ECE 3510 Exam 3 given: Spring 10

(The space between problems has been removed.)

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

1. (5 pts) a) What is the name of the PID tuning methods used on homework FC1?

   b) Why are PID tuning methods used instead of the more analytical methods we learn in this class.

2. (10 pts) Below are a list of reasons to add a compensator to a feedback system. After each of the reasons, list all of the compensators that would be a good choice for the achieving the desired result without significant negative side-effects. Select your answers from the list of possible answers below. Answers may be used more than once or not at all. Each blank may have more than one answer.

   a) Increase the speed of the system response ________________

   b) Decrease overshoot ________________

   c) Decrease the settling time ________________

   d) Reduce the steady-state error ________________

   e) Eliminate the steady-state error for a DC input ________________

   f) Mostly reject constant disturbances ________________

   g) Completely reject constant disturbances ________________

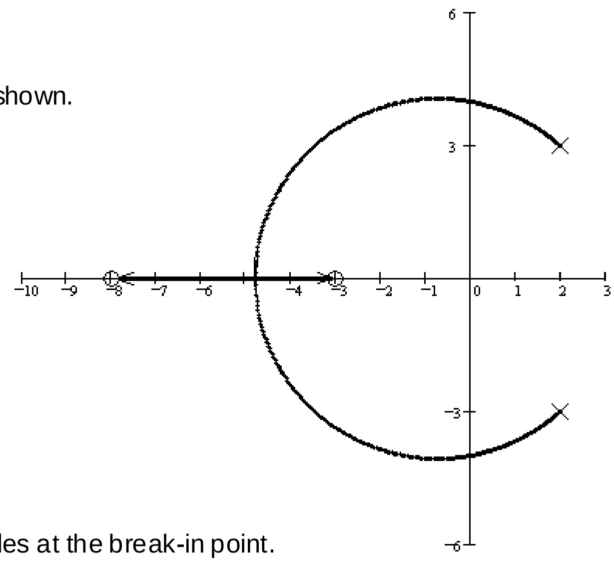
Possible Answers

PI
I
PD
Lag
Lead
Over
Under

Open-book part

1. (12 pts) It looks like -4.7 is a break-in point for the root-locus plot shown.

   a) Determine if this is true, show work.



   b) Answer the following without making more calculations

   The gain required to place a closed loop pole at -4.7 is:

   A) LESS than the gain required to place the closed loop poles at the break-in point.

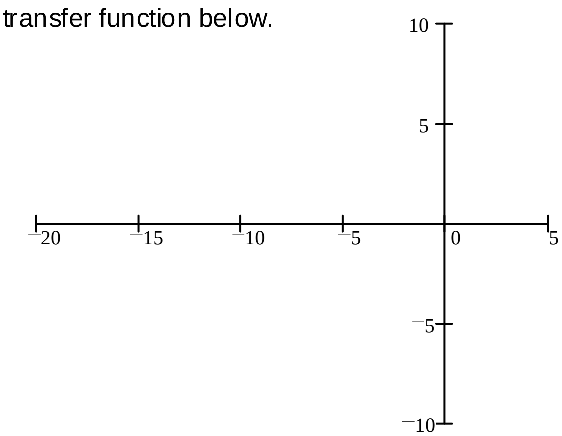
   B) THE gain required to place the closed loop poles at the break-in point.

   C) GREATER than the gain required to place the closed loop poles at the break-in point.

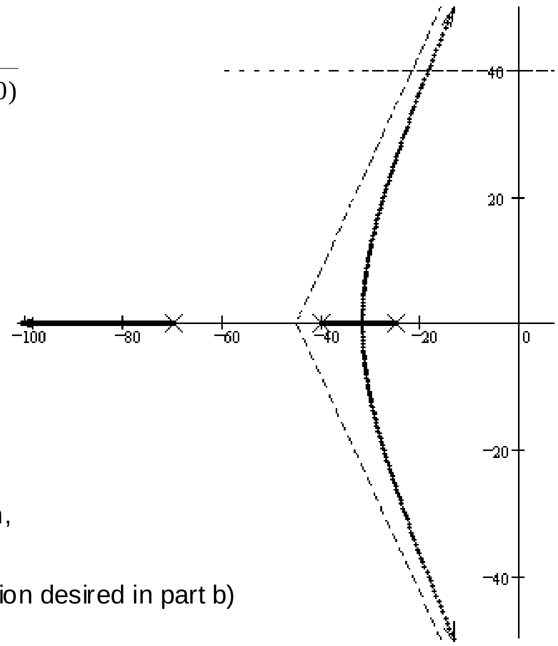
   D) It isn't possible to answer this without more calculations.

