# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig. 1.1</td>
<td>Power Quality Concerns</td>
<td>2</td>
</tr>
<tr>
<td>Fig. 1.2</td>
<td>Structural and Electrical System Susceptibility</td>
<td>3</td>
</tr>
<tr>
<td>Fig. 2.1</td>
<td>Two Possible System Configurations of DVR</td>
<td>12</td>
</tr>
<tr>
<td>Fig. 2.2</td>
<td>Basic Configuration of DSTATCOM</td>
<td>18</td>
</tr>
<tr>
<td>Fig. 2.3</td>
<td>System Configuration of UPQC</td>
<td>26</td>
</tr>
<tr>
<td>Fig. 3.1</td>
<td>Very Short Interruptions</td>
<td>35</td>
</tr>
<tr>
<td>Fig. 3.2</td>
<td>Long Interruptions</td>
<td>35</td>
</tr>
<tr>
<td>Fig. 3.3</td>
<td>Voltage Sag or Dip</td>
<td>36</td>
</tr>
<tr>
<td>Fig. 3.4</td>
<td>Voltage Swell</td>
<td>37</td>
</tr>
<tr>
<td>Fig. 3.5</td>
<td>Voltage Flicker</td>
<td>38</td>
</tr>
<tr>
<td>Fig. 3.6</td>
<td>Harmonics</td>
<td>39</td>
</tr>
<tr>
<td>Fig. 3.7</td>
<td>Transient Voltage at the Switched Shunt Capacitor</td>
<td>41</td>
</tr>
<tr>
<td>Fig. 3.8</td>
<td>Magnified Transient Voltage at the Low Voltage Capacitor</td>
<td>41</td>
</tr>
<tr>
<td>Fig. 3.9</td>
<td>Voltage spike</td>
<td>42</td>
</tr>
<tr>
<td>Fig. 3.10</td>
<td>Voltage Unbalance</td>
<td>42</td>
</tr>
<tr>
<td>Fig. 3.11</td>
<td>Disturbances caused by the Energization of a Capacitor Bank</td>
<td>48</td>
</tr>
<tr>
<td>Fig. 4.1</td>
<td>Schematic Diagram of DVR</td>
<td>52</td>
</tr>
<tr>
<td>Fig. 4.2</td>
<td>Equivalent Circuit Diagram of DVR</td>
<td>53</td>
</tr>
<tr>
<td>Fig. 4.3</td>
<td>PI Controller</td>
<td>56</td>
</tr>
<tr>
<td>Fig. 4.4</td>
<td>Hysteresis Band Voltage Control</td>
<td>57</td>
</tr>
<tr>
<td>Fig. 4.5</td>
<td>Membership function Input variable “Error”</td>
<td>58</td>
</tr>
<tr>
<td>Fig. 4.6</td>
<td>Membership function Input variable “Error rate”</td>
<td>58</td>
</tr>
<tr>
<td>Fig. 4.7</td>
<td>Membership function for output</td>
<td>58</td>
</tr>
</tbody>
</table>
Fig. 4.8 Main System without DVR 60
Fig. 4.9 PI Controller Subsystem 61
Fig. 4.10 Main Diagram of DVR with Fuzzy Logic Controller 62
Fig. 4.11 DVR Subsystem 62
Fig. 4.12 Fuzzy Logic Controller Subsystem 63
Fig. 4.13 Phase Modulation (for control angle δ) Subsystem 63
Fig. 4.14 Voltage $V_{RMS}$ at the load point: without DVR 64
Fig. 4.15 Voltage $V_{RMS}$ at the load point: with 5 kv energy Storage 65
Fig. 4.16 Voltage $V_{RMS}$ at the load point: with 3 kv energy Storage 65
Fig. 4.17 Voltage $V_{RMS}$ at the load point: with 8 kv energy Storage 66
Fig. 4.18 Voltage $V_{RMS}$ at the load point: without DVR 67
Fig. 4.19 Voltage $V_{rms}$ at the load point: with 6.5kV Energy Storage 67
Fig. 4.20 Voltage $V_{RMS}$ at the load point: with 6kv Energy Storage 68
Fig. 4.21 Voltage VRMS at the load point: with 4kv Energy Storage 68
Fig. 4.22 Voltage $V_{rms}$ at the load point: with 8kv Energy Storage 69
Fig. 4.23 Voltage VRMS at the load point: without DVR 70
Fig. 4.24 Voltage $V_{rms}$ at the load point: with DVR

