List of Figures

Figure. No	Figure Details	Page No
	Chapter I	1 480 110
1.2-1	Results of A Survey on The Causes of Power Quality Problems	1.9
1.4.1-1	Fourier Series Representation of Distorted Waveform	1.13
1.4.1-2	Relationship Between P, Q And S In Sinusoidal Condition	1.15
1.4.2-1	Relationship of Components of The Apparent Power	1.18
1.5.1-1	Arc Furnace Operation In An Unbalanced Mode Allows Triplen Harmonics To Reach The Power System Despite A Delta Connected Transformer	1.20
1.6.1-1	Switch-Mode Power Supply	1.23
1.6.1-2	Smps Current And Harmonic Spectrum	1.24
1.6.2-1	Input Current & Voltage Waveform For Fluorescent Lamp With Magnetic Ballast	1.26
1.6.2-2	Input Current & Voltage Waveform For Fluorescent Lamp With Electronic Ballast	1.28
1.7.1-1	Voltage & Current And Waveform For CSI-Type ASD .	1.32
1.7.1-2	Voltage & Current Waveform For PWM-Type ASD	1.32
1.7.1-3	Six-Pulse Dc ASD	1.35
1.7.1-4	PWM ASD	1.36
1.7.1-5	Large AC ASD s	1.36
1.7.1-6	Effect of PWM ASD Speed on AC Current Harmonics	1.37
1.7.2-1	Equivalent Circuit For An Arcing Device.	1.38
1.7.3-1	Transformer Magnetizing Characteristic	1.40
1.7.3-2a	Transformer Magnetizing Current Waveforms And Applied Voltage	1.41
1.8.2-1	Impedance Versus Frequency For Inductive System	1.44
1.8.3-1	System With Parallel Resonance Problem	1.46
1.8.3-2	At Harmonic Frequencies, The Shunt Capacitor Bank Appears In Parallel With The System Inductance. (A) Simplified Distribution Circuit; (B) Parallel Resonant Circuit As Seen From The Harmonic Source	1.47
1.8.3-3	System Frequency Response As Capacitor Size Is Varied In Relation To Transformer	1.49
1.8.4-1	System With Potential Series Resonance Problems	1.50
1.8.4-2	Frequency Response of A Circuit With Series Resonance	1.51
1.8.5-1	Effect of Resistive Loads on Parallel Resonance	1.52

xii

.

Figure. No	Figure Details	Page No
1.9.1-1	Typical Capacitor Current From A System In 11th-Harmonic Resonance.	1.55
1.9.2-1	Zero Sequence Flux In Three Legged Core Transformers Enters The Tank And The Air And Oil Space	1.59
1.10-1	Components of Electric Power	1.61
1.10-2	Power Tetrahedron	1.61
	Chapter II	
2.4.1.1-1	Single Tuned Filter	2.8
2.4.1.2-1	Double Tuned Filter	2.10
2.5.1-1	Shunt Active Filter	2.16
2.5.1-2	Series Active Filter	2.16
2.5.1-3	Combination of Shunt Active Filter And Shunt Passive Filter	2.17
2.5.1-4	Combination of Series Active Filter And Shunt Passive Filter	2.18
2.5.1-5	Combination of Series Active Filter Connected In Series With And Shunt Passive Filter	2.18
2.6.1-1	Square Wave Inverter	2.23
2.6.2-2	Three Phase PWM Waveforms And Harmonics Spectrum	2.25
2.6.2-3	Three Phase Inverter $V_{II1}(Rms)/V_d$ As A Function of M_a	2.27
2.7-1	Three Phase Four Wire Three Leg Converter	2.29
2.7-2	Three Phase Four Wire Four Leg Converters	2.29
2.7-3	Hysteresis Band Current Control	2.31
2.8.1-1	Three-Phase Three-Wire System	2.32
2.8.1-2	α-βCoordinates Transformer	2.33
2.8.1-3	Instantaneous Space Vector	2.34
2.8.1-4(a)	Physical Meaning of The Instantaneous Power Defined In The $lpha$ - eta -O Reference Frame	2.38
2.8.1-4(b)	Compensation of All Undesirable Power of The Load By Using A Shunt Active Filter	2.38
2.8.1.1-1	Shunt Active Power Filter Control Scheme Using larp Theory	2.39
2.8.1.2-2	Source Voltages And Load Currents Alpha Beta Components For Voltage And Current	2.41
2.8.1.2-3	Source Voltages And Currents	2.41
2.8.1.2-4	Filter Currents	2.42
2.8.1.2-5	Dc Bus Voltage	2.42
2.8.2-1	Shunt Active Power Filter Control Scheme Using Sine Multiplication Theory	2.43
2.8.2-2	Input Source Voltages	2.45

