ELEC 341 – Graded Assignments

Assignment A-6

10 Marks

Learning Objectives

- Proportional Control
- Open & Closed Loop Transfer Functions
- Pole-Zero Plots
- Steady-State Error
- Controller Tuning

- Matlab
  - zpk()
  - margin()
  - pzmap()
- Simulink
  - n/a

The simple control system in Fig 1 has a plant G and a feedback path H, with the Open-Loop pole-zero plot and DC-Gain shown in Fig 2.

U and Y are desired and actual velocity with units (m/s).

H is your micro-controller dynamics which introduces the pole at 2CF, as shown in Fig 2.

Calc 1 1 mark(s) Open-Loop Transfer Function

Compute the open-loop transfer function GH.

- C1_GH (pure) = Actual Speed / Desired Speed

Recall, the word "Dynamics" IMPLIES unity gain.

*Technically, the open-loop transfer function is Kp*GH. Why did we neglect Kp ???*

Calc 2 1 mark(s) Ultimate Gain

Use **margin()** to find Ku.

- C2_Ku = Ultimate Gain

Does the Controller Gain K have physical units ???

What does this value actually represent in practice ???

Figure 1

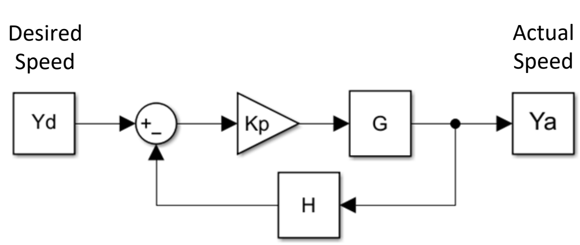
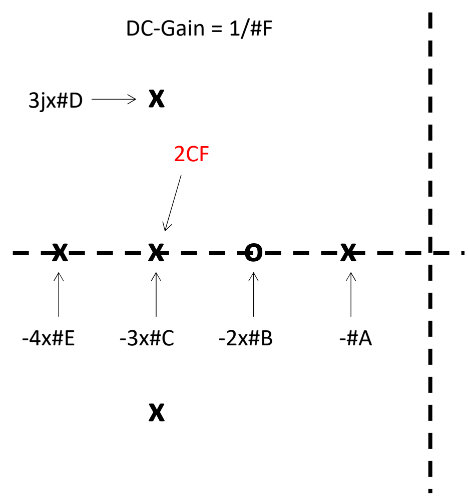


Figure 2



Kp is not just a scale factor once you compute the closed-loop transfer function. Its value affects the pole locations, so you do have to choose one to compute a CL Xfer Func.

Calc 3 1 mark(s) Closed-Loop Transfer Function

Compute the closed-loop transfer function T with **Kp = Ku/2**.
Calculate the steady-state error for that value of Kp.

- C3_T (pure) = Actual Speed / Desired Speed
- C3_Ess (%) = Percentage Difference between Desired & Actual Speed

Ku/2 was a somewhat arbitrary value. What happens to Ess if it is changed ???

Is Ess small enough to neglect, or would it be an important design criteria if you were optimizing this controller ???

Fig 1 1 mark(s) Pole-Zero Plot

Use **pzmap()** to generate the Pole-Zero plot of the OL Transfer Function.

- PZ Plot of OL Xfer Function

What is the general shape of the response you would expect based on the location of the poles & zeros ???

Do the zero locations matter at all ???

You decided to control position instead of velocity so you integrated the output of the plant G, as shown in Fig 3, and replaced the velocity sensor with a position sensor.

Do everything all over again.

Calc 4 2 mark(s) Position Control System

Compute the closed-loop transfer function T with **Kp = Ku/2**.

- C4_Kp = Controller Gain
- C4_T (pure) = Actual Position / Desired Position

Figure 3

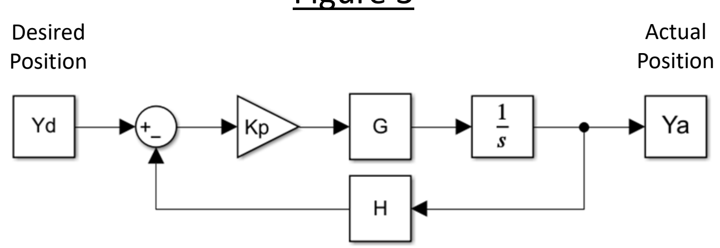


Fig 2 1 mark(s) Pole-Zero Plot

Use **pzmap()** to generate the Pole-Zero plot of the OL Transfer Function.

- PZ Plot of O-L Xfer Function

Is there anything about this plot that would suggest a significantly different step response than the previous system ???

What difference do you expect ???

Fig 3 1 mark(s) Step Response

Generate the step response of both Closed-Loop transfer functions with **Kp = Ku/2**.
Of course, each transfer function has a different Kp and Ku.
Plot both curves on the same figure.
Use the same time vector for both. Use the time vector from the curve with the longer settle time.

- Velocity C-L Step Response Blue
- Position C-L Step Response Green

How do these two curves compare ??? Is there a FUNDAMENTAL difference ???

Did you predict this from the Pole-Zero plot ??? Could you have ???

*Time for some **DESIGN WORK**. Develop a P-Controller which satisfies the following GOALS for the Position Control System.*

- *Minimum rise time*
- *Minimum settle time*
- *Minimum peak time*
- *< 2% Overshoot*

Calc 5 1 mark(s) Tuned Gain

Compute the gain.

- C5_K = Tuned Gain

Fig 4 1 mark(s) Tuned Response

Plot the step response of the Closed-Loop Position Control System to compare the responses of the original and tuned gains. Plot both curves on the same figure.
Use the same time vector for both. Choose the one with the longer settle time.

- Original C-L Step Response Green
- Tuned C-L Step Response Black
- Add a legend with the corresponding gain values, rounded to the nearest integer

- Also Show a Zoom-in version to verify the Overshoot criteria was met

Why didn't you minimize Steady-State error ??? Not important ???