# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE NO.</th>
<th>PAGE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>3</td>
</tr>
<tr>
<td>1.2</td>
<td>5</td>
</tr>
<tr>
<td>1.3</td>
<td>6</td>
</tr>
<tr>
<td>1.4</td>
<td>9</td>
</tr>
<tr>
<td>1.5</td>
<td>9</td>
</tr>
<tr>
<td>1.6</td>
<td>11</td>
</tr>
<tr>
<td>2.1</td>
<td>27</td>
</tr>
<tr>
<td>2.2</td>
<td>39</td>
</tr>
<tr>
<td>2.3</td>
<td>40</td>
</tr>
<tr>
<td>3.1</td>
<td>53</td>
</tr>
<tr>
<td>3.2</td>
<td>60</td>
</tr>
<tr>
<td>3.3</td>
<td>61</td>
</tr>
<tr>
<td>3.4</td>
<td>62</td>
</tr>
<tr>
<td>3.5</td>
<td>63</td>
</tr>
<tr>
<td>4.1</td>
<td>68</td>
</tr>
<tr>
<td>4.2</td>
<td>72</td>
</tr>
</tbody>
</table>
4.3 Estimate of parameters using WM and WM with UDF (by-pass scheme) 73
5.1 Second order oscillatory system with computer connection 77
5.2 Measuring Realisation 83
5.3 Response of the simulated system (SG output) 85
5.4 Estimates of the simulated system using FM 86
5.5 Estimates of the simulated system under 2% noise condition using FM 87
5.6 Estimates of the simulated system using FM with by-pass scheme 88
5.7 Estimates of Simulated system using WM 89
5.8 Estimates of Simulated system under 2% noise condition using WM 90
5.9 Estimates of simulated system using WM with by-pass scheme 91
5.10 Conveyor belt system 94
5.11 Strain gauge (SG) output and estimate of mass in conveyor belt system at rest using FM 95
5.12 Strain gauge (SG) output and estimate of mass in conveyor belt system at rest using WM 96
5.13 Strain gauge (SG) output and estimate of mass flow rate of grain transported by the conveyor belt system using FM and WM 97
5.14 Total mass transported by the conveyor belt system using FM and WM 98
6.1 Structure of adaptive observer 107
6.2 System for identification 109
6.3 Estimate of parameters (a) parameter $a_1$
   (b) parameter $a_2$ 117
6.3 Estimate of parameters (c) parameter $b_1$
   (d) parameter $b_2$ 118
6.4 Error in states (a) state $x_1$ (b) state $x_2$
6.5 Estimate of parameters using FM for different state variable filter structures
   (a) parameter $a_1$ (b) parameter $a_2$
6.5 Estimate of parameters using FM for different state variable filter structures (c) parameter $b_1$
   (d) parameter $b_2$
6.6 Error in states using FM for different state variable filter structures (a) state $x_1$ (b) state $x_2$
6.7 (a) Estimate of parameters (b) Error in states, using FM with by-pass scheme ($f_1 = 0$)
6.8 Estimate of parameters using WM for different state variable filter structures (a) parameter $a_1$
   (b) parameter $a_2$
6.8 Estimate of parameters using WM for different state variable filter structures (c) parameter $b_1$
   (d) parameter $b_2$
6.9 Error in states using WM for different state variable filter structures (a) state $x_1$ (b) state $x_2$
6.10 (a) Estimate of parameters (b) Error in states, using WM with by-pass scheme ($f_1 = 0$)
7.1 Structure of adaptive observer
7.2 System for identification
7.3 Estimate of parameters with FM (a) parameters $a_1$, $a_2$, $a_3$ & $a_4$ (b) parameters $b_1$, $b_2$, $b_3$ & $b_4$
7.3 Estimate of parameters with FM (c) parameters $a_5$, $a_6$, $a_7$ & $a_8$ (d) parameters $b_5$, $b_6$, $b_7$ & $b_8$
7.4 Error in states with FM (a) states $x_1,x_2$ (b) states $x_3,x_4$
7.5 Estimates of parameters with FM using by-pass scheme (a) parameters $a_1$, $a_2$, $a_3$ & $a_4$ (b) parameters $b_1$, $b_2$, $b_3$ & $b_4$
7.5 Estimates of parameters with FM using by-pass scheme
(c) parameters \(a_5, a_6, a_7, \& a_8\) (d) parameters \(b_5, b_6, b_7, \& b_8\)
151