.9

Figure. No	Figure Details	Page No
2.8.2-3	Input Source Currents	2.45
2.8.2-4	Load Currents	2.45
2.8.2-5	Filter Currents	2.45
2.8.2-6	Dc Bus Voltage	2.46
2.8.2-7	Input Source Voltages And Currents	2.46
2.8.2-8	Load Currents	2.46
2.8.2-9	Filter Currents	2.47
2.8.2-10	Dc Bus Voltages	2.47
2.8.3-1	Shunt Active Power Filter Control Scheme Using Synchronous Reference Frame Theory	2.48
2.8.3-2	Source Currents And Voltages	2.50
2.8.3-3	I _d -I _q Components	2.51
2.8.3-4	Load Currents	2.51
2.8.3-5	Dc Bus Voltage	2.51
2.9.1-1	Principal Scheme of A Boost Pfc Converter	2.53
2.9.1-2	Hysteresis Control Scheme	2.54
2.9.1-3	Borderline Control Scheme	2.55
2.9.2-4	Simulated System Using Matlab For Upf Boost Converter	2.57
2.9.2-5	Simulated Waveform of Input Voltage, Input Current, Output Dc Voltage & Voltage Across Inductor Respectively	2.58
2.9.3-6	Rectifier With Pfc Assembled on Pcb	2.59
2.9.3-7	Schematic of Pfc Circuit	2.60
2.9.3-8	Input Voltage And Current	2.61
2.9.3-9	Voltage Across Device	2.61
2.9.3-10	Voltage Across Inductor	2.62
2.9.3-11	Voltage & Current Waveform of Rectifier Without Pfc	2.62
	Chapter III	
3.1-1	Harmonic Distortion At Pcc	3.6
3.2-1	Relationship Between System Impedance And Voltage Distortion	3.8
3.3-1	Basic Principle of Shunt Passive Filter	3.9
3.3-2	Basic Principle of Shunt Active Filter	3.10
3.4-1	Block Diagram Showing Main Components of The Series Active Filter	3.13
3.4-2	Components Diagram of The Series Active Filter	3.13
Figure. No	Figure Details	Page No

xiv

2 4 1 1	Circle Diagram of The Series Filter	2.15
3.4.1-1	Circle Diagram of The Series Filter	3.15
3.5-1	Circuit Configuration of Combined System	3.20
3.5-2	Detailed Circuit Configuration of Series Active Filter on Per-Phase Base	3.21
3.5-3	Equivalent Circuit on Per-Phase Base For Figure 3.5-1	3.21
3.5-4	Equivalent Circuit For Fundamental Frequency	3.22
3.5-5	Equivalent Circuit For Harmonic Frequencies	3.23
3.6-1	Traction Substation Having Small Linear Load	3.29
3.7.1-1	Transformation of Voltage Signals Into Orthogonal Coordinates	3.31
3.7.1-2	Instantaneous Real And Imaginary Power Calculations	3.33
3.7.1-3	$V_{c\alpha}$ And $V_{c\beta}$ Calcultation	3.35
3.7.1-4	Transformation of Orthogonal Voltage Back Into Three Phase	3.37
	Voltage	· .
3.10-1	Schematic Diagram of Series Active Filter Developed	3.42
3.11-1	Control Logic Diagram of Switching Sequence of Series Active Filter	3.45
3.11-2	Photograph of Front View of The Panel	3.46
3.11-3	Photograph of Components on The Front Side of The Panel	3.47
3.11-4	Photograph of The Components Mounted on Bottom Flange	3.48
3.12.1-1	Simulation Block Diagram Used For Series Active Filter Simulation	3.49
3.12.1-2	Distorted Waveform At Load Bus Before Compensation	3.50
3.12.1-3	Compensation Waveform of Series Active Filter To Compensate	3.50
0.12.1	The Distortion In Voltage	5.50
3.12.1-4	Waveform At Load Bus After Compensation Through Series Active	3.51
2 4 2 2 4	Filter	2 52
3.12.2-1	Load Voltage Waveform For R-Y-B Phase (Without Compensation)	3.53
3.12.2-2	Load Voltage Waveform For R-Y-B Phase (With Compensation)	3.54
3.12.2-3	Load Current Waveform For R-Y-B-Phase (Without Compensation)	3.55
3.12.2-4	Load Current Waveform For R-Y-B-Phase (With Compensation)	3.56
3.12.2-5	Transformer Output Voltage Waveform For R-Y-B Phase (With Fundamental Added)	3.57
3.13.1-1	Load Voltage Waveform For R-Y-B Phase (Without Compensation)	3.64
Figure. No	Figure Details	Page No
3.13.1-2	Load Voltage Waveform For R-Y-B Phase (With Compensation)	3.64
•.	Chapter IV	
4.2.1-1	% Negative Sequence Current For An Industrial Feeder	4.4
4.2.3-1	High Neutral Currents In Circuits Serving Single-Phase Nonlinear	4.7
A	Loads.	лO
4.2.3-2	Flow of Third-Harmonic Current In Three-Phase Transformers	4.8
		-
		XV

