### List of Figures

<table>
<thead>
<tr>
<th>Fig.no.</th>
<th>Description of Figure</th>
<th>Page no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Block diagram of an electric variable speed drive system</td>
<td>2</td>
</tr>
<tr>
<td>1.2</td>
<td>Open-loop volts per hertz speed control of induction motor</td>
<td>15</td>
</tr>
<tr>
<td>1.3</td>
<td>(a) Separately excited dc motor (b) vector controlled induction motor</td>
<td>17</td>
</tr>
<tr>
<td>3.1</td>
<td>$\Psi_s$ movement relative to $\Psi_r$ under influence of voltage vectors</td>
<td>46</td>
</tr>
<tr>
<td>3.2</td>
<td>Inverter voltage space vectors</td>
<td>49</td>
</tr>
<tr>
<td>3.3</td>
<td>Selection of suitable voltage space vector in sector $I (-30^\circ$ to $+30^\circ)$</td>
<td>50</td>
</tr>
<tr>
<td>3.4</td>
<td>Block diagram of conventional DTC</td>
<td>51</td>
</tr>
<tr>
<td>3.5</td>
<td>Starting transients of speed, torque, stator currents and stator flux for CDTC-IM drive</td>
<td>54</td>
</tr>
<tr>
<td>3.6</td>
<td>Starting transients in phase and line voltages of CDTC-IM drive</td>
<td>55</td>
</tr>
<tr>
<td>3.7</td>
<td>Steady state plots of speed, torque, stator currents and stator flux for CDTC based IM drive at 1200 rpm</td>
<td>56</td>
</tr>
<tr>
<td>3.8</td>
<td>The phase and line voltages for CDTC based IM drive during the steady state</td>
<td>56</td>
</tr>
<tr>
<td>3.9</td>
<td>Harmonic Spectrum of stator current along with THD</td>
<td>57</td>
</tr>
<tr>
<td>3.10</td>
<td>Locus of stator flux</td>
<td>57</td>
</tr>
<tr>
<td>3.11</td>
<td>Transients in speed, torque, stator currents and stator flux during step change in load:30 N-m load is applied at 0.5 s and removed at 0.6 s</td>
<td>58</td>
</tr>
<tr>
<td>3.12</td>
<td>The phase and line voltages during a step change in load torque: a 30 N-m load torque is applied at 0.5 s and removed at 0.6 s</td>
<td>58</td>
</tr>
<tr>
<td>3.13</td>
<td>Transients in speed, torque, stator currents and stator flux during speed reversal: speed is changed from +1200 rpm to -1200 rpm at 0.7 s</td>
<td>59</td>
</tr>
<tr>
<td>3.14</td>
<td>The phase and line voltage variations during the speed reversal (speed is changed from +1200 rpm to -1200 rpm at 0.7s)</td>
<td>60</td>
</tr>
</tbody>
</table>
3.15 Transients in speed, torque, stator currents and stator flux during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35s 60

3.16 The phase and line voltage variations during the speed reversal (speed is changed from -1200 rpm to +1200 rpm at 1.35s) 61

3.17 The torque and speed characteristics in four quadrants for CDTC based IM drive 61

3.18 Three-phase voltage source inverter 62

3.19 Possible switching states of the inverter 63

3.20 Voltage space vectors produced by an inverter 65

3.21 Active and zero states in a sector 67

3.22 Gating signal generation using SVPWM scheme in sector-I 69

3.23 Block diagram of proposed SVPWM based DTC 71

3.24 Simulation results of SVPWM based DTC: starting transients 73

3.25 Starting transients in phase and line voltages for SVPWM algorithm based DTC drive 74

3.26 Simulation results of CSVPWM based DTC: steady-state plots at 1200 rpm 75

3.27 The phase and line voltages of SVPWM based DTC drive during the steady state operation 75

3.28 Harmonic Spectrum of stator current along with THD for SVPWM based DTC-IM drive 76

3.29 Locus of stator flux in SVPWM based DTC-IM drive 76

3.30 Transients during step change in load torque (a 30 N-m load torque is applied at 0.5 s and removed at 0.6s) 77

3.31 The phase and line voltages of SVPWM based DTC during step change in load torque (a 30 N-m load torque is applied at 0.5 s and removed at 0.6s) 77

