ECE 3510 Exam 3 given: Spring 11

(The space between problems has been removed.)

This part of the exam is Closed book, Closed notes, No Calculator.

Your answers should specific, clear, concise, and legible, or I'll assume you don't know.

1. (8 pts) a) What is an "unconventional root-locus plot" (the subject of homework RL8)?

   b) Why would such a plot be useful?

   c) Give an example of its use.

2. (3 pts) Ladder logic was originally developed to help design logic circuits based on what type of part?

3. (3 pts) Some compensators use differentiators, but real differentiators have some serious issues. What is the most important issue (the reason given in lab 5b for moving the differentiator into the feedback part of the loop).

   Extra credit for naming the second most important issue.

4. (16 pts) The following questions are about compensators ($C(s)$) in a standard unity-feedback system.

   a) List 2 advantages of having an integrator in the compensator.

   1) 2)

   b) What is the disadvantage of using just an integrator (I) alone?

   c) What type of compensator retains the advantages of part a) without the disadvantage of part b)?

   d) What is the advantage of having an differentiator in the compensator?

   e) What is the disadvantage of using just a differentiator (D) alone? This is the theoretical disadvantage, not the practical issues asked for in question 3

   f) What type of compensator retains the advantage of part d) without the disadvantage of part e)?

   g) What type of compensator has all the advantages above?

   h) What other type of compensator does about the same job as that of part c) and why would you use it instead?

   i) What other type of compensator does about the same job as that of part f) and why would you use it instead?

Answers

1. a) Like a regular root locus plot except that the gain is held constant and the plot shows how the closed-loop poles move as the result of changing some variable other than gain.

   b) You would like to see how the closed-loop poles are affected by some variable other than gain.

   c) In the PLL lab, the loop "gain" was fixed ($k_{pd}k_{pll}$) , but we had to design a filter and needed to see how the closed-loop poles were affected by the filter time-constant. To do this, we drew an unconventional root-locus plot.

2. Electromechanical relays (and simple switches).

3. A true differentiator would produce an impulse when the input is a step. No real differentiator can do this.

   Extra credit Differentiators are high-pass filters and accentuate the noise.

4. a) 1) Eliminates steady-state error for a step (DC) input. 2) Eliminates the affects of a DC disturbance.

   b) Slows down the speed of the system. Also bends asymptotes rightward and pulls centroid toward origin.

   c) PI d) Improves transient response. e) The system will have no DC gain. f) PD g) PID

   h) Lag, doesn't need active components and associated power supply.

   i) Lead, doesn't need active components and associated power supply.

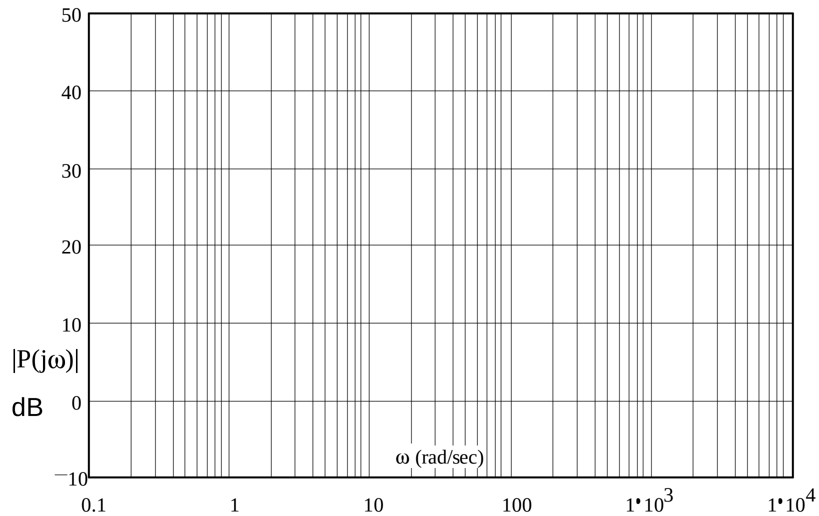
   Doesn't need a differentiator with its associated issues (see question 3)

