

Contents

1	Introduction	1
1.1	Background	1
1.2	What This Book Is About	2
1.3	Motivation	2
1.4	Major Contributions of This Book	3
1.5	Overview of the Book Chapters	3
1.6	Overall Message of the Book	4
	References	4
2	Fundamentals of Reversible Logic	7
2.1	Preliminaries	7
2.2	Basic Definitions	8
2.3	Reversible Logic Gates	9
2.3.1	Feynman Gate	9
2.3.2	Toffoli Gate	11
2.3.3	Fredkin Gate	11
2.4	Reversible Logic Synthesis	12
2.5	Overview of Reversible Logic Synthesis Methods	12
2.6	The Elimination of Garbage in Binary Reversible Circuits	14
	References	15
3	Methods of Reversible Logic Synthesis	17
3.1	Reversible Expansions and Reversible Spectral Transforms	17
3.1.1	Reversible Ternary Shannon and Davio Expansions	19
3.1.2	Reversible Shannon Spectral Transforms	21
3.1.3	Reversible Davio Spectral Transforms	23

3.2	The Elimination of Garbage in Ternary Reversible Circuits	26
3.3	Reversible Decision Trees (RDTs)	29
3.4	Reversible Decision Diagrams (RDDs)	31
3.5	Reversible Lattice Circuits	32
3.5.1	Symmetric and Non-symmetric Functions	34
3.5.2	Two-Dimensional Lattice Circuits	35
3.5.3	Three-Dimensional Lattice Circuits	37
3.5.4	Algorithms for Realizing the Shannon/Davio Expansions of Ternary Functions into 3D Lattice Circuits	43
3.5.5	Complete Example for the Implementation of Ternary Functions Using 3D Lattice Circuits	48
3.5.6	New Minimal Realization Method for 3D Lattice Circuits.	55
3.5.7	Lattice Circuit Synthesis Using ISID.	60
3.5.8	The Creation of Reversible Lattice Structures.	60
3.5.9	3D Ternary Davio Reversible Lattice Structures	64
3.6	Reversible Fast Transform Circuits	69
3.7	Group-Theoretic Representations.	78
3.8	Reversible Reconstructability Analysis Circuits.	81
3.8.1	Ternary MRA.	83
3.8.2	Reversible MRA (RMRA).	86
3.9	Reversible Programmable Gate Array (RPGA)	87
3.9.1	Definitions.	87
3.9.2	(2 * 2) Net Structures and RPGAs	88
3.9.3	The New Reversible Gate (SALEEM).	89
3.9.4	Novel Design of RPGA Based on the SALEEM Reversible Gate	89
3.10	Reversible Cascade Circuits	94
3.11	Spectral-Based Synthesis Method	95
3.12	Transformation-Based Network Synthesis of Fredkin-Toffoli Cascade Gates	99
3.13	Heuristic Algorithm for Reversible Logic Synthesis.	102
3.14	Constructive Synthesis of Reversible Circuits by NOT and (n - 1)-CNOT Gates	104
3.15	Summary.	109
	References.	109
4	Evaluation of the Reversible Logic Synthesis Methodologies	111
4.1	NPN-Classification of Logic Functions	111
4.2	New Evaluation Procedure of Reversible Synthesis Methods	112

4.3	Comparison Between the Various Reversible Synthesis Methodologies	116
4.4	Summary	116
	References.	117
5	Reversible Sequential Logic Circuits	119
5.1	Reversible Flip Flops	119
5.1.1	Reversible RS Flip Flop	120
5.1.2	Reversible Clocked RS Flip Flop	121
5.1.3	Reversible D Flip Flop	122
5.1.4	Reversible JK Flip Flop.	123
5.1.5	Reversible T Flip Flop	124
5.1.6	Reversible Master-Slave Flip Flop.	125
5.1.7	The Superiority of Using the SALEEM Gate in Reversible Flip Flops Design	126
5.2	Complex Reversible Sequential Circuits.	126
5.3	Novel Reversible Sequential Elements.	129
5.3.1	New Design of Reversible T Flip Flop	129
5.3.2	New Design of Reversible D Flip Flop	130
5.3.3	New Design of Reversible JK Flip Flop	130
5.3.4	New Design of Reversible Master-Slave Flip Flops	131
5.3.5	Evaluation of the New Reversible Flip Flops	132
5.4	Multiple-Valued Reversible Sequential Circuits.	133
5.5	Summary	133
	References.	134
6	Quantum Logic Circuits and Quantum Computing	135
6.1	Background	135
6.2	Quantum Bits and Superposition.	137
6.3	Qubit Registers.	138
6.4	Quantum Logic Gates	139
6.5	Quantum Logic Circuits.	141
6.6	Synthesis of Quantum Logic Circuits	144
6.7	Binary Quantum Decision Trees and Diagrams.	145
6.8	Fundamentals of Ternary Quantum Computing.	146
6.9	Quantum Computing for the Reversible Structures	148
	References.	149
7	Wavelets and Multiwavelets Implementation Using Quantum Computing	153
7.1	Introduction	153
7.2	Quantum Circuits for Perfect Shuffle Permutation Matrices.	154

7.3	Quantum Wavelet Algorithms.	156
7.3.1	Wavelet Pyramidal and Packet Algorithms.	157
7.3.2	Daubechies $D^{(4)}$ Wavelet Factorization	158
7.4	Quantum Implementation of Daubechies $D^{(4)}$ Wavelet	160
7.5	Quantum Implementation of Daubechies $D^{(4)}$ Multiwavelet	161
7.5.1	Computation of Discrete Multiwavelet Transform	162
7.5.2	Computation of Inverse Discrete Multiwavelet Transform.	163
7.5.3	A New Quantum Implementation of Daubechies $D^{(4)}$ Multiwavelet Transform	163
7.5.4	A New Quantum Implementation of Inverse Daubechies $D^{(4)}$ Multiwavelet Transform.	167
	References.	170
8	Conclusions and Future Researches.	171
8.1	Conclusions	171
8.2	Promising Areas of Further Researches	173
	References.	174

Reversible Logic Synthesis Methodologies with
Application to Quantum Computing

Taha, S.M.R.

2016, XIII, 174 p., Hardcover

ISBN: 978-3-319-23478-6