```matlab
% load variables in workspace of LAB0 (parameters according to motor 8)
load params_inertial_case.mat
load params_estimated_LAB0.mat
load PID_params_LAB0.mat
```

```matlab
% open simulink model (we added the antiwindup component)
open_system('robust_tracking_integral_BONUS.slx');
set_param('robust_tracking_integral_BONUS','SolverType', 'Variable-step', 'Solver', 'ode45', 'S
```

```matlab
Beq = Beq_hat;                              % mot.B + mld.B/gbox.N^2;
Jeq = Jeq_hat;
model.km = (drv.dcgain*mot.Kt)/(Req*Beq + mot.Kt*mot.Ke);
model.Tm = (Req*Jeq)/(Req*Beq + mot.Kt*mot.Ke);
sens.enc.pulse2deg = 360/2000; % in lab da cambiare in 360/4096

%   non-encapsulated SS data
A = [0, 1; 0, -1/model.Tm];
B = [0; model.km/(gbox.N*model.Tm)];
C = [1, 0];
D = 0;

%   SS data encapulated in a SS object
sys = ss(A, B, C, D);

%compute N_x, N_u
S = [A,B;C,0];
b=[0 0 1]';
N = linsolve(S,b); %Sx=b
N_x = [N(1) N(2)];
N_u = N(3);

% define H1 filter
H1.wc = 2*pi*50;
H1.d = 1/sqrt(2);
H1s = tf([H1.wc^2,0],[1, 2*H1.d*H1.wc, H1.wc^2]);
[numH1, denH1] = tfdata(H1s,'v');

%specs
spec.ts5    = 0.15;          % Settling-time
spec.Mp     = 0.1;           % Overshoot
spec.damp   = log(1/spec.Mp) / (sqrt(pi^2+(log(1/spec.Mp))^2));
spec.wn     = 3 / (spec.damp*spec.ts5);
```

```matlab
step_size = 70;
awu.Kw = [5,10,20,5/ctrl.ts5 , 20]
```

```
awu = struct with fields:
    Kw: [5 10 20 33.3333 20]
```

Robust Tracking Design

```matlab
%poles
sigma=-spec.damp*spec.wn;
omega_d=spec.wn*sqrt(1-spec.damp^2);

p4 = [sigma+omega_d*j , sigma-omega_d*j , sigma ];
p2 = [sigma , sigma , sigma ];
p3 = [2*sigma+omega_d*j , 2*sigma-omega_d*j , 2*sigma ];
