EE 661 *Modern Control* **Project #3**

Due Date: Friday, December 5, 2014

Download a copy of the "zipped" mat-file, **`ee661_proj3_ss_model.zip`** from the EE661 / Project area of **MyCourses**. This zip-file contains a **`mat`**-file by the same name containing a Matlab ss-object, also by the same name. This is a continuous-time 8-pole, 3-output, 3-input state-space model of a very simple flexible structure, in ss-object form.

Write an m-file script (or function) that will do the following:

1) Using the null-space method shown in class, design a state-feedback matrix *K* that will place the poles of *A - BK* at the following locations:

$$1.005 * \begin{bmatrix} -65 + 5900i \\ -65 - 5900i \\ -3 + 180i \\ -3 - 180i \\ -4 + 130i \\ -4 - 130i \\ -5 + 50i \\ -5 - 50i \end{bmatrix}$$

2) Again using the null-space method shown in class, design an observer-error feedback matrix *L* that will place the poles of *A - LC* at the following locations:

$$0.995 * \begin{bmatrix} -65 + 5900i \\ -65 - 5900i \\ -3 + 180i \\ -3 - 180i \\ -4 + 130i \\ -4 - 130i \\ -5 + 50i \\ -5 - 50i \end{bmatrix}$$

3) Verify that the standalone controller is stable (if you've done this right so far, it will be stable).

4) Plot the characteristic loci of this system, and from the plot determine the stability margins. The characteristic loci plot must be based on the FRF of the compensated open-loop state-space model, because there are no measured-FRF data for this system.

5) Derive the matrices for the closed-loop model. Determine the locations of the closed-loop poles, and compare these to the locations that were intended during the design of *K* and *L*.

6) **Using grammians**, determine the controllability and observability **of the 16-pole closed-loop model**. This is like asking if we can put *another* control loop around the closed-loop. Explain the results.

7) Plot the FRF-**magnitude** of the ***open-loop uncompensated system*** and the ***complete closed-loop system*** plots for the three "direct" I/O paths (input 1 to output 1, input 2 to output 2, input 3 to output 3), all in the same axes. Discuss (compare and contrast) the open-loop and closed-loop plots.

8) For comparison purposes, use Matlab's "**`place`**" function to generate K_m and L_m matrices. You should compare two things: (a) Are the norms of these feedback matrices about the same as the norms of the ones you designed using the null-space method, in steps (1) and (2)?
(b) Is the standalone controller stable if you use K_m and L_m, instead of *K* and *L* ?

Submit your m-file by email, and a short report (hardcopy) of your answers and results. The m-file should create the characteristic loci plots, and do all the necessary computations for your report. The m-file should be well-commented, so I can easily see what each part of it is doing.