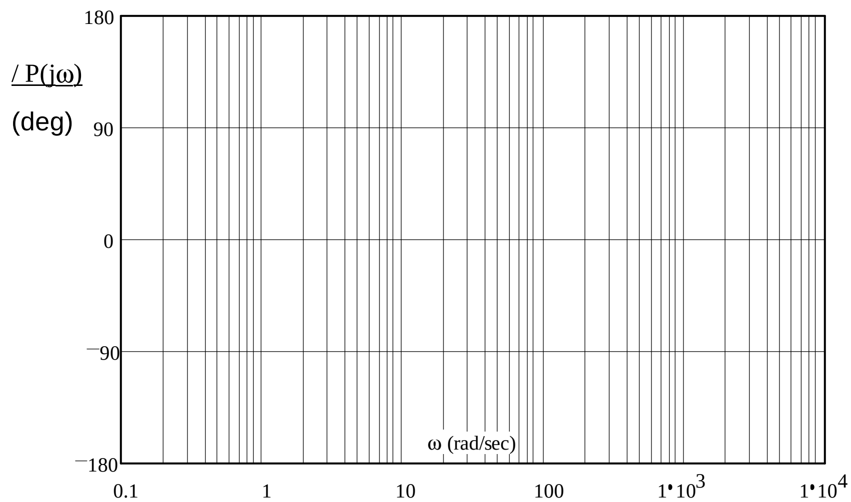
Open-book part

ECE 3510 Exam 3 Spring 11 p2

1. (20 pts) Sketch the Bode plot for the following transfer function. Make sure to label the graphs as necessary to show the magnitudes and slopes. Also draw the "smooth" lines.

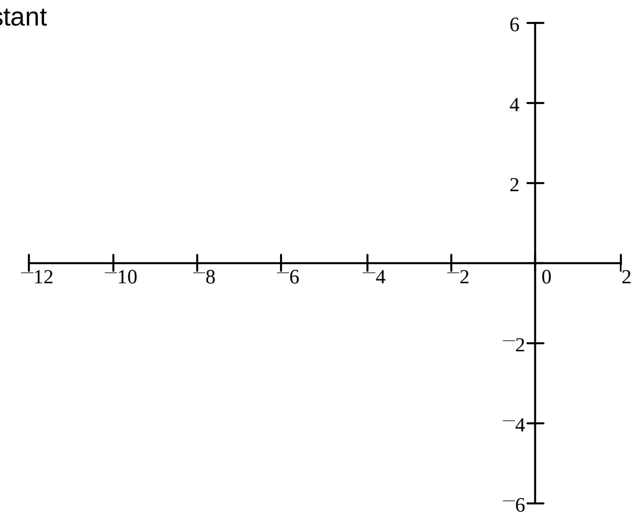
$$P(s) := \frac{10^5 \cdot s \cdot (s+100)}{(s+2)\cdot\left(s^2+400\cdot s+10^6\right)}$$





2. (20 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below. The root-locus should be plotted for an increasing g.

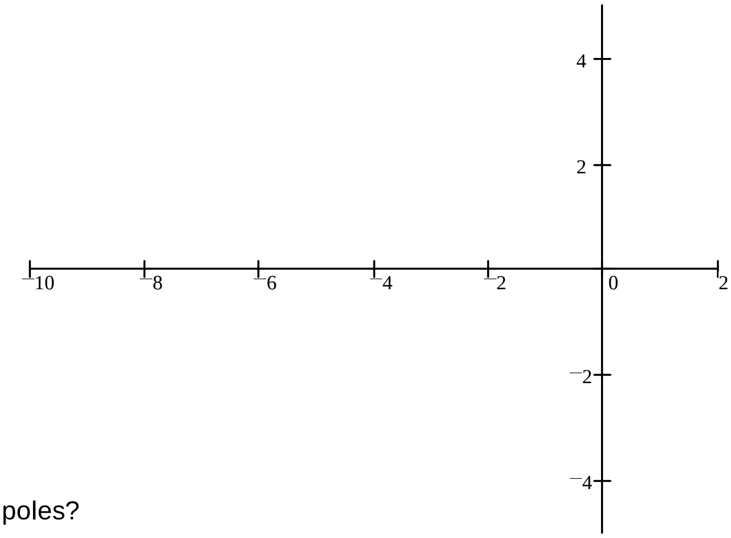
$$G(s) = \frac{k\cdot s\cdot(g\cdot s+1)}{(s+4\cdot g)\cdot(s+5)} \qquad k = 2 \quad \text{and is constant}$$



b) Draw an arrow to the place(s) on your root locus where you would like to place the closed-loop poles for minimal ringing and the shortest settling time. Extra credit if you find the value of g needed.

