

Contents

1	Theory	1
1.1	Graphs, Networks, Terminals, Structure Function	2
1.2	Network Reliability	6
1.2.1	Binary Networks with Independent Binary Components	6
1.2.2	Network Components with Independent Lifetimes	8
1.2.3	Concluding Remarks: Network Resilience	10
1.3	D-Spectra	11
1.3.1	Introduction	11
1.3.2	D-Spectrum of a Single-Step Network	12
1.3.3	Formula for Network <i>DOWN</i> Probability	17
1.3.4	Networks with Many States	20
1.3.5	D-Spectrum and Signature	21
1.3.6	Renewal Process of Component Failures	23
1.4	Series, Parallel and Recurrent Systems	24
1.4.1	Spectra of Parallel, Series and Recurrent Networks	24
1.4.2	Generalized Series and Parallel Multistate Systems	28
1.5	Networks with Colored Links	29
1.6	Network Component Importance	31
1.6.1	Birnbaum Measure of Component Importance	31
1.6.2	BIM-Spectrum	32
1.6.3	BIMs for Network with Several States	34
1.6.4	Joint Reliability Importance	36
1.7	Reliability Gradient	37
1.7.1	Border States. Evolution Process	37
1.7.2	Gradient Formula	39
1.8	Basic Monte Carlo Algorithms	41
1.8.1	Testing the Network Terminal Connectivity	41
1.8.2	Estimating the D-Spectra and Component Importance	42

1.8.3	Estimating the Gradient Vector	43
1.8.4	Accuracy of Monte Carlo Reliability Estimation	43
1.9	D-Spectra for Multi-Step Systems	46
	References	49
2	Applications	51
2.1	Network Under Attack: Symmetric Versus Scale-Free Network	51
2.2	Network Reliability Design	55
2.2.1	Introductory Remarks	55
2.2.2	The Dodecahedron Network	56
2.2.3	Gradient-Based Network Reorganization	57
2.3	Optimal Predisaster Design of Transportation Network	62
2.3.1	Formulation of the Problem. The Network	62
2.3.2	Scenario A	63
2.3.3	Scenario B	64
2.3.4	Scenario C	64
2.4	Network Disintegration	67
2.4.1	Introduction	67
2.4.2	Discrete Densities of the Transition Times	67
2.4.3	The Cumulative D-Spectra and State Probabilities	68
2.4.4	Network State Probabilities as Function of q	69
2.4.5	Network Resilience	71
	References	71
	Index	73