



COMPUTATIONAL METHODS for ELECTRIC POWER SYSTEMS

MARIESA CROW



CRC PRESS

Contents

1	Introduction	1
2	The Solution of Linear Systems	3
2.1	Gaussian Elimination	4
2.2	LU Factorization	9
2.2.1	LU Factorization with Partial Pivoting	16
2.2.2	LU Factorization with Complete Pivoting	20
2.3	Condition Numbers and Error Propagation	22
2.4	Relaxation Methods	23
2.5	Conjugate Gradient Methods	28
2.6	Problems	34
3	Systems of Nonlinear Equations	37
3.1	Fixed Point Iteration	38
3.2	Newton-Raphson Iteration	42
3.2.1	Convergence Properties	45
3.2.2	The Newton-Raphson for Systems of Nonlinear Equations	46
3.2.3	Modifications to the Newton-Raphson Method	50
3.3	Power System Applications	51
3.3.1	Power Flow	52
3.3.2	Regulating Transformers	60
3.3.3	Decoupled Power Flow	64
3.3.4	Fast Decoupled Power Flow	66
3.3.5	PV Curves and Continuation Power Flow	69
3.3.6	Three-phase Power Flow	76
3.4	Problems	78
4	Sparse Matrix Solution Techniques	81
4.1	Storage Methods	82
4.2	Sparse Matrix Representation	87
4.3	Ordering Schemes	89
4.3.1	Scheme 0	97
4.3.2	Scheme I	98
4.3.3	Scheme II	104
4.3.4	Other Schemes	106
4.4	Power System Applications	108
4.5	Problems	112

5 Numerical Integration	117
5.1 One-Step Methods	118
5.1.1 Taylor Series-based methods	118
5.1.2 Forward-Euler method	119
5.1.3 Runge-Kutta methods	119
5.2 Multistep Methods	120
5.2.1 Adam's methods	126
5.2.2 Gear's methods	129
5.3 Accuracy and Error Analysis	130
5.4 Numerical Stability Analysis	134
5.5 Stiff Systems	141
5.6 Step-Size Selection	145
5.7 Differential-Algebraic Systems	148
5.8 Power System Applications	149
5.8.1 Transient Stability Analysis	150
5.9 Mid-Term Stability Analysis	159
5.10 Problems	162
6 Optimization	167
6.1 Least Squares State Estimation	168
6.1.1 Weighted Least Squares Estimation	171
6.1.2 Bad Data Detection	174
6.1.3 Nonlinear Least Squares State Estimation	177
6.2 Steepest Descent Algorithm	178
6.3 Power System Applications	184
6.3.1 Optimal Power Flow	184
6.3.2 State Estimation	195
6.4 Problems	200
7 Eigenvalue Problems	205
7.1 The QR Algorithm	206
7.1.1 Shifted QR	212
7.1.2 Deflation	213
7.2 Arnoldi Methods	213
7.3 Linear Model Identification	220
7.3.1 Prony Method	221
7.3.2 The Levenberg-Marquardt Method	223
7.4 Power System Applications	230
7.4.1 Participation Factors	230
7.4.2 Modal Analysis	231
7.5 Problems	235
References	237
Index	241