ELEC 341 – Graded Assignments

Assignment A6
Proportional Control

10 Marks

Learning Objectives

Proportional Control
Rate & Position Control
Pole-Zero Plots
Final Value
Steady-State Error
Heuristic Tuning

Matlab
- zpk()
- margin()
- pzmap()

The rate control system in Fig 1 has a plant EMS, a unity gain sensor SEN, and operates at the specified Control Frequency. The controller does not use any weighted sum filters.

EMS and SEN have the Open-Loop pole-zero plot shown in Fig 2.

Q1 3 mark(s) Rate Control

Compute the open-loop transfer function GH.
Find the Ultimate Gain Ku. This is also called Kappa *(𝕂)*
Compute the closed-loop transfer function X with **K = Ku/2**.
Calculate the steady-state error Ess of X.

GH	Input = Desired Speed (m/s)	Output = Measured Speed (m/s)
Ku	Ultimate proportional gain (ie. 𝕂)	
X	Input = Desired Speed (m/s)	Output = Actual Speed (m/s)
Ess	Percentage difference between Desired & Actual Speed.	

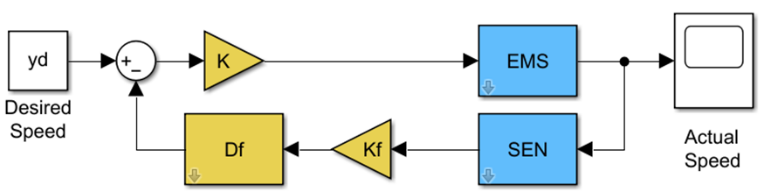
- Q1.GH (pure) LTI
- Q1.Ku (Vs/m) Scalar
- Q1.X (pure) LTI
- Q1.Ess (%) Scalar

The open-loop transfer function is KGH, not GH. Why neglect K ???

The OL-TF & CL-TF both have pure physical units. Is this a coincidence ???

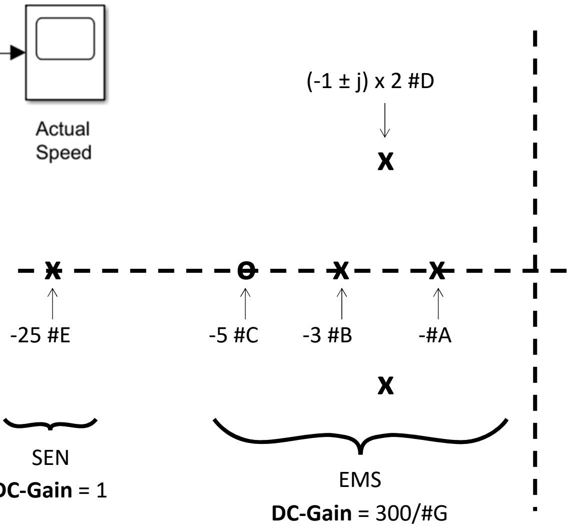
What are the physical units of Controller Gain K ??? What is the physical meaning ???

Figure 1



CF = 10 #F

Figure 2



The speed sensor is replaced with a position sensor and position is controlled.
Now the plant G is as shown in Fig 3. Do everything all over again.

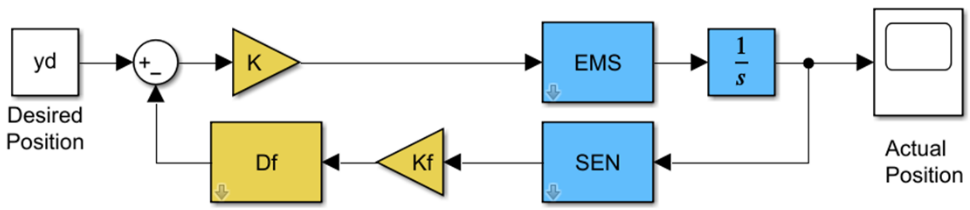
Q2 3 mark(s) Position Control

Compute:

GH	Input = Desired Position (m)	Output = Measured Position (m)
Ku	Ultimate proportional gain (ie. K)	
X	Input = Desired Position (m)	Output = Actual Position (m)
Ess	Percentage difference between Desired & Actual Position.	

- Q2.GH (pure) LTI
- Q2.Ku (Vs/m) Scalar
- Q2.X (pure) LTI
- Q2.Ess (%) Scalar

Figure 3



COW:

*Use **pzmap()** to check your OLTFs. Are all the poles & zeros in the right place ???*
Plot the impulse response of all OL and CL TFs.
Plot the step response of all OL and CL TFs.
Are they stable ??? Should they be ???
Is the FV what you would expect ???
Did you observe a FUNDAMENTAL difference between speed and position control ???
Was this expected ???

*You must be able to **PREDICT** your results to answer any of these questions.*
*It's the only way to verify your results **MAKE SENSE**.*

*Now for some **DESIGN** work.*

***CAUTION**:*

By default, OS is measured with respect to FV, not the Input Signal (desired final value).

In a closed-loop system, FV ≠ Input Signal when Ess > 0.

Q3 2 mark(s) Rate RCGs

For the speed control system, find the gain K to satisfy each of the following **INDIVIDUAL** Requirements.

Requirement #1: 30% Ess

Requirement #2: 0% Overshoot / Minimum Ess

- Q3.K1 (Vs/m) Scalar
- Q3.K2 (Vs/m) Scalar

Q4 2 mark(s) Position RCGs

For the position control system, find the gain K to satisfy each of the following **INDIVIDUAL** Requirements.

Requirement #1: 10% Overshoot

Requirement #2: 0% Overshoot / Minimum Ts

- Q4.K1 (V/m) Scalar
- Q4.K2 (V/m) Scalar

Why minimize Ts instead of Ess in position control ???