

Contents

Chapter 1	Four-Valued Logic and Its Applications	
1.1	Introduction	1
1.2	Mathematical Basis	2
1.2.1	Four-Valued Boolean Algebra B_4	2
1.2.2	Boolean Expression	3
1.2.3	Mapping $B_4^n \rightarrow B_4$ and Boolean Functions	3
1.2.4	Vector Forms	4
1.2.5	Canonical Forms	5
1.2.6	Expressions for Boolean Functions	5
1.3	STAR Expansions, Boolean Difference and Boolean Differential	8
1.3.1	Expansion Formulae	8
1.3.2	Boolean Difference	11
1.3.3	Boolean Differential	13
1.3.4	Geometrical Interpretation	15
1.4	Combined Components	19
1.4.1	Front and Rear Values	19
1.4.2	Binary Coding	21
1.4.3	Interpretation for Testing	22
1.5	Boolean Equations	22
1.5.1	Basic Concepts	22
1.5.2	Equations $A_1 \cdot A_2 \cdots A_n \cdot j = 0$ with $j=1, D, \bar{D}$; and $A_1 = x_1$ or \bar{x}_1	23
1.5.3	Deriving Star Expansion Via Solving Equation	24
1.6	Test Generation for Combinational Circuits	27
1.6.1	Fault and (Static) Test	27
1.6.2	The Test for Single Fault	31
1.7	Statistical Test Generation for Sequential Circuits	39
1.7.1	Example to Derive Tests	39
1.7.2	Comparison with Other Method	40
1.8	Identification of Hazards and Dynamic Testing	42
1.8.1	The Dynamic Behavior and Dynamic Tests of Combinational Circuit	42
1.8.2	Identification of Hazards	46
1.8.3	Dynamic Tests and Hazardous Tests	51
1.9	Transition Logic	56
1.9.1	Proposition Calculus and Predicate Calculus	56
1.9.2	Logical Inferences	58
1.9.3	Other Logic	59

1.10 Comparison with Other Logics.....	59
1.10.1 Addition of States.....	60
1.10.2 Extension to Power Set.....	60
1.10.3 Merging of States.....	61
1.10.4 Extension by Direct Product.....	63
References.....	64
 Chapter 2 Computer System Diagnosis and Society Diagnosis	
2.1 Introduction (PMC Model).....	65
2.1.1 Self-Diagnosis of System.....	65
2.1.2 Basic Definitions.....	68
2.2 One Step System Diagnosis for PMC Model.....	69
2.2.1 The Characterization Problem.....	69
2.2.2 Diagnosing Algorithm.....	73
2.2.3 Optimal Design.....	75
2.3 The Extension of System Diagnosis.....	76
2.3.1 Extension along Diagnostic Goals.....	76
2.3.2 Extension along Models.....	78
2.3.3 Extension along the State Values.....	81
2.3.4 Extension along Diagnosing Method.....	83
2.3.5 The Combination of Different Extensions.....	84
2.4 The Application of System Diagnosis.....	85
2.4.1 The Diagnosis for Analog Circuits.....	85
2.4.2 Fault-Tolerant Computing.....	89
2.4.3 Society Diagnosis.....	90
References.....	93
 Chapter 3 Testability Design via Testability Measures	
3.1 Introduction.....	95
3.1.1 The Problem of Testability and Its Measure.....	95
3.1.2 Definition of Testability and Measures.....	96
3.1.3 Testability in Term of Controllability and Observability.....	99
3.1.4 Testability Measure and Algorithm.....	99
3.1.5 J.Hayes' Suggestion.....	100
3.1.6 Problems Studied in this Chapter.....	101
3.2 Testability Design.....	102
3.2.1 Testability Measure.....	102
3.2.2 Means to Improve Testability.....	104
3.2.3 Constraints A,B,C,D,E and Objective Function F.....	105
3.2.4 ILP Problem for Testability.....	107
3.2.5 Asynchronous Sequential Circuits.....	108
3.2.6 Experimental Results.....	108
3.3 Design for Testability at Module Level.....	110
3.3.1 Definition of Testability.....	111
3.3.2 Probability Function.....	111
3.3.3 Controllability Spectrum.....	114
3.3.4 Observability Spectrum.....	115
3.3.5 Modifications and Other Problems.....	115