3.32 Transients in speed, torque, current and flux during speed reversal (speed is changed from +1200 rpm to -1200 rpm at 0.7 s) 78
3.33 Transients in phase and line voltages during speed reversal  
(speed is changed from +1200 rpm to -1200 rpm at 0.7 s)  
3.34 Transients in speed, torque, current and flux during speed reversal  
(speed is changed from -1200 rpm to +1200 rpm at 1.35 s)  
3.35 Transients in phase and line voltages during speed reversal  
(speed is changed from -1200 rpm to 1200 rpm at 1.35 s)  
3.36 Speed-torque characteristic of SVPWM based DTC drive in four-quadrants  
3.37 Three level diode clamp inverter  
3.38 Function equivalent of three level VSI  
3.39 Space vectors of three level inverter  
3.40 Space vectors of three level inverter with sector and sub sector definition  
3.41 Mapping of vectors of sector 1 to fictitious vectors  
3.42 Block diagram of proposed SVPWM based DTC  
3.43 Starting transients in speed, torque, currents and flux for simplified  
SVPWM algorithm based 3-level inverter fed DTC-IM  
3.44 Starting transients in phase and line voltages for simplified SVPWM  
algorithm based 3-level inverter fed DTC-IM  
3.45 Steady state plots of speed, torque, currents and flux for simplified  
SVPWM algorithm based 3-level inverter fed DTC-IM  
3.46 Steady state plots of phase and line voltages for simplified SVPWM  
algorithm based 3-level inverter fed DTC-IM  
3.47 Harmonic spectra of steady state line current for simplified SVPWM  
algorithm based 3-level inverter fed DTC-IM  
3.48 Locus of stator flux for simplified SVPWM algorithm based 3-level  
inverter fed DTC-IM  
3.49 Transients during step change in load for simplified SVPWM algorithm  
based 3-level inverter fed DTC-IM: a 30 N-m load is applied at 0.5 sec  
3.50 Phase and line voltages during a step change in load for simplified
SVPWM algorithm based 3-level inverter fed DTC-IM: a 30 N-m load is applied at 0.5 sec

3.51 Transients in speed, torque, currents and flux during speed reversal for simplified SVPWM algorithm based 3-level inverter fed DTC-IM
(speed is changed from 1200 rpm to -1200 rpm at 0.7 s)

3.52 Transients in phase and line voltages during speed reversal for simplified SVPWM algorithm based 3-level inverter fed DTC-IM
(simplified is changed from 1200rpm to -1200rpm at 0.7s)

3.53 Transients in speed, torque, currents and flux during speed reversal for simplified SVPWM algorithm based 3-level inverter fed DTC-IM
(speed is changed from -1200 rpm to +1200 rpm at 1.35 s)

3.54 Transients in phase and line voltages during speed reversal for simplified SVPWM algorithm based 3-level inverter fed DTC-IM
(simplified is changed from -1200rpm to +1200rpm at 1.35s)

3.55 Four-quadrant operation of proposed simplified SVPWM algorithm based 3-level inverter fed induction motor drive

4.1 Voltage space vectors produced by an inverter

4.2 Diode-clamped multilevel inverter circuit topologies
(a) Three-level (b) Five-level.

4.3 Triangular carrier and reference signals (a) n-level PWM scheme where n is even (b) n-level PWM scheme where n is even

