

- Preface p. xiii
- 1. Introduction p. 1
- 1.1 What is Control? p. 1
- 1.2 Open-Loop and Closed-Loop Control Systems p. 2
- 1.3 Other Classifications of Control Systems p. 6
- 1.4 On the Road to Control System Analysis and Design p. 10
- 1.5 Matlab, Simulink, and the Control System Toolbox p. 11
- References p. 12
- 2. Linear Systems and Classical Control p. 13
- 2.1 How Valid is the Assumption of Linearity? p. 13
- 2.2 Singularity Functions p. 22
- 2.3 Frequency Response p. 26
- 2.4 Laplace Transform and the Transfer Function p. 36
- 2.5 Response to Singularity Function p. 51
- 2.6 Response to Arbitrary Inputs p. 58
- 2.7 Performance p. 62
- 2.8 Stability p. 71
- 2.9 Root-Locus Method p. 73
- 2.10 Nyquist Stability Criterion p. 77
- 2.11 Robustness p. 81
- 2.12 Closed-Loop Compensation Techniques for Single-Input, Single-Output Systems p. 87
- 2.12.1 Proportional-integral-derivative compensation p. 88
- 2.12.2 Lag, lead, and lead-lag compensation p. 96
- 2.13 Multivariable Systems p. 105
- Exercises p. 115
- References p. 124
- 3. State-Space Representation p. 125
- 3.1 The State-Space: Why Do I Need It? p. 125
- 3.2 Linear Transformation of State-Space Representations p. 140
- 3.3 System Characteristics from State-Space Representation p. 146
- 3.4 Special State-Space Representations: The Canonical Forms p. 152
- 3.5 Block Building in Linear, Time-Invariant State-Space p. 160
- Exercises p. 168
- References p. 170
- 4. Solving the State-Equations p. 171
- 4.1 Solution of the Linear Time Invariant State Equations p. 171
- 4.2 Calculation of the State-Transition Matrix p. 176
- 4.3 Understanding the Stability Criteria through the State-Transition Matrix p. 183
- 4.4 Numerical Solution of Linear Time-Invariant State-Equations p. 184
- 4.5 Numerical Solution of Linear Time-Varying State-Equations p. 198
- 4.6 Numerical Solution of Nonlinear State-Equations p. 204
- 4.7 Simulating Control System Response with Simulink p. 213
- Exercises p. 216
- References p. 218

- 5. Control System Design in State-Space p. 219
- 5.1 Design: Classical vs. Modern p. 219
- 5.2 Controllability p. 222
- 5.3 Pole-Placement Design Using Full-State Feedback p. 228
- 5.3.1 Pole-placement regulator design for single-input plants p. 230
- 5.3.2 Pole-placement regulator design for multi-input plants p. 245
- 5.3.3 Pole-placement regulator design for plants with noise p. 247
- 5.3.4 Pole-placement design of tracking systems p. 251
- 5.4 Observers, Observability, and Compensators p. 256
- 5.4.1 Pole-placement design of full-order observers and compensators p. 258
- 5.4.2 Pole-placement design of reduced-order observers and compensators p. 269
- 5.4.3 Noise and robustness issues p. 276
- Exercises p. 277
- References p. 282
- 6. Linear Optimal Control p. 283
- 6.1 The Optimal Control Problem p. 283
- 6.1.1 The general optimal control formulation for regulators p. 284
- 6.1.2 Optimal regulator gain matrix and the riccati equation p. 286
- 6.2 Infinite-Time Linear Optimal Regulator Design p. 288
- 6.3 Optimal Control of Tracking Systems p. 298
- 6.4 Output Weighted Linear Optimal Control p. 308
- 6.5 Terminal Time Weighting: Solving the Matrix Riccati Equation p. 312
- Exercises p. 318
- References p. 321
- 7. Kalman Filters p. 323
- 7.1 Stochastic Systems p. 323
- 7.2 Filtering of Random Signals p. 329
- 7.3 White Noise, and White Noise Filters p. 334
- 7.4 The Kalman Filter p. 339
- 7.5 Optimal (Linear, Quadratic, Gaussian) Compensators p. 351
- 7.6 Robust Multivariable LQG Control: Loop Transfer Recovery p. 356
- Exercises p. 370
- References p. 371
- 8. Digital Control Systems p. 373
- 8.1 What are Digital Systems? p. 373
- 8.2 A/D Conversion and the z-Transform p. 375
- 8.3 Pulse Transfer Functions of Single-Input, Single-Output Systems p. 379
- 8.4 Frequency Response of Single-Input, Single-Output Digital Systems p. 384
- 8.5 Stability of Single-Input, Single-Output Digital Systems p. 386
- 8.6 Performance of Single-Input, Single-Output Digital Systems p. 390
- 8.7 Closed-Loop Compensation Techniques for Single-Input, Single-Output Digital Systems p. 393
- 8.8 State-Space Modeling of Multivariable Digital Systems p. 396
- 8.9 Solution of Linear Digital State-Equations p. 402

- 8.10 Design of Multivariable, Digital Control Systems Using Pole-Placement: Regulators, Observers, and Compensators p. 406
- 8.11 Linear Optimal Control of Digital Systems p. 415
- 8.12 Stochastic Digital Systems, Digital Kalman Filters, and Optimal Digital Compensators p. 424
- Exercises p. 432
- References p. 436
- 9. Advanced Topics in Modern Control p. 437
- 9.1 Introduction p. 437
- 9.2 H[infinity] Robust, Optimal Control p. 437
- 9.3 Structured Singular Value Synthesis for Robust Control p. 442
- 9.4 Time-Optimal Control with Pre-shaped Inputs p. 446
- 9.5 Output-Rate Weighted Linear Optimal Control p. 453
- 9.6 Nonlinear Optimal Control p. 455
- Exercises p. 463
- References p. 465
- Appendix A Introduction to MATLAB, SIMULINK and the Control System Toolbox p. 467
- Appendix B Review of Matrices and Linear Algebra p. 481
- Appendix C Mass, Stiffness, and Control Influence Matrices of the Flexible Spacecraft p. 487
- Answers to Selected Exercises p. 489
- Index p. 495