Homework 5

CSE Spring 2023

Due: 22 Mar 2023

1. *(5 points)* For an open loop system represented by the following transfer function:

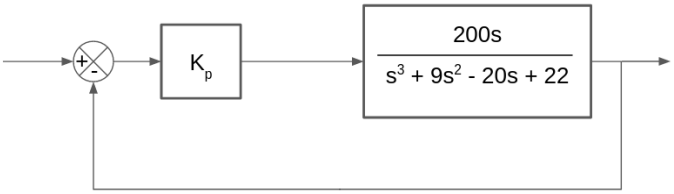
$$\frac{200s}{s^3 + 9s^2 - 20s + 22}$$

   (a) Plot the gain and phase Bode plots and submit the plots.

   (b) Find the phase and gain at input $\omega = 0.1$ rad/s, $\omega = 1.0$ rad/s and $\omega = 100$ rad/s.

   (c) Determine the gain and phase margins.

2. *(5 points)* You want to build a proportional controller to the system given in the previous task.



   (a) Plot the root locus (and submit the plot).

   (b) Determine the value K_p to use in the proportional controller such that the system would behave similarly to a 2nd order system with damping ratio $\zeta = 0.5$ (in terms of settling time - ignore the steady state offset).

   Hint. The damping ratio for systems that behave similarly to 2nd order systems is roughly equal to the cosine of the angle between the horizontal line and the line connecting a dominant pole to 0 on the s-plane. The cosine for this angle for a complex number s can be found as $\frac{Re(s)}{\sqrt{Re(s)^2+Im(s)^2}}$ where $Re(s)$ represents the real and $Im(s)$ the imaginary part. The damping ratio is also given by many software packages when plotting root locus.

   (c) Plot the locations of the poles of the closed loop system, using the value of K_p found in the previous subtask. Also plot the step response of this system together with the step response of a system with the following transfer function:

$$\frac{1}{s^2 + s + 1}.$$

   (This transfer function corresponds to a second order system with damping ration $\zeta = 0.5$, so you can visually compare the two.)