4.4 Simulation results of 2-level SVPWM based DTC: starting transients in speed, torque, currents and flux

4.5 Simulation results of 2-level SVPWM based DTC: starting transients in phase and line voltages

4.6 Simulation results of 2-level SVPWM based DTC: steady-state plots of speed, torque, currents and flux at 1200 rpm

4.7 Simulation results of 2-level SVPWM based DTC: steady state plots
of phase and line voltages

4.8 Harmonic Spectrum of line current for 2-level SVPWM based DTC along with THD

4.9 Harmonic Spectrum of line voltage for 2-level SVPWM based DTC along with THD

4.10 The locus of the stator flux for 2-level SVPWM based DTC

4.11 Transients for 2-level SVPWM based DTC during step change in load:
a 30 N-m load is applied at 0.5 sec.

4.12 Phase and line voltages for 2-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec

4.13 Transients for 2-level SVPWM based DTC during speed reversal:
speed is changed from 1200 rpm to -1200 rpm at 0.7 s

4.14 Transients in phase and line voltages for 2-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s

4.15 Transients for 2-level SVPWM based DTC during speed reversal:
speed is changed from -1200 rpm to +1200 rpm at 1.35 s

4.16 Transients in phase and line voltages for 2-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s

4.17 Speed-torque characteristics of 2-level SVPWM based DTC in four quadrants

4.18 Simulation results of 3-level SVPWM based DTC: starting transients in speed, torque, currents and flux

4.19 Simulation results of 3-level SVPWM based DTC: starting transients in phase and line voltages

4.20 Simulation results of 3-level SVPWM based DTC: steady-state plots of speed, torque, currents and flux at 1200 rpm
4.21 Simulation results of 3-level SVPWM based DTC: steady state plots of phase and line voltages.

4.22 Harmonic Spectrum of line current for 3-level SVPWM based DTC along with THD.

4.23 Harmonic Spectrum of line voltage for 3-level SVPWM based DTC along with THD.

4.24 The locus of the stator flux for 3-level SVPWM based DTC

4.25 Transients for 3-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.26 Phase and line voltages for 3-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.27 Transients for 3-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.28 Transients in phase and line voltages for 3-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.29 Transients for 3-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.30 Transients in phase and line voltages for 3-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.31 Speed-torque characteristics of 3-level SVPWM based DTC in four quadrants.

4.32 Simulation results of 5-level SVPWM based DTC: starting transients in speed, torque, currents and flux.

4.33 Simulation results of 5-level SVPWM based DTC: starting transients in phase and line voltages.

4.34 Simulation results of 5-level SVPWM based DTC: steady-state plots
of speed, torque, currents and flux at 1200 rpm.

4.35 Simulation results of 5-level SVPWM based DTC: steady state plots of phase and line voltages.

4.36 Harmonic Spectrum of line current for 5-level SVPWM based DTC along with THD.

4.37 Harmonic Spectrum of line current for 5-level SVPWM based DTC along with THD.

4.38 The locus of the stator flux for 5-level SVPWM based DTC.

4.39 Transients for 5-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.40 Phase and line voltages for 5-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.41 Transients for 5-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.42 Transients in phase and line voltages for 5-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.43 Transients for 5-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.44 Transients in phase and line voltages for 5-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.45 Speed-torque characteristics of 5-level SVPWM based DTC in four quadrants.

4.46 Simulation results of 7-level SVPWM based DTC: starting transients in speed, torque, currents and flux.
4.47 Simulation results of 7-level SVPWM based DTC: starting transients in phase and line voltages.

4.48 Simulation results of 7-level SVPWM based DTC: steady-state plots of speed, torque, currents and flux at 1200 rpm.

4.49 Simulation results of 7-level SVPWM based DTC: steady state plots of phase and line voltages.

4.50 Harmonic Spectrum of line current for 7-level SVPWM based DTC along with THD.

4.51 Harmonic Spectrum of line voltage for 7-level SVPWM based DTC along with THD.

4.52 The locus of the stator flux for 7-level SVPWM based DTC.

4.53 Transients for 7-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.54 Phase and line voltages for 7-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.55 Transients for 7-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.56 Transients in phase and line voltages for 7-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.57 Transients for 7-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.58 Transients in phase and line voltages for 7-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.59 Speed-torque characteristics of 7-level SVPWM based DTC in four quadrants.

