University of Wisconsin-Madison
Department of Electrical and Computer Engineering
ECE 332 - Feedback Control Systems, Fall Semester 1998
Problem Set #6

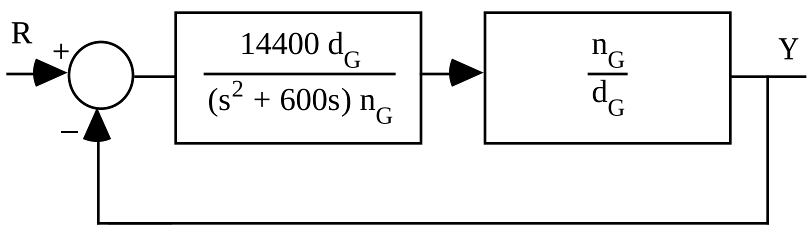
Distributed: Friday, October 16

Due: Friday, October 23

Reading: Please finish reading the remainder of Dorf, Chapter 5.

Design Problems Based on Notes of 10/14 Lecture (distributed in class)

Problem 1: Consider a variant of the example in the notes of the 10/14 lecture, in particular, consider a block diagram of the form:



Here (n_G, d_G) represent the true numerator and denominator of the system being controlled. In contrast, $(\tilde{n}_G, \tilde{d}_G)$ represent our "best guess" of these quantities that were used in designing our controller. Let us suppose we have the correct numerator, but errors in the denominator. In particular:

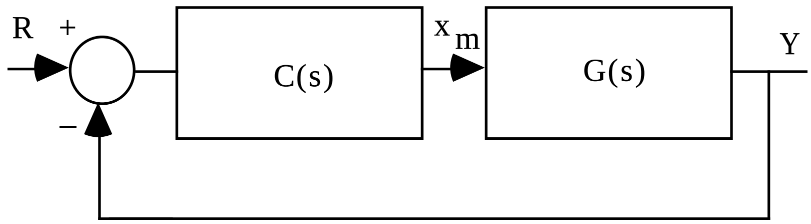
$$n_G(s) = n_G(s) = 500(s + 20)$$

$$d_G(s) = s^2 + 50s + 10000; \quad d_G(s) = s^2 + \alpha s + 10000$$

a) Compute $S_{\alpha}^{T}(s)$ for the close loop transfer function $T_{Y,R}(s)$ above, and evaluate your result about the nominal point $\alpha^o = 50$.

b) Note that when our design is based upon exact information, with $\alpha = 50$, the closed loop transfer function above has a constant numerator, and a denominator with two distinct negative real roots. Therefore Y(s) of a unit step input (R(s) = 1/s) is easy to compute. Based on this nominal Y(s), and your $S_{\alpha}^{T}(s)$, compute the $\Delta Y(s)$ for a +10% change in α away from $\alpha^o = 50$ (i.e., your predicting the change in the Laplace transform of the step response output if α were to change from 50 to 55). Comment on whether or not you believe this result indicates that the step response for $\alpha = 55$ will be much different from that with $\alpha = 50$.

Design Problem 2: Using MATLAB and the design method of lecture 10/14, design a transfer function C(s) to be used in the following feedback configuration:



$$G(s) = \frac{12144(2s + 1)}{s^4 + 1.8s^3 + 222s^2 + 201s + 12144}$$

where:

The resulting closed loop system is required to meet the following specs: step response settling time of 0.2 seconds or less; P.O. of 15 % or less.

Note: you will find the MATLAB functions "SERIES" and "FEEDBACK" very helpful in your block diagram manipulations.

You solution must describe your methodology for choosing C(s), and must show MATLAB step response output for the closed loop system that demonstrates that specs are met.

Please also compute the transfer function from R to X_m (feel free to use MATLAB to assist in this computation), and plot $x_m(t)$ due to a unit step at the input r.

Textbook Problems

Dorf, Chapter 5, **Problems**

P5.14 - Observe that you have two values to solve for - the location of the single zero, and the leading gain coefficient for the reduced order system.

Dorf, Chapter 5, **Design Problems**

DP5.4

DP5.6