

Contents

Abstract	iii
List of Figures	xiii
List of Tables	xvii
List of Acronyms	xix
Notations	xxi
Chapter 1. Introduction	1
1.1 Background and Motivation.....	1
1.2 Literature Review.....	2
1.2.1 Neutral Point Clamped MLI.....	3
1.2.2 Flying Capacitor MLI	4
1.2.3 Cascaded H-Bridge MLI	5
1.2.4 Hybrid Cascaded MLI.....	6
1.2.5 Switched Capacitor Based MLI.....	8
1.3 PWM Control Techniques for Control of MLI.....	12
1.3.1 Multicarrier sinusoidal PWM.....	13
1.3.2 Space Vector Modulation PWM	14
1.3.3 Selective Harmonics Elimination PWM.....	15
1.4 Meta-Heuristic Optimization Algorithms.....	17
1.4.1 Genetic Algorithm (GA).....	18
1.4.2 Particle Swarm Optimization (PSO).....	18
1.4.3 Ant Colony Optimization (ACO).....	19
1.4.4 Whale Optimization (WO).....	20
1.4.5 Grey Wolf Optimization (GWO).....	21
1.5 Objectives of Thesis.....	22
1.6 Conclusion	23
1.7 Organisation of Thesis.....	24

Chapter 2. Harmonic Minimization in HC-MLI Using Modified Particle Swarm Optimization.....	27
2.1 Introduction.....	27
2.2 Hybrid Cascaded MLI.....	28
2.3 Solution Using PSO.....	30
2.3.1 Limitations of PSO	31
2.4 Proposed Modified PSO.....	32
2.4.1 Improvement in weighting factor.....	33
2.4.2 Improvements in cognitive and social parameters	34
2.4.3 Mutation in velocity using DE/best/1 mutation strategy.....	35
2.4.4 Velocity Limits.....	35
2.5 SHE-PWM Applied to MPSO Optimized HC-MLI.....	37
2.6 Capacitor Voltage Balancing in HC-MLI Through MPSO.....	40
2.6.1 Capacitor Voltage Balancing Conditions.....	41
2.6.2 Capacitor Voltage Balancing at Higher Modulation Indices.....	48
2.7 Closed-loop control of HC-MLI Using Proposed Algorithm.....	49
2.7.1 Voltage Controller.....	50
2.8 Capacitor Calculation.....	53
2.9 Simulation Studies	54
2.9.1 Operation at $m_a = 0.55$.....	55
2.9.2 Operation at $m_a = 1.2$.....	55
2.9.3 Controller Performance During Change in DC-Link Voltage.....	58
2.9.4 Harmonic Analysis of Output Voltages at Different m_a	60
2.9.5 Effects of Inductive Load on Capacitor Voltage Balancing at Higher Modulation Index.....	61
2.10 Experimental Verification.....	64
2.10.1 Dynamic Performance of HC-MLI.....	69
2.11 Conclusion.....	69
Chapter 3. Harmonic Minimization in HC-MLI Using Modified Whale Optimization.....	71
3.1 Introduction.....	71
3.2 Mathematical Model of Whale Optimization Algorithm.....	71
3.2.1 Encircling Prey.....	71

3.3 Bubble-Net Attacking Method (Exploitation Phase)	72
3.3.1 Shrinking Encircling Mechanism.....	72
3.3.2 Spiral Updating Position Mechanism.....	74
3.3.3 Search for prey.....	74
3.4 Merits of WO Algorithm.....	75
3.5 Limitation of WO Algorithm.....	75
3.6 Proposed Modifications in WO Algorithm.....	75
3.7 Application of MWO Based SHE-PWM in HC-MLI.....	79
3.8 Simulation Studies.....	85
3.8.1 Working at $m_a = 0.6$	85
3.8.2 Working at $m_a = 1.1$	85
3.9 Experimental Verification.....	88
3.10 Conclusion.....	91
 Chapter 4. Harmonic Minimization in HC-MLI Using Modified Whale Optimization.....	 93
4.1 Introduction.....	93
4.2 Mathematical Modelling of GWO Algorithm.....	93
4.2.1 Encircling Prey.....	94
4.2.2 Attacking Prey (Exploitation Phase)	95
4.2.3 Search for Prey (Exploration Phase)	95
4.2.4 Hunting Mechanism.....	96
4.3 Limitations of GWO.....	96
4.4 Modified GWO Algorithm.....	97
4.4.1 Proposed Variable Weights in MGWO.....	99
4.5 Implementation of SHE-PWM in MGWO Optimized HC-MLI.....	101
4.6 Simulation Verification.....	104
4.6.1 Operation at $m_a = 0.6$	106
4.6.2 Operation at $m_a = 1.1$	106
4.7 Experimental verification.....	107
4.8 Comparison Between GWO and MGWO.....	110
4.9 Comparison Among MPSO, MWO and MGWO.....	110
4.10 Conclusion.....	111

Chapter 5. A 17-Level Diode Assisted Switched Capacitor Multilevel Inverter	113
5.1 Introduction.....	113
5.2 Proposed 17-level Diode Assisted Switched-Capacitor MLI.....	113
5.3 Extended Structure of Proposed DASC-MLI.....	121
5.3.1 Generalized Configuration of the Proposed DASC-MLI.....	122
5.4 Switching Scheme.....	123
5.5 Capacitance Calculation.....	124
5.6 Conduction Loss of the Proposed DASC-MLI.....	126
5.7 Switching Loss Calculation.....	128
5.8 Ripple Loss Analysis.....	129
5.9 Comparison with Other Reported topologies.....	130
5.10 Simulation Studies.....	133
5.11 Experimental Validation.....	136
5.11.1 Steady State Performance.....	137
5.11.2 Dynamic Performance.....	140
5.11.3 Calculation of Efficiency.....	141
5.12 Conclusion.....	141
Chapter 6. A 17-Level Reduced Voltage Stress Switched Capacitor Multilevel Inverter.....	143
6.1 Introduction.....	143
6.2 Proposed Reduced Voltage Stress 17-level Switched-Capacitor MLI.....	143
6.3 Generation of Voltage Levels.....	144
6.4 Generalized Structure of the Proposed RVSC-MLI.....	151
6.5 Switching Scheme.....	153
6.6 Capacitance Calculation.....	154
6.7 Switching Loss Calculation.....	156
6.8 Conduction Loss Analysis.....	157
6.9 Ripple Loss Analysis.....	157
6.10 Comparison with Other Reported SC-MLI Topologies.....	158
6.11 Simulation Studies.....	161
6.12 Experimental Validation	165

6.12.1 Steady State Performance.....	165
6.12.2 Dynamic Performance.....	168
6.13 Conclusion.....	169
Chapter 7. Conclusion and Future Scope.....	171
7.1 Conclusion.....	171
7.2 Future Scope.....	173
References	175
List of Publications	187