4.2.3-3	Arc Furnace Operation In An Unbalanced Mode Allows Triplen Harmonics To Reach The Power System Despite A Delta Connected Transformer.	4.9
4.3-1(a)	Schematic of Conventional Induction Motor Drive	4.11
4.3-1(b)	Torque V/S Speed Characteristic With Balanced And Unbalanced Condition	4.11
4.4-1	A Simple Three-Phase System	4.12
4.4-2	Decoupled Phases of The Three Phase System	4.14
4.4.1.2-1	Mutually Coupled Series Impedances	4.19
4.4.1.3-1	Three-Phase Wye Connected Source	4.21
4.4.1.3-2	Three-Phase Impedance Load Model	4.22
4.4.3-1	Schematic of Three-Phase, Four-Wire Compensated System	4.25
4.5.1-1	Per-Phase Stator Referred Equivalent Circuits of An Induction Motor	4.32
4.5.2-1(a)	Speed-Torque Curves of An Induction Motor With Unbalance Stator Voltages	4.37
4.5.2-1(b)	Speed-Torque Curves of An Induction Motor With Unbalance Stator Voltages & Balance Stator Voltage For Single Phasing	4.37
4.5.2-2	Per Phase Equivalent Circuit of Induction Motor For Calculation of Speed Torque Characteristics Under Unbalance Stator Voltage Condition.	4.38
4.5.3-1	Harmonic Equivalent Circuits of An Induction Motor	4.41
4.6.1-1	Electromagnetic Compensator	4.44
4.7.2.1-1	Block Diagram For Simulation	4.51
4.7.2.1-2(a)	Unbalanced Input Voltages	4.52
4.7.2.1-2(b)	Compensating Reference Voltages Without Accounting Zero Sequence Components	4.52
4.7.2.1-2(c)	Compensating Reference Voltages With Accounting Zero Sequence Components	4.53
Figure. No	Figure Details	Page No
4.7.2.1-2(d)	Load Voltages After Compensation Without Accounting Zero Sequence Components	4.53
4.7.2.1-2(e)	Load Voltages After Compensation With Accounting Zero Sequence Components	4.54
4.7.2.2-1	Schematic Diagram of Experimental Setup	4.55
4.7.2.2-2	Experimental Set-Up	4.56
4.7.2.2-3	Unbalance Input Voltages	4.59
4.7.2.2-4	$V_{\alpha R}$ & $V_{\beta R}$ For Reference Input Voltages	4.59
	V_{α} & V_{β} For Input Voltages To Be Sensed	4.60

4.7.2.2-7	p_{ac} & q_{ac} In α - β Reference Frame After Filtration	4.61
4.7.2.2-8	$V_{\alpha N}$ & $V_{\beta N}$ In $\alpha\text{-}\beta$ Reference Frame After Filtration	4.61
4.7.2.2-9	Compensating Reference Voltages	4.62
4.7.2.2-10	Three Phase Balance Load Voltage After Compensation	4.62
	Chapter V	
5.5-1A	Block Diagram For Simulation	5.10
5.5-1B	Control Block Diagram For Simulation	5.11
5.5-2	A-B-C To α - β -0 Frame	5.11
5.5-3	Cross Product & Dot Product For p_{ac} & q_{ac} of The Signal In $\alpha\text{-}\beta\text{-}0$	5.12
	Frame	x
5.5-4	Compensating Reference Voltage Signal V_{\alpha c} & V_{\beta c} In α - β -0 Frame	5.12
5.6-1	Input Side Source Voltage Having Distortion & Unbalance	5.14
5.6-2	A-B-C To α - β -O Conversion (Voltage Signal V_{\alpha} & V_{\beta} In α - β -O Frame)	5.14
5.6-3	q_{ac} & q_{ac} of The Signal In α - β -0 Frame	5.15
5.6-4	Compensating Reference Voltage Signal V_{\alpha C} & V_{\beta C} ln $\alpha \text{-}\beta \text{-}0$ Frame	5.15
5.6-5	Compensating Voltage To Compensate Harmonics & Unbalance	5.16
5.6-6	Load Bus Voltage After Compensation	5.16
	·	

.