p4 = [2*sigma+omega_d*j , 2*sigma-omega_d*j , 3*sigma ];
```

```matlab
%space model with augmented state
zer = zeros(2,1);
Ae=[0 C; zer A];
Be=[0; B];
Ce=[0 C];
```

```matlab
%1st pole
ctrl.Kw = awu.Kw(4);
Ke = acker(Ae,Be,p1);
sim('robust_tracking_integral_BONUS');
data.tr1    = MotorData.time;
data.thlr1  = MotorData.signals(1).values;
```

```matlab
%2nd pole
ctrl.Kw = awu.Kw(4);
Ke = acker(Ae,Be,p2);
sim('robust_tracking_integral_BONUS');
data.tr2    = MotorData.time;
data.thlr2  = MotorData.signals(1).values;
```

```matlab
%3rd pole
ctrl.Kw = awu.Kw(4);
Ke = acker(Ae,Be,p3);
sim('robust_tracking_integral_BONUS');
data.tr3    = MotorData.time;
data.thlr3  = MotorData.signals(1).values;
```
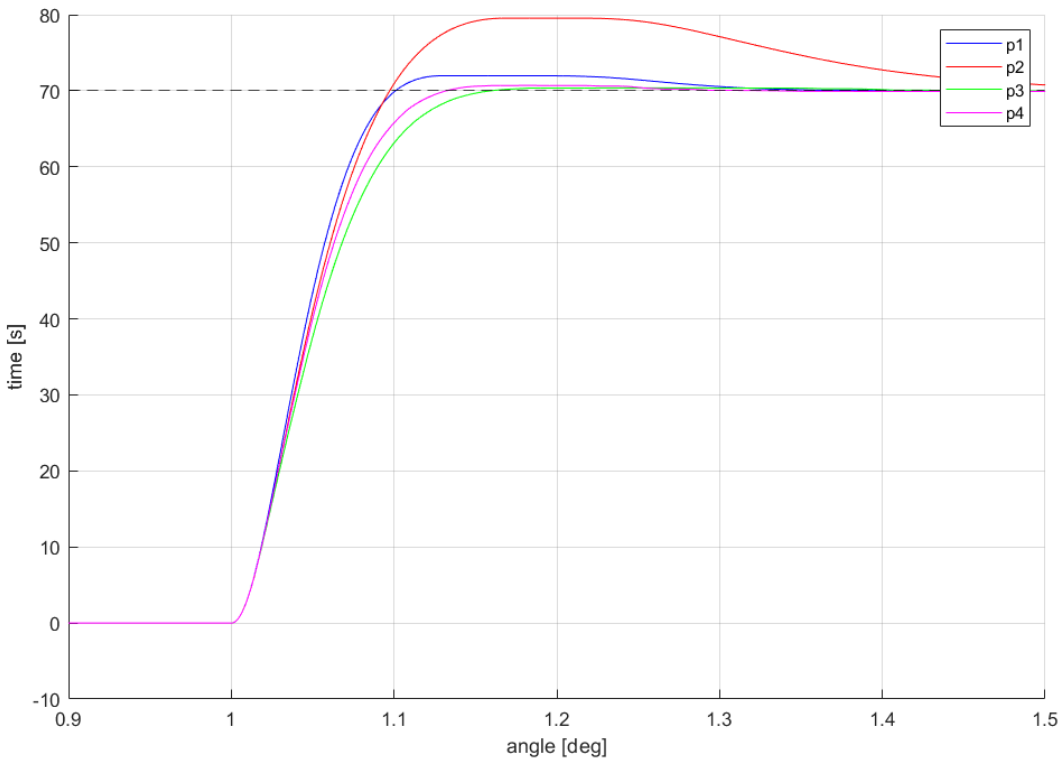
```matlab
%4th pole
ctrl.Kw = awu.Kw(4);
Ke = acker(Ae,Be,p4);
sim('robust_tracking_integral_BONUS');
data.tr4    = MotorData.time;
data.thlr4  = MotorData.signals(1).values;
```

```matlab
figure('Renderer', 'painters', 'Position', [10 10 900 600])
hold on;
```

```matlab
plot(data.tr1,data.th1r1,'b');
plot(data.tr2,data.th1r2,'r');
plot(data.tr3,data.th1r3,'g');
plot(data.tr4,data.th1r4,'m');
yline(step_size,'k--')
hold off;
legend('p1','p2','p3','p4');
xlabel('angle [deg]');
ylabel('time [s]');
grid on
xlim([0.9,1.5]);
```


P2 don't works well

```matlab
awu.Kw = [0.7,1,2, 3]
```

```
awu = struct with fields:
    Kw: [0.7000 1 2 3]
     p: [3×3 double]
```

p1:

```matlab
Ke = acker(Ae,Be,p1);
ctrl.Kw = awu.Kw(1);
sim('robust_tracking_integral_BONUS');
data.p1.t1   = MotorData.time;
data.p1.th1  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(2);
```

3

```matlab
