

# Contents

<i>List of Figures</i>	<i>xiii</i>
<i>List of Tables</i>	<i>xvii</i>
<i>Preface</i>	<i>xix</i>
<i>Acknowledgments</i>	<i>xxi</i>
<i>Abbreviations</i>	<i>xxiii</i>
<i>Symbols</i>	<i>xxv</i>
<b>1. Introduction</b>	<b>1</b>
1.1 Design and Optimization Scenarios	1
1.1.1 Engineering applications	2
1.1.2 Medical applications	2
1.1.3 Finance	3
1.1.4 Humanities and social sciences	3
1.2 Electromagnetic Design Challenges	3
1.2.1 Fabrication sensitivity	4
1.2.2 Material sensitivity	4
1.3 Objectives and Scope	4
1.4 Organization of the Book	5
1.5 Summary	7
<i>References</i>	7
<b>2. Soft Computing Techniques</b>	<b>9</b>
2.1 Artificial Neural Networks	10
2.1.1 Concept of ANN	10
2.1.2 Back-propagation algorithm	14
2.1.3 Matlab code for ANN	17
2.2 Genetic Algorithm (GA)	18
2.2.1 Overview	18
2.2.2 Terminologies of GA	18
2.2.2.1 Reproduction or selection	19
2.2.2.2 Crossover	20
2.2.2.3 Mutation	20

## viii CONTENTS

2.2.3	Matlab code for GA	21
2.3	Particle Swarm Optimization (PSO)	26
2.3.1	Basic concept of PSO	26
2.3.1.1	Binary PSO and real valued PSO (RPSO)	27
2.3.1.2	Single objective PSO and multi-objective PSO	29
2.3.2	Matlab code of PSO	31
2.4	Bacterial Foraging Optimization	34
2.4.1	Basic concept	34
2.4.2	Terminologies in BFO	34
2.4.2.1	Chemotaxis	35
2.4.2.2	Swarming	36
2.4.2.3	Reproduction	36
2.4.2.4	Elimination and dispersal	36
2.4.3	Algorithm of BFO	36
2.4.4	Matlab code for BFO	40
2.5	Summary	42
	<i>References</i>	43
<b>3.</b>	<b>Soft Computing in Electromagnetics: A Review</b>	<b>45</b>
3.1	Overview	45
3.2	Radar Absorbers	46
3.3	Frequency Selective Surfaces	48
3.4	Antenna Design and Optimization	49
3.4.1	Antenna miniaturization	49
3.4.2	Antenna pattern synthesis	50
3.4.3	Performance enhancement	52
3.5	Metamaterial Structures	53
3.6	Invisibility Cloaks	57
3.7	Microwave Devices	58
3.8	Summary	58
	<i>References</i>	59
<b>4.</b>	<b>Bacterial Foraging Optimization For Metamaterial Antennas</b>	<b>65</b>
4.1	Overview	65
4.2	Challenges in Metamaterial Antenna design	67
4.3	BFO for Metamaterial Antenna Design	67
4.3.1	Multiband metamaterial fractal antenna	68
4.3.1.1	Fractal antenna design	69
4.3.1.2	Performance enhancement using BFO	70
4.3.2	Mutual coupling reduction	76
4.3.2.1	Design of microstrip antenna array	77
4.3.2.2	Mutual coupling reduction using metamaterial	78
4.4	Summary	81
	<i>Reference</i>	81

