

MS1(E) 020-1411

Shunt Power Quality Compensator Based on 3-Leg Center-Split Inverter

by

Tang Jing

Master of Science in Electrical and Electronics Engineering

02/2003



**Faculty of Science and Technology
University of Macau**

TABLE OF CONTENTS

LIST OF FIGURES	iv
LIST OF TABLES	ix
GLOSSARY	xi
CHAPTER 1: Introduction.....	1
1.1 Power Quality	1
1.2 Current Quality Issues.....	8
1.3 Reactive Power Compensation and Harmonic Control Technique	16
1.4 Power Quality Compensator	18
1.4.1 General Configuration of Power Quality Compensator.....	18
1.4.2 Shunt Power Quality Compensator in Three-Phase Four-Wire System 4-Leg Inverter and 3-Leg Center-Split Inverter	23
1.5 Pulse Width Modulation	26
1.6 Works of This Thesis	31
CHAPTER 2: Parameter Detection of Shunt Power Quality Compensator	33
2.1 System Configuration of Shunt Power Quality Compensator	33
2.2 Discussion of Instantaneous Reactive Power Theory	34
2.2.1 Generalized Instantaneous Reactive Power Theory.....	34
2.2.2 Equivelant Instantaneous Reactive Power Theory in $\alpha - \beta - 0$ Coordinate for Three-Phase Four-Wire System	36
2.3 Simplified Computation of Reference Currents.....	38
2.4 Simulation Results	42
2.5 Summary	43
CHAPTER 3: 3-DSCH (3-Dimension Sign Cubical Hysteresis) PWM Control Theory	45
3.1 Mathematical Model of 3-Leg Center-Split Inverter as Power Quality Compensator	46
3.1.1 Definition of Switching Function.....	46
3.1.2 Mathematical Model in a,b,c Coordinate.....	48

3.1.3 Mathematical Model in $\alpha, \beta, 0$ Coordinate.....	50
3.2 3-Dimension PWM Theory.....	52
3.2.1 Transforming Three-Phase Quantities	52
3.2.2 2-Level and 3-Level 3-Dimension Voltage Vectors in Three-Phase Four-Wire Systems.....	53
3.2.3 3-Dimension Theory in Multi-Level Inverter System	56
3.3 3-Dimension Sign Cubical Hysteresis PWM Control Method	59
3.3.1 Basic Control Strategy	59
3.3.2 3DSCH Method of 2-Level Inverter System	61
3.3.3 3DSCH Method of 3-Level Inverter System	64
3.3.4 Double-Band 3DSCH Method of 5-Level Inverter System.....	67
3.3.4.1 5-Level 3-Dimension Voltage Vectors	68
3.3.4.2 Control Strategy of Double-Band 3DSCH PWM Method.....	71
3.4 Simulation Results	74
3.5 Discussion	76
3.5.1 Comparison of 2-Level, 3-Level and 5-Level Inverter Modulations	76
3.5.2 Comparison of Conventional Hysteresis Method and 3DSCH Method	78
3.6 Summary	84
CHAPTER 4: D.C. Imbalance Issue of 3-Leg Center-Split Inverter	85
4.1 Analysis of d.c. Voltage Unit.....	86
4.1.1 Analysis of d.c. Voltage Unit of 2-Level 3-Leg Center-Split Inverter	87
4.1.2 Analysis of d.c. Voltage Unit of 3-Level 3-Leg Center-Split Inverter	89
4.2 Adaptive Zero Shifting 3DSCH PWM Method.....	93
4.2.1 Basic Principle of Adaptive Zero Shifting 3DSCH PWM Method	93
4.2.2 Adaptive Zero Shifting 3DSCH PWM Method in 2-Level and 3-Level Inverter Systems	94
4.3 Simulation Results of 3-Level Inverter System	96

4.4 Discussion	98
4.5 Summary	101
CHAPTER 5: Experimental Study of 3-Leg Center-Split Inverter as Shunt	
Power Quality Compensator	103
5.1 Design of Experimental Circuits.....	103
5.1.1 System Structure	104
5.1.2 3-Level 3-Leg Center-Split Inverter Structure.....	105
5.1.3 Discussion of System Parameters	106
5.2 Hardware of Digital Control System.....	109
5.2.1 Advantages and Disadvantages of TMS320F2407	109
5.2.2 Constitution of Digital Control System	111
5.2.3 Discussion	115
5.3 Software of Digital Control System.....	116
5.4 Experimental Results	119
5.4.1 Unbalance Load Experiment.....	120
5.4.2 Balacne Load Experiment.....	121
5.4.3 Power Factor Experiment.....	122
5.4.4 One Phase Open Experiment	123
5.4.5 Dynamic Experiment	124
5.4.6 Experimental Comparison of Conventional Hysteresis Method and 3DSCH Method.....	125
5.4.7 D.C. Voltage Imbalance Experiments.....	126
5.5 Summary	127
CHAPTER 6: Conclusion.....	129
BIBLIOGRAPHY	131
APPENDIX A: Publications	138
APPENDIX B: Photo of System.....	139