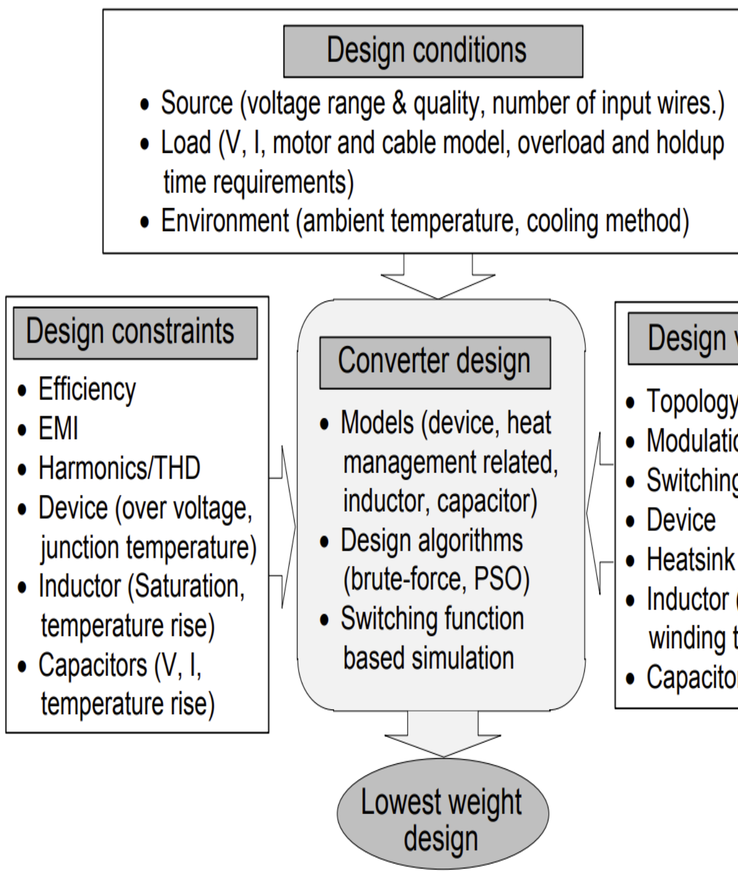


Fig. 2. Formulation of converter design optimization [2].