4.60 Simulation results of 9-level SVPWM based DTC: starting transients in
4.61 Simulation results of 9-level SVPWM based DTC: starting transients in phase and line voltages.

4.62 Simulation results of 9-level SVPWM based DTC: steady-state plots of speed, torque, currents and flux at 1200 rpm.

4.63 Simulation results of 9-level SVPWM based DTC: steady state plots of phase and line voltages.

4.64 Harmonic Spectrum of line current for 9-level SVPWM based DTC along with THD.

4.65 Harmonic Spectrum of line voltage for 9-level SVPWM based DTC along with THD.

4.66 The locus of the stator flux for 9-level SVPWM based DTC.

4.67 Transients for 9-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.68 Phase and line voltages for 9-level SVPWM based DTC during step change in load: a 30 N-m load is applied at 0.5 sec.

4.69 Transients for 9-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.70 Transients in phase and line voltages for 9-level SVPWM based DTC during speed reversal: speed is changed from 1200 rpm to -1200 rpm at 0.7 s.

4.71 Transients for 9-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.72 Transients in phase and line voltages for 9-level SVPWM based DTC during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s.

4.73 Speed-torque characteristics of 9-level SVPWM based DTC in four quadrants.
5.1 The primitive open-end winding induction motor drive  
5.2 Space vector locations of inverter-1 (Left) and inverter-2 (Right)  
5.3 Resultant space vector combinations in the dual-inverter scheme  
5.4 The open-end winding induction motor drive with two isolated power supplies  
5.5 Resolution of the reference voltage space vector in the middle and outer sectors  
5.6 The proposed decoupled PWM strategy  
5.7 d-q model of an open-end winding induction motor  
5.8 Starting transients of speed, torque, stator currents and stator flux for proposed decoupled PWM based DTC-IM drive  
5.9 Starting transients in phase and line voltages for proposed decoupled PWM based DTC-IM drive  
5.10 Steady state plots of speed, torque, stator currents and stator flux for proposed decoupled PWM based DTC-IM drive at 1200 rpm  
5.11 The phase and line voltages for proposed decoupled PWM based DTC-IM drive during the steady state  
5.12 Harmonic Spectrum of stator current along with THD.  
5.13 Harmonic Spectrum of stator voltage along with THD.  
5.14 Locus of stator flux in proposed decoupled PWM based DTC-IM drive  
5.15 Transients in speed, torque, stator currents and stator flux during step change in load: a 30 N-m load is applied at 0.5 s and removed at 0.6 s  
5.16 The phase and line voltages during a step change in load torque: a 30 N-m load torque is applied at 0.5 s and removed at 0.6 s  
5.17 Transients in speed, torque, stator currents and stator flux during speed reversal: speed is changed from +1200 rpm to -1200 rpm at 0.7 s.  
5.18 The phase and line voltage variations during the speed reversal (speed is changed from +1200 rpm to -1200 rpm at 0.7s)
5.19 Transients in speed, torque, stator currents and stator flux during speed reversal: speed is changed from -1200 rpm to +1200 rpm at 1.35 s 173

5.20 The phase and line voltage variations during the speed reversal (speed is changed from -1200 rpm to +1200 rpm at 1.35 s) 173

