

```
1 clc;
2 close all;
3
4 K_u = 1.2; % [-]
5 R_a = 2.08; % [ohm]
6 K_m = 24e-3; % [N*m/A]
7 J = 0.0051; % [kg*m^2]
8 K_b = 0.024; % [V*sec/rad]
9 L_a = 0.26e-3; % [H]
10 b = 0.009; % [kg*m^2/rad*sec]
11 N_r = 57/11; % [-]
12
13 simulation_time = 100; % [sec]
14 simulation_start_time = 0; % [sec]
15 simulation_end_time = simulation_start_time + ✓
simulation_time; % [sec]
16 integration_step_time = 0.0001; % [sec]
17
18 u_t = 1; % [V]
19 T_d = 0; % [N*m]
20
21 %% Q1.3.
22
23 Q13_sim = sim("Q1sim.slx");
24
25 fig1 = figure ("Name","θ - Step Response for u(t) = 1*1 ✓
(t); Td(t) = 0",'Position',[100 350 900 500]);
26 hold all
27 grid on
28 grid minor
29
30 plot (Q13_sim.theta.time, Q13_sim.theta.signals.values ✓
,'LineWidth',2,'Color',"#0072BD")
31
32
```

```
33 title ("θ - Step Response for u(t) = 1*1(t); Td(t) = 0");
34 subtitle("Almog Dobrescu 214254252")
35 ylabel("θ(t) [rad]")
36 xlabel("t [sec]")
37 grid on
38 grid minor
39 legend({'θ(t)'}, 'FontSize', 11, 'Location', 'southeast')
40 %exportgraphics(fig1, '1.3grap1.png', 'Resolution', 1200);
41
42 %% Q1.4
43
44 K_u = 1.2; % [-]
45 R_a = 2.08; % [ohm]
46 K_m = 24e-3; % [N*m/A]
47 J = 0.0051; % [kg*m^2]
48 K_b = 0.024; % [V*sec/rad]
49 L_a = 0; % [H]
50 b = 0.009; % [kg*m^2/rad*sec]
51 N_r = 57/11; % [-]
52
53 simulation_time = 100; % [sec]
54 simulation_start_time = 0; % [sec]
55 simulation_end_time = simulation_start_time + ✓
simulation_time; % [sec]
56
57 u_t = 1; % [V]
58 T_d = 0; % [N*m]
59
60 Q14_sim = sim("Q1sim.slx");
61
62 fig2 = figure ("Name", "θ - Step Response for u(t) = 1*1 ✓
(t); T_d(t) = 0; L_a = 0", 'Position', [250 350 900 500]);
63 hold all
64 grid on
65 grid minor
```

```
66
67 plot (Q13_sim.theta.time, Q13_sim.theta.signals.values✓
,'LineWidth',2,'Color','#0072BD')
68 plot (Q14_sim.theta.time, Q14_sim.theta.signals.values✓
,'--','LineWidth',2,'Color','#D95319')
69
70 title ("θ - Step Response for u(t) = 1*1(t); T_d(t) = 0;✓
L_a = 0");
71 subtitle("Almog Dobrescu 214254252")
72 ylabel("θ(t) [rad]")
73 xlabel("t [sec]")
74 legend({'θ(t), L_a = 0.26e-3', 'θ(t), L_a =✓
0'}, 'FontSize',11 , 'Location','southeast')
75 %exportgraphics(fig2, '1.4grap1.png','Resolution',1200);
76
77 %% Q2.1.
78
79 p = tf(0.1492,[0.01061 0.0342 0]);
80 mp = 0.20;
81 zeta = (abs(log(mp))) / sqrt(pi^2 + (abs(log(mp))^2));
82 ts_5 = 1;
83 omega_n = (log(1/0.05)) / (zeta * ts_5);
84
85 % rltool(p);
86
87 %% Q2.3.
