

Contents

1	Integrated Computer Models of 3-D Comb Drive Electrostatic MEMS Structures.....	1
	<i>Sławomir Wiak, Krzysztof Smółka</i>	
1.1	Introduction	1
1.2	Solid Modeling of 3D MEMS Structures	2
1.2.1	Case Study – Accelerometer	4
1.2.2	Case Study – Actuator for Micromirror Driving	5
1.3	Complex Strategy	7
1.3.1	Case Study – Accelerometer	9
1.3.2	Case Study – Actuator for Micromirror Driving	14
1.4	Conclusions	17
	References	17
2	Multi-objective Design Optimization of Slotless PM Motors Using Genetic Algorithms Based on Analytical Field Calculation.....	19
	<i>L. Belguerras, L. Hadjout</i>	
2.1	Introduction	19
2.2	Electromagnetic Modeling of the Study Slotless PMSM	20
2.2.1	Motor Topologies.....	20
2.2.2	Analytical Modeling.....	20
2.2.3	Electromagnetic Torque	22
2.2.4	Model Validating	24
2.3	Multi-objective Optimization	25
2.3.1	Dominance	26
2.3.2	Pareto Optimality	26
2.3.3	Evolutionary Multi-objective Optimization Algorithms	27
2.3.4	Elitist Non-dominated Sorting Genetic Algorithm (NSGAI)	28
2.3.4.1	NSGAI Algorithm	30
2.3.4.2	Crowding Distance	31
2.4	Design Optimization	31
2.4.1	Objective Functions	32
2.4.2	Design Variables	33
2.4.3	Inequality Constraints	33
2.5	Optimization Results	34
2.6	Conclusion	37
	References	37

3	The FEM Parallel Simulation with Look Up Tables Applied to the Brushless DC Motor Optimization.....	39
	<i>Jakub Bernat, Jakub Kołota, Sławomir Stepień</i>	
3.1	Introduction	39
3.2	The Parallel Simulation Technique.....	40
3.3	Look-Up Tables with Integral Coefficients	42
3.4	The Parallel System Realization	43
3.5	Brushless DC Motor Model.....	44
3.6	The Optimization Problem.....	46
3.7	The Simulated Annealing Algorithm.....	47
3.8	The Rosenbrock Valley Problem.....	48
3.9	The Rastragin's Problem.....	50
3.10	Simulation Experiment Results	52
3.11	The Brushless DC Motor Torque Analysis.....	55
3.12	Conclusions	57
	References	57
4	Fast Algorithms for the Design of Complex-Shape Devices in Electromechanics.....	59
	<i>Eugenio Costamagna, Paolo Di Barba, Maria Evelina Mognaschi, Antonio Savin</i>	
4.1	Introduction	59
4.2	Reducing Three Dimensions to Two	59
4.3	The Need for Fast Solvers: Schwarz-Christoffel Mapping as a Possible Answer.....	60
4.4	Modern Numerical Methods for SC Mapping	61
4.5	Towards a Coordinated Approach for Field Analysis, Using Both FE and SC.....	65
4.6	Analysis of a Magnetic Levitator with Superconductors.....	66
4.6.1	A Principle of Equivalence	66
4.6.2	Application in 2D Magnetostatics.....	68
4.6.3	Outer-Field Problem: Results.....	72
4.6.4	Test Problem: Diamagnetic Model of a Superconductor	77
4.6.5	Case Study: Trapped-Flux Model of a Magnetic Bearing.....	78
4.6.6	An Application in Automated Optimal Design.....	83
4.7	Conclusion.....	84
	References	84
5	Optimization of Wound Rotor Synchronous Generators Based on Genetic Algorithms.....	87
	<i>Xavier Jannot, Philippe Dessante, Pierre Vidal, Jean-Claude Vannier</i>	
5.1	Introduction	87
5.2	Wound Rotor Synchronous Generator Model	88
5.2.1	Electromagnetic Modeling of the WRSG	88
5.2.1.1	Air Gap Magnetic Flux Density Computation at No Load	89

