

Contents

1	Introduction	1
2	Hyperbolic Systems of Balance Laws	7
2.1	Linear PDE Representation	7
2.2	Initial and Boundary Conditions	10
2.3	Examples of 2×2 Systems	11
2.3.1	Double-Pipe Heat Exchanger	12
2.3.2	Transportation Pipeline	14
2.4	Boundary Input Configurations for 2×2 Systems	19
2.5	Summary	22
3	State-Space Representation	23
3.1	Abstract State and Output Equations	24
3.1.1	Homogeneous State Equation	24
3.1.2	Boundary and Observation Operators	26
3.1.3	Boundary Control System	28
3.1.4	State Equation in Additive Form	29
3.1.5	State Equation in Factor Form	33
3.2	Resolvent Operator	35
3.3	Strongly Coupled Systems	39
3.4	Summary	42
4	Transfer Function Representation	43
4.1	Definition and Properties	43
4.2	Transfer Function Matrices	46
4.2.1	Collocated Inputs	46
4.2.2	Anti-collocated Inputs	48
4.3	Analytical Expressions	49
4.3.1	Collocated Inputs	50
4.3.2	Anti-collocated Inputs	53
4.3.3	Systems of Conservation Laws	54

4.4	Pole–Zero Analysis	55
4.5	Strongly Coupled Systems	57
4.5.1	Transfer Function Matrices	57
4.5.2	Transfer Function Conversion Formulas	59
4.6	Frequency Responses	61
4.7	Examples	62
4.7.1	Double-Pipe Heat Exchanger	62
4.7.2	Transportation Pipeline.	71
4.8	Summary	75
5	Constant Steady-State Analysis.	77
5.1	Decoupled System	78
5.1.1	Collocated Inputs	78
5.1.2	Anti-collocated Inputs	80
5.1.3	Systems of Conservation Laws	81
5.2	Transfer Function-Based Approach	82
5.2.1	Decoupled System.	82
5.2.2	Strongly Coupled Systems	83
5.3	Examples	84
5.3.1	Double-Pipe Heat Exchanger	84
5.3.2	Transportation Pipeline.	87
5.4	Summary	88
6	Time-Domain Representation	89
6.1	Impulse Responses.	90
6.1.1	Preliminary Results	91
6.1.2	Collocated Inputs	95
6.1.3	Anti-collocated Inputs	97
6.1.4	Systems of Conservation Laws	100
6.2	Examples	101
6.2.1	Double-Pipe Heat Exchanger	101
6.2.2	Transportation Pipeline.	104
6.3	Summary	106
7	PCA-Based Approximation.	107
7.1	Classical PCA	108
7.1.1	Continuous PCA	108
7.1.2	Discrete PCA	111
7.2	Neural Network–Based PCA	115
7.2.1	Feed-Forward PCA (FF-PCA) Neural Network	115
7.2.2	Hebbian PCA (GHA-PCA) Neural Network	117
7.3	Example: Heat Exchanger Impulse Response.	119
7.3.1	Classical PCA.	120
7.3.2	Neural PCA	122
7.4	Summary	126

Contents	xi
8 Conclusions and Future Works	127
References	131
Index	143

Modeling and Analysis of Linear Hyperbolic Systems of
Balance Laws

Bartecki, K.

2016, XXV, 146 p. 44 illus., Hardcover

ISBN: 978-3-319-27500-0