88
89 p = tf(0.1492,[0.01061 0.0342 0]);
90
91 poles_p = pole(p);
92
93 rad2deg(atan2(4.2849,-4.2));
94 rad2deg(atan2(4.2849,-7.4234));
95
96 s = complex(-4.2, 4.2849);
```

```
97 expr = (0.1492*(s+5.3028)) / (0.01061*s^2 + 0.0342*s);
98 k = 1/abs(expr);
99
100 % rltool(p)
101
102 %% Q2.4.
103
104 p = tf(K_u*K_m*N_r,[J*L_a J*R_a+b*L_a b*R_a+K_b*K_m*N_r^2✓
0]);
105 c = 0.4239*tf([1 5.3028],1);
106 G = c*p / (1+c*p);
107 bandwidth(G);
108
109 %% Q2.5.
110
111 K_u = 1.2; % [-]
112 R_a = 2.08; % [ohm]
113 K_m = 24e-3; % [N*m/A]
114 J = 0.0051; % [kg*m^2]
115 K_b = 0.024; % [V*sec/rad]
116 L_a = 0; % [H]
117 b = 0.009; % [kg*m^2/rad*sec]
118 N_r = 57/11; % [-]
119
120 simulation_time = 100; % [sec]
121 simulation_start_time = 0; % [sec]
122 simulation_end_time = simulation_start_time + ✓
simulation_time; % [sec]
123
124 theta_ref = pi/4; % [V]
125 T_d = 0; % [N*m]
126 k_p = 2.2479;
127 k_d = 0.4239;
128
129 t = 0:0.01:2;
```

```
130
131 p = tf(K_u*K_m*N_r,[J*L_a J*R_a+b*L_a b*R_a+K_b*K_m*N_r^2✓
0]);
132 c = 0.4239*tf([1 5.3028],1);
133 G = c*p / (1+c*p);
134
135 [Q25y, Q25time] = step(G*theta_ref,t);
136 infoQ25 = stepinfo(G*theta_ref, "SettlingTimeThreshold",✓
0.05);
137
138 fig3 = figure ("Name","θ - Step Response for θ_ref = π/4*1✓
(t); T_d(t) = 0; L_a = 0",'Position',[400 350 900 500]);
139 hold all
140 grid on
141 grid minor
142
143 plot(Q25time, Q25y,'LineWidth',2,'Color','#0072BD')
144
145 title ("θ - Step Response for θ_ref = π/4*1(t); T_d(t) =✓
0; L_a = 0");
146 subtitle("Almog Dobrescu 214254252 ")
147 ylabel("θ(t) [rad]")
148 xlabel("t [sec]")
149 legend({'θ(t)'},'FontSize',11 ,'Location','southeast')
150 %exportgraphics(fig3, '2.5grap1.png','Resolution',1200);
151
152 %%
153
154 K_u = 1.2; % [-]
155 R_a = 2.08; % [ohm]
156 K_m = 24e-3; % [N*m/A]
157 J = 0.0051; % [kg*m^2]
158 K_b = 0.024; % [V*sec/rad]
159 L_a = 0; % [H]
160 b = 0.009; % [kg*m^2/rad*sec]
```

```
161 N_r = 57/11; % [-]
162
163 simulation_time = 100; % [sec]
164 simulation_start_time = 0; % [sec]
165 simulation_end_time = simulation_start_time + ✓
simulation_time; % [sec]
166
167 theta_ref = pi/4; % [V]
168 T_d = 0; % [N*m]
169 k_p = 2.2479;
170 k_d = 0.4239;
171
172 t = 0:0.01:2;
173
174 p = tf(K_u*K_m*N_r,[J*L_a J*R_a+b*L_a b*R_a+K_b*K_m*N_r^2 ✓
0]);
175 c = 0.4239*tf([1 5.3028],1);
176 G = 1 / (1+c*p);
177
178 [Q251y, Q251time] = step(G*theta_ref,t);
179
180 fig4 = figure ("Name","e - Step Response for  $\theta_{ref} = \pi/4*1 ✓
(t)$ ;  $T_d(t) = 0$ ;  $L_a = 0$ ", 'Position',[550 350 900 500]);
181 hold all
182 grid on
183 grid minor
184
185 plot(Q251time, Q251y, 'LineWidth',2, 'Color','#0072BD')