<b>5. PSO for Radar Absorbers</b>	<b>84</b>
5.1 Introduction	84
5.2 Types of Radar Absorbers	85
5.2.1 Salisbury screen	85
5.2.2 Magnetic absorbers	86
5.2.3 Dallenbach layer	86
5.2.4 Circuit analog RAM	86
5.2.5 Jaumann absorber	86
5.3 Radar Absorber Design Procedure	86
5.4 PSO for Design Optimization	87
5.4.1 Jaumann absorber optimization	88
5.4.2 Multilayer RAM optimization	90
5.5 Challenges and Issues in Conventional Absorber	95
5.6 Microwave Metamaterial Absorber	96
5.6.1 Overview	96
5.6.2 Design of microwave metamaterial absorber	97
5.6.3 PSO implementation	99
5.6.4 Simulation results and discussion	99
5.7 Terahertz Absorber Design for Biomedical Application	100
5.7.1 Overview	100
5.7.2 Biomedical spectroscopy system	101
5.7.3 Design of metamaterial based terahertz absorber	103
5.7.4 Performance enhancement using PSO	104
5.7.5 Simulation results and discussion	106
5.8 Summary	107
<i>References</i>	108
<b>6. Characterization of Planar Transmission Lines Using ANN</b>	<b>111</b>
6.1 Planar Transmission Line	112
6.1.1 Microstrip lines	112
6.1.2 Slot line transmission line	113
6.2 ANN Implementation	113
6.2.1 Generation of data	114
6.2.2 Training of the neural network	114
6.2.3 Testing	114
6.3 Analysis and Design of Microstrip Transmission Line	115
6.3.1 Analysis of microstrip line	115
6.3.2 Design of microstrip line	117
6.4 Analysis and Design of Slotline	119
6.4.1 Analysis of slotline	119
6.4.2 Design of slotline	121
6.5 Summary	123
<i>References</i>	123

## x CONTENTS

<b>7. Fault Detection in Antenna Arrays</b>	<b>124</b>
7.1 Preliminaries and Overview	124
7.2 Artificial Neural Network for Array Fault Detection	125
7.2.1 Antenna array design	127
7.2.2 ANN implementation	129
7.2.3 Results	131
7.3 PSO for Array Fault Detection	133
7.3.1 PSO implementation	133
7.3.2 Results and discussion	137
7.4 BFO for Array Fault Finding	142
7.4.1 BFO implementation	142
7.4.2 Results and discussion	144
7.5 Hybrid Technique	147
7.6 Summary	150
<i>References</i>	151
<b>8. Multi-Objective Particle Swarm Optimization for Active Terahertz Devices</b>	<b>155</b>
8.1 Introduction to Terahertz Technology	155
8.1.1 Properties of terahertz spectrum	156
8.1.2 Applications	156
8.1.2.1 Space platform	156
8.1.2.2 Security	157
8.1.2.3 Biomedical field	157
8.1.3 Challenges of terahertz technology	157
8.1.3.1 Material issues	157
8.1.3.2 Design issues	158
8.1.3.3 Fabrication issues	158
8.1.3.4 Characterization issues	158
8.2 Trends in Active Terahertz Devices	158
8.2.1 MEMS based tuning	159
8.2.2 Photo excitation	160
8.2.3 Electrical actuation	161
8.2.4 Thermal actuation	161
8.3 Design of Terahertz Device	161
8.3.1 Design of terahertz absorber	163
8.3.2 Performance enhancement analysis	166
8.4 Soft Computing for Performance Enhancement	168
8.4.1 MOPSO based computational engine	168
8.4.2 High performance ultra-thin absorber	169
8.5 Soft Computing for Active Terahertz Absorber	171
8.5.1 Selection of tuning mechanism	171
8.5.2 Implementation of tuning mechanism	173
8.5.3 PSO for design of active absorber array	175
8.5.3.1 Design procedure	176
8.5.3.2 Concept of adaptive tuning	177

	CONTENTS	xi
8.6 Fabrication Sensitivity Analysis		177
8.7 Summary		178
<i>References</i>		179
<b>9. Soft Computing based CAD Packages for EM Applications</b>		<b>182</b>
9.1 CAD Package for Metamaterial Structures		182
9.1.1 Equivalent circuit analysis of square SRR		183
9.1.2 Equivalent circuit analysis of circular SRR		187
9.1.3 Development of CAD package using PSO		189
9.1.4 Optimization of metamaterial structures		190
9.1.4.1 Square SRR		191
9.1.4.2 Circular SRR		192
9.1.4.3 Comparison of PSO and GA		193
9.1.5 Applications of the CAD package		193
9.2 Path Loss Prediction in Urban and Rural Environment		195
9.2.1 Overview		195
9.2.2 Propagation model and path loss prediction		196
9.2.3 CAD Package using ANN		196
9.2.3.1 Generation of data		197
9.2.3.2 Training of the ANN		197
9.2.3.3 Testing		197
9.2.4 CAD model		198
9.2.5 Results and discussion		199
9.3 Summary		201
<i>References</i>		201
<i>Author Index</i>		205
<i>Subject Index</i>		213