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2015 - 2016 Fall Term
Deadline: 31.12.2015

FEEDBACK CONTROL SYSTEMS (KON 313E)

HOMEWORK ASSIGNMENT - 3

Question 1: Block diagram for a control system is given below.

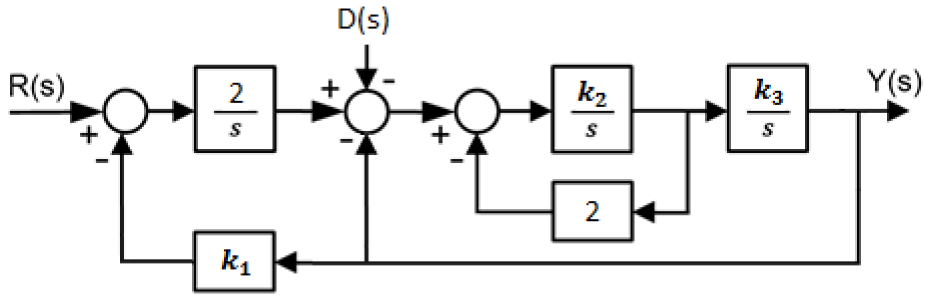

Figure 1: A closed-loop control system.

a. Obtain the closed-loop transfer function for the given system ($D(s) = 0$).

b. In the closed-loop, it is known that system does not have any steady state error for the step type reference inputs and two of the closed-loop poles are located at $s_{1,2} = -1 \pm i\sqrt{7}$. Find the values of k_1, k_2 ve k_3 parameters.

c. If a step type disturbance is applied to the input $D(s)$ then does the system have any steady-state error in the closed-loop? Examine.

d. Plot the root-locus for the positive and negative values of the parameter k_3 on the same figure.

Question 2: A RLC circuit is given below.

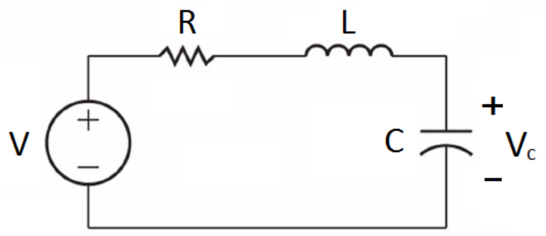

Figure 2: RLC circuit.

If a sinusoidal input signal (V) is applied to the system, variation of the voltage on capacitor (V_c) is given in Figure 3.

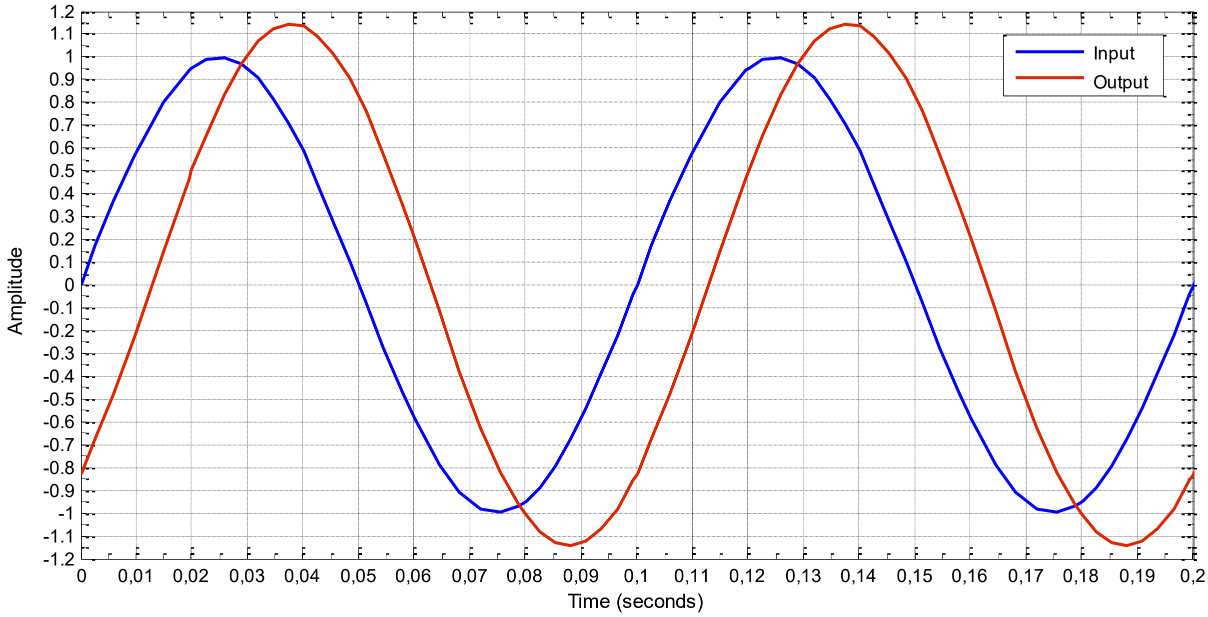

Figure 3: Frequency response of the open-loop system.

a. Obtain the $G(s) = \frac{V_c(s)}{V(s)}$ transfer function of the RLC circuit in terms of the parameters R, L and C.

b. It is known that $\mathrm{L} = 0.1\ H$ then find the values of parameters R and C.

c. Open-loop system is converted to the closed-loop system with a PI controller $F(s) = \frac{k\,(s-20)}{s}$ as in Figure 4. Draw the Nyquist plot and find the value range of the parameter k in which closed-loop system remains stable using Nyquist stability criterion.

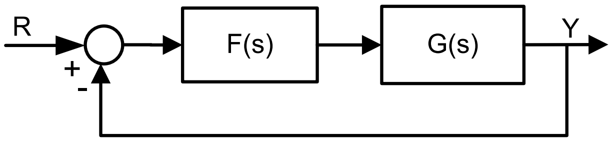

Figure 4: *Closed-loop control system with unit feedback.*

Question 3: An open-loop transfer function is given below.

$$G(s) = \frac{k\,(s+\mu)}{s\,(s^2+s+1)}$$

a. Find the interval of parameter k in which closed-loop system is stable in terms of the parameter μ using Routh-Hurwitz method.

b. For $\mu = -1$ draw the Nyquist plot $(k = 1)$. Use the Nyquist stability criterion to find the value range of the parameter k in which closed-loop system is stable.

c. For $\mu = 1$ find the value range of the parameter k in which all closed-loop system poles are located on the left side of the line $s = -0.2$ using Nyquist criterion (Hint: It is required to modify Nyquist path appropriately).

d. System is controlled with a controller of $F(s) = \frac{(s^2+s+1)}{(s+1)(s+100)}$. For $k = 10$ draw the Bode magnitude and phase plots asymptotically ($\mu = 10$). Calculate the phase and gain margins. Comment on the stability of system.

e. If the sinusoidal input signal $x(t) = 2\,sin(t)$ is applied to the system then obtain the expression of output $y(t)$ in the steady-state ($k = {}^1\!/_2$ and $\mu = 2$).

<u>Question 4:</u> For the system whose open-loop Bode magnitude plot is given in Figure 5,

