

Contents

1	Introduction	1
	References.	4
2	Control and Modeling of Microgrids	7
2.1	Control of AC Microgrids	7
2.1.1	Control Objectives in AC Microgrids	7
2.1.2	Primary Control Techniques in AC Microgrids.	9
2.1.3	Secondary Control.	28
2.1.4	Tertiary Control	31
2.2	Dynamic Modeling of AC Microgrids	32
2.2.1	Voltage-Controlled Voltage Source Inverters	32
2.2.2	Current-Controlled Voltage Source Inverters.	36
2.3	Control of DC Microgrids	38
2.3.1	Control Objectives	38
2.3.2	Standard Control Technique	39
	References.	41
3	Introduction to Multi-agent Cooperative Control	45
3.1	Synchronization in Nature, Social Systems, and Coupled Oscillators	46
3.1.1	Synchronization in Animal Motion in Collective Groups	46
3.1.2	Leadership in Animal Groups on the Move	49
3.1.3	Synchronization in Coupled Oscillators and Electric Power Systems	50
3.2	Communication Graphs for Interconnected Systems.	51
3.2.1	Graph Matrices–Algebraic Graph Theory	53

3.3	Cooperative Control of Multi-agent Systems on Communication Graphs	54
3.3.1	Consensus and the Cooperative Regulator Problem	54
3.3.2	Synchronization and the Cooperative Tracker Problem	57
3.3.3	More General Agent Dynamics and Vector States	60
3.4	Time-Varying Edge Weights and Switched Graphs	62
	References.	64
4	Distributed Control of AC Microgrids.	67
4.1	Distributed Secondary Frequency Control.	69
4.2	Distributed Secondary Frequency and Power Control.	73
4.2.1	Distributed Cooperative Control Protocol for Frequency and Active Power Sharing.	75
4.2.2	Case Studies	79
4.3	Distributed Secondary Voltage Control of AC Microgrids	82
4.3.1	Secondary Voltage Control Objectives	84
4.3.2	Distributed Secondary Voltage Control Using Feedback Linearization	85
4.3.3	Case Studies	91
4.4	Distributed Secondary Voltage and Reactive Power Control of AC Microgrids	95
	References.	97
5	Multi-objective and Adaptive Distributed Control of AC Microgrids	99
5.1	Multi-objective and Two-Layer Control Framework for AC Microgrids	99
5.1.1	Control Layer 1: Frequency Control and Voltage Control of VCVSIs	105
5.1.2	Control Layer 2: Active and Reactive Power Controls of CCVSIs	107
5.1.3	Case Studies	111
5.2	Adaptive and Distributed Voltage Control for AC Microgrids	124
5.2.1	The Adaptive and Distributed Controller Design.	127
5.2.2	Case Studies	132
	References.	138
6	Droop-Free Distributed Control of AC Microgrids.	141
6.1	Droop-Free Cooperative Control Framework	143
6.1.1	Microgrid as a Cyber-Physical System	143
6.1.2	Cooperative Control Policy	144
6.1.3	Voltage Estimation Policy.	148
6.2	System-Level Modeling	150
6.2.1	Distribution Network Model	151
6.2.2	Dynamic Model of the Control and Cyber Subsystems.	153

6.2.3	Dynamic Model of the Entire Microgrid	155
6.2.4	Controller Design Guideline	157
6.2.5	Steady-State Performance Analysis	158
6.3	Experimental Verification	160
6.3.1	Performance Assessment	161
6.3.2	Communication Delay and Channel Bandwidth	163
6.3.3	Plug-and-Play Study	165
6.3.4	Failure Resiliency in Cyber Domain	166
6.4	Summary	168
	Appendix	168
	References.	169
7	Cooperative Control for DC Microgrids	173
7.1	Distributed Cooperative Controller for DC Microgrids	175
7.1.1	Graphical Representation of DC Microgrids	175
7.1.2	Cooperative Secondary Control Framework	176
7.1.3	Voltage Observer	179
7.2	Analytical Model Development for DC Microgrids	184
7.2.1	Global Dynamic Model.	184
7.2.2	Guidelines for Controller Design.	185
7.2.3	Steady-State Analysis	186
7.3	Distributed Adaptive Droop Control for DC Microgrids: An Alternative Solution	188
7.4	Experimental Performance Evaluation	190
7.4.1	Design Procedure	191
7.4.2	Droop Controller Versus Cooperative Controller.	195
7.4.3	Load Change Performance Assessment.	196
7.4.4	Plug-and-Play Capability.	199
7.4.5	Cyber-Link Failure Resiliency.	200
7.5	Summary	201
	Appendix	202
	References.	207
8	Distributed Assistive Control of DC Microgrids	211
8.1	Introductory of Power Buffer and Distributed Control	212
8.1.1	Operational Principle of Power Buffer.	212
8.1.2	Distributed Control	213
8.2	System-Level Modeling of DC Microgrid with Power Buffers.	214
8.3	Multi-player Game for Optimal Control	218
8.3.1	Microgrid Loads as Players in a Differential Game.	219
8.3.2	Policy Iteration to Solve the Coupled AREs	222
8.4	Case Studies	223
8.4.1	Impedance Adjustment by Tuning Buffer Voltage	225
8.4.2	Steady-State and Small-Signal Decomposition	227

8.4.3	Conventional Approach: Deactivated Power Buffers	227
8.4.4	Assistive Controller: Single Assisting Neighbor	229
8.4.5	Assistive Controller: Multiple Assisting Neighbors	231
8.4.6	Communication Delay and Channel Bandwidth	231
8.5	Summary	233
	Appendix	233
	References.	236
Index	239

Cooperative Synchronization in Distributed Microgrid
Control

Bidram, A.; Nasirian, V.; Davoudi, A.; Lewis, F.L.

2017, XVI, 242 p. 129 illus., 68 illus. in color., Hardcover

ISBN: 978-3-319-50807-8