3.4 Applications.....116
 References.....117

Chapter 4 NMRC: A Technique for Redundancy

4.1 Introduction.....119
 4.2 NMRC System Model.....120
 4.2.1 System Description.....120
 4.2.2 Fault Pattern.....121
 4.2.3 Maximum Likelihood Selection.....122
 4.3 Analysis of Fault Tolerance Capability.....123
 4.3.1 Definitions123
 4.3.2 Module-FT Degree.....124
 4.3.3 Module-Comparator FT Degree.....126
 4.4 Optimal NMRC System Design.....126
 4.5 An Example for Comparison Analysis.....129
 4.5.1 Performance Comparison.....129
 4.5.2 Cost Comparison.....130
 4.5.3 Reliability Comparison.....130
 4.5.4 Diagnosability Comparison.....131
 4.6 Conclusion.....132
 References.....133
 Appendix134
 4.A.1 The Proof of Theorem 4.4.....134
 4.A.2 The Proof of Lemma 2.....134

Chapter 5 Fault Tolerance of Switching Interconnection β -Networks

5.1 Introduction.....135
 5.1.1 Multicomputer Systems.....135
 5.1.2 Connecting Capability and Structure of ICN.....136
 5.1.3 β -elements and β -network.....136
 5.1.4 Communication Delay.....137
 5.1.5 Fault Model for a β -element.....138
 5.2 General Inequalities.....140
 5.2.1 Proof of $\lfloor \log_2 n \rfloor + 1 \leq d \leq n$140
 5.2.2 Proof of $K \leq d - 1$141
 5.3 ISE-MISE-RMISE.....141
 5.3.1 ISE.....141
 5.3.2 MISE143
 5.3.3 RMISE.....144
 5.4 $C_{1,t}^n$ β -networks.....146
 5.4.1 Definition of $C_{1,t}^n$ Networks.....146
 5.4.2 Expressions for K and d.....146
 5.4.3 Relative Optimization.....147
 5.4.4 Maximize d.....147
 5.4.5 Maximize K.....147

5.5 RFT Network	148
5.5.1 Switching Elements	148
5.5.2 RFT Networks	150
5.5.3 Routing Algorithm and Fault-Tolerance	152
5.6 Conclusion	154
References	155
Chapter 6 The Connectivity of Hypergraph and the Design of Fault Tolerant Multibus Systems	
6.1 Introduction	157
6.2 Connectivity of Hypergraph	159
6.2.1 Definitions	159
6.2.2 Basic Theorems	160
6.2.3 Properties of Hypergraph with the Best Connectivity	163
6.3 BIB Design and the Optimized Multibus System	164
6.3.1 BIB Design	164
6.3.2 Theorems	165
6.3.3 Optimized Design	167
6.4 WBIB and the Optimized Multibus System	168
6.4.1 Examples of WBIB	168
6.4.2 Definitions of WBIB Design	170
6.4.3 WBIB Design for $\delta=2$	171
6.4.4 WBIB Design for $\delta=3$	173
6.4.5 WBIB Design for $\delta>3$	175
6.5 Generation of WBIB to Other Networks	175
6.5.1 Reduced to Simple Graph	175
6.5.2 Optimized Sparse Crossbar Network	176
6.5.3 Optimized Multibus System with Common Memories	176
6.6 Conclusion	178
References	180
Appendix: The Proof of Theorem 6.6	181
Chapter 7 TMR Design of Distributed System for Sequential Faults	
7.1 Introduction	185
7.2 DFT Concept	187
7.3 The Fault Tolerance Degree	188
7.3.1 The Operations of Graph	188
7.3.2 The Degree of Fault Tolerance	190
7.3.3 The Center of Fault Tolerance	191
7.4 The Relationship Between the Architecture and the Fault Tolerance Degree	193
7.5 Optimal Design	195
7.5.1 Cost Optimal	195
7.5.2 $T_x(G)$ Optimal	195
7.6 Conclusion	197
References	197