

Contents

Part I Preliminaries

1 Singular Perturbation Methods and Time-Scale Techniques	3
1.1 Modelling	3
1.1.1 Singularly Perturbed Phenomena	4
1.1.2 Linear Time-Invariant Singularly Perturbed Systems	8
1.1.3 Nonlinear Singularly Perturbed Systems	9
1.1.4 Hybrid Singularly Perturbed Systems	9
1.2 Time-Scale and Frequency-Scale Analysis	10
1.2.1 Time-Scale and Multiple Time-Scales	10
1.2.2 Multiple Frequency-Scales	14
1.3 Slow-Fast Decomposition Method	16
1.3.1 Decoupling Transformation	16
1.3.2 Construction of Slow and Fast Subsystems	17
1.4 Controllability and Observability	21
1.5 Conclusion	24
References	25
2 Theoretical Foundation of Finite Frequency Control	29
2.1 The Laplace Transform	29
2.2 Frequency Division Strategies	33
2.2.1 Weighting Functions	33
2.2.2 General Kalman-Yakubovich-Popov Lemma	36
2.3 Characterization of Control Performance Index	40
2.3.1 Characterization of Finite Frequency Ranges	40
2.3.2 Window Norm	42
2.3.3 Frequency Domain Inequalities	44
2.4 Conclusion	46
References	46

Part II Singularly Perturbed Systems Analysis and Synthesis

3	Stabilization of Singularly Perturbed Systems.	51
3.1	Stability Analysis of Dynamical Systems	51
3.2	Stability Analysis and Integration	54
3.3	Stability Theory on Time Domain	55
3.3.1	Method Based on Slow and Fast Subsystems	55
3.3.2	A Descriptor-System Method	57
3.4	Stability Theory on Frequency Domain	59
3.5	Conclusion	64
	References.	65
4	Finite Frequency H_∞ Control for Singularly Perturbed Systems	67
4.1	Background Information for H_∞ Control of Singularly Perturbed Systems	67
4.2	Finite Frequency H_∞ State Feedback Control.	70
4.3	Finite Frequency H_∞ Output Feedback Control	76
4.3.1	The Slow Subsystem and Associated H_∞ Controller in the Low-Frequency Domain	81
4.3.2	The Fast Subsystem and Associated Controller in the High-Frequency Domain	86
4.4	A Descriptor-System Approach for H_∞ Control of Singularly Perturbed Systems.	96
4.4.1	Shaping the High-Frequency Characteristics of a Singularly Perturbed Systems	100
4.4.2	Shaping the Low-frequency Characteristics of a Singularly Perturbed Systems	103
4.5	Finite Frequency H_∞ Tracking Problem	106
4.6	Finite Frequency H_∞ Model Matching Problem.	108
4.7	Conclusion	117
	References.	117
5	Finite Frequency Positive Real Control for Singularly Perturbed Systems.	119
5.1	Passivity and Positive Real Property.	119
5.2	Methods Based on Slow-Fast Decomposition.	121
5.2.1	State Feedback Control for General Linear Systems	122
5.2.2	Finite Frequency Positive Real Control for Singularly Perturbed Systems	127
5.3	A Descriptor-System Method for Strictly Positive Real Control of Singularly Perturbed Systems	130
5.4	Conclusion	134
	References.	135

6 The Sensitivity-Shaping Problem for Singularly Perturbed Systems.	137
6.1 Sensitivity Function and Complementary Sensitivity Function . . .	137
6.2 Finite Frequency S/T Mixed Sensitivity Design for SISO Singularly Perturbed Systems	140
6.3 Finite Frequency H_-/H_∞ Control for MIMO Singularly Perturbed Systems	146
6.4 Fault Detection for Singularly Perturbed Systems.	157
6.4.1 Internal Stability Conditions	162
6.4.2 Disturbance Attenuation Conditions	164
6.4.3 Fault Sensitivity Conditions	167
6.5 Conclusion	176
References.	176

Part III Applications

7 Applications	181
7.1 Background of Applications of Singular Perturbation Methods . .	181
7.1.1 Applications of Singular Perturbation Methods in Aerospace	181
7.1.2 Applications of Singular Perturbation Methods in Mechanical Systems	182
7.1.3 Applications of Singularly Perturbed Methods in Electrical and Electronic Circuits Systems	183
7.1.4 Applications of Singular Perturbation Methods in Chemical Reactions and Reactors	185
7.1.5 Applications of Singular Perturbation Methods in Biology	186
7.1.6 Applications of Singular Perturbation Methods in Other Areas	187
7.2 Wind Turbines Control Using Linear Parameter Varying Singularly Perturbed Model	187
7.2.1 Stability Analysis of Open-Loop System.	191
7.2.2 Controller Design	195
7.2.3 Algorithm of Synthesis	197
7.2.4 Simulation Examples.	198
7.3 Robust H_∞ Controller for Miniature Quad-Rotors in Hovering . .	201
7.3.1 Modelling	204
7.3.2 Design of H_∞ Controller for Miniature UAVs in Hovering.	209
7.3.3 The Flexible Strategy	211
7.3.4 Numerical Examples	212
7.4 Conclusion	217
References.	217
Index	225

Finite Frequency Analysis and Synthesis for Singularly
Perturbed Systems

Cai, C.; Wang, Z.; Xu, J.; Zou, Y.

2017, XIV, 227 p. 64 illus., 41 illus. in color., Hardcover

ISBN: 978-3-319-45404-7