# Table of Contents

Acknowledge xi

Lists of Figures xvii

Lists of Tables xxiii

Preface xxv

**1. Introduction ..... 1**

1.1 Introduction ..... 1

1.2 High Gain Converters in Microgrid ..... 3

1.3 State of the Art of High Gain Converter ..... 4

1.4 Challenges Associated with the Conventional High Gain Converters ..... 11

1.5 Desired Characteristic for High Gain Converter ..... 12

1.6 Scope of the Thesis ..... 13

**2. High Gain Minimum Phase Quadratic Boost Hybrid Inverter ..... 19**

2.1 Introduction ..... 19

2.2 Minimum Phase Quadratic Boost Hybrid Inverter ..... 20

2.2.1 Operating Principle of High Gain Hybrid Inverter ..... 21

2.2.2 Operating Modes of the Proposed High Gain Hybrid Inverter ..... 22

2.2.3 Steady-State Analysis ..... 23

2.2.4 High Frequency Ripple Analysis ..... 25

2.2.5 AC and DC Power Expressions ..... 27

2.2.6 Switch Stress and Current Expressions ..... 29

2.3 Small Signal Analysis of Proposed Hybrid Inverter ..... 29

2.4 Hybrid PWM Control Technique ..... 32

2.5 Simulation Studies ..... 35

2.5.1 Minimum Phase Property of Proposed Hybrid Inverter ..... 35

2.5.2 PWM for High Gain Inverter ..... 38

2.5.3 Steady-State Operation ..... 40

2.5.4 Duty Cycle Variation ..... 40

2.6 Conclusion ..... 41

**3. Quadratic Boost Derived Hybrid Multi-Output Converters ..... 45**

3.1 Introduction ..... 45

3.2 Quadratic Boost Derived Hybrid Multi-Output Converters ..... 46

3.2.1 Proposed High Gain Hybrid Multi-Output Converters ..... 47
3.2.2 Operating Modes of the Proposed Hybrid Multi-Output Converter ..... 49
3.2.3 Steady-State Analysis ..... 49
3.2.4 AC and DC Power Expressions ..... 51
3.2.5 Switch Stress and Current Expressions ..... 53
3.3 Small Signal Analysis of Proposed Converter ..... 55
3.4 Simulation Studies ..... 57
3.4.1 Proposed Converter in Parallel Mode ..... 58
3.4.2 Proposed Converter in Series Mode ..... 59
3.4.3 Dynamic Performance ..... 60
3.5 Conclusion ..... 62
**4. Switched-Boost Modified Z-Source Inverters Topologies ..... 65**
4.1 Introduction ..... 65
4.2 Switched-Boost Modified ZSIs Topologies ..... 66
4.2.1 Proposed Topologies of Switched-Boost Modified ZSIs ..... 66
4.2.2 Operating Principle of SB-ZSI ..... 67
4.2.3 Operating Principle of DC-qZSI ..... 71
4.2.4 Operating Principle of CC-qZSI ..... 72
4.3 Passive Components Design ..... 75
4.4 Voltage and Current Stresses ..... 78
4.5 PWM Control Technique ..... 78
4.6 Comparative Analysis of the Proposed ZSI with Others ZSIs ..... 80
4.6.1 Components Count and Gain ..... 81
4.6.2 Voltage and Current Stresses ..... 81
4.6.3 Stored Energy Analysis and Reliability ..... 82
4.6.4 Power Loss and Efficiency Analysis ..... 88
4.7 Extension of Proposed ZSI for Enhance Boost Capability ..... 89
4.8 Simulation of Switched-Boost Modified ZSIs Topologies ..... 91
4.8.1 Simulation of SB-ZSI ..... 92
4.8.2 Simulation of DC-qZSI ..... 92
4.8.3 Simulation of CC-qZSI ..... 96
4.9 Comparative Analysis of Proposed Converters ..... 96
4.10 Conclusion ..... 99

**5. Experimental Verification ..... 101**
5.1 Introduction ..... 101
5.2 Verification of Minimum Phase Quadratic Boost Hybrid Inverter ..... 101
5.2.1 Steady-State Operation ..... 102
5.2.2 Performance Analysis ..... 105
5.2.3 Dynamic Loads Variation Analysis ..... 107
5.3 Verification of Quadratic Boost Derived Hybrid Multi-Output Converters ..... 108
5.3.1 Proposed Converter in Parallel Mode ..... 109
5.3.2 Proposed Converter in Series Mode ..... 110
5.3.3 Experimental Performance Analysis ..... 112
5.3.4 Efficiency Analysis ..... 116
5.3.5 Dynamic Load Variation ..... 117
5.4 Experimental Verification of Switched-Boost Modified ZSI Topologies ..... 119
5.4.1 Steady-State Verification of CC-qZSI ..... 120
5.4.2 Harmonic Analysis ..... 123
5.4.3 Efficiency Analysis ..... 124
5.5 Conclusion ..... 124
**6. Conclusion and Future Scope ..... 127**
6.1 Conclusion ..... 127
6.2 Future Scope of the Research ..... 130

**Appendix A ..... 133**

**Appendix B ..... 139**

**Appendix C ..... 145**

**Appendix D ..... 147**

**Appendix E ..... 149**

**Appendix F ..... 153**

**References ..... 159**

**List of Publications ..... 169**