2. (14 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below. The root-locus should be plotted for an increasing a.

$$G(s) = \frac{3\cdot(s+2\cdot a)}{(s+5)\cdot(s+a)}$$



3. (28 pts) Consider transfer function: $G(s) := \dfrac{100}{(s+25)\cdot(s+40)\cdot(s+70)}$



The gain is set at 452, so that one of the closed-loop poles is at

$s := -24.48 + 27.2\cdot j$

Further calculations yield:

Settling time: $0.163\cdot\text{sec}$

Steady-state error to a unit-step input: 60.8%

a) What is the % overshoot?

b) You wish to increase the frequency of ringing to 40 rad/sec (b = 40) without changing the % overshoot at all. Add a compensator with a single zero so that you will be able to do this.

Note: If you can't calculate the zero location or doubt your calculation, assume it is at -50 for the rest of this problem.

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

i) What is the gain?

ii) What is the 2% settling time? Use the second-order approximation.

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

iv) List those things that improved with this compensation?

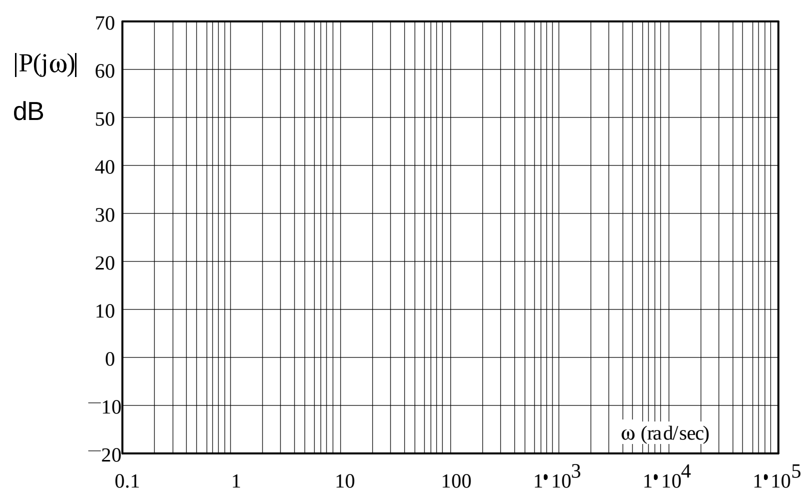
d) Add another compensator: $C_2(s) := \dfrac{s+2}{s}$ and maintain the gain of part c)

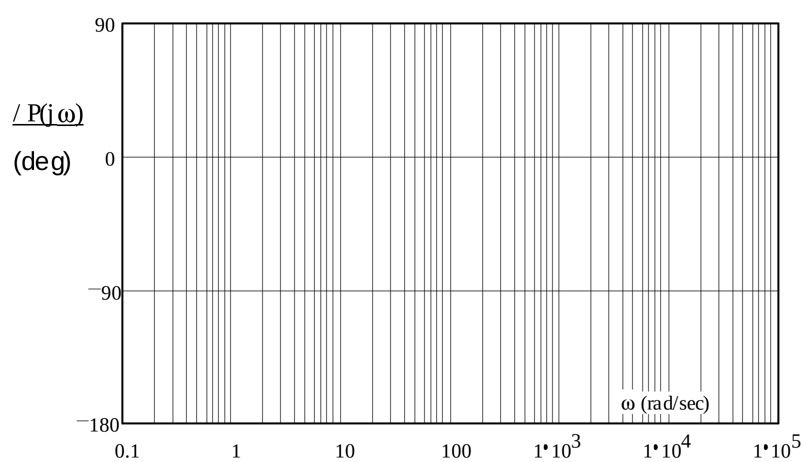
i) What is this type of compensator called and what is its purpose?

ii) Calculate what you need to in order to show that this compensator achieved its purpose.

