

Contents

List of Figures	xvii
List of Tables	xxiii
Symbols and Abbreviations	xxv
Abbreviations	xxv
Scalar and Vector Signals	xxvi
General Symbols	xxvi
Operators and Functions	xxx
Criteria	xxxiii
Chapter 1. Introduction	1
1.1. An Overview of the Recent History of Process Control in Industry	1
1.2. Where are We Today?	2
1.3. The Contribution of this Book	3
1.4. Synopsis	5
Chapter 2. Preliminary Material	7
2.1. Introduction	7
2.2. General Representation of a Closed-loop System and Closed-loop Stability	8
2.2.1. General Closed-loop Set-up	8
2.2.2. Closed-loop Transfer Functions and Stability	9
2.2.3. Some Useful Algebra for the Manipulation of Transfer Matrices	11
	xi

2.3.	LFT-based Representation of a Closed-loop System	12
2.4.	Coprime Factorisations	14
2.4.1.	Coprime Factorisations of Transfer Functions or Matrices	14
2.4.2.	The Bezout Identity and Closed-loop Stability	18
2.5.	The ν -gap Metric	20
2.5.1.	Definition	20
2.5.2.	Stabilisation of a Set of Systems by a Given Controller and Comparison with the Directed Gap Metric	22
2.5.3.	The ν -gap Metric and Robust Stability	23
2.6.	Prediction-error Identification	24
2.6.1.	Signals Properties	25
2.6.2.	The Identification Method	26
2.6.3.	Usual Model Structures	28
2.6.4.	Computation of the Estimate	29
2.6.5.	Asymptotic Properties of the Estimate	30
2.6.6.	Classical Model Validation Tools	33
2.6.7.	Closed-loop Identification	36
2.6.8.	Data Preprocessing	37
2.7.	Balanced Truncation	38
2.7.1.	The Concepts of Controllability and Observability	38
2.7.2.	Balanced Realisation of a System	40
2.7.3.	Balanced Truncation	42
2.7.4.	Numerical Issues	42
2.7.5.	Frequency-weighted Balanced Truncation	43
2.7.6.	Balanced Truncation of Discrete-time Systems	45
 Chapter 3. Identification in Closed Loop for Better Control Design		 47
3.1.	Introduction	47
3.2.	The Role of Feedback	48
3.3.	The Effect of Feedback on the Modelling Errors	51
3.3.1.	The Effect of Feedback on the Bias Error	51
3.3.2.	The Effect of Feedback on the Variance Error	54
3.4.	The Effect of Model Reduction on the Modelling Errors	56
3.4.1.	Using Model Reduction to Tune the Bias Error	57
3.4.2.	Dealing with the Variance Error	57
3.5.	Summary of the Chapter	62

Chapter 4. Dealing with Controller Singularities in Closed-loop Identification	65
4.1. Introduction	65
4.2. The Importance of Nominal Closed-loop Stability for Control Design	66
4.3. Poles and Zeroes of a System	67
4.4. Loss of Nominal Closed-loop Stability with Unstable or Nonminimum-phase Controllers	69
4.4.1. The Indirect Approach	70
4.4.2. The Coprime-factor Approach	72
4.4.3. The Direct Approach	76
4.4.4. The Dual Youla Parametrisation Approach	78
4.5. Guidelines for an Appropriate Closed-loop Identification Experiment Design	80
4.5.1. Guidelines for the Choice of an Identification Method	80
4.5.2. Remark on High-order Models Obtained by Two-stage Methods	81
4.6. Numerical Illustration	82
4.6.1. Problem Description	82
4.6.2. The Indirect Approach	84
4.6.3. The Coprime-factor Approach	87
4.6.4. The Direct Approach	94
4.6.5. The Dual Youla Parametrisation Approach	98
4.6.6. Comments on the Numerical Example	107
4.7. Summary of the Chapter	110
 Chapter 5. Model and Controller Validation for Robust Control in a Prediction-error Framework	111
5.1. Introduction	111
5.1.1. The Questions of the Cautious Process Control Engineer	111
5.1.2. Some Answers to these Questions	112
5.2. Model Validation Using Prediction-error Identification	116
5.2.1. Model Validation Using Open-loop Data	117
5.2.2. Control-oriented Model Validation Using Closed-loop Data	122
5.2.3. A Unified Representation of the Uncertainty Zone	128
5.3. Model Validation for Control and Controller Validation	129

5.3.1.	A Control-oriented Measure of the Size of a Prediction-error Uncertainty Set	129
5.3.2.	Controller Validation for Stability	132
5.3.3.	Controller Validation for Performance	134
5.4.	The Effect of Overmodelling on the Variance of Estimated Transfer Functions	137
5.4.1.	The Effect of Superfluous Poles and Zeroes	137
5.4.2.	The Choice of a Model Structure	140
5.5.	Case Studies	142
5.5.1.	Case Study I: Flexible Transmission System	142
5.5.2.	Case Study II: Ferrosilicon Production Process	148
5.6.	Summary of the Chapter	156
 Chapter 6. Control-oriented Model Reduction and Controller Reduction		159
6.1.	Introduction	159
6.1.1.	From High to Low Order for Implementation Reasons	159
6.1.2.	High-order Controllers	160
6.1.3.	Contents of this Chapter	161
6.2.	A Closed-loop Criterion for Model or Controller Order Reduction	161
6.3.	Choice of the Reduction Method	164
6.4.	Model Order Reduction	165
6.4.1.	Open-loop Plant Coprime-factor Reduction	166
6.4.2.	Performance-preserving Closed-loop Model Reduction	170
6.4.3.	Stability-preserving Closed-loop Model Reduction	177
6.4.4.	Preservation of Stability and Performance by Closed-loop Model Reduction	181
6.5.	Controller Order Reduction	182
6.5.1.	Open-loop Controller Coprime-factor Reduction	183
6.5.2.	Performance-preserving Closed-loop Controller Reduction	184
6.5.3.	Stability-preserving Closed-loop Controller Reduction	192
6.5.4.	Other Closed-loop Controller Reduction Methods	195
6.6.	Case Study: Design of a Low-order Controller for a PWR Nuclear Power Plant Model	196
6.6.1.	Description of the System	196
6.6.2.	Control Objective and Design	197
6.6.3.	System Identification	199
6.6.4.	Model Reduction	201

6.6.5. Controller Reduction	203
6.6.6. Performance Analysis of the Designed Controllers	204
6.7. Classification of the Methods and Concluding Remarks	207
6.8. Summary of the Chapter	208
Chapter 7. Some Final Words	211
7.1. A Unified Framework	211
7.2. Missing Links and Perspectives	212
7.3. Model-free Control Design	213
References	215
Index	223

<http://www.springer.com/978-1-85233-918-0>

Process Modelling for Control
A Unified Framework Using Standard Black-box
Techniques

Codrons, B.

2005, XXXIII, 229 p., Hardcover

ISBN: 978-1-85233-918-0