Energy Storage of 6.68kv 70
Fig. 4.25 Voltage VRMS at the load point: with 6.2kv

Energy Storage 71
Fig. 4.26 Voltage VRMS at the load point: with 5.6kv

Energy Storage 71
Fig. 4.27 Voltage $V_{RMS}$ at the load point: with 8 KV

Energy Storage 72
Fig. 4.28 Voltage $V_{RMS}$ at the load point: without DVR 73
Fig. 4.29 Voltage \( V_{\text{rms}} \) at the load point: with DVR

Energy Storage of 4.9kv

Fig. 4.30 Voltage \( V_{\text{RMS}} \) at the load point: with 3kv

Energy Storage

Fig. 4.31 Voltage \( V_{\text{RMS}} \) at the load point: with 2kv

Energy Storage

Fig. 4.32 Voltage \( V_{\text{RMS}} \) at the load point: with 7kv

Energy Storage

Fig. 4.33 Voltage \( V_{\text{RMS}} \) at the load point: without DVR

Fig. 4.34 Voltage \( V_{\text{RMS}} \) at the load point: with DVR

Energy storage 6.8kv

Fig. 5.1 Basic circuit diagram of the DSTATCOM system

Fig. 5.2 Block diagram of the control circuit equipped

With the function of voltage regulation and Harmonic Damping

Fig. 5.3 Conventional DC Link Voltage based PI Controller

Fig. 5.4 Fast Acting DC Link Voltage based PI Controller

Fig. 5.5 Block Diagram of Fuzzy Logic Controller

Fig. 5.6 Main System without DSTATCOM

Fig. 5.7 Main System with DSTATCOM

Fig. 5.8 Three phase Voltages of Distribution System without DSTATCOM

Fig. 5.9 Three Phase Voltages of Distribution System with DSTATCOM

Fig. 5.10 Three Phase Source Currents of Distribution System
without DSTATCOM

Fig. 5.11 Three Phase Source Currents of Distribution System

with DSTATCOM

Fig. 5.12 Compensating Currents with DSTATCOM

Fig. 5.13 DC Voltage of DSTATCOM

Fig. 5.14 Harmonic Spectrum of Phase-A Source Current

Fig. 5.15 Main System without DSTATCOM

Fig. 5.16 Main System with DSTATCOM

Fig. 5.17 Source Voltage and Current

Fig. 5.18 DSTATCOM with PI Controller

Fig. 5.19 DSTATCOM Subsystem

Fig. 5.20 Injected Currents

Fig. 5.21 Load Voltage and Current

Fig. 5.22 Transient Response of the Conventional DC Link Voltage Controller

Fig. 5.23 Transient Response of the Fast Acting DC Link Voltage Controller

Fig. 5.24 Transient response of the Conventional Fuzzy Logic Controller

Fig. 5.25 Transient response the FA Fuzzy Logic Controller

Fig. 5.26 DSTATCOM with Fuzzy Logic Controller Subsystem

Fig. 6.1 Detailed Power Circuit Structure of a 3-Phase UPQC

Fig. 6.2 Controlling circuit of Shunt Active Filter

Fig. 6.3 Block diagram of D.C Link Voltage PI Controller
Fig. 6.4 Basic structure of Fuzzy Control System 122
Fig. 6.5 Series Active Filter Control Block 125
Fig. 6.6 Main System without UPQC 128
Fig. 6.7 Three Phase Voltage Source Subsystem 128
Fig. 6.8 Main System with UPQC 129
Fig. 6.9 Series Active Filter/Shunt Active Filter Sub system 130
Fig. 6.10 Shunt Active Filter with PI Controller Sub system 130
Fig. 6.11 Series Active Filter Controller Sub system 131
Fig. 6.12 Non Linear Load Subsystem 131
Fig. 6.13 Shunt Active Filter with FLC Subsystem 132
Fig. 6.14 Fuzzy Logic Controller Subsystem 132
Fig. 6.15 Three Phase Source Current (UPQC with PI Controller) 134
Fig. 6.16 Source Current in Phase-A (UPQC with PI Controller) 135
Fig. 6.17 Compensation Current in Phase-A (UPQC with PI Controller) 135