- 5.2.1.2 Computation of Magnetic Flux Density in the Iron
Paths91
 - 5.2.1.3 Magnetic Field Circulation in the WRSG91
 - 5.2.1.4 Computation of Rotor Magnetomotive Force93
 - 5.2.2 Losses and Thermal Model95
 - 5.2.2.1 Losses' Estimation95
 - 5.2.2.2 Thermal Modeling97
 - 5.2.2.3 Thermal Loop98
- 5.3 Optimization Problem99
 - 5.3.1 Interest of Designing with Optimization Procedure99
 - 5.3.2 Choice of the Optimization Technique100
- 5.4 Optimization with Genetic Algorithm100
 - 5.4.1 Objectives of Optimization: Single and Multi-objective
Optimization100
 - 5.4.2 Principle of Genetic Algorithm101
 - 5.4.2.1 Initialization103
 - 5.4.2.2 Evaluation103
 - 5.4.2.3 Ranking103
 - 5.4.2.4 Selection103
 - 5.4.2.5 Crossover104
 - 5.4.2.6 Mutation104
 - 5.4.2.7 Discrete Variable Handling104
- 5.5 Mono-objective Optimization of a WRSG Range104
 - 5.5.1 Independent Optimization of Three Different Machines105
 - 5.5.2 Classical Design Approach Covering a WRSG Range107
 - 5.5.3 Simultaneous Optimization of a Series of Machines108
- 5.6 Multi-objective Optimization of a WRSG Range110
- 5.7 Conclusion112
- References112

**6 Simple and Fast Algorithms for the Optimal Design of Complex
Electrical Machines.....115**

Kazumi Kurihara, Tomotsugu Kubota, Yuki Imaizumi

- 6.1 Introduction115
- 6.2 Experimental Motor and Circuit116
- 6.3 Method for Analysis117
 - 6.3.1 Finite Element Analysis (FEA)117
 - 6.3.2 Response Surface Methodology (RSM)120
- 6.4 Steady-State Performance Characteristics120
 - 6.4.1 EMF Due to PMs121
 - 6.4.2 No-Load Performance Characteristics121
 - 6.4.3 Load Performance Characteristics123
 - 6.4.4 Torque Ripple and Efficiency125
- 6.5 Starting Performance Characteristics127
- 6.6 Conclusions127
- Acknowledgments128
- References128

7	The Flock of Starlings Optimization: Influence of Topological Rules on the Collective Behavior of Swarm Intelligence.....	129
	<i>Francesco Riganti Fulginei, Alessandro Salvini</i>	
7.1	Introduction	129
7.2	Standard PSO Overview	130
7.3	Influence of Topological Rules: From Particle Swarm to Flock of Starlings Optimization	132
7.4	FSO Validation and Comparison with the PSO Results	135
7.5	Remarks	142
7.6	Conclusions	144
	References	145
8	Multilevel Data Classification and Function Approximation Using Hierarchical Neural Networks.....	147
	<i>M. Alper Selver, Cüneyt Güzelış</i>	
8.1	Introduction	147
8.2	Theoretical Framework.....	149
8.2.1	Function Approximation Using HNN	150
8.2.2	Classification Using HNN.....	152
8.3	Applications.....	153
8.3.1	Transfer Function Initialization for Three Dimensional Medical Volume Visualization.....	154
8.3.2	Quality Classification of Marble Slabs	158
8.3.3	Classification of Radar Data	160
8.4	Discussions and Conclusions.....	162
	References	164
9	Parametric Identification of a Three-Phase Machine with Genetic Algorithms.....	167
	<i>L. Simón, J.M. Monzón</i>	
9.1	Introduction	167
9.2	Continuous Model FEM and Differential Formulation of Electromagnetic Field	169
9.2.1	Magnetostatic	169
9.2.2	Magnetodynamic.....	170
9.3	Discrete Model FEM	171
9.4	Boundary Conditions of the Continuous Model	172
9.5	Lumped Parametric Model Identification	174
9.5.1	Parameter Estimation to All the Geometries	175
9.6	FEM Analysis	176
9.7	Parametric Adjustment by Genetic Algorithms	177
9.7.1	Optimality	177
9.7.2	Fitness Procedure	178
9.8	Results	179
9.9	Conclusions	183
	References	183

