

Contents

	page
Abstract	i
Acknowledgements	iii
Contents	v
List of Figures	vii
List of Tables	viii
List of Symbols	xiii
List of Abbreviations	xv
Chapter 1: Introduction	1
1.1 Literature Review	6
1.1.1 Control schemes for DC-DC stage of AC-DC-DC Converter	6
1.1.2 Control schemes for PFC stage of AC-DC-DC Converter	11
1.1.3 Control schemes for single-stage AC-DC Converter	12
1.2 Event Triggered Control	13
1.2.1 Concept of Event-triggered Control	14
1.3 Sliding Mode Control	15
1.4 Event-triggered Sliding Mode Control	16
1.5 Integral Sliding mode Control (ISMC)	17
1.6 Motivation and Research Objectives	18
1.7 Organization of Thesis	22
1.8 Publications	23
Chapter 2: Event-triggered Sliding mode control for Efficiency improvement in DC-DC stage	25
2.1 Isolated Half-bridge converter and SMC Controller Design	25
2.1.1 System Description	26
2.1.2 Sliding Mode Control	27
2.2 Event-triggered Sliding Mode Control	27
2.2.1 Existence of practical sliding mode	28
2.2.2 Stability of the closed loop system in practical Sliding mode	30
2.2.3 Admissible event-triggering scheme	30
2.3 Relationship between ETSMC and HM-SMC	31
2.3.1 Hysteresis-Modulation based Sliding Mode Control	32
2.3.2 Comparison of HM-SMC with ETSMC	33
2.3.3 HM-SMC as a special case of ETSMC	33
2.4 Simulation Studies	34
2.4.1 Classical SMC vs Event-triggered SMC:	35
2.4.2 ETSMC and Load Variation	35
2.5 Experimental Studies	37
2.5.1 Classical SMC vs Event-triggered SMC	37
2.5.2 ETSMC and Input Variation	38
2.5.3 ETSMC and Load Variation	39
2.5.4 Efficiency improvement	40
2.6 Summary	41
Chapter 3: Event-triggered Sliding Mode Control for a pre-regulator PFC stage	43
3.1 Background of Non-linear loads	45
3.2 Preliminaries of Loss-free Resistor	45
3.3 Sliding mode based loss-free resistor (SLFR)	46
3.3.1 Switching function	47
3.3.2 Control Law	47
3.3.3 Equivalent Control	48
3.3.4 Ideal Sliding Dynamics Analysis	48
3.3.5 Analysis of System dynamics	49
3.4 Event-triggered SLFR	49
3.4.1 Event-triggered SMC for PFC	50
3.4.2 Comparison of HM-SMC and ETSMC	50
3.5 Simulation and Experimentation Studies	51
3.5.1 Event-triggered vs Classical SLFR	51

3.5.2	<i>ETSMC and Load variation</i>	52
3.5.3	<i>Experimental validation</i>	53
3.6	Summary	54
Chapter 4: Event-triggered Sliding Mode Control for Single-stage single-phase PFC application		55
4.1	Adaptive Sliding mode based Loss Free Resistor (ASLFR)	56
4.2	Realizing Adaptive Sliding mode based Loss free Resistor (ASLFR)	57
4.2.1	<i>General Model</i>	57
4.2.2	<i>System Description</i>	58
4.2.3	<i>Proposed Switching function</i>	59
4.2.4	<i>Reference current generation</i>	59
4.2.5	<i>Control Law</i>	60
4.2.6	<i>Equivalent Control</i>	60
4.3	Analysis of the Sliding Mode Control	60
4.3.1	<i>Reachability Condition</i>	61
4.3.2	<i>Stability of the closed loop system during Sliding mode</i>	62
4.4	Simulation Studies	64
4.4.1	<i>Adaptive nature of proposed SLFR</i>	64
4.4.2	<i>Comparative Analysis</i>	66
4.5	Experimental Studies	68
4.5.1	<i>Test Case-I: Response to Load Transient</i>	69
4.5.2	<i>Test Case-II: Response to Line Variation</i>	70
4.5.3	<i>Test Case-III: Response to change in Reference Output Voltage</i>	71
4.5.4	<i>Harmonic Analysis</i>	72
4.6	Event-triggered Implementation of ASLFR	73
4.6.1	<i>Classical v/s ETSMC</i>	73
4.6.2	<i>ETSMC and Load Variation</i>	75
4.7	Summary	76
Chapter 5: Adaptive Sliding mode based Loss-free Resistor for a single stage three-phase modular PFC application		77
5.1	System Description	78
5.1.1	<i>System Dynamics</i>	79
5.1.2	<i>Design for CCM operation</i>	80
5.2	Proposed Control Scheme	81
5.2.1	<i>Switching function</i>	82
5.2.2	<i>Reference current generation</i>	83
5.2.3	<i>Control Law</i>	83
5.2.4	<i>Equivalent Control</i>	84
5.3	Analysis of the Sliding Mode Control	84
5.3.1	<i>Reachability Condition</i>	84
5.3.2	<i>Stability of the closed loop system during Sliding mode</i>	85
5.4	Simulation Studies	88
5.4.1	<i>Adaptive nature of proposed SLFR</i>	88
5.4.2	<i>Comparative Analysis</i>	90
5.5	Experimental Studies	91
5.5.1	<i>Test Case-I: Steady state Response</i>	92
5.5.2	<i>Test Case-II: Response to Load Transient</i>	94
5.5.3	<i>Test Case-III: Response to Line Variation</i>	95
5.5.4	<i>Test Case-IV: Response to change in Reference Output Voltage</i>	95
5.5.5	<i>Harmonic Analysis</i>	96
5.6	Summary	96
Chapter 6: Integral Sliding mode Control for PFC and ZSC Converters		99
6.1	Principle of ISM based Controller	100
6.1.1	<i>Switching Surface</i>	101
6.1.2	<i>Control Law</i>	101
6.1.3	<i>Existence of Sliding mode</i>	102
6.2	Single stage Boost PFC Application	103
6.2.1	<i>System Description and dynamic model</i>	103
6.2.2	<i>Proposed ISM Control (The overall control)</i>	104
6.2.3	<i>Simulation Studies</i>	107
6.2.4	<i>Case I: Transient response</i>	107
6.2.5	<i>Case II: Steady state response</i>	107
6.3	ISM Controller for Z-Source Converter with Uncertainty in Parameters	110
6.3.1	<i>System description and dynamic modelling</i>	111
6.3.2	<i>Proposed ISM Control (The overall control)</i>	113
6.3.3	<i>Design of PID controller using the Reduced order model</i>	113
6.3.4	<i>Effects of Asymmetry in the Z-network</i>	116

6.3.5	<i>Simulation Studies</i>	117
6.4	Summary	119
Chapter 7: Discussion and Conclusion		121
References		125