3. (30 pts) Consider the transfer function below.

$$G(s) := \frac{s+3}{s\cdot\left(s^2+2\cdot s+5\right)}$$



a) Find the departure angle from a complex pole.

b) Draw a root locus plot. Calculate the centroid and accurately draw the departure angle.

c) Is there any decent place to locate the closed-loop poles?

d) You would like to place your closed-loop poles to get a settling time of 4/3 sec and 4% overshoot (using the second-order assumption). Add the simplest possible compensator to accomplish this and calculate what the compensator should be.

Note: If you can't calculate the zero location or doubt your calculation, assume it is at -1 for the rest of this problem.

e) With the compensator in place and a closed-loop pole at the location desired in part d)

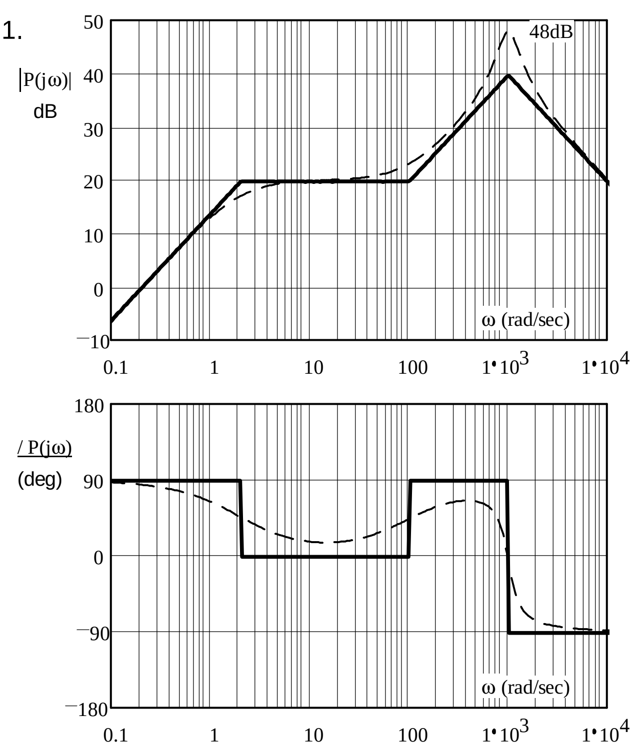
i) What is the gain?

ii) What is the steady-state error to a unit-step input?

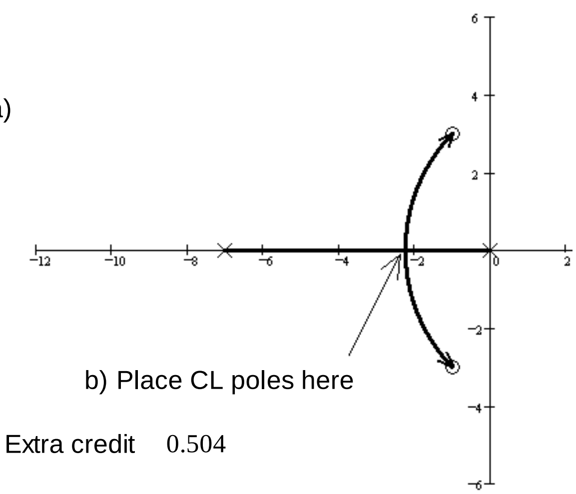
f) OK, now that this compensator is in place, is a settling time of 4/3 sec and 4% overshoot really the best you can do? If not, what should be done. Justify your answer.

Answers

1.



2. a)

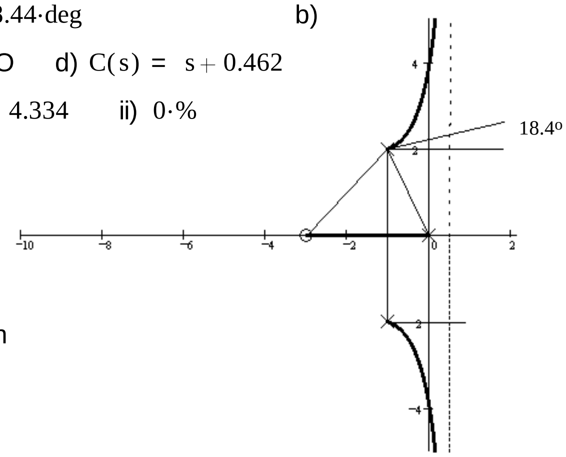


Extra credit 0.504

3. a) $18.44\cdot\text{deg}$ b)

c) NO d) $C(s) = s + 0.462$

e) i) 4.334 ii) $0\cdot\%$



4.

3. f) Draw and look at the new root-locus... Obviously turning up the gain so that the closed-loop poles move to points near -6 would result in a significant improvement in both speed and much less ringing.