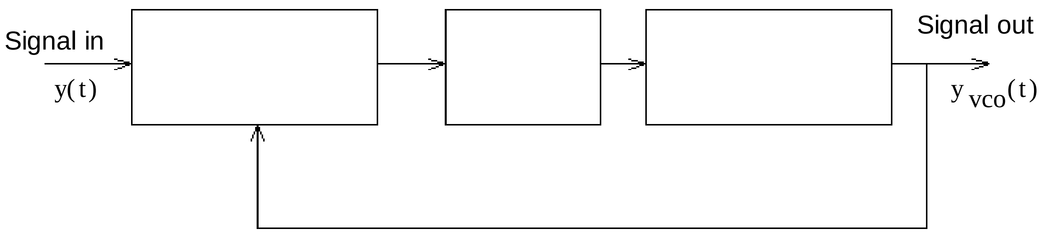
ECE 3510 Exam 3 given: Spring 15

(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. (6 pts) Identify the blocks (in words) in the phase-locked-loop shown below.



2. (7 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.

3. (6 pts) in Homework FC1 you explored ways to use a compensator with a system who's transfer function is unknown.
   a) What type of compensator?

   b) What is this method called? (What would you type into Google to learn more?)

   c) Were would the data come from for the type of calculations you made in FC1?

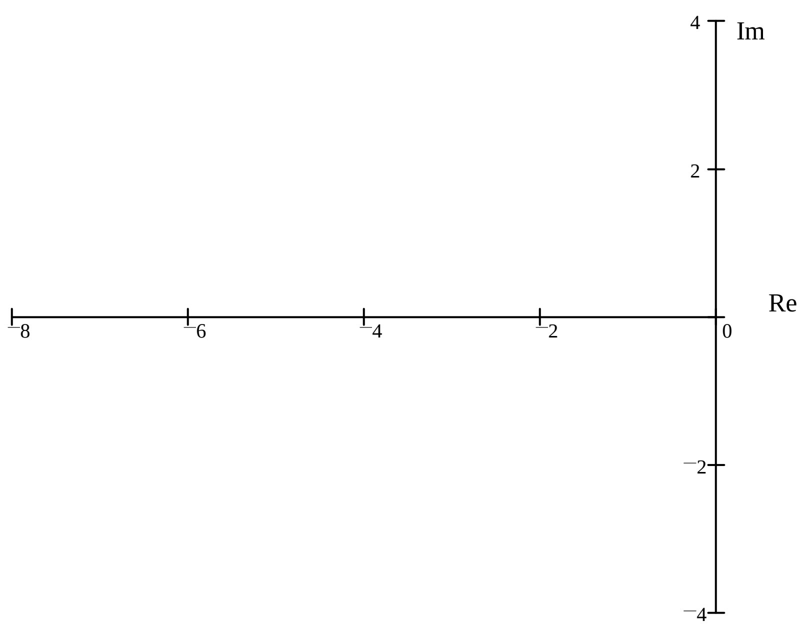
4. (3 pts) An instrumentation amplifier is a good way to implement what function(s) or block(s) in a typical feedback loop?

5. (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).

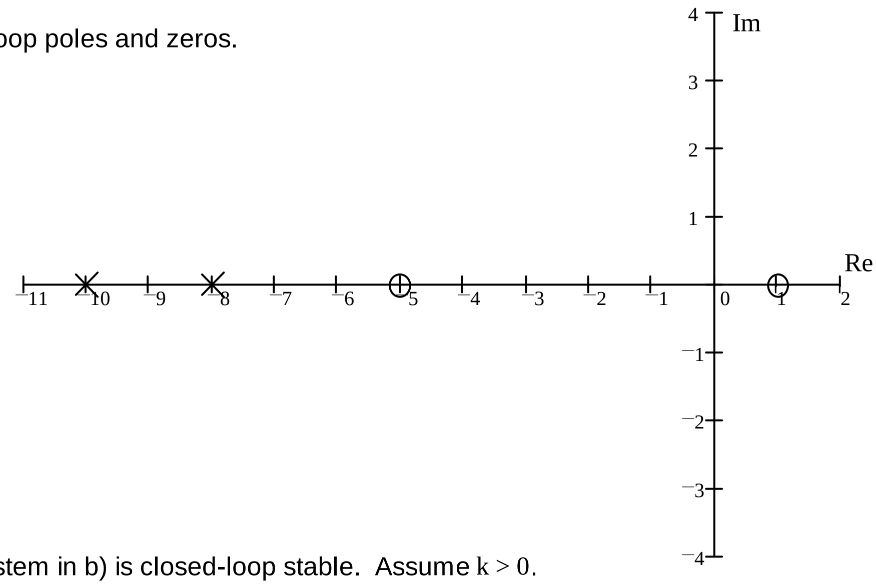
   Extra credit for naming the second most important issue.