sim('robust_tracking_integral_BONUS');
data.p1.t2   = MotorData.time;
data.p1.th2  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(3);
sim('robust_tracking_integral_BONUS');
data.p1.t3   = MotorData.time;
data.p1.th3  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(4);
sim('robust_tracking_integral_BONUS');
data.p1.t4   = MotorData.time;
data.p1.th4  = MotorData.signals(1).values;

figure('Renderer', 'painters', 'Position', [10 10 900 600])
hold on;
plot(data.p1.t1,data.p1.th1,'b');
plot(data.p1.t2,data.p1.th2,'r');
plot(data.p1.t3,data.p1.th3,'g');
plot(data.p1.t4,data.p1.th4,'m');
yline(step_size,'k--')
yline(step_size*1.1,'k')
hold off;
legend('Kw_1','Kw_2','Kw_3','Kw_4');
xlabel('angle [deg]');
ylabel('time [s]');
grid on
xlim([0.9,1.5]);
```
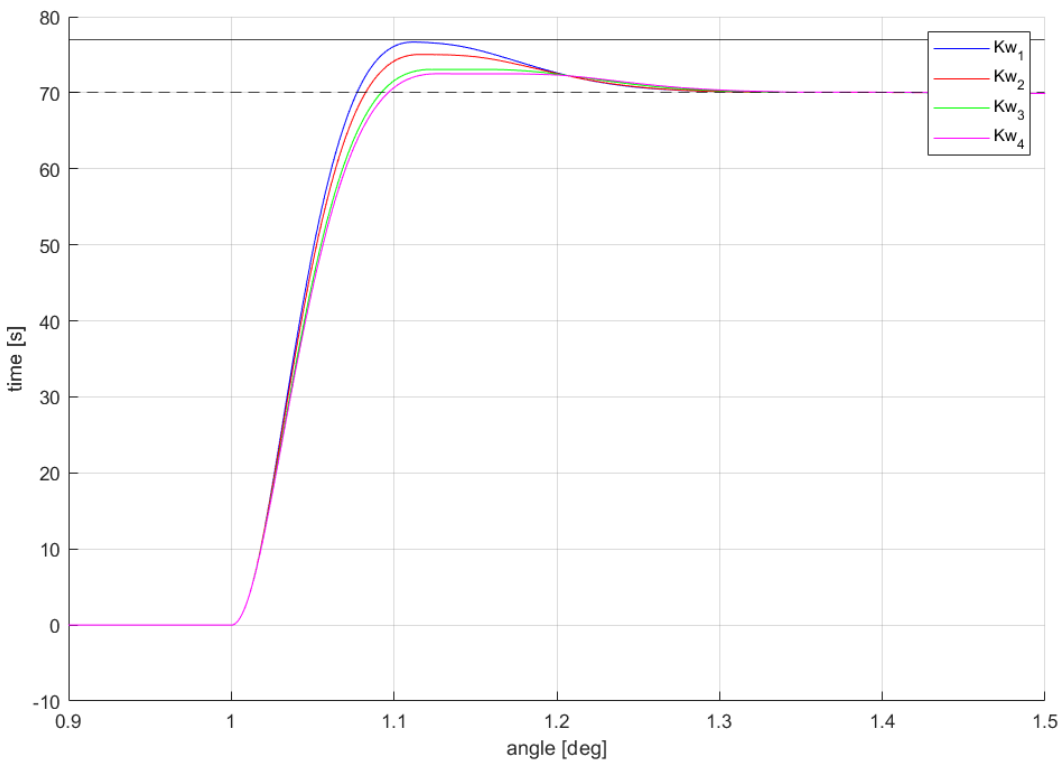
```
stepinfo(data.p1.th1,data.p1.t1,"SettlingTimeThreshold",0.05)
```

```
ans = struct with fields:
        RiseTime: 0.0506
    SettlingTime: 1.1841
     SettlingMin: 63.1120
     SettlingMax: 76.6631
       Overshoot: 9.3968
      Undershoot: 1.2428e-25
            Peak: 76.6631
        PeakTime: 1.1116
```

```
stepinfo(data.p1.th2,data.p1.t2,"SettlingTimeThreshold",0.05)
```

```
ans = struct with fields:
        RiseTime: 0.0536
    SettlingTime: 1.1794
     SettlingMin: 63.2175
     SettlingMax: 75.0350
       Overshoot: 7.0961
      Undershoot: 1.2430e-25
            Peak: 75.0350
        PeakTime: 1.1158
```

```
awu.Kw = [0.05,0.1,0.5, 1]
```

```
awu = struct with fields:
    Kw: [0.0500 0.1000 0.5000 1]
     p: [3×3 double]
```

p3:

```
Ke = acker(Ae,Be,p3);
ctrl.Kw = awu.Kw(1);
sim('robust_tracking_integral_BONUS');