7.6 Error in states with FM using by-pass scheme
(a) states \(x_1, x_2\) (b) states \(x_3, x_4\)
152

7.7 Estimates of parameters with WM (a) parameters \(a_1, a_2, a_3, \& a_4\) (b) parameters \(b_1, b_2, b_3, \& b_4\)
153

7.8 Error in states with WM (a) states \(x_1, x_2\) (b) states \(x_3, x_4\)
154

7.9 Estimates of parameters with WM using by-pass scheme
(a) parameters \(a_1, a_2, a_3, \& a_4\) 
(b) parameters \(b_1, b_2, b_3, \& b_4\)
155

7.10 Error in states with WM using by-pass scheme
(a) states \(x_1, x_2\) (b) states \(x_3, x_4\)
156

8.1 Explicit self tuning controller
163

8.2 Control scheme for the explicit pole assignment controller
168

8.3 Modified control scheme for the explicit pole assignment controller
174

8.4 Estimate of Process parameters - Indirect adaptive pole assignment controller with FM
(a) Approach I (b) Approach II (c) Approach III
178

8.5 Estimates of controller parameters - Indirect adaptive pole assignment controller with FM
(a) Approach I (b) Approach II (c) Approach III
179

8.6 Process input - Indirect adaptive pole assignment controller with FM
(a) Approach I (b) Approach II (c) Approach III
180
8.7 Process output and setpoint - Indirect adaptive pole assignment controller with FM
(a) Approach I (b) Approach II (c) Approach III 181

8.8 Estimate of Process parameters - Indirect adaptive pole assignment controller with WM
(a) Approach I (b) Approach II (c) Approach III 182

8.9 Estimate of controller parameters - Indirect adaptive pole assignment controller with WM
(a) Approach I (b) Approach II (c) Approach III 183

8.10 Process input - Indirect adaptive pole assignment controller with WM
(a) Approach I (b) Approach II (c) Approach III 184

8.11 Process output and setpoint - Indirect adaptive pole assignment controller with WM
(a) Approach I (b) Approach II (c) Approach III 185

8.12 Estimate of Process parameters - Implicit minimum variance controller with FM
(a) Approach I (b) Approach II (c) Approach III 192

8.13 Process input - Implicit minimum variance controller with FM
(a) Approach I (b) Approach II (c) Approach III 193

8.14 Process output and setpoint - Implicit minimum variance controller with FM
(a) Approach I (b) Approach II (c) Approach III 194

8.15 Estimate of Process parameters - Implicit minimum variance controller with WM
(a) Approach I (b) Approach II (c) Approach III 195

8.16 Process input - Implicit minimum variance controller with WM
(a) Approach I (b) Approach II (c) Approach III 196

8.17 Process output and setpoint - Implicit minimum variance controller with WM
(a) Approach I (b) Approach II (c) Approach III 197
8.18 Block diagram of overall structure of state variable feedback pole placement control system 202

8.19 Estimate of Process parameters - State variable feedback pole placement controller with FM
   (a) Approach I (b) Approach II (c) Approach III 209

8.20 Error in States - State variable feedback pole placement controller with FM
   (a) Approach I (b) Approach II (c) Approach III 210

8.21 Feedback gain parameters - State variable feedback pole placement controller with FM
   (a) Approach I (b) Approach II (c) Approach III 211

8.22 Process input - State variable feedback pole placement controller with FM
   (a) Approach I (b) Approach II (c) Approach III 212

8.23 Process output and setpoint - State variable feedback pole placement controller with FM
   (a) Approach I (b) Approach II (c) Approach III 213

8.24 Estimate of Process parameters - State variable feedback pole placement controller with WM
   (a) Approach I (b) Approach II (c) Approach III 214

8.25 Error in States - State variable feedback pole placement controller with WM
   (a) Approach I (b) Approach II (c) Approach III 215

8.26 Feedback gain parameters - State variable feedback pole placement controller with WM
   (a) Approach I (b) Approach II (c) Approach III 216

8.27 Process input - State variable feedback pole placement controller with WM
   (a) Approach I (b) Approach II (c) Approach III 217

8.28 Process output and setpoint - State variable feedback pole placement controller with WM
   (a) Approach I (b) Approach II (c) Approach III 218