

Content

Abstract	vii
Acknowledgment	xi
List of Figures	xiii
List of Tables	xvii
List of Acronyms	xix
Symbols Used	xxi
Chapter 1. Introduction	1
1.1 Background and Motivation.....	1
1.2 Literature Survey on Isolated DC-DC Converters	4
1.2.1 Voltage-fed Isolated DC-DC Converters (PWM-type)	4
1.2.2 Current-fed Isolated DC-DC Converters (PWM-type):	7
1.2.3 Isolated DC-DC Converters (Resonant-type).....	9
1.2.4 Impedance Network-based Isolated Converters	10
1.2.5 Vulnerability of the Electrolytic Capacitors in Power Converters	12
1.2.6 Maximum Power Point Tracking under Partial Shading Conditions	13
1.3 Challenges with the Existing Systems	15
1.4 Objective of the Thesis.....	16
1.5 Organization of the Thesis	18
Chapter 2. Electrolytic Capacitor-less Isolated DC-DC Resonant Converters.....	21
2.1 Introduction	21
2.2 Proposed Converter -1 (Dual-Half Active Bridge Resonant Converter)	21
2.3 Operation of the Proposed DHABRC	22

2.3.1 Interval 1: ($T_0 - T_1$) Fig. 2.3 (a)	23
2.3.2 Interval 2: ($T_1 - T_2$) Fig. 2.3 (b)	23
2.3.3 Interval 3: ($T_2 - T_3$) Fig. 2.3 (c)	25
2.3.4 Interval 4: ($T_3 - T_4$) Fig. 2.3 (d)	25
2.3.5 Interval 5: ($T_4 - T_5$) Fig. 2.3 (e)	26
2.3.6 Interval 6: ($T_5 - T_6$) Fig. 2.3 (f)	26
2.3.7 Interval 7: ($T_6 - T_7$) Fig. 2.3 (g)	26
2.3.8 Interval 8: ($T_7 - T_8$) Fig. 2.3 (h)	26
2.4 Proposed Converter -2 (Asymmetrical Dual Active Bridge Resonant Converter)	26
2.5 Operation of the Proposed ADABRC	28
2.6 Steady-State Analysis of Proposed Resonant Converters Using FHA	28
2.6.1 Mathematical Model	28
2.6.2 Bridge Currents and Voltages	29
2.6.3 Equivalent AC Impedance	31
2.6.4 Gain of the Converter	31
2.6.5 Necessary Condition for ZVS	32
2.6.6 Sufficient Condition for ZVS and Effect of Dead Time	33
2.7 Design Optimization for the Proposed Converter DHABRC	35
2.7.1 Selection of Normalized Switching Frequency (F)	35
2.7.2 Selection of the Quality Factor (Q)	35
2.7.3 Selection of Converter Gain (M)	36
2.7.4 Inductance Ratio (K), Tank Components, and Dead Time	37
2.7.5 Voltage Stress	38
2.7.6 Design of the Film Capacitors	38
2.8 Results for DHABRC	40
2.8.1 Simulation Results	40
2.8.2 Experimental Results	42

2.8.3	Verification of the Efficacy of Analysis	44
2.8.4	Verification of using Film Capacitor	44
2.9	Results for ADABRC	47
2.9.1	Simulation Results	47
2.9.2	Experimental Results	50
2.10	Efficiency Analysis	51
2.11	Comparison with Similar Topologies	51
2.12	Conclusion	52
Chapter 3. Solar PV Integration of Electrolytic Capacitor-less Isolated DC-DC Resonant Converter		53
3.1	Introduction	53
3.2	Solar PV Integration of Dual Half Active Bridge Resonant Converter	53
3.3	Particle Swarm Optimization	54
3.4	Simulation Results for PSCs using PSO	58
3.5	Experimental Results for PSCs using PSO	62
3.6	Grey Wolf Optimization (GWO)	65
3.7	Experimental Results under GWO	68
3.7.1	Results under Uniform Irradiance Conditions (UIC)	68
3.7.2	Results under Partial Shading Conditions (PSCs)	69
3.8	Comparison with the Existing Converters	73
3.9	Conclusion	74
Chapter 4. Pseudo DC-Link Based Two-Stage Topology for Solar PV to Grid-Tied System		75
4.1	Introduction	75
4.2	Design of the Phase Locked Loop (PLL)	76