186
187 title ("e - Step Response for  $\theta_{ref} = \pi/4*1(t)$ ;  $T_d(t) = ✓
0$ ;  $L_a = 0$ ");
188 subtitle("Almog Dobrescu 214254252 ")
189 ylabel("e(t) [rad]")
190 xlabel("t [sec]")
191 legend({'e(t)'}, 'FontSize',11 , 'Location','southeast')
```

```
192 %exportgraphics(fig4, '2.5grap2.png','Resolution',1200);
193
194 %%
195
196 K_u = 1.2; % [-]
197 R_a = 2.08; % [ohm]
198 K_m = 24e-3; % [N*m/A]
199 J = 0.0051; % [kg*m^2]
200 K_b = 0.024; % [V*sec/rad]
201 L_a = 0; % [H]
202 b = 0.009; % [kg*m^2/rad*sec]
203 N_r = 57/11; % [-]
204
205 simulation_time = 2.5; % [sec]
206 simulation_start_time = 0; % [sec]
207 simulation_end_time = simulation_start_time + ✓
simulation_time; % [sec]
208 integration_step_time = 0.0001; % [sec]
209
210 theta_ref = pi/4; % [V]
211 T_d = 0; % [N*m]
212 k_p = 2.2479;
213 k_d = 0.4239;
214 t = simulation_start_time:integration_step_time:✓
simulation_time;
215
216 p = tf(K_u*K_m*N_r,[J*L_a J*R_a+b*L_a b*R_a+K_b*K_m*N_r^2✓
0]);
217 poles_p = pole(p);
218 epsilon = 1/abs(poles_p(2)*75);
219
220 Q26_sim = sim("Q2sim.slx");
221
222 pure_c = 0.4239*tf([1 5.3028],1);
223 pure_G = pure_c*p / (1+pure_c*p);
```

```
224
225 pseudo_c = k_p + tf([k_d 1], [epsilon 1]);
226 pseudo_G = pseudo_c*p / (1+pseudo_c*p);
227
228 [Q25y, Q25time] = step(pure_G*theta_ref,t);
229
230 fig5 = figure ("Name"," $\theta$  - Step Response for  $\theta_{ref} = \pi/4*1$ ✓
(t);  $T_d(t) = 0$ ;  $L_a = 0$ ", 'Position', [700 350 900 500]);
231 hold all
232 grid on
233 grid minor
234
235 plot(Q25time, Q25y, 'LineWidth',2, 'Color', "#0072BD")
236 plot (Q26_sim.theta.time, Q26_sim.theta.signals.values✓
, '--', 'LineWidth',2, 'Color', "#D95319")
237
238 title (" $\theta$  - Step Response for  $\theta_{ref} = \pi/4*1(t)$ ;  $T_d(t) =$ ✓
0;  $L_a = 0$ ");
239 subtitle("Almog Dobrescu 214254252")
240 ylabel(" $\theta(t)$  [rad]")
241 xlabel("t [sec]")
242 legend({' $\theta(t)$ , pure PD', ' $\theta(t)$ , pseudo PD'}, 'FontSize', 11✓
, 'Location', 'southeast')
243 %exportgraphics(fig5, '2.6grap1.png', 'Resolution', 1200);
244
245
246 pure_G = 1 / (1+pure_c*p);
247 [Q25y2, Q25time2] = step(pure_G*theta_ref,t);
248
249 fig6 = figure ("Name"," $\theta$  - Step Response for  $\theta_{ref} = \pi/4*1$ ✓
(t);  $T_d(t) = 0$ ;  $L_a = 0$ ", 'Position', [100 200 900 500]);
250 hold all
251 grid on
252 grid minor
253
```



```
254 plot(Q25time2, Q25y2, 'LineWidth',2, 'Color', "#0072BD")
255 plot (Q26_sim.e_output.time, Q26_sim.e_output.signals.✓
values , '--', 'LineWidth',2, 'Color', "#D95319")
256
257 title ("e - Step Response for  $\theta_{ref} = \pi/4 * 1(t)$ ;  $T_d(t) =$ ✓
0;  $L_a = 0$ ");