6. (20 pts) Sketch the root-locus plots for the following open-loop transfer function and pole-zero plot.
   Use only the rules you were told to memorize, that is, you may estimate details like breakaway points and departure angles from complex poles. Show your work where needed (like calculation of the centroid).
   Draw things like the asymptote angles carefully.

   a) $\mathbf{G}(s) = \dfrac{(s+2)\cdot(s+3)}{s\cdot(s+1)\cdot(s+5)\cdot(s+7)}$



b) Sketch the root-locus for the given open-loop poles and zeros.

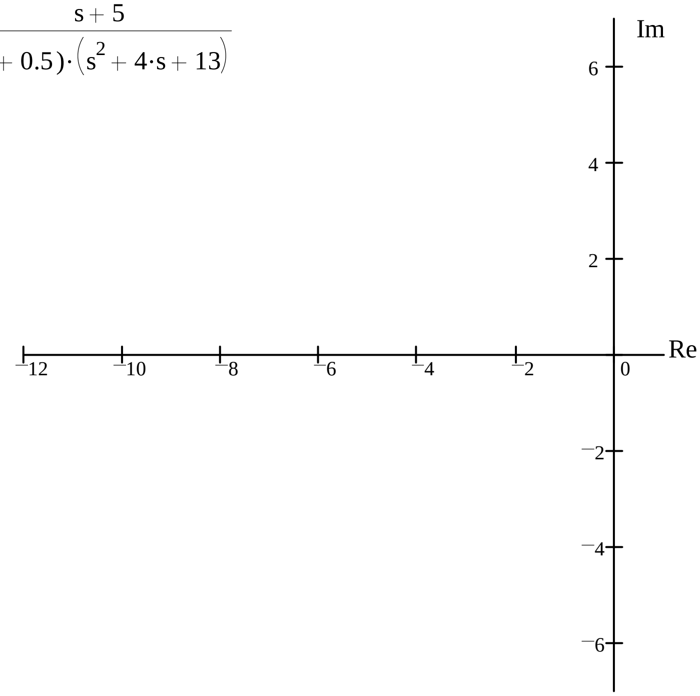


c) Find the range of gain (k) for which the system in b) is closed-loop stable. Assume $k > 0$.

Open book part

1. (35 pts) Consider the transfer function: $G(s) := \dfrac{s+5}{(s+0.5)\cdot\left(s^2+4\cdot s+13\right)}$

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 1/3 sec and keep the ringing frequency of the open-loop system. 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 -3 for the rest of this problem.
For the remaining problem, the compensator in place and a closed-loop pole at the location desired in part d)

e) What is the gain?

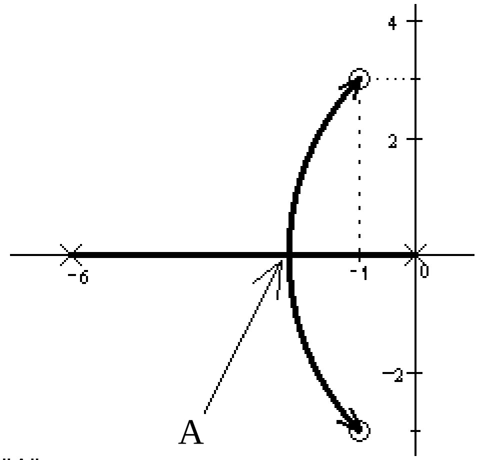
f) What is the steady-state error to a unit-step input?

g) What is the % overshoot?

h) This system is used to position cereal boxes for filling.
Do you the values you found in parts f) and g) will be OK?