4.2.1 Transformation of Reference Frames/ Coordinate Systems	76
4.2.2 Design of the PLL control using PI controller	80
4.2.3 Design of the PLL control using K-factor Controller.....	81
4.2.4 Simulation Results Corresponding the PI and the K-factor Controller	83
4.3 State-space Modelling of the Voltage Source Inverter (VSI)	84
4.4 Design of the Inner Current Control Loop.....	86
4.4.1 Plant Transfer Function for the Current Control	86
4.4.2 PI Controller for Current Control	87
4.4.3 Complete Open Loop Transfer function.....	88
4.4.4 Modulus Optimum Tuning Criterion.....	89
4.5 Design of the Outer Voltage Control Loop.....	91
4.5.1 Plant Transfer Function for the Voltage Control.....	92
4.5.2 PI Controller for Voltage Control.....	93
4.5.3 Equivalent Inner Current Control Loop.....	93
4.5.4 Revised Open Loop Transfer function	94
4.5.5 Symmetrical Optimum Tuning Criterion (SOTC).....	95
4.6 Design of the LC Filter	97
4.7 Pseudo DC Link Capacitor Required.....	97
4.8 Simulation Results Under PSCs With Resistive Load	99
4.9 Experimental Results Under PSCs with Resistive Load.....	102
4.10 Simulation Results for Solar PV to Grid-Tied Condition	105
4.11 Conclusion	107

Chapter 5. Expandable Input Impedance-Sourced Isolated DC-DC Resonant Converter 109

5.1 Introduction	109
5.2 Proposed converter.....	110

5.3	Expandable input impedance-sourced network (EIIS)	110
5.3.1	DTs Switching State	110
5.3.2	(1-D) T_s Switching State	112
5.4	Expandable Input Impedance Sourced Isolated Resonant Converter	116
5.4.1	Interval I: ($T_0 - T_1$)	116
5.4.2	Interval II: ($T_1 - T_2$)	116
5.4.3	Interval III: ($T_2 - T_3$)	116
5.5	PSO Algorithm for PSC	118
5.6	Design of the Converter	119
5.6.1	Modeling of the IRC	120
5.6.2	Calculation of Voltage Gain and Power	121
5.6.3	Soft-Switching Realization	121
5.7	Design of the Proposed Topology	122
5.7.1	Normalized Switching Frequency (F)	122
5.7.2	Gain (λ), turns ratio (n_t), and Inductance Ratio (K)	122
5.7.3	Quality Factor	123
5.7.4	Resonant Components	124
5.7.5	Design of the EIIS Network Inductors	124
5.7.6	Design of Film Capacitors of the EIIS Network	124
5.7.7	Design of Film Capacitors (FC) of IRC	125
5.8	Experimental Verification	127
5.8.1	Steady State Results for Proposed Expandable Input Impedance Sourced Isolated Resonant Converter	127
5.8.2	Experimental Results for Soft-switching	130
5.8.3	Results Under Uniform Irradiance Conditions	132
5.8.4	Results Under PSCs and Dynamic Irradiance Conditions	132
5.8.5	Verification of Film Capacitor Usage	135

5.9 Design Flexibility with EHS and Inegration with Grid System.....	136
5.10 Conclusion.....	138
Chapter 6. Conclusion and Scope of Future Work.....	139
6.1 Introduction.....	139
6.2 Conclusion	139
6.3 Scope of the Future Work	141
Bibliography.....	143
List of Publications	163