Contents

Preface v

I Analysis of differential-algebraic equations 1

1 Introduction 3
- 1.1 Solvability concepts . . . 5
- 1.2 Index concepts . . . 6
- 1.3 Applications . . . 8
- 1.4 How to use this book in teaching . . . 11

2 Linear differential-algebraic equations with constant coefficients 13
- 2.1 Canonical forms . . . 13
- 2.2 The Drazin inverse . . . 22
- 2.3 Explicit representation of solutions . . . 27
- 2.4 Generalized solutions . . . 32
- 2.5 Control problems . . . 48
- Bibliographical remarks . . . 52
- Exercises . . . 53

3 Linear differential-algebraic equations with variable coefficients 56
- 3.1 Canonical forms . . . 56
- 3.2 Local and global invariants . . . 80
- 3.3 The differentiation index . . . 95
- 3.4 Differential-algebraic operators and generalized inverses . . . 114
- 3.5 Generalized solutions . . . 132
- 3.6 Control problems . . . 138
- Bibliographical remarks . . . 147
- Exercises . . . 147

4 Nonlinear differential-algebraic equations 151
- 4.1 Existence and uniqueness of solutions . . . 151
- 4.2 Structured problems . . . 167
- 4.3 Over- and underdetermined problems . . . 182
- 4.4 Control problems . . . 189
- 4.5 Differential equations on manifolds . . . 195
- Bibliographical remarks . . . 210
- Exercises . . . 210

II Numerical solution of differential-algebraic equations 215

5 Numerical methods for strangeness-free problems 217
5.1 Preparations . . . 218
5.2 One-step methods . . . 224
5.3 Multi-step methods . . . 254
Bibliographical remarks . . . 270
Exercises . . . 270

6 Numerical methods for index reduction 273
6.1 Index reduction for linear problems . . . 274
6.2 Index reduction for nonlinear problems . . . 279
6.3 Index reduction via feedback control . . . 284
6.4 Index reduction by minimal extension . . . 286
Bibliographical remarks . . . 295
Exercises . . . 295

7 Boundary value problems 298
7.1 Existence and uniqueness of solutions . . . 299
7.2 Multiple shooting . . . 304
7.3 Collocation . . . 314
Bibliographical remarks . . . 348
Exercises . . . 348

8 Software for the numerical solution of differential-algebraic equations 352
Bibliographical remarks . . . 355
Exercises . . . 355

Final remarks 357

Bibliography 359

Index 373