Contents

1 Polynomial Matrix Fraction Descriptions .................... 1
  1.1 Right Coprime Matrix Fraction Description .............. 1
  1.2 Left Coprime Matrix Fraction Description ............... 10

2 State Feedback Control .................................. 17
  2.1 State Feedback in the Time Domain ...................... 18
  2.2 Parameterization of the State Feedback in the Frequency
       Domain ............................................. 20

3 State Observers .......................................... 27
  3.1 The Reduced-order Observer in the Time Domain .......... 28
  3.2 Parameterization of the Full-order Observer in the Frequency
       Domain ............................................. 32
  3.3 Parameterization of the Reduced-order Observer in the
       Frequency Domain .................................... 36

4 Observer-based Compensators ............................... 51
  4.1 The Observer-based Compensator in the Time Domain ...... 52
  4.2 Representations of the Observer-based Compensator in the Frequency Domain .................................... 54
  4.3 Computation of the Observer-based Compensator in the Frequency Domain .................................... 54
  4.4 Summary of the Steps for the Design of Observer-based
       Compensators in the Frequency Domain .................. 64
  4.5 Prevention of Problems Caused by Input-signal Restrictions . 70

5 Parametric Compensator Design ............................. 81
  5.1 Parametric Design of State Feedback in the Time Domain ... 82
  5.2 Parametric Design of State Feedback in the Frequency Domain 84
       5.2.1 Definition of the Pole Directions .................. 84
       5.2.2 Parametric Expression of the State Feedback ...... 85
5.2.3 Relation Between the Pole Directions and the Closed-loop Eigenvectors ........................................ 89
5.2.4 Relation Between the Pole Directions and the Invariant Parameter Vectors ..................................... 90
5.3 Parameterization of the State Feedback Gain Using the Pole Directions .............................................. 90
5.4 Parametric Design of Reduced-order Observers in the Frequency Domain ........................................ 92
  5.4.1 Definition of the Observer Pole Directions .......... 92
  5.4.2 Parametric Expression for the Observer Design ...... 93
  5.4.3 Relation Between the Observer Pole Directions and the Left Eigenvectors of the Observer ............... 97
  5.4.4 Parameterization of Observers in the Time Domain Using the Pole Directions ............................. 99
5.5 Parametric Design of Reduced-order Observers in the Time Domain .............................................. 103

6 Decoupling Control ........................................ 107
  6.1 Diagonal Decoupling ........................................ 108
    6.1.1 Criterion for Diagonal Decoupling .................. 108
    6.1.2 A Simple Solution of the Diagonal Decoupling Problem 111
    6.1.3 Diagonal Decoupling Using the Parametric Approach . 115
  6.2 Decoupling with Coupled Rows ............................. 119
    6.2.1 Decoupling of Non-minimum Phase Systems ......... 119
    6.2.2 Decoupling of Non-decouplable Systems ........... 124
    6.2.3 Decoupling of Non-minimum Phase and Non-decouplable Systems .............................................. 127

7 Disturbance Rejection Using the Internal Model Principle . 131
  7.1 Time-domain Approach to Disturbance Rejection .......... 132
  7.2 State Feedback Control of the Augmented System in the Frequency Domain ...................................... 142
  7.3 State Observer for the Non-augmented System in the Frequency Domain ......................................... 147
  7.4 Design of the Observer-based Compensator with an Internal Signal Model in the Frequency Domain ........ 148

8 Optimal Control and Estimation ........................... 167
  8.1 The Linear Quadratic Regulator in the Time Domain ...... 168
  8.2 The Linear Quadratic Regulator in the Frequency Domain . 169
  8.3 The Stationary Kalman Filter in the Time Domain .......... 174
  8.4 The Stationary Kalman Filter in the Frequency Domain .... 177
9 Model-matching Control with Two Degrees of Freedom .... 185
  9.1 Model-based Feedforward Control in the Time Domain .... 187
  9.2 Model-based Feedforward Control in the Frequency Domain . 189
  9.3 Tracking Control by State Feedback in the Time Domain .... 190
  9.3.1 Tracking Controller without Disturbance Rejection .... 190
  9.3.2 Tracking Controller with Disturbance Rejection .... 191
  9.4 Tracking Control by State Feedback in the Frequency Domain 195
  9.5 Observer-based Tracking Control in the Time Domain .... 198
  9.6 Observer-based Tracking Control in the Frequency Domain .... 200

10 Observer-based Compensators with Disturbance
  Rejection for Discrete-time Systems ................. 209
  10.1 Discrete-time Control in the Time Domain .......... 210
  10.2 Discrete-time Control in the Frequency Domain .... 215

11 Optimal Control and Estimation for Discrete-time Systems 225
  11.1 The Linear Quadratic Regulator in the Time Domain .... 226
  11.2 The Linear Quadratic Regulator in the Frequency Domain ... 227
  11.3 The Stationary Kalman Filter in the Time Domain .... 232
  11.4 The Stationary Kalman Filter in the Frequency Domain .... 237
    11.4.1 Parameterization of the Stationary Kalman Filter for an a posteriori Estimate in the Frequency Domain .... 237
    11.4.2 Frequency-domain Design of the Stationary Kalman Filter ............................................. 246
  11.5 Observer-based Compensators with a posteriori State
    Estimate in the Frequency Domain ...................... 255

A Appendix .................................................. 267
  A.1 Computing a Row-reduced Polynomial Matrix \( \tilde{D}_\kappa(s) \) .... 267
  A.2 Proof of Theorem 4.1 .................................. 272

References .......................................................... 277

Index ............................................................. 281
Design of Observer-based Compensators
From the Time to the Frequency Domain
Hippe, P.; Deutscher, J.
2009, XIII, 285 p., Hardcover
ISBN: 978-1-84882-536-9