EE160 Homework 1

Deadline: 2022-10-2, 23:59:59, Submit your homework on Blackboard

1. Fig. 1 below shows a classical RLC circuit consisting of a resistor with given resistance $R = 3\Omega$, two inductors with given inductance $L_1 = 5H$ and $L_2 = 4H$, and a capacitor with given capacitance $C = 2F$.

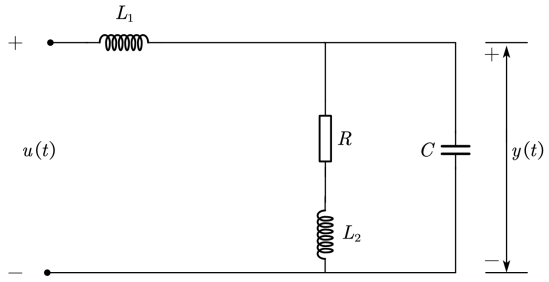


Figure 1: RLC system

   (a) Show that the system output $y(t)$ satisfies a differential equation with respect to the input $u(t)$. **(10')**

   (b) Write the transfer function $\frac{Y(s)}{U(s)}$, with initial conditions $y(0) = 0$, $\dot{y}(0) = 0$, $\ddot{y}(0) = 0$. **(10')**

2. Find the inverse Laplace transform $x(t)$ of the following functions **(10')**

   (a) $X(s) = \frac{e^{-s}}{s-1}$

   (b) $X(s) = \frac{1}{s(s+2)^3(s+3)}$

   (c) $X(s) = \frac{s+1}{s(s^2+2s+2)}$

3. A feedback control system has the structure shown in Fig. 2, determine the closed-loop transfer function $\frac{Y(s)}{R(s)}$ by block diagram simplification. **(10')**

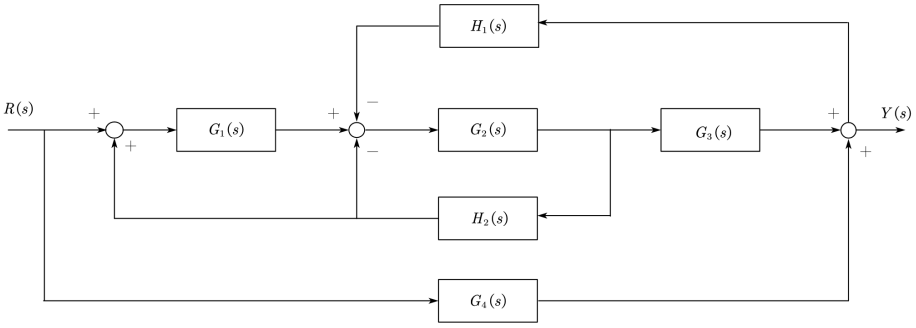


Figure 2: Block diagram

4. Derive the transfer function $\frac{C(s)}{R(s)}$ of the signal flow graph in Fig. 3. **(10')**

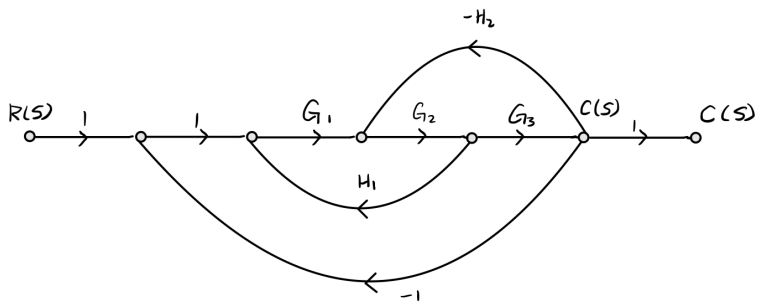
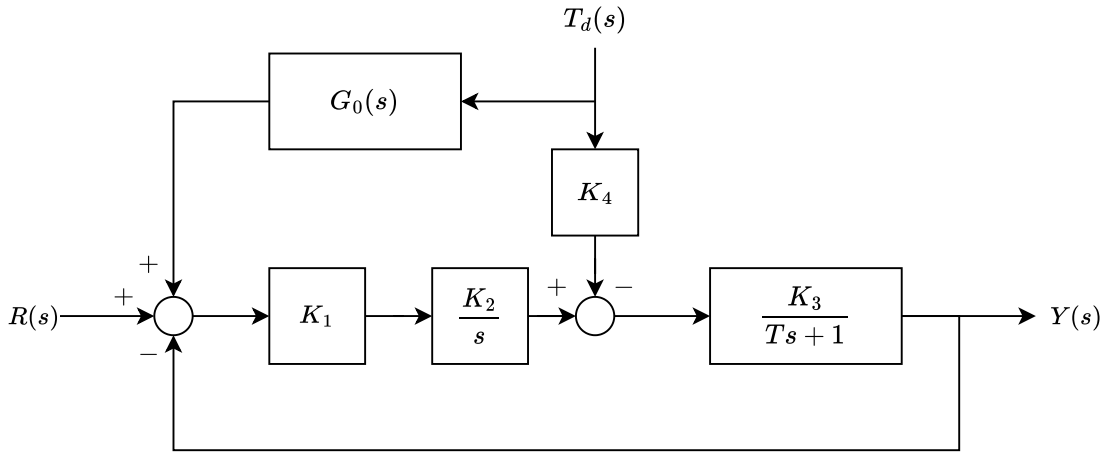


Figure 3: Signal flow graph

5. Consider the following system block diagram

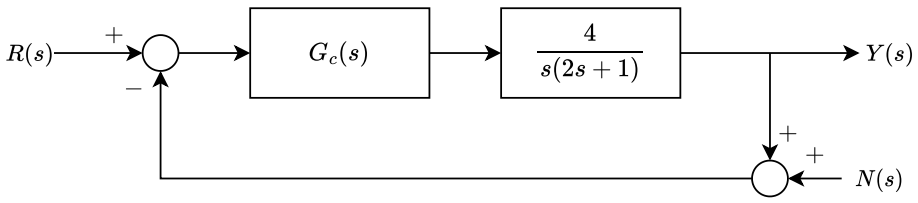


(a) Convert the block diagram to the signal flow graph. **(10')**

(b) Determine the corresponding transfer function for $\frac{Y(s)}{R(s)}$ and $\frac{Y(s)}{T_d(s)}$. **(10')**

(c) To eliminate the impact of $T_d(s)$ on $Y(s)$, what should $G_0(s)$ be? **(10')**

6. Consider the following block diagram



(a) When $r(t) = t$, $n(t) = 1(t)$, $G_c(s) = 1$, calculate the steady-state error of the system. **(10')**

(b) When $r(t) = 1(t)$, $n(t) = 0$, plot the step response up to the end time ***30s*** of the closed-loop system with $G_c(s) = \frac{1}{s+20}$ and $\frac{10}{s+20}$, respectively. Give the corresponding ***closed-loop system*** transfer function under each controller.

(Note: You can use MATLAB, Python, etc. Hint: use *tf* function to create the open-loop system, then use *feedback* function to generate the closed-loop system, and use *step* function to get the step response). **(10')**