data.p3.t1   = MotorData.time;
data.p3.th1  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(2);
sim('robust_tracking_integral_BONUS');
data.p3.t2   = MotorData.time;
data.p3.th2  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(3);
sim('robust_tracking_integral_BONUS');
data.p3.t3   = MotorData.time;
data.p3.th3  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(4);
sim('robust_tracking_integral_BONUS');
data.p3.t4   = MotorData.time;
data.p3.th4  = MotorData.signals(1).values;

figure('Renderer', 'painters', 'Position', [10 10 900 600])
hold on;
plot(data.p3.t1,data.p3.th1,'b');
plot(data.p3.t2,data.p3.th2,'r');
plot(data.p3.t3,data.p3.th3,'g');
plot(data.p3.t4,data.p3.th4,'m');
yline(step_size,'k--')
```

```
yline(step_size*1.1,'k')
hold off;
legend('Kw_1','Kw_2','Kw_3','Kw_4');
xlabel('angle [deg]');
ylabel('time [s]');
grid on
xlim([0.9,1.5]);
```
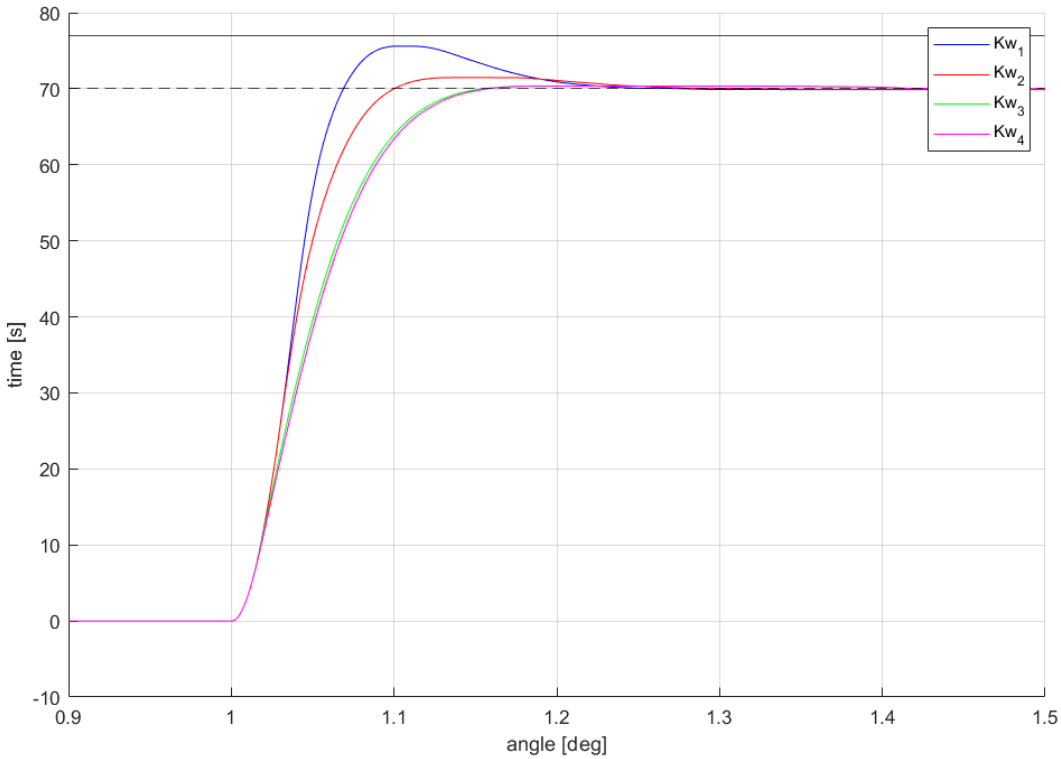


```
stepinfo(data.p3.th1,data.p3.t1,"SettlingTimeThreshold",0.05)
```

```
ans = struct with fields:
        RiseTime: 0.0418
    SettlingTime: 1.1519
     SettlingMin: 63.0323
     SettlingMax: 75.6034
       Overshoot: 8.1139
      Undershoot: 1.2454e-25
            Peak: 75.6034
        PeakTime: 1.1019
```

```
stepinfo(data.p3.th2,data.p3.t2,"SettlingTimeThreshold",0.05)
```

```
ans = struct with fields:
        RiseTime: 0.0566
    SettlingTime: 1.0816
     SettlingMin: 63.1086
     SettlingMax: 71.4678
       Overshoot: 2.0043
      Undershoot: 1.2430e-25
            Peak: 71.4678
        PeakTime: 1.1502
```

```
awu.Kw = [0.03,0.045,0.05, 0.09]
```

```
awu = struct with fields:
    Kw: [0.0300 0.0450 0.0500 0.0900]