Fig. 6.18 Compensation Voltage (UPQC with PI Controller) 135
Fig. 6.19 Load Voltage and Current (UPQC with PI Controller) 135
Fig. 6.20 Source Voltage in Phase A (UPQC with PI Controller) 136
Fig. 6.21 Three Phase Source Voltage (UPQC with PI Controller) 136
Fig. 6.22 Three Phase Load Current (UPQC with PI Controller) 136
Fig 6.23 Load Current in Phase A (UPQC with PI Controller) 137
Fig. 6.24 Injected Voltages (UPQC with PI Controller) 137
Fig. 6.25 DC Link Current (UPQC with PI Controller) 137
Fig 6.26 Load Voltage in Phase A (UPQC with PI Controller) 137
Fig. 6.27 Injected Voltage (UPQC with FL Controller) 138
Fig. 6.28 Load Voltage (UPQC with FL Controller) 138
Fig. 6.29 Load Voltage and Current (UPQC with FL Controller) 138
Fig. 6.30 Three Phase Source Voltage (UPQC with FL Controller) 138
Fig. 6.31 Source Voltage in Phase A (UPQC with FL Controller) 139
Fig. 6.32 Three Phase Load Current (UPQC with FL Controller) 139
Fig. 6.33 Load Current in Phase A (UPQC with FL Controller) 139
Fig. 6.34 Source Current in Phase A (UPQC with FL Controller) 140
Fig. 6.35 Three Phase Source Current (UPQC with FL Controller) 140
Fig. 6.36 Compensation Current (UPQC with FL Controller) 140
Fig. 6.37 Compensation Current in Phase A (UPQC with FL Controller) 141
Fig. 6.38 Compensation Voltage (UPQC with FL Controller) 141
Fig. 6.39 DC Link Current (UPQC with FL Controller) 141
Fig. 6.40 UPQC with synchronous revolving theory 143
Fig. 6.41 Shunt Controller Subsystem 144
Fig. 6.42 Series Controller Subsystem 145
Fig. 6.43 Shunt Controller with FL Controller Subsystem 145
Fig. 6.44 Source Current in Phase A (UPQC with PI Controller) 146
Fig. 6.45 Source voltage in Phase A (UPQC with PI Controller) 146
Fig. 6.46 Three Phase Source voltage (UPQC with PI Controller) 147
Fig. 6.47 Three Phase Source currents (UPQC with PI Controller) 147
Fig. 6.48 Three Phase Load Voltage (UPQC with PI Controller) 147
Fig. 6.49 Compensated Voltage (UPQC with PI Controller) 147
Fig. 6.50 Compensated Current in Phase A (UPQC with PI Controller) 148
Fig. 6.51 Injected Voltage in Phase A
(UPQC with PI Controller) 148

Fig. 6.52 Injected Current in Phase A
(UPQC with PI Controller) 148

Fig. 6.53 DC Link Voltage (UPQC with PI Controller) 148

Fig. 6.54 Load Voltage and Current (Power Factor)
(UPQC with PI Controller) 149

Fig. 6.55 Load Current in Phase A (UPQC with PI Controller) 149

Fig. 6.56 Source Current in Phase A (UPQC with FL Controller) 149

Fig. 6.57 Source Voltage in Phase A (UPQC with FL Controller) 149

Fig. 6.58 Three Phase Source Voltage (UPQC with FL Controller) 150

Fig. 6.59 Three Phase Source Current (UPQC with FL Controller) 150

Fig. 6.60 Compensated Voltages (UPQC with FL Controller) 150

Fig. 6.61 3-Phase Load Current (UPQC with FL Controller) 150

Fig. 6.62 Load Current in Phase A (UPQC with FL Controller) 151

Fig. 6.63 Compensated Current in Phase A
(UPQC with FL Controller) 151

Fig. 6.64 Voltage Injection in Phase A
(UPQC with FLC Controller) 151

Fig. 6.65 Current Injection in Phase A
(UPQC with FL Controller) 151

Fig. 6.66 DC Link Voltage (UPQC with FL Controller) 152

Fig. 6.67 Load Voltage and Current (Power Factor)
(UPQC with FL Controller) 152