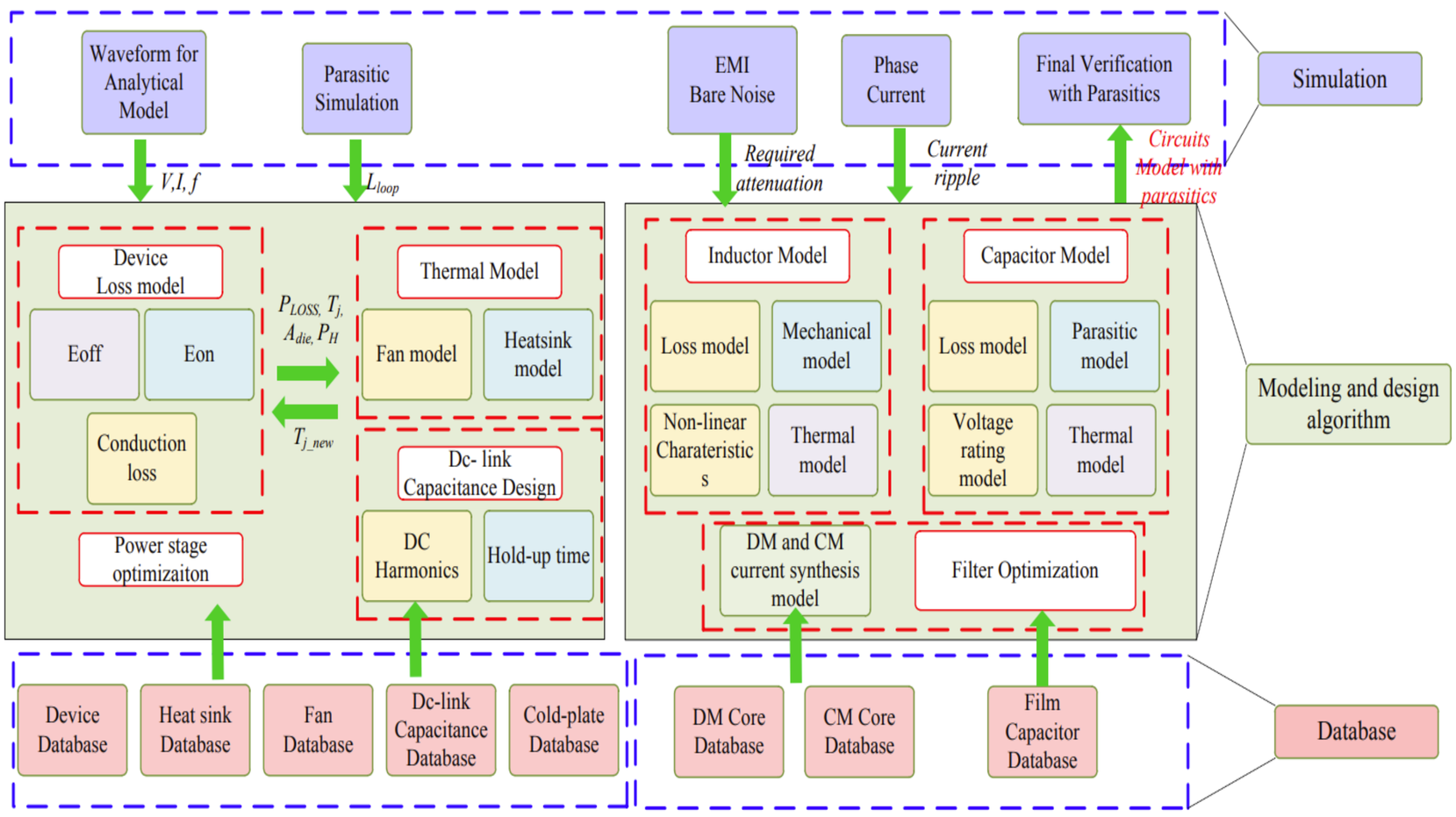


Fig. 3. Architecture of the design tool [3].

DESIGN RESULT

- Design of a three phase dc–ac motor drive by performing a system level optimization.

Specifications:

Induction motor: 40KW, 400Hz, 400V, 0.91 power factor.

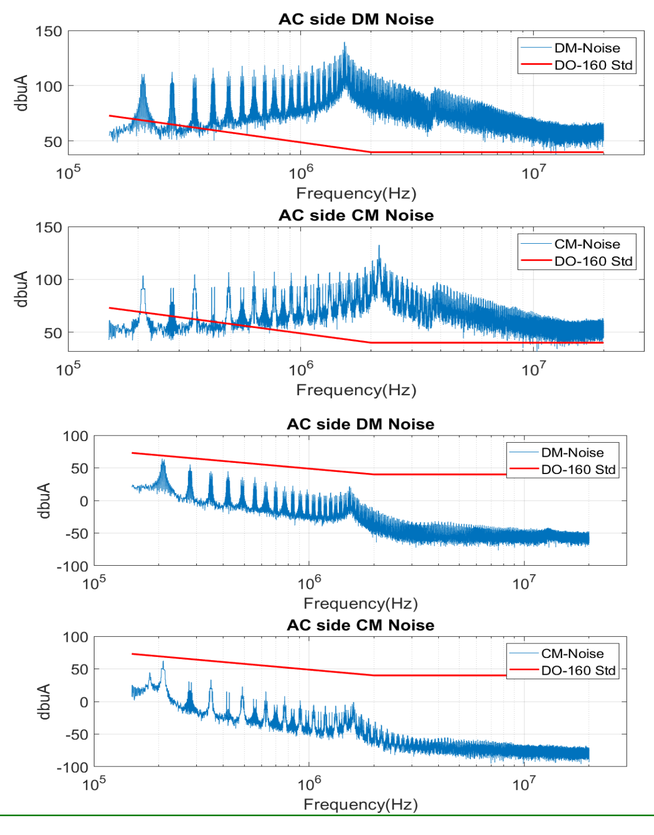
Motor Drive: 45kVA, 600VDC, 70kHz, SVPWM.

Environment conditions

Ambient temperature = 65^{0}C.
Maximum junction temperature = 150^{0}C.
Forced air cooling.

EMI standard consideration:

AC side two stage passive filter (DO-160)



	Without Optimization		With Optimization	
	Weight (g)	Loss (W)	Weight (g)	Loss (W)
DM filter	0.75µF, 12µH		1.5µF, 6µH	
CM filter	41nF,25µH		21nF, 91µH	
DM Inductor	3233	338	1702	242
CM Inductor	83.71	28.78	230.44	44.43
DM Capacitor	435.45	2.282	659	52.22
CM Capacitor	31.45	6.523	24.2	0.11
Sw. Devices (2) GaN	743	214 (70.2, 143.8)	743	224.5 (72.32, 152.18)
Heatsink	279		302	
Total	4806	589 (98.56%)	3660.5	563.4 (98.62%)
Cdc	334µF		310µF	

CONCLUSION

- This poster presents the details of the comprehensive design tool for the three-phase motor drive system.
- The design tool integrates state-of-the-art optimization algorithms for a complete converter design. Also customizable to user preferences using MATLAB GUI.
- The converter is optimized for minimum weight by selecting design variables considering design constraints and conditions configured by users.
- The above results are evident that there is a significant reduction in the converter weight after performing optimization.
- Also, Today's high-performance computing systems make it easy to overcome the challenge of longer computational time.

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