Introduction to control systems
TI0118

Homework II

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:

$$
\begin{aligned}
G1(s) &= \frac{1}{(s+7)}, \quad G2(s) = \frac{1}{(s^2+2s+3)}, \\
G3(s) &= \frac{1}{(s+4)}, \quad G4(s) = \frac{1}{s}, \\
G5(s) &= \frac{5}{(s+7)}, \quad G6(s) = \frac{1}{(s^2+5s+10)}, \\
G7(s) &= \frac{3}{(s+2)}, \quad G8(s) = \frac{1}{(s+6)}.
\end{aligned}
$$

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

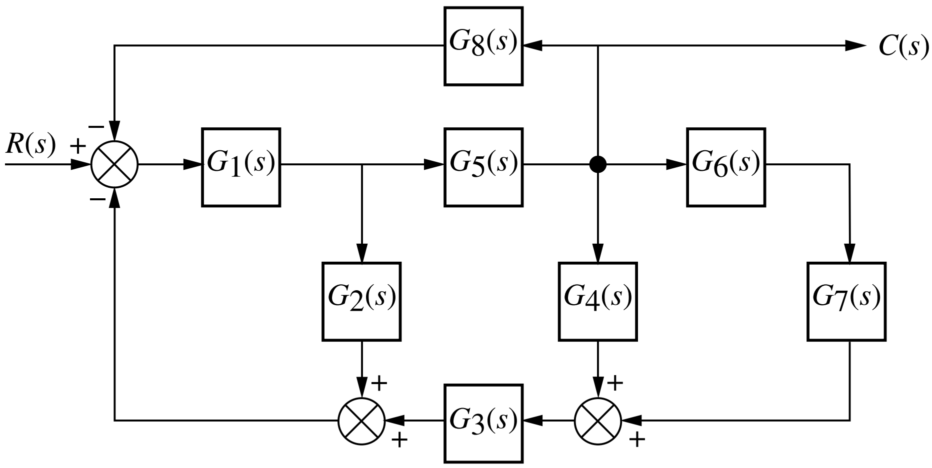

Figure 1: Block diagram for Exercise 2.

Exercise 3

20 Points

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

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

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):

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

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 $\delta u(t) = Acos(2t)$, 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.