

# Contents

<b>List of Figures</b>	<b>V</b>
<b>List of Tables</b>	<b>IX</b>
<b>Nomenclature</b>	<b>XII</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Multiplication process	1
1.2 Multiplier architecture	3
1.3 Terminology	3
1.3.1 Normalized gate delay model	3
1.3.2 Redundant binary (RB) number system	5
1.3.3 Addition of two natural binary (NB) numbers to give a RB number	5
1.3.4 Addition of two RB numbers	6
1.3.5 Some properties of RB number	8
1.3.6 RB to NB conversion	8
1.4 Thesis structure	10
<b>2 Partial Product Generation</b>	<b>11</b>
2.1 Non-Booth method of partial product generation	12
2.2 Booth's algorithm	13
2.2.1 Booth radix-4 encoding	13
2.2.2 Booth radix-8 encoding	15

2.3	Circuits for radix $-4$ MBE	16
2.3.1	Modified Booth encoding	16
2.3.2	Best proposed circuits by others	16
2.3.3	New Booth encoder (BE-new) and new Booth selector (BS-new)	19
2.3.4	Comparison of the BE-new and BS-new	21
2.4	Radix-64 encoding using redundant arithmetic	24
2.4.1	Example of partial product generation using radix-64 algorithm	28
<b>3</b>	<b>Partial Product Accumulation</b>	<b>32</b>
3.1	Array multiplier	33
3.1.1	Delay analysis of full adder	33
3.1.2	16x16 bit multiplication using Booth algorithm	34
3.1.3	Conventional and delay optimized array multiplier	35
3.1.4	Delay analysis	37
3.2	Wallace tree	38
3.3	Partial product accumulation using 3:2 compressor in Wallace tree	39
3.4	Partial product accumulation using 4:2 compressor in Wallace tree	41
3.4.1	4:2 compressor	41
3.4.2	Use of 4:2 compressors in Wallace tree	46

3.5	Partial product accumulation using RB adder in Wallace tree	48
3.5.1	Example of use of RB addition	49
3.5.2	Redundant binary adder	50
3.5.3	Use of RB adder in a 16x16 multiplication	53
3.6	Delay comparisons of different accumulation methods	54
<b>4</b>	<b>Final Adder in Multiplication</b>	<b>57</b>
4.1	Carry look ahead adder	57
4.2	Equivalent binary converter	61
4.3	Carry look ahead EBC	65
<b>5</b>	<b>Parallel Multiplier Architectural Choices</b>	<b>70</b>
5.1	Array multiplier with CLA (AMCLA)	70
5.2	Array multiplier with CLEBC (AMCLEBC)	73
5.3	Wallace tree multiplier using 3:2 compressors with CLA (WM32CLA)	74
5.4	Wallace tree multiplier using 3:2 compressors with CLEBC (WM32CLEBC)	76
5.5	Wallace tree multiplier using 4:2 compressors with CLA (WM42CLA)	78
5.6	Wallace tree multiplier using 4:2 compressors with CLEBC (WM42CLEBC)	80
5.7	Wallace tree multiplier using RB adder with CLA (WMRBCLA)	81
5.8	Wallace tree multiplier using RB adder with CLEBC (WMRBCLEBC)	83

5.9	Radix 64 multiplier with CLA (radix64CLA)	85
5.10	Radix 64 multiplier with CLEBC (radix64CLEBC)	87
<b>6</b>	<b>Parallel Multiplier Implementation</b>	<b>89</b>
6.1	VHDL coding of multipliers	89
6.2	Synthesis of multipliers	90
6.3	Hardware and operating system used	92
6.4	Criteria in Evaluating Multiplier	92
6.5	Simulation results	93
6.6	Comparisons of architectures	93
<b>7</b>	<b>Conclusion</b>	<b>102</b>
7.1	Summary of work done	102
7.2	Future work	103
	7.2.1 Exploration and designing of serial parallel multiplier architectures	103
	7.2.2 Development of a multiplier synthesis tool	104
	<b>References</b>	<b>105</b>
	<b>Appendix A</b>	
	<b>Appendix B</b>	
	<b>Brief Biographies</b>	
	<b>List of Publications</b>	