

Contents

1	Fault Tolerant Control	1
1.1	Fault and Failure and Their Classification	1
1.1.1	Modeling Faults and Failures	4
1.2	Fault Detection and Isolation (FDI)	6
1.3	Fault Tolerant Control Systems	7
1.3.1	Passive Fault Tolerant Control Systems	7
1.3.2	Active Fault Tolerant Control Systems	9
1.3.3	Control Allocation	10
1.4	Summary	11
1.5	Notes and References	11
	References	12
2	Integral Sliding Mode Control	17
2.1	Introduction	17
2.2	Problem Statement and Equivalent Control	18
2.2.1	Sliding Mode Control Laws	20
2.3	Reachability Problem	20
2.4	A Simple Simulation Example	21
2.4.1	Spring Mass Damper System	22
2.4.2	Simulation Objective and SMC Design	23
2.4.3	Simulation Results	24
2.5	Practical Sliding Mode Control Law	25
2.6	Properties of the Sliding Mode	26
2.7	Integral Sliding Mode Control (ISMC)	27
2.7.1	Introduction	27
2.7.2	Problem Statement and ISM Controller Design	28
2.7.3	Design Principles	28
2.7.4	Integral Switching Surface	30
2.7.5	Integral Sliding Mode Control Laws	31
2.7.6	The Reachability Condition	31

2.7.7	Properties of Integral Sliding Mode	32
2.7.8	Simulation Example	32
2.8	Sliding Modes as a Candidate for FTC	34
2.9	Notes and References	35
	References	36
3	Design and Analysis of an Integral Sliding Mode Fault Tolerant Control Scheme	39
3.1	System Description and Problem Formulation	39
3.2	Integral Sliding Mode Controller Design.	44
3.2.1	Integral-Type Switching Surface Design	44
3.2.2	Closed-Loop Stability Analysis	46
3.2.3	Integral Sliding Mode Control Laws.	48
3.2.4	Design of the Controller Gains	50
3.3	Simulations.	51
3.3.1	Sliding Mode Fault Reconstruction Scheme.	54
3.3.2	Manoeuvre and Fault Scenarios	57
3.4	Summary	59
3.5	Notes and References.	60
	References	60
4	A Fault Tolerant Direct Control Allocation Scheme with Integral Sliding Modes	63
4.1	Problem Formulation	63
4.2	Integral Sliding Mode FTC Scheme with Direct Control Allocation.	65
4.2.1	Design of Feedback Gain F	70
4.3	Simulations.	71
4.4	Nonlinear Simulation Results	72
4.5	Summary	78
4.6	Notes and References.	79
	References	79
5	An Output Integral Sliding Mode FTC Scheme Using Control Allocation	81
5.1	Problem Formulation	81
5.2	ISM Controller Design	83
5.2.1	Closed-Loop Stability Analysis	87
5.2.2	LMI Synthesis.	88
5.2.3	ISM Control Laws	90
5.3	Simulations.	92
5.3.1	Simulation Results	98
5.4	Summary	100
5.5	Notes and References.	101
	References	101

6	An Augmentation Scheme for Fault Tolerant Control Using Integral Sliding Modes	103
6.1	System Description and Problem Formulation	104
6.2	Integral Sliding Mode Controller Design	107
6.2.1	Stability Analysis of the Closed-Loop Sliding Motion	109
6.2.2	Integral Sliding Mode Control Laws	111
6.3	Case Study: Yaw Damping of a Large Transport Aircraft	113
6.3.1	Baseline Controller	114
6.3.2	Fault Tolerant Control	115
6.3.3	Nonlinear Simulation Results	116
6.4	Summary	120
6.5	Notes and References	120
	References	121
7	Nonlinear Integral Sliding Mode	123
7.1	Nonlinear Aircraft Model	123
7.1.1	Strict Feedback Form	125
7.2	Control Law Development	127
7.2.1	Nominal Backstepping Control Law	128
7.2.2	Control Allocation	129
7.2.3	Integral Sliding Mode Design	131
7.3	Simulations	133
7.3.1	RECOVER Benchmark Model	133
7.3.2	Outer-Loop Control	134
7.3.3	Results	135
7.4	Summary	146
7.5	Notes and References	146
	References	147
8	Linear Parameter Varying FTC Scheme Using Integral Sliding Modes	149
8.1	Problem Formulation	149
8.2	Integral Sliding Mode Controller Design	152
8.2.1	Design of Integral Switching Function	152
8.2.2	Closed-Loop Stability Analysis	155
8.2.3	ISM Control Laws	156
8.2.4	Design of the State Feedback Gain	159
8.3	Simulations	160
8.3.1	Control Design Objectives	162
8.3.2	Simulation Results	163
8.4	Summary	166
8.5	Notes and References	166
	References	167

9 Real-Time Implementation of an ISM Fault Tolerant Control Scheme on the SIMONA Flight Simulator	169
9.1 SIMONA Research Simulator (SRS)	169
9.2 Design and SRS Implementation	171
9.2.1 SRS Implementation.	171
9.3 SRS Piloted Evaluation Results	173
9.3.1 Fault-Free	175
9.3.2 Elevator Jam	175
9.3.3 Stabiliser Runaway	178
9.3.4 Pilot Feedback.	178
9.4 Summary	179
9.5 Notes and References.	179
References	179
Appendix A: Benchmark Model of Large Transport Aircraft	181
Appendix B: Closed-Loop Stability and Feedback Gain Synthesis.	189
Index	195

Fault Tolerant Control Schemes Using Integral Sliding
Modes

Hamayun, M.T.; Edwards, C.; Alwi, H.

2016, XVIII, 199 p. 69 illus., 49 illus. in color., Hardcover

ISBN: 978-3-319-32236-0