

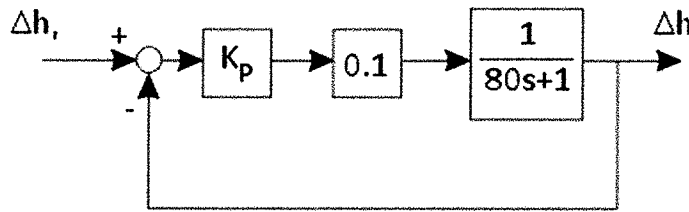
ME 422 – Quiz 3

Winter 2011

In giving your answer, the answer alone is not enough. Make sure you clearly give your rationale for arriving at the answer. It must be clear to me how you arrive at your answer.

Weights:

1. A tank system has the level control system

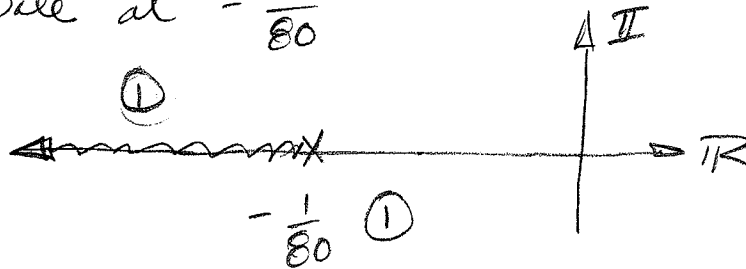


16% (2)

- a. Draw the system's root locus.

Use $G_{OL} = \frac{K_p \cdot 0.1}{80s+1}$

OL pole at $-\frac{1}{80}$



16% (3)

- b. Describe the operation of the system as K_p is increased. Are there any values of K_p that cause the system to be unstable? To oscillate? How exactly does the system's behavior change as K_p is increased? Be sure to include the rationale for your answers.

Since CL poles stay on IR axis and are to left of $-\frac{1}{80}$, always stable, no oscillations.

As K_p increases, CL pole move to left and system's speed increases.

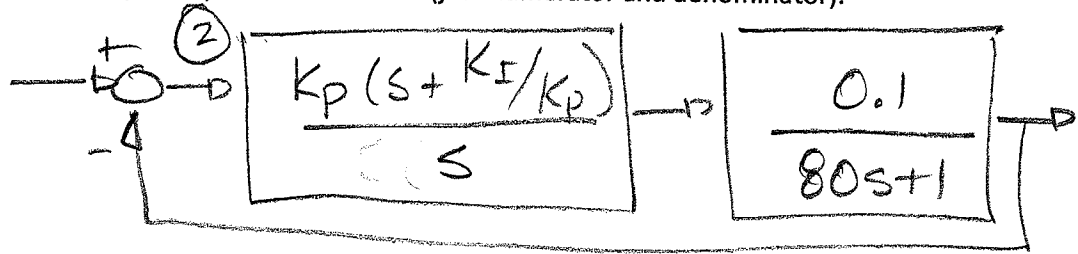
16% (3)

- c. In the above loop, the valve gain is actually 0.1 gpm/%-valve-opening. The design steady state of the valve is 65%. With a unit step input, how high could K_p be set without saturating the valve?

Input to 0.1 block is % value opening. It can increase by 35%, up to 100%. For step of 1", K_p , which has units %/in could be 35 without saturating valve. Explanation

16% (3)

d. Now outfit the loop with a PI controller. Calculate G_{OL} for the PI loop in a compact form that will allow you to plot the root locus (just numerator and denominator).



$$G_{OL} = \frac{K_p (s + K_I/K_p) 0.1}{s(80s + 1)} = \frac{K_p (s + K_I/K_p) 0.1 / 80}{s(s + 1/80)}$$

36%

With the PI controller,

18

e. Consider the three cases, all with $K_p > 0$: i) $K_i < 0$, ii) $K_i/K_p < 1/80$, iii) $K_i/K_p > 1/80$. Draw the root locus for each of these cases in the table below. For each case and for low, medium, and high values of K_p , answer yes or no to the questions about stability and oscillatory behavior.

Case	$K_i < 0$	$K_i/K_p < 1/80$	$K_i/K_p > 1/80$
Root locus			
K_p low	Stable? <u>N</u> (Y/N) Oscillates? <u>N</u> (Y/N)	Stable? <u>Y</u> (Y/N) Oscillates? <u>N</u> (Y/N)	Stable? <u>Y</u> (Y/N) Oscillates? <u>N</u> (Y/N)
K_p medium	Stable? <u>N</u> (Y/N) Oscillates? <u>N</u> (Y/N)	Stable? <u>Y</u> (Y/N) Oscillates? <u>N</u> (Y/N)	Stable? <u>Y</u> (Y/N) Oscillates? <u>Y</u> (Y/N)
K_p high	Stable? <u>N</u> (Y/N) Oscillates? <u>N</u> (Y/N)	Stable? <u>Y</u> (Y/N) Oscillates? <u>N</u> (Y/N)	Stable? <u>Y</u> (Y/N) Oscillates? <u>N</u> (Y/N)

0.5 each

9 pts