Introduction to control systems
TI0118

Homework II

Guidelines

You must solve each exercise using hand calculations and compare your results on Matlab/Octave. The report for the homework must be sent in a **single pdf document** by **11 June, 2017**. Note that **delays will be penalized** (<24h: 20% penalty; <48h: 40% penalty; etc.).

Your report must include:

- The relevant steps, the results and your comments on each exercise.

- The Matlab/Octave code developed for solving each exercise. This can be included as part of the single exercise or in a separate section of the report (for instance, as an appendix).

- The graphs required in the exercises.

Exercise 1   20 Points

The unit steps responses of two systems A and B are recorded and reported in the files `HW2_ex1_dataA.txt` and `HW2_ex1_dataB.txt`, respectively. In each file, the first column gives the time vector t and the second column gives the output response y.

It is required to:

1. Load the data in Matlab/Octave and plot the two responses.

2. Estimate the transfer functions for the system A and B.

3. Compare your estimated systems with the ones provided in the data.

Exercise 2   25 Points

Find the transfer function, $T(s) = C(s)/R(s)$, for the system in Figure (1), using the following methods:

1. Block diagram reduction.

2. Matlab/Octave. Use the following transfer functions:

$$G1(s) = \frac{1}{(s+7)}, \quad G2(s) = \frac{1}{(s^2 + 2s + 3)},$$

$$G3(s) = \frac{1}{(s+4)}, \quad G4(s) = \frac{1}{s},$$

$$G5(s) = \frac{5}{(s+7)}, \quad G6(s) = \frac{1}{(s^2 + 5s + 10)},$$

$$G7(s) = \frac{3}{(s+2)}, \quad G8(s) = \frac{1}{(s+6)}.$$

Hint: Use the `append` and `connect` commands in Matlab/Octave Control System Toolbox/Package.
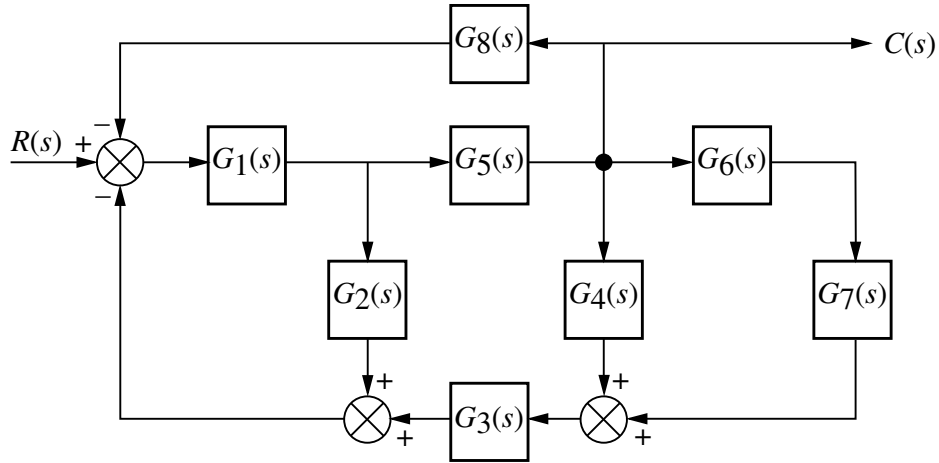

Figure 1: Block diagram for Exercise 2.

Exercise 3   20 Points

The system in state space given in (1) represents the forward path of a unity feedback system.

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -4 & -5 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} u \tag{1}$$

$$y = \begin{bmatrix} 0 & 1 & 1 \end{bmatrix} \mathbf{x}$$

Constructing the Routh table in Matlab/Octave, use the Routh-Hurwitz criterion to determine if the closed loop is stable.

Exercise 4 35 Points

For a system with the state and output equations given in (2):

$$\dot{x}(t) = x^2(t) - u(t)x(t) - 2u(t)$$
$$y(t) = x^3(t) + u^3(t) \tag{2}$$

1. Calculate the state and output equilibrium points when $u(t) = u_{eq} = 1$.

2. Define the linearised system around the equilibrium points and analise the stability of the system.

3. Compare the linearised and nonlinear system responses $\delta y(t)$ for an input $\delta u(t) = A\cos(2t)$, whit $A = 0.1$ applied at $t = 0$.

4. **Extra (5 points)**: Investigate how the responses differ when the input amplitude assumes the values $[0.05, 0.15, 0.2]$.

5. **Extra (5 points)**: Calculate the error between linearised and nonlinear system in point (3) and point (4). Comment your findings.

Hint: Use the command `ode45` to simulate the nonlinear system.