ECE 3510 homework RL5

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These problems should be done using MATLAB or some other program that creates root-locus plots. You will need to print one or more plots for each problem. Each plot should be labeled and explained clearly on the same page as the plot. Where applicable, also point out the added poles and/or zeros the compensator and explain why you chose the compensation that you did. You may write this in by hand and point to the individual poles and zeros. Refer to the step response curve for "speed" information. Prints of those curves are nice, but not required. Be careful, Matlab is constantly changing the scales on your plots. This can make it very hard to compare them.

You can use File –> Page Setup to make smaller plots and print more than one plot per page. You can also use <Alt-Print Screen> on the keyboard to capture the current window to the clipboard, then paste that into an image program (like Paint) to create pages of plots.

I suggest you read the help on the back of this handout before you begin.

1. a) Homework RL2 problem 1c. Experiment with moving the pole at -4 (no plot needed), just describe what happens, especially when you move it right of -2. Put the pole back at -4. Experiment with adding pole(s) and/or zero(s) to keep the root locus on the left side of the $j\omega$ axis for all values of gain (no plot needed), just describe what you added and where.

   b) Homework RL2 problem 1c. Add a compensator to your system. This compensator will add one pole and one zero to the open-loop (OL) transfer function. The new pole must lie somewhere between -10 and +2, you choose where. Same goes for the zero. Look at fig. 4.4 in the text. For good damping characteristics, you would like to keep the imaginary part of your closed-loop (CL) poles $\leq$ to the real part. For quick response, you would like the poles to be as far left as possible. Choose the locations of your OL pole and OL zero to best meet these requirements. Find the best gain factor for your new system. Plot the root locus of this new system showing the point(s) on the root locus you determined to be the best position for the CL pole(s) with squares (like Matlab does). Indicate the gain.

   c) Homework RL2 problem 1d.

   d) Homework RL2 problem 1d. Repeat part b above for this system, only this time your added pole and zero are limited to -16 to +2.

2. a) Homework RL3 problem 1a.

   b) Homework RL3 problem 1b.

   c) Homework RL3 problem 1b. Add a compensator. Your compensator may have up to 2 poles (0, 1, or 2) and they may be complex. Same for the zeros. All must lie between -20 and +2 and -12j and +12j. Choose the best possible poles and/or zeros, find the best gain and plot like you did for 1b.

3. Homework RL4 problem 1. Confirm the departure angles (find a point very close to the pole and figure out the angle from its location). Find the true Im-axis crossing point and the gain at that point. Also find the break away (in) point.

4. Enter in the plant G(s) of the crude servo: 1643/(s*(s+16.64)*(s+53.78)).
   Add a PI compensator (a pole at 0 and a zero at -0.1).
   Find the gain for a 0.707 damping factor. Record the time it takes the step response to reach 1 the first time.
   Save this: Compensators –> Store/Retrieve etc..
   Add a zero at -16.64 and repeat, saving under a different name.
   Adjust the zero location further to the right while pushing the gain and watching the step response to find an even better combination. Again record the time it takes the step response to reach 1 the first time and save. Print the Root locus and the step response.
   You will be using this device to build widgets. The time per widget is 10 times the time you recorded in each case. Your profit per widget is 1 cent. Your fixed costs per 8-hour day is $250. Describe the results to your company of each of the 3 compensators above.

5. Create the most interesting root locus plot that you can with no more than 10 poles and 10 zeros. Have some fun with this. You can go over 10 poles and zeros if you want, but the fewer the better to make the figure you want.

Answers

4. You go broke at $168/day. You make $101/day. You make $161/day.

Help on Back —>

Matlab's SISO tool (single-input/single-output tool)

The SISO tool can be used to draw and manipulate rool-locus plots of single-input / single-output systems. It is part of the Matlab Control System Toolbox.

To use the SISO tool, you first need to create the open-loop transfer function "object" in matlab. There are several ways to do this, but I recommend this way:

6. Define the variable "s" as a special TF model
```
s = tf('s');
```
This only needs to be done once, after that any other expression of s will automatically be interpreted by Matlab as a transfer function.

7. Enter your transfer function as a rational expression in s For example,
```
G = s/(s^2 + 2*s +10);
```
Now G is a "transfer function object" of the transfer function $G(s) = \frac{s}{s^2 + 2s + 10}$

Now type:
```
sisotool(G)
```
- You can close the Bode plot views by: View –> Open-Loop Bode (uncheck).
- You will need to observe the step response: Analysis –> Response to Step Command (If this window opens right on top of the first window, move it off to the side.)
- You can get rid of the plant input (u, green line) by: right-click anywhere on plot area –> Systems –> Closed Loop: r to u (green) (uncheck).

To edit the compensator poles and zeros;
- You can add a pole or zero to the real axis by: click X or O button –> click on plot where you want the pole or zero. You can later drag it left and right. You can erase it with the eraser tool.
- OR add, delete or change compensator poles or zeros by clicking in the "Current Compensator" area. That will open the "Edit Compensator C" box.
- OR: right-click anywhere on plot area –> Add or Delete or Edit.

You can't modify the Plant poles and zeros (at least as far as I know).
- Choose: Compensators –> Format –> Zero/pole/gain: or your gain will suddenly go negative when you pull poles or zeros into the right-half plane
- You can move the pink square around on the root locus to change the compensator gain. The gain is shown in the "Current Compensator" area just above the plot.
- In order to effectively evaluate changes, you will need to inhibit Matlab's constant rescaling of the plot: right-click anywhere on root-locus plot area –> Properties –> Limits –> uncheck the Autoscale boxes and set limits to match the aspect ratio of your window..

Play with this until you are ready to start the Homework.

Start Homework RL5. Read up through problem 1a and refer back to homework RL2. Back in the Matlab Command window, type:

`G = 1/(s*(s+2))` to create the transfer function.

Notice that I left out the pole at -4, because we will want to manipulate that. Go back to SISO tool. File –> Import –> G –> "–>" to the G –> OK. Erase any extra pink poles left over from the last analysis. Add a real axis pole anywhere, then, after adding it, drag it to the -4 position. "Current Compensator will show: C(s) = 1 x 1/(s+4). You are now ready to work problem 1a – have fun.

More information

On the homework web page, find the Matlab Tutorial in pdf form, SISO tool tutorial starts on page 23.

Matlab Help
- Type: help sisotool at the command prompt. Or...
- Select Help –> Full Product Family Help –> Control System Toolbox –> Using the SISO Design Tool and the LTI Viewer –> SISO Design Tool