5.21 The torque and speed characteristics in four quadrants for proposed decoupled PWM based DTC-IM drive. 174

6.1 Principal of proposed NSHCPWM strategy 176

6.2 Clamping inverters with in region $0^\circ \leq \theta \leq 60^\circ$ 177

6.3 Zero- Crossing of the instantaneous phase voltages corresponding to the reference voltage Space Vector. 181

6.4 Preconisation of NSHC with three instantaneous phase reference quantities. 182

6.5 Starting transients of speed, torque, stator currents and stator flux for NSHCPWM based DTC-IM drive 185

6.6 Starting transients in phase and line voltages of NSHCPWM based DTC-IM drive 186

6.7 Steady state plots of speed, torque, stator currents and stator flux for NSHCPWM based DTC-IM drive at 1200 rpm 186

6.8 The phase and line voltages for NSHCPWM based DTC-IM drive during the steady state 187

6.9 Harmonic Spectrum of stator current along with THD. 187

6.10 Harmonic Spectrum of stator voltage along with THD. 187

6.11 Locus of stator flux in NSHCPWM based DTC-IM drive 188

6.12 Transients in speed, torque, stator currents and stator flux during step change in load for NSHCPWM based DTC-IM: a 30 N-m load is applied at 0.5 s and removed at 0.6 s 188

6.13 The phase and line voltages during a step change in load torque for NSHCPWM based DTC-IM: a 30 N-m load torque is applied at 0.5 s and
6.14 Transients in speed, torque, stator currents and stator flux during speed reversal NSHCPWM based DTC-IM: speed is changed from +1200 rpm to -1200 rpm at 0.7 s

6.15 The phase and line voltage variations during the speed reversal for NSHCPWM based DTC-IM (speed is changed from +1200 rpm to -1200 rpm at 0.7s)

6.16 Transients in speed, torque, stator currents and stator flux during speed reversal NSHCPWM based DTC-IM: speed is changed from -1200 rpm to +1200 rpm at 1.35 s

6.17 The phase and line voltage variations during the speed reversal for NSHCPWM based DTC-IM (speed is changed from -1200 rpm to +1200 rpm at 1.35s)

6.18 The torque and speed characteristics in four quadrants for NSHCPWM based DTC-IM drive

6.19 Common mode voltage variations in NSHCPWM based DTC-IM drive

7.1 Three-phase VSI fed induction motor

7.2 Voltage space vectors of a three-phase VSI

7.3 Voltage space vectors and 60° sector definitions

7.4 Voltage space vectors and formation of AZSPWM algorithms

7.5 Voltage space vectors and formation of NSPWM algorithm

7.6 waveforms of (a) actual gating time ($T_{ga}$) and offset time ($T_{offset}$) (b) Modulating wave

7.7 Reference phase voltages in all sectors in NSPWM algorithm

7.8 Scalar implementation of NSPWM algorithm (in first sector)

7.9 Block diagram of proposed RCMVPWM based DTC.

7.10 Variation of common mode voltage for SVPWM

7.11 Variation of common mode voltage for AZSPWM1
7.12 Variation of common mode voltage for AZSPWM2 215
7.13 Variation of common mode voltage for NSPWM 216
7.14 (a) Steady state plots
   (b) Harmonic spectra of line current for SVPWM at $M_0=0.815$ ($f=45\text{Hz}$) 217
7.15 (a) Steady state plots
   (b) Harmonic spectra of line current for AZSPWM1 at $M_0=0.815$ ($f=45\text{Hz}$) 218
7.16 (a) Steady state plots
   (b) Harmonic spectra of line current for AZSPWM3 at $M_0=0.815$ ($f=45\text{Hz}$) 219
7.17 (a) Steady state plots
   (b) Harmonic spectra of line current for NSPWM at $M_0=0.815$ ($f=45\text{Hz}$) 220
7.18 Simulation results of AZSPWM1 based DTC: starting transients. 222
7.19 Starting transients in phase and line voltages for AZSPWM1 algorithm based DTC drive. 222
7.20 Simulation results of AZSPWM1 based DTC:
   steady-state plots at 1200 rpm. 223
7.21 The phase and line voltages of AZSPWM1 based DTC drive during the steady state operation. 223
7.22 Harmonic Spectrum of stator current along with THD for AZSPWM1 based DTC-IM drive. 224
7.23 Locus of stator flux in AZSPWM1 based DTC-IM drive. 224
7.24 Transients during step change in load torque
   (a 30 N-m load torque is applied at 0.5 s and removed at 0.6s). 225
7.25 The phase and line voltages of AZSPWM1 based DTC during step change in load torque (a 30 N-m load torque is applied at 0.5 s and removed at 0.6s). 225
7.26 Transients in speed, torque, current and flux during speed reversal
   (speed is changed from +1200 rpm to -1200 rpm at 0.7 s). 226
7.27 Transients in phase and line voltages during speed reversal
7.28 Transients in speed, torque, current and flux during speed reversal
(speed is changed from +1200 rpm to -1200 rpm at 0.7 s).