258 subtitle("Almog Dobrescu 214254252")
259 ylabel("e(t) [rad]")
260 xlabel("t [sec]")
261 legend({'e(t), pure PD', 'e(t), pseudo PD'}, 'FontSize', 11✓
, 'Location', 'northeast')
262 %exportgraphics(fig6, '2.6grap2.png', 'Resolution', 1200);
263
264 fig7 = figure ("Name", "u - Step Response for  $\theta_{ref} = \pi/4 * 1$ ✓
(t);  $T_d(t) = 0$ ;  $L_a = 0$ ", 'Position', [250 200 900 500]);
265 hold all
266 grid on
267 grid minor
268
269 plot (Q26_sim.u_output.time, Q26_sim.u_output.signals.✓
values , 'LineWidth',2, 'Color', "#D95319")
270
271 title ("u - Step Response for  $\theta_{ref} = \pi/4 * 1(t)$ ;  $T_d(t) =$ ✓
0;  $L_a = 0$ ");
272 subtitle("Almog Dobrescu 214254252")
273 ylabel("u(t) [V]")
274 xlabel("t [sec]")
275 legend({'u(t), pseudo PD'}, 'FontSize', 11✓
, 'Location', 'northeast')
276 %exportgraphics(fig7, '2.6grap3.png', 'Resolution', 1200);
277
278 %%
279
280 K_u = 1.2; % [-]
281 R_a = 2.08; % [ohm]
```

```
282 K_m = 24e-3; % [N*m/A]
283 J = 0.0051; % [kg*m^2]
284 K_b = 0.024; % [V*sec/rad]
285 L_a = 0; % [H]
286 b = 0.009; % [kg*m^2/rad*sec]
287 N_r = 57/11; % [-]
288 zeta = sqrt(2)/2;
289 omega_n = 60; % [rad/sec]
290
291 simulation_time = 2.5; % [sec]
292 simulation_start_time = 0; % [sec]
293 simulation_end_time = simulation_start_time + ✓
simulation_time; % [sec]
294 integration_step_time = 0.0001; % [sec]
295
296 theta_ref = pi/4; % [V]
297 T_d = 0; % [N*m]
298 k_p = 2.2479;
299 k_d = 0.4239;
300 t = simulation_start_time:integration_step_time:✓
simulation_time;
301
302 p = tf(K_u*K_m*N_r,[J*L_a J*R_a+b*L_a b*R_a+K_b*K_m*N_r^2 ✓
0]);
303 poles_p = pole(p);
304 epsilon = 1/abs(poles_p(2)*75);
305
306 Q27_sim = sim("Q27sim.slx");
307 infoQ27 = stepinfo(Q27_sim.theta.signals.values,Q27_sim.✓
theta.time,'SettlingTimeThreshold',0.05);
308
309 fig8 = figure ("Name","Step Response for  $\theta_{ref} = \pi/4 \cdot 1(t)$  ✓
with Pre-Filter",'Position',[400 200 900 500]);
310 hold all
311 grid on
```

```
312 grid minor
313
314 plot (Q27_sim.theta.time, Q27_sim.theta.signals.values✓
, 'LineWidth', 2, 'Color', "#0072BD")
315 plot (Q27_sim.e_output.time, Q27_sim.e_output.signals.✓
values , 'LineWidth', 2, 'Color', "#D95319")
316 plot (Q27_sim.u_output.time, Q27_sim.u_output.signals.✓
values , '-.', 'LineWidth', 2, 'Color', "#7E2F8E")
317
318 title ("Step Response for  $\theta_{ref} = \pi/4 * 1(t)$  with Pre-✓
Filter");
319 subtitle("Almog Dobrescu 214254252")
320 ylabel("Amplitude")
321 xlabel("t [sec]")
322 legend({' $\theta(t)$ ', 'e(t)', 'u(t)'}, 'FontSize', 11✓
, 'Location', 'northeast')
323 %exportgraphics(fig8, '2.7grap1.png', 'Resolution', 1200);
324
```