

LIST OF TABLES

Table 2.1	Critical contingencies for IEEE 14-bus system	20
Table 2.2	PMU locations for IEEE 14-bus system	20
Table 2.3	Three most critical buses under contingencies for IEEE 14-bus system	23
Table 2.4	Critical contingencies for New England 39-bus system	25
Table 2.5	PMU locations for New England 39-bus system	26
Table 2.6	Three most critical buses under contingencies for New England 39-bus system	28
Table 2.7	Critical contingencies for 246-bus NRPG system	32
Table 2.8	PMU locations for 246-bus NRPG system	33
Table 2.9	Three most critical buses under contingencies for 246-bus NRPG system	37
Table 3.1	Voltage magnitude of critical buses at point-1 ($\lambda=0$, $k=0.2$, 0.5)	47
Table 3.2	Voltage magnitude of critical buses at point-1 ($\lambda=0$, $k=1.0$, 1.2)	47
Table 3.3	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=0.2$, 0.5)	48
Table 3.4	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=1.0$, 1.2)	48
Table 3.5	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=0.2$, 0.5)	49
Table 3.6	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=1.0$, 1.2)	49
Table 3.7	Constants a_1 , a_2 , a_3 for $k=0.2$	50
Table 3.8	Constants a_1 , a_2 , a_3 for $k=0.5$	50
Table 3.9	Constants a_1 , a_2 , a_3 for $k=1.0$	51
Table 3.10	Constants a_1 , a_2 , a_3 for $k=1.2$	51
Table 3.11	Voltage stability margin by two approaches for $k = 0.2$	52
Table 3.12	Voltage stability margin by two approaches for $k = 0.5$	52
Table 3.13	Voltage stability margin by two Approaches for $k = 1.0$	53

Table 3.14	Voltage stability margin by two approaches for $k = 1.2$	53
Table 3.15	Voltage Magnitude of critical buses at point-1 ($\lambda=0, k=0.2$)	56
Table 3.16	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=0.5$)	57
Table 3.17	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=1.0$)	57
Table 3.18	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=1.2$)	58
Table 3.19	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=0.2$)	58
Table 3.20	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=0.5$)	59
Table 3.21	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=1.0$)	59
Table 3.22	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=1.2$)	60
Table 3.23	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=0.2$)	60
Table 3.24	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=0.5$)	61
Table 3.25	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=1.0$)	61
Table 3.26	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=1.2$)	62
Table 3.27	Constants a_1, a_2, a_3 for $k=0.2$	62
Table 3.28	Constants a_1, a_2, a_3 for $k=0.5$	63
Table 3.29	Constants a_1, a_2, a_3 for $k=1.0$	63
Table 3.30	Constants a_1, a_2, a_3 for $k=1.2$	64
Table 3.31	Voltage stability margin by two approaches for $k = 0.2$	64
Table 3.32	Voltage stability margin by two approaches for $k = 0.5$	65
Table 3.33	Voltage stability margin by two approaches for $k = 1.0$	65
Table 3.34	Voltage stability margin by two approaches for $k = 1.2$	66
Table 3.35	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=0.2$)	70
Table 3.36	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=0.5$)	71
Table 3.37	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=1.0$)	71
Table 3.38	Voltage magnitude of critical buses at point-1 ($\lambda=0, k=1.2$)	72

Table 3.39	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=0.2$)	72
Table 3.40	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=0.5$)	73
Table 3.41	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=1.0$)	73
Table 3.42	Loading factor of critical buses at point-2 ($V=0.95$ p.u., $k=1.2$)	74
Table 3.43	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=0.2$)	74
Table 3.44	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=0.5$)	75
Table 3.45	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=1.0$)	75
Table 3.46	Loading factor of critical buses at point-3 ($V=0.90$ p.u., $k=1.2$)	76
Table 3.47	Constants a_1, a_2, a_3 for $k=0.2$	76
Table 3.48	Constants a_1, a_2, a_3 for $k=0.5$	77
Table 3.49	Constants a_1, a_2, a_3 for $k=1.0$	77
Table 3.50	Constants a_1, a_2, a_3 for $k=1.2$	78
Table 3.51	Voltage stability margin by two approaches for $k = 0.2$	78
Table 3.52	Voltage stability margin by two approaches for $k = 0.5$	79
Table 3.53	Voltage stability margin by two approaches for $k = 1.0$	79
Table 3.54	Voltage stability margin by two approaches for $k = 1.2$	80
Table 4.1	Real power loading margin under critical contingencies (IEEE 14-bus system)	96
Table 4.2	Reactive power loading margin under critical contingencies (IEEE 14-bus system)	98
Table 4.3	Real power loading margin under critical contingencies (New England 39-bus system)	100
Table 4.4	Reactive power loading margin under critical contingencies (New England 39-bus system)	102
Table 4.5	Real power loading margin under critical contingencies (NRPG 246-bus system)	106
Table 4.6	Reactive power loading margin under critical contingencies (NRPG 246-bus system)	107
Table 5.1	Maximum real power loadability of critical bus under critical contingencies obtained by CPF method (IEEE 14-bus system)	117

Table 5.2	Maximum reactive power loadability of critical bus under critical contingencies obtained by CPF method (IEEE 14-bus system)	118
Table 5.3	Real power loadability of the system with and without STATCOM	120
Table 5.4	Reactive power loadability of the system with and without STATCOM	120
Table 5.5	Maximum real power loadability of critical bus under critical contingencies obtained by CPF method (New England 39-bus system)	121
Table 5.6	Maximum reactive power loadability of critical bus under critical contingencies obtained by CPF method (New England 39-bus system)	122
Table 5.7	Real power loadability of the system with and without STATCOM	124
Table 5.8	Reactive power loadability of the system with and without STATCOM	125
Table 5.9	Maximum real power loadability of critical bus under critical contingencies obtained by CPF method (NRPG 246-bus system)	126
Table 5.10	Maximum reactive power loadability of critical bus under critical contingencies obtained by CPF method (NRPG 246-bus system)	126
Table 5.11	Real power loadability of the system with and without STATCOM	129
Table 5.12	Reactive power loadability of the system with and without STATCOM	129
Table A.1	Bus data for the IEEE-14 bus system	158
Table A.2	Line data for the IEEE-14 bus system	158
Table B.1	Bus data for New England 39-bus system	160
Table B.2	Line data for the New England 39-bus system	161
Table C.1	Bus data for NRPG 246-bus system	165
Table C.2	Line data for NRPG 246-bus system	172

LIST OF ABBREVIATIONS

PMU	:	Phase measurement unit
GPS	:	Global Positioning System
ANN	:	Artificial neural network
ANN-GA	:	Artificial neural network and genetic algorithm
GA	:	Genetic algorithm
WAMS	:	Wide area monitoring system
NRPG	:	North region power grid
KCL	:	Kirchhoff's current law
PSAT	:	Power system analysis toolbox
VSM	:	Voltage stability margin
C.C.	:	Critical contingency
B.O.I.	:	Bus observability index
T.O.I.	:	Total observability index
VCPI	:	Voltage collapse proximity index
EORF	:	Enhanced-Online-Random-Forest
CPF	:	Continuation power flow
M.C.B.	:	Most critical bus number
P.A.	:	Proposed approach
SCADA	:	Supervisory control and data acquisition
Z	:	Combined PMU locations obtained for all critical contingencies
R	:	Ranking
L.O.	:	Line outage