7.29 Transients in phase and line voltages during speed reversal
(speed is changed from -1200 rpm to +1200 rpm at 1.35 s).

7.30 Speed-torque characteristic of AZSPWM1 based DTC drive
in four-quadrants.

7.31 Simulation results of AZSPWM2 based DTC: starting transients.

7.32 Starting transients in phase and line voltages for
AZSPWM2 algorithm based DTC drive.

7.33 Simulation results of AZSPWM2 based DTC:
steady-state plots at 1200 rpm.

7.34 The phase and line voltages of AZSPWM2 based DTC drive
during the steady state operation.

7.35 Harmonic Spectrum of stator current along with THD for
AZSPWM2 based DTC-IM drive.

7.36 Locus of stator flux in AZSPWM2 based DTC-IM drive.

7.37 Transients during step change in load torque
(a 30 N-m load torque is applied at 0.5 s and removed at 0.6s).

7.38 The phase and line voltages of AZSPWM1 based DTC during
step change in load torque (a 30 N-m load torque is applied
at 0.5 s and removed at 0.6s).

7.39 Transients in speed, torque, current and flux during speed reversal
(speed is changed from +1200 rpm to -1200 rpm at 0.7 s).

7.40 Transients in phase and line voltages during speed reversal
(speed is changed from +1200 rpm to -1200 rpm at 0.7 s).

7.41 Transients in speed, torque, current and flux during speed reversal
(speed is changed from -1200 rpm to +1200 rpm at 1.35 s).
7.42 Transients in phase and line voltages during speed reversal (speed is changed from -1200 rpm to 1200 rpm at 1.35 s).

7.43 Speed-torque characteristic of AZSPWM2 based DTC drive in four-quadrants.

7.44 Simulation results of NSPWM based DTC: starting transients.

7.45 Starting transients in phase and line voltages for NSPWM algorithm based DTC drive.

7.46 Simulation results of NSPWM based DTC:
steady-state plots at 1200 rpm.

7.47 The phase and line voltages of NSPWM based DTC drive during the steady state operation.

7.48 Harmonic Spectrum of stator current along with THD for NSPWM based DTC-IM drive.

7.49 Locus of stator flux in NSPWM based DTC-IM drive.

7.50 Transients during step change in load torque (a 30 N-m load torque is applied at 0.5 s and removed at 0.6s).

7.51 The phase and line voltages of NSPWM based DTC during step change in load torque (a 30 N-m load torque is applied at 0.5 s and removed at 0.6s).

7.52 Transients in speed, torque, current and flux during speed reversal (speed is changed from +1200 rpm to -1200 rpm at 0.7 s).

7.53 Transients in phase and line voltages during speed reversal (speed is changed from +1200 rpm to -1200 rpm at 0.7 s).

7.54 Transients in speed, torque, current and flux during speed reversal (speed is changed from -1200 rpm to +1200 rpm at 1.35 s).

7.55 Transients in phase and line voltages during speed reversal (speed is changed from -1200 rpm to 1200 rpm at 1.35 s).

7.56 Speed-torque characteristic of NSPWM based DTC drive in
four-quadrants.

7.57 Common mode voltage variations in SVPWM base DTC drive 243
7.58 Common mode voltage variations in AZSPWM1 base DTC drive 243
7.59 Common mode voltage variations in AZSPWM2 base DTC drive 244
7.60 Common mode voltage variations in NSPWM base DTC drive 244