10 Ridge Polynomial Neural Network for Non-destructive Eddy Current Evaluation.....	185
<i>Tarik Hacib, Yann Le Bihan, Mohammed Rachid Mekideche, Nassira Ferkha</i>	
10.1 Introduction	185
10.2 Higher Order Neural Network	187
10.2.1 Pi-Sigma Neural Network	187
10.2.2 Ridge Polynomial Neural Network	189
10.3 Forward Problem Definition	189
10.4 Implementation of RPNN for Solving the Inverse Problem	191
10.5 Results	192
10.5.1 Training Without Noise.....	194
10.5.2 Training with Noise.....	196
10.6 Conclusion	198
References	199
11 Structural-Systematic Approach in Magnetic Separators Design.....	201
<i>Vasiliy F. Shinkarenko, Mikhaylo V. Zagirnyak, Irina A. Shvedchikova</i>	
11.1 Introduction	201
11.2 Search Methodology Substantiation	202
11.3 Determination of Electromagnetic Separators Species Diversity	205
11.4 Systematics Rank Structure as the Basis for a New Concept of Design Procedures Dataware	208
11.5 Interspecific Synthesis of New Magnetic Separator Structures Using the Law of Electromechanical Systems Homologous Series.....	210
11.6 Conclusion	216
References	217
12 Weight Reduction of Electromagnet in Magnetic Levitation System for Contactless Delivery Application.....	219
<i>Do-Kwan Honga, Byung-Chul Woo, Dae-Hyun Koo, Ki-Chang Lee</i>	
12.1 Introduction	219
12.2 Passive Guidance Control and Optimization of Electromagnet.....	221
12.3 Optimum Design.....	222
12.4 Response Surface Methodology	224
References	226
13 Genetic Algorithm Applied in Optimal Design of PM Disc Motor Using Specific Power as Objective.....	229
<i>Goga Cvetkovski, Lidija Petkovska, Sinclair Gair</i>	
13.1 Introduction	229
13.2 Permanent Magnet Disc Motor Description	230
13.3 GA Optimization Method Description.....	230
13.3.1 Reproduction.....	231
13.3.2 Crossover	232
13.3.3 Mutation.....	232
13.3.4 Fitness Scaling	232

13.3.4.1	Linear Scaling.....	233
13.3.4.2	Power Law Scaling.....	234
13.3.4.3	Boltzmann Selection.....	234
13.4	GA Optimal Design of Permanent Magnet Disc Motor.....	236
13.5	GA Optimal Design Results of PM Disc Motor	240
13.6	PM Disc Motor FEM Modeling and Magnetic Field Analysis.....	240
13.7	Conclusion	245
References		246

14 Magnetically Nonlinear Iron Core Characteristics of Transformers

Determined by Differential Evolution.....247

Gorazd Štumberger, Damir Žarko, Amir Tokic, Drago Dolinar

14.1	Introduction	247
14.2	Dynamic Model of a Single-Phase Transformer.....	248
14.3	Approximation Functions	248
14.3.1	Simple Analytic Saturation Curve.....	249
14.3.2	Analytic Saturation Curve with Bend Adjustment.....	250
14.3.3	Approximation with Exponential Functions	251
14.4	Determining Approximation Function Parameters by Differential Evolution.....	251
14.4.1	Description of Differential Evolution Algorithm	251
14.4.2	Objective Function.....	253
14.5	Results	254
14.6	Conclusion	258
Acknowledgments		258
References		258

15 Different Methods for Computational Electromagnetics:

Their Characteristics and Typical Practical Applications261

Arnulf Kost

15.1	Introduction	261
15.2	The Finite Element Method (FEM)	262
15.3	The Boundary Element Method.....	263
15.4	The Moments Method (MoM).....	264
15.5	The Finite Difference Time Domain Method (FDTD)	264
15.6	The Transmission Line Matrix Method (TLM)	265
15.7	Other Single Method and Need for Hybrid and Even More Effective.....	265
15.8	Hybrid FEM/BEM – Method for Quasistationary Fields	266
15.9	Hybrid FEM/BEM Method for Waves	267
15.10	Hybrid MoM/GTD Method	267
15.11	Hybrid BEM/IBC and FEM/IBC Method.....	269
15.12	Non Linear FEM and FEM/IBC with Complex Effective Reluctivity	270
15.13	Laser Trimming of IC Resistors Industrial Production Using	271

