ECE 3510 homework # 12 Due: Thur, 3/9/06

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2/28/06

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 clearly. On the same page as the plot, please print what you had to type into matlab to get that plot. You may write that by hand. If you are using a GUI interface, you should write down what you had to enter in the various fields.

1. a) Homework 10 problem 3c. Experiment with moving the pole at -4 (no plot needed), just describe what happens. 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 added and where.

   b) Homework 10 problem 3c. Add a compensator to your system. This compensator will add one pole and one zero to the open-loop 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 on p. 59 in the text. For good damping characteristics, you would like to keep the imaginary part of your 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 pole and zero to best meet these requirements. Find the best gain factor for your new system. Plot the root locus of this new system and indicate the point you determined to be the best by showing the gain at that point.

   c) Homework 10 problem 3d.

   d) Homework 10 problem 3d. Repeat part b above for this system, only this time your added pole and zero are limited to -16 to +2.

2. a) Homework 11 problem 1a.

   b) Homework 11 problem 1b.

   c) Homework 11 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.

   d) Homework 11 problem 1c. Confirm that if $b \leq a + 2$ then the system remains unstable. Choose the best possible values for a and b within the limits of -8 and 0, find the best gain and plot.

3. a) Homework 11 problem 2.

   b) Homework 11 problem 3.

   c) Homework 11 problem 4. Confirm the departure angles.

   d) Homework 11 problem 4. Add a compensator. Your compensator may have up to 4 poles and they may be complex. Same for the zeros. All must lie between -6 and +2 and -4j and +4j. Choose the best possible poles and/or zeros, find the best gain and plot.

ECE 3510 Exam 2 Study Guide

The 2nd Exam will be on Thursday 3/2/06.

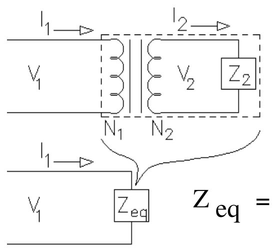
It will be a **closed book, no calculator** exam, but will include some information shown below.

<u>The exam will cover</u>

1. The advantages of state space over classical frequency-domain techniques.
2. Steady-state sinusoidal response. You should be ready to do some complex arithmetic by hand.
   Angles may be reported in the this form: $\tan^{-1}\left(\frac{12}{5}\right)$

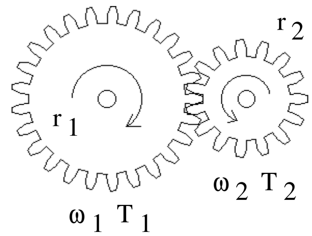
3. Electrical analogies of mechanical systems, particularly translational and rotational systems. Memorize the basics, you will be given anything you need for transformers, etc. in abbreviated form.

   Example of material to be included with exam:



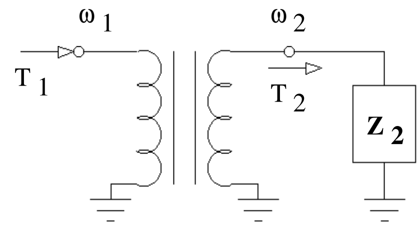
$$Z_{eq} = \left(\frac{N_1}{N_2}\right)^2 \cdot Z_2$$

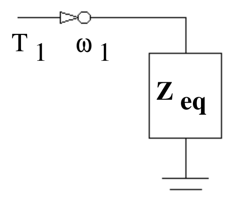
Gears



$$N = \frac{r_2}{r_1} = \frac{\omega_1}{\omega_2} = \frac{T_2}{T_1}$$

$= \text{gear tooth ratio} \left(\frac{N_2}{N_1}\right)$





$$\mathbf{Z}_{eq} = N^2 \cdot \mathbf{Z}_2 = \left(\frac{r_2}{r_1}\right)^2 \cdot \mathbf{Z}_2$$

4. Control system characteristics and the objectives of a "good" control system. See pgs. 57 - 58
5. Elimination of steady-state error, p. 61.
6. Rejection of constant disturbances, p. 63.
7. Root - Locus method
   a) Main rules (memorize)
   b) Additional rules. You will be given anything you need in abbreviated form.

      Example of material to be included with exam:

      The breakaway points are also solutions to: $\displaystyle\sum_{all} \frac{1}{(s + - p_i)} = \sum_{all} \frac{1}{(s + - z_i)}$

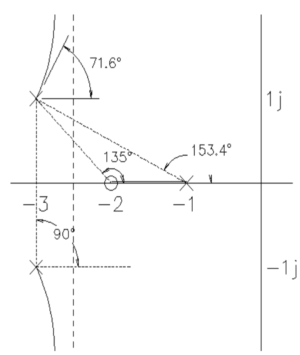
      Gain at any point on the root locus: $\displaystyle k = \frac{1}{|G(s)|}$

      Phase angle of G(s) at any point on the root locus: $\arg(G(s)) = \arg(N(s)) - \arg(D(s)) = \pm 180^o \quad \pm 360^o \ldots$

      Or: $\displaystyle \arg\left(\frac{1}{G(s)}\right) = \arg(D(s)) - \arg(N(s)) = \pm 180^o \quad \pm 360^o \ldots$

      Departure angles from complex poles:

      $180 - 90 - 153.4 + 135 = 71.6 \quad \text{deg}$



   c) Important conclusions from root locus, p. 82.
   d) Simple root-locus design, the placement of additional poles and zeros in order to affect the root locus.

8. Homeworks 7 - 11
9. Labs 3 - 5