ICPC 024 Control Systems II

For Assessment III

Make 11 groups of 4 students per group. Each group shall follow the sequence:

1. Pick up a third-order, 2-(or 3-)input and multiple-output circuit.
   - There are a lot of books on circuits you can hunt through to get a circuit that appeals to you; expand your hunt to pick up circuits having amplifiers, particularly the Op-Amps.
2. Obtain 2 models – M_1 using nodal analysis, and M_2 using mesh analysis, and demonstrate a transformation matrix T such that $A_2 = TA_1T^{-1}$ and $B_2 = TB_1$.
   - Plot the transformation in 3-D.
3. Compute the eigenvalues and eigenvectors of A_1 and A_2, and answer the following:
   - If a matrix T_1 is composed of the eigenvectors of A_1 as columns, what is $T_1^{-1}A_1T_1$?
   - Why do get this? Have you expected this result a priori?
   - Under what conditions might your expectation not be met?
   - Is the result same if you have performed $T_1A_1T_1^{-1}$? Why/why not?
4. Check the stability of the *system* using A_1, A_2, $T_1^{-1}A_1T_1$, and $T_2^{-1}A_2T_2$, where the matrix T_2 is composed of the eigenvectors of A_2 as columns.
   - What is the computational effort, in terms of the total number of multiplications required, in solving for the matrix P, and checking its sign-definiteness?
5. Compute e^{A_1t} and obtain e^{A_2t} using T.
6. Compute the designated outputs of the circuit. Assume arbitrary initial conditions on the choice of state variables, and assume that input-1 is a unit step while input-2 is $\cos \omega t$.
   - Obtain the plots of $x_1(t)$, $x_2(t)$, and $x_3(t)$, and the outputs; clearly indicate the initial conditions.

7. Show that the *system* is controllable using and all the models.

   - Use both the criteria:

   $$rank\left[B : AB : A^2B\right] = n$$

   and the Hautus' criterion

   $$rank\left[\lambda_i I - A : -B\right] = n \quad \forall\lambda_i \in \text{eigenvalues of } A$$

8. Repeat the above exercise and show that the *system* is observable using and all the models.

   - Anything you notice?

9. Take one of the models and design at least 4 different controllers to meet the same set of specifications – desired eigenvalues $\Lambda = \{a,\ b \pm jc\}$, $a, b, c \in \Re$, i.e, one real eigenvalue and a pair of complex conjugates.

   - What if $a = 0$?

10. Design more than one (different) full- and reduced-order observers.

11. And, finally show all the wiring diagrams (using summing amplifiers etc.) for the complete control system.

12. It is desirable that your final artefact, suitably scaled, is tested in the laboratory.

You may use MATLAB for computations and plots; not for the solutions. You may email to me if there are any doubts.

LAST DATE: April 19, 2019, 5 p.m.