15.14	Equation Solvers	271
15.15	Improvements in Adaptive Mesh Generation	274
15.16	Conclusions	274
	References	275
16	Methods of Homogenization of Laminated Structures.....	261
	<i>Nabil Hihat, Piotr Napieralski, Jean-Philippe Lecoq, Ewa Napieralska-Juszczak</i>	
16.1	Introduction.....	277
16.2	Optimization Methods.....	279
16.2.1	Solving Optimization Problem.....	280
16.2.2	Linear Programming.....	280
16.2.3	Nonlinear Programming.....	283
16.2.4	Unconstrained Optimization Problems.....	286
16.2.5	Direct Search Method: Hook-Jeeves.....	290
16.3	Homogenization Method Principle.....	293
16.3.1	Magnetic Characteristics $\mu(B, \alpha)$	296
16.3.2	Homogenization Method Application.....	298
16.4	Conclusion.....	301
	References.....	301
17	Applications Examples.....	303
17.1	Comparative Finite-Elements and Permeance-Network Analysis for Design Optimization of Switched Reluctance Motors.....	304
	<i>Dan Ilea, Frédéric Gillon, Pascal Brochet, Mircea M. Radulescu</i>	
17.1.1	Introduction.....	304
17.1.2	Permeance Network Analysis	304
17.1.2.1	Airgap Permeance	304
17.1.2.2	Poles and Back-Iron Permeances	305
17.1.2.3	Complete Permeance Network	306
17.1.3	Finite-Element Analysis.....	306
17.1.4	Motor Specifications and Simulation Results Analysis	307
17.1.5	Conclusions.....	310
17.2	Lumped Parametric Model of an Electrostatic Induction Micromotor.....	311
	<i>Francisco Jorge Santana-Matin, José Miguel Monzon-Verona, Santiago Garcia-Alonso, Juan Antonio Montiel-Nelson</i>	
17.2.1	Introduction.....	311
17.2.2	Lumped Parametric Equivalent Circuit Model	312
17.2.3	Fitting of Lumped Parameters Using GA in Steady State	313
17.2.3.1	Objective Function	313
17.2.3.2	GA Parameters	316
17.2.3.3	Lumped Parameters in Stationary State.....	317

17.2.4	Time Domain Analysis	318
17.2.4.1	Transient State of the Physical Model	318
17.2.5	Conclusions.....	321
17.3	Contribution to Optimization and Modeling by Reluctances Network.....	322
	<i>Abdelghani Kimouche, Mohamed Rachid Mekideche, Ammar Boulassel, Tarik Hacib, Hicham Allag</i>	
17.3.1	Introduction.....	322
17.3.2	Linear Stepping Motor Study.....	322
17.3.2.1	Finite Element Method Analysis	322
17.3.2.2	Magnetic Equivalent Circuit Modeling	324
17.3.3	Magnetic Force Computation	327
17.3.4	Optimization	328
17.3.5	Conclusion	331
17.4	Optimization and Computer Aided Design of Special Transformers.....	332
	<i>Marija Cundeva-Blajer, Snezana Cundeva, Ljupco Arsov</i>	
17.4.1	Introduction.....	332
17.4.2	Optimization Design Procedure of CCVIT.....	332
17.4.2.1	CCVIT Mathematical Model: FEM-3D Coupled with Least Squares Method	333
17.4.2.2	CCVIT GA Optimization	335
17.4.2.3	Results CCVIT	336
17.4.3	Optimization Design Procedure of RWT.....	337
17.4.3.1	Initial Study of RWT.....	337
17.4.3.2	RWT GA Optimization	338
17.4.3.3	Results CAD RWT	339
17.4.4	Conclusions.....	341
17.5	Effects of Geometric Parameters on Performance of a SRM by Numerical-Analytical Approach	342
	<i>A. Bentounsi, R. Rebbah, F. Rebahi, H. Djeghloud, H. Benalla, S. Belakehal, B. Batoun</i>	
17.5.1	Introduction.....	342
17.5.2	Preliminary Design Process	342
17.5.3	Results by FEM Simulation	343
17.5.4	Results by EMC Simulation.....	347
17.5.5	Conclusion	349
17.6	Multiphysics Method for Determination of the Stator Winding Temperature in an Electrical Machine	350
	<i>Zlatko Kolondzovski</i>	
17.6.1	Introduction.....	350
17.6.2	Method.....	351
17.6.2.1	2D Axi-symmetric Numerical Multiphysics Model	351
17.6.2.2	3D Numerical Heat-Transfer Model.....	353
17.6.3	Results and Discussion	354

- 17.6.3.1 Results for the Temperatures in a Steady State
Performance354
 - 17.6.3.2 Experimental Validation of the Multiphysics
Method356
 - 17.6.4 Conclusion358
- 17.7 Particle Swarm Optimization for Reconstitution of
Two-Dimentional Groove Profiles in Non Destructive Evaluation.....359
*Ammar Hamel, Hassane Mohellebi, Mouloud Feliachi,
Farid Hocini*
 - 17.7.1 Introduction.....359
 - 17.7.2 Particle Swarm Optimization360
 - 17.7.2.1 Validation with Test Functions361
 - 17.7.3 Problem Description364
 - 17.7.4 Results365
 - 17.7.5 Conclusion366
- References366