2. (10 pts) a) Point "A" is a special point on the root locus plot.
What is it called?

   b) Determine if point "A" is at -2. Show your evidence. I want to see specific calculations and numbers to justify your answer.



   c) The gain required to place a closed loop pole at -2 is:
   Answer without making more calculations.

   A) LESS than the gain required to place the closed loop poles at point "A".
   B) THE SAME as the gain required to place the closed loop poles at point "A".
   C) GREATER than the gain required to place the closed loop poles at point "A".
   D) It isn't possible to answer this without more calculations.

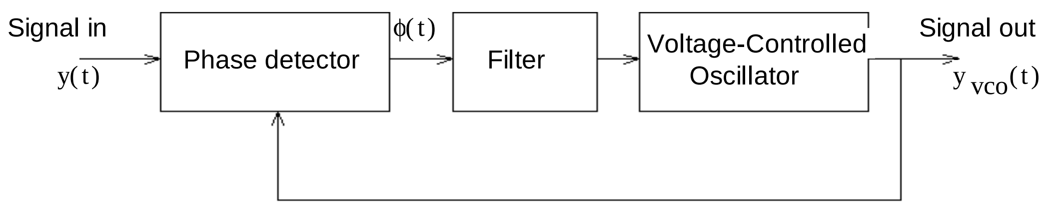
3. (10 pts) You have designed a compensator with the following:
A pole at the origin   A zero at -1   A zero at -20   Gain of 15

   a) Draw the block diagram of a compensator that could give these.
   Use the factors k_P, k_i, and k_d in the normal way.

   b) Find the k_p, k_i, & k_d of this compensator.

Answers

1.



2. 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.

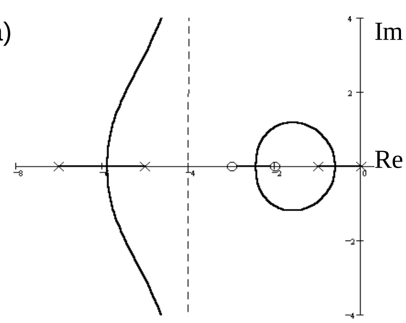
3. a) PID   b) PID tuning OR Ziegler Nicols   c) Experimental measurements

4. The summer with + and - , and the gain block

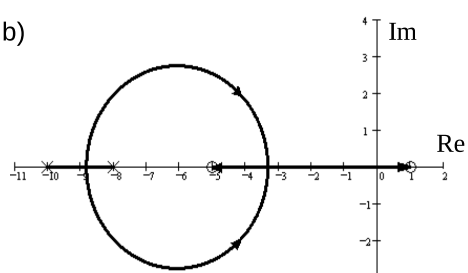
5. A true differentiator would produce an impulse when the input is a step. No real differentiator can do this.

   Differentiators are high-pass filters and accentuate the noise.

6. a)

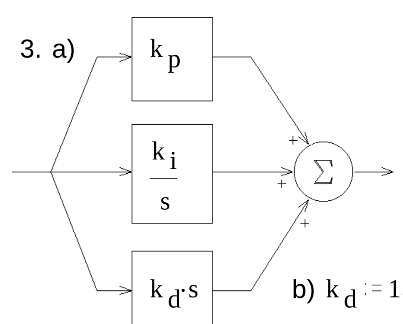


b)



c) $k < 16$

3. a)



b) $k_d := 15$
$k_i := 300$
$k_p := 315$

1. a) $18.44 \cdot deg$ b) 0.25   c) NO   d) $C(s) = s + 4.716$

   e) 23.1   f) $1.18 \cdot \%$ g) 0.0004%   h) Yes

2. a) Break-away point   b) NO   c) A)   3. above at right