
CONTENTS

Foreword	ix
PREFACE	xi
Part I COMPONENTS AND PHENOMENA	1
1 INTRODUCTION	3
1.1 Why another Book?	3
1.2 Voltage Stability	4
1.3 Power System Stability Classification	7
1.4 Structure of this Book	10
1.5 Notation	12
2 TRANSMISSION SYSTEM ASPECTS	13
2.1 Single-Load Infinite-Bus System	13
2.2 Maximum Deliverable Power	15
2.3 Power-Voltage Relationships	22
2.4 Generator Reactive Power Requirement	25
2.5 A First Glance at Instability Mechanisms	26
2.6 Effect of Compensation	31
2.7 VQ Curves	38
2.8 Effect of Adjustable Transformer Ratios	41
2.9 Problems	44
3 GENERATION ASPECTS	47
3.1 A review of synchronous machine theory	47
3.2 Frequency and voltage controllers	64

3.3	Limiting devices affecting voltage stability	73
3.4	Voltage-reactive power characteristics of synchronous generators	78
3.5	Capability curves	86
3.6	Effect of machine limitations on deliverable power	89
3.7	Problems	91
4	LOAD ASPECTS	93
4.1	Voltage Dependence of Loads	94
4.2	Load Restoration Dynamics	97
4.3	Induction Motors	99
4.4	Load Tap Changers	113
4.5	Thermostatic Load Recovery	123
4.6	Generic Aggregate Load Models	126
4.7	HVDC Links	131
4.8	Problems	132
Part II	INSTABILITY MECHANISMS AND ANALYSIS METHODS	135
5	MATHEMATICAL BACKGROUND	137
5.1	Differential Equations (qualitative theory)	137
5.2	Bifurcations	153
5.3	Differential-Algebraic Systems	161
5.4	Multiple time scales	166
6	MODELLING : SYSTEM PERSPECTIVE	175
6.1	Outline of a general dynamic model	175
6.2	Network modelling	178
6.3	A detailed example	184
6.4	Time-scale decomposition perspective	193
6.5	Equilibrium equations for voltage stability studies	194
6.6	Detailed example (continued): equilibrium formulation	206
6.7	Number-Crunching Problem	210
7	LOADABILITY, SENSITIVITY AND BIFURCATION ANALYSIS	213

7.1	Loadability Limits	214
7.2	Sensitivity Analysis	223
7.3	Bifurcation Analysis	226
7.4	Eigenvector and Singular Vector Properties	246
7.5	Loadability or Bifurcation Surface	249
7.6	Loadability Limits in the Presence of Discontinuities	255
7.7	Problems	260
8	INSTABILITY MECHANISMS AND COUNTERMEASURES	263
8.1	Types of Countermeasures	263
8.2	Classification of Instability Mechanisms	265
8.3	Examples of Short-term Voltage Instability	269
8.4	Countermeasures to Short-term Instability	275
8.5	Case Studies of Long-term Voltage Instability	277
8.6	Corrective Actions against Long-term Instability	286
8.7	Problems	297
9	CRITERIA AND METHODS FOR VOLTAGE SECURITY ASSESSMENT	299
9.1	Voltage Security: Definitions and Criteria	299
9.2	Contingency Evaluation	304
9.3	Loadability Limit Computation	322
9.4	Secure Operation Limit Determination	334
9.5	Eigenanalysis for Instability Diagnosis	338
9.6	Examples from a Real-life System	343
9.7	Real-time Issues	356
	REFERENCES	359
	INDEX	377



<http://www.springer.com/978-0-387-75535-9>

Voltage Stability of Electric Power Systems

van Cutsem, T.; Vournas, C.

1998, XI, 378 p., Softcover

ISBN: 978-0-387-75535-9