     p: [3×3 double]
```

p4:

```
Ke = acker(Ae,Be,p4);
ctrl.Kw = awu.Kw(1);
sim('robust_tracking_integral_BONUS');
data.p4.t1   = MotorData.time;
data.p4.th1  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(2);
sim('robust_tracking_integral_BONUS');
data.p4.t2   = MotorData.time;
data.p4.th2  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(3);
sim('robust_tracking_integral_BONUS');
data.p4.t3   = MotorData.time;
data.p4.th3  = MotorData.signals(1).values;
ctrl.Kw = awu.Kw(4);
sim('robust_tracking_integral_BONUS');
data.p4.t4   = MotorData.time;
data.p4.th4  = MotorData.signals(1).values;

figure('Renderer', 'painters', 'Position', [10 10 900 600])
hold on;
plot(data.p4.t1,data.p4.th1,'b');
plot(data.p4.t2,data.p4.th2,'r');
plot(data.p4.t3,data.p4.th3,'g');
plot(data.p4.t4,data.p4.th4,'m');
yline(step_size,'k--')
yline(step_size*1.1,'k')
hold off;
legend('Kw_1','Kw_2','Kw_3','Kw_4');
xlabel('angle [deg]');
ylabel('time [s]');
grid on
xlim([0.9,1.5]);
```
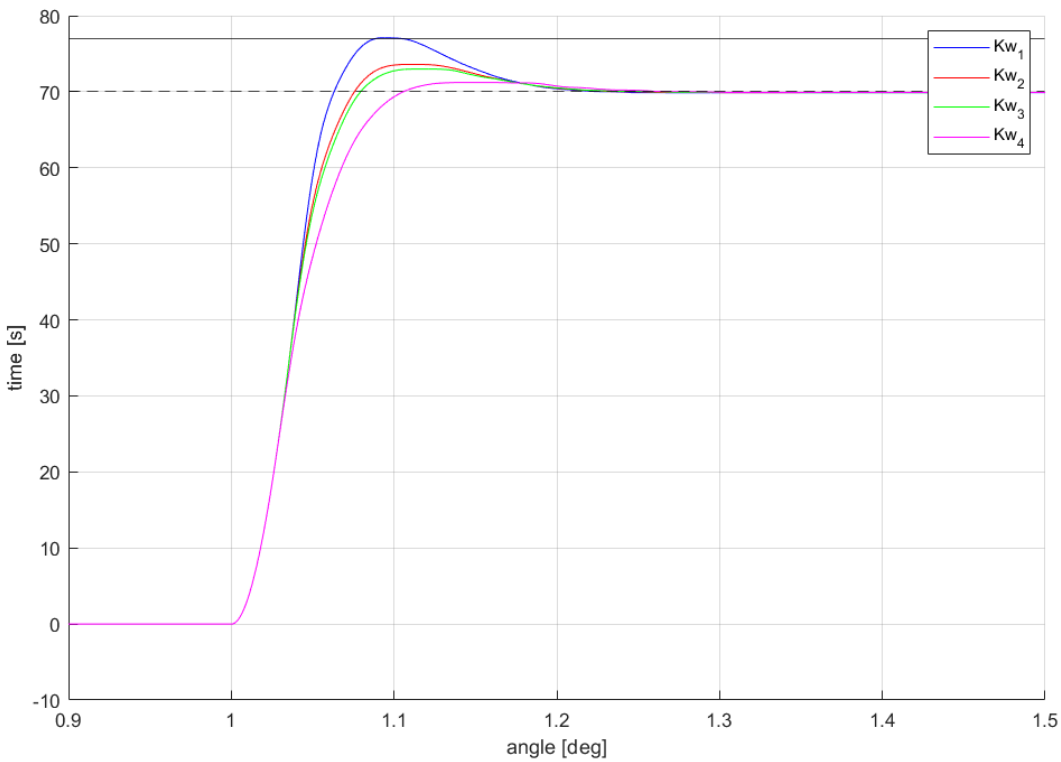
```matlab
stepinfo(data.p4.th1,data.p4.t1,"SettlingTimeThreshold",0.05)
```

```
ans = struct with fields:
      RiseTime: 0.0386
   SettlingTime: 1.1449
    SettlingMin: 63.1641
    SettlingMax: 77.0995
      Overshoot: 10.2821
     Undershoot: 1.2457e-25
          Peak: 77.0995
       PeakTime: 1.0932
```

```matlab
stepinfo(data.p4.th2,data.p4.t2,"SettlingTimeThreshold",0.05)
```

```
ans = struct with fields:
      RiseTime: 0.0454
   SettlingTime: 1.1184
    SettlingMin: 63.0928
    SettlingMax: 73.5936
      Overshoot: 5.0094
     Undershoot: 1.2427e-25
          Peak: 73.5936
       PeakTime: 1.1067
```