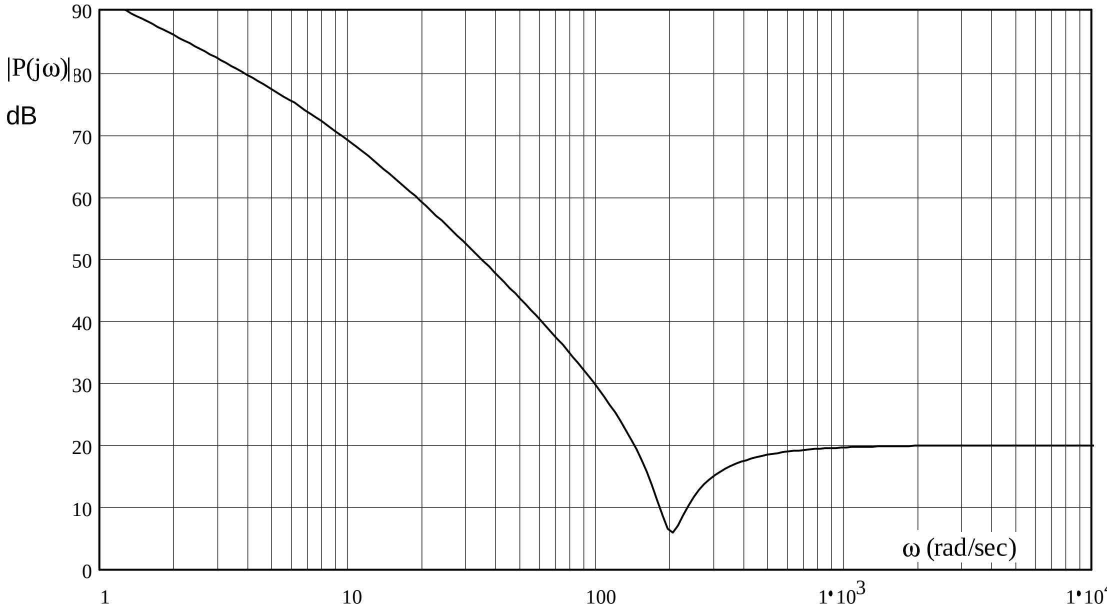
4. (15 pts) Sketch the Bode plots for the following transfer function. Make sure to label the graphs as necessary to show the magnitudes and slopes. Also draw the "smooth" lines.

$$P(s) = \frac{100\cdot\left(s^2+3\cdot s+900\right)}{s\cdot(s+2000)}$$





5. (16 pts) Given the magnitude Bode plot of a system, estimate the transfer function of the system. Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane). Use a straight edge and show your work (how you made your estimate).



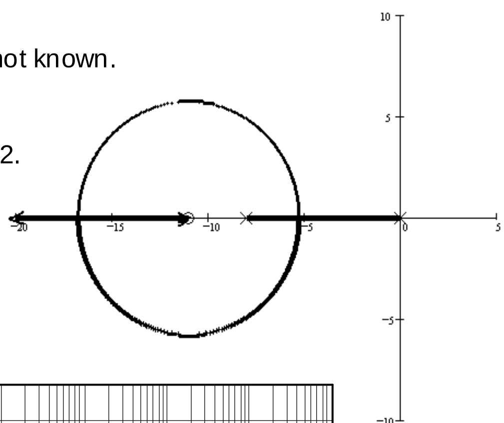
Answers

Closed book 1. a) Ziegler-Nichols b) Because the transfer function is not known.

2. a, b & c) PD & Lead d) PI & Lag e) PI f) Lag g) PI

Open book 1. a) NO b) C

2.



3. a) $5.92 \cdot \%$

b) $C(s) := (s + 59.75)$

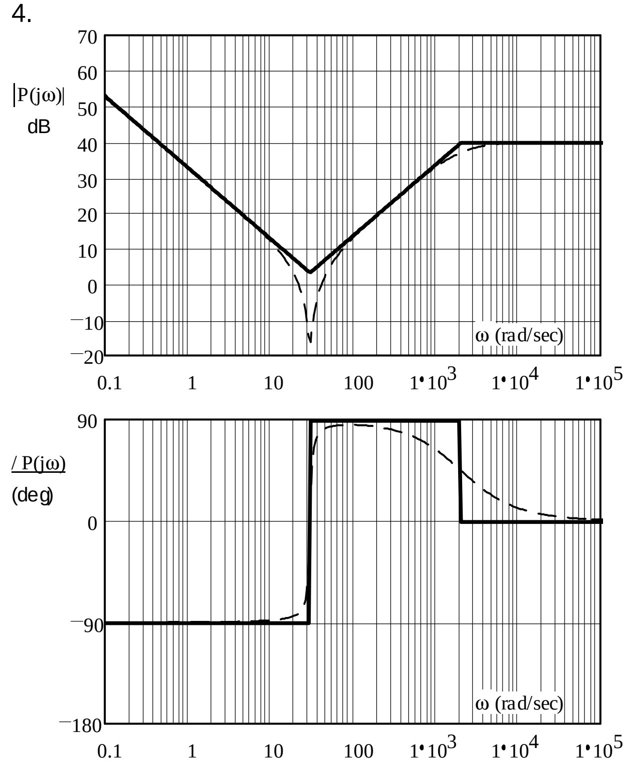
	For z = -50
c) i) 18.8	20.7
ii) $0.111 \cdot sec$	same
iii) $38.4 \cdot \%$	$40.4 \cdot \%$

iv) Speed and steady-state error

d) i) PI, used to eliminate steady-state error

ii) $e_{step} = \dfrac{1}{1 + k \cdot \infty} = 0 \cdot \%$

4.



5. $P(s) = \dfrac{10 \cdot \left(s^2 + 40 \cdot s + 40000\right)}{s \cdot (s + 10)}$