ELEC 341 – Graded Assignments

Assignment A7
Delay, Filters & PD-Control

100 Marks

Required Files

Available on Canvas

- **e341-a7.pdf** *Assignment description (this document)*
- **a7Submit.p** *Grading script (**LATEST** version)*
- **e341-APE.pdf** *Instructions for submitting graded work (for reference)*

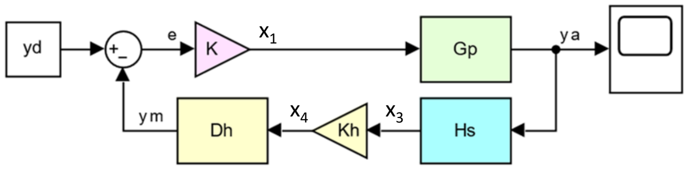
Topics

Delay LTI Model
- feedback dynamics

Filtering
- FIR & IIR

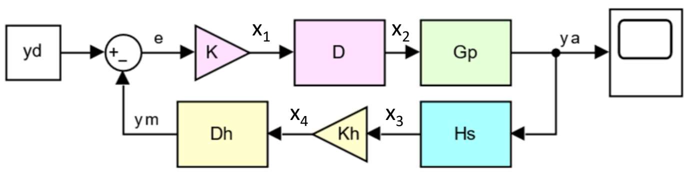
PD Control
- branch dynamics

Figure 1



Parameter	Value	Physical Units
CF	#A x 10	Hz
DC	30	%
τ_f	#B + #C	ms

Figure 2



A proportional controller **K** controls a plant **Gp** with a sensor **Hs**, as shown in **Figure 1**.
Gp and **Hs** have the Open-Loop characteristics specified in **Assignment A6**.
Specify the forward path gain **G**: $\mathbf{G = y_a/x_1}$
Specify the feedback path gain **H**: $\mathbf{H = x_4/y_a}$

1. 0 mark(s) Open-Loop TF
- Q1.G (m/V) LTI
- Q1.H (m/m) LTI

The micro-controller ISR executes at the Control Frequency **CF** with a Duty-Cycle **DC**.
Find the total delay multiple **N** that accounts for duty-cycle & hold delay.
Find the associated controller pole frequency $\boldsymbol{\omega_p}$ and feedback dynamics $\mathbf{D_h}$.

2. 15 mark(s) Delay Overhead
- Q2.N (pure) Scalar
- Q2.wp (m/V) Scalar
- Q2.Dh (pure) LTI

***COW**: The **frequency** is of a pole is always positive, even when its in the left-half plane.*
Is the dynamics pole dominant ??? Would it be wise to add a filter ???

Sensor noise is compensated by an FIR filter with a time constant τ_f.
Find the number of filter coefficients **NC** (none below 2%).
Find the weighting coefficients **W**, filter delay $\mathbf{N_f}$ and new total delay multiple **N**.
Determine the associated pole frequency $\boldsymbol{\omega_p}$.

3. 20 mark(s) FIR Filter

• Q3.NC	(pure)	Scalar
• Q3.W	(pure)	1x**NC** Vector
• Q3.Nf	(pure)	Scalar
• Q3.N	(pure)	Scalar
• Q3.wp	(rad/s)	Scalar

COW: *Plot the continuous curve* $e^{-t/\tau f}$ & raw coefficients. Do they match ???

RCG: **1% < $\mathbf{OS_u}$ < 3%**
Re-calculate $\mathbf{D_h}$ to include the FIR filter delay.
Find the proportional controller gain **K** that satisfies the above RCG.
Find settle time $\mathbf{T_s}$ and steady-state error $\mathbf{E_{ss}}$.

4. 15 mark(s) P-Control

• Q4.K	(V/m)	Scalar
• Q4.Ts	(s)	Scalar
• Q4.Ess	(%)	Scalar

The proportional controller in **Figure 1** is replaced by a PD-controller in **Figure 2**.
Use the controller zero to cancel the most dominant **system** pole.
Find the controller dynamics **D**.

5. 10 mark(s) PD Dynamics

• Q5.D	(pure)	LTI

Find the master gain **K** that satisfies the RCG from **Q4**.
Find the corresponding normalized (**K=1**) proportional $\mathbf{K_p}$ and derivative $\mathbf{K_d}$ gains.

6. 10 mark(s) PD Control

• Q6.Kp	(pure)	Scalar
• Q6.Kd	(pure)	Scalar

Find settle time $\mathbf{T_s}$ and steady-state error $\mathbf{E_{ss}}$.

7. 5 mark(s) PD Metrics

• Q7.Ts	(s)	Scalar
• Q7.Ess	(%)	Scalar

COW: *Did* T_s *and/or* E_{ss} *get better with PD-Control ???*

The proportional controller in **Figure 1** is replaced by a PI-controller in **Figure 2**.
Use the controller zero to cancel the most dominant **system** pole.
Find the controller dynamics **D**.

8. 10 mark(s) PI Dynamics

- Q8.D (pure) LTI

Find the master gain **K** that satisfies the RCG from **Q4**.
Find the corresponding normalized (**K=1**) proportional $\mathbf{K_p}$ and integral $\mathbf{K_i}$ gains.

9. 10 mark(s) PI Control

- Q9.Kp (pure) Scalar
- Q9.Ki (pure) Scalar

Find settle time $\mathbf{T_s}$ and steady-state error $\mathbf{E_{ss}}$.

10. 5 mark(s) PI Metrics

- Q10.Ts (s) Scalar
- Q10.Ess (%) Scalar

COW: *Did T_s and/or E_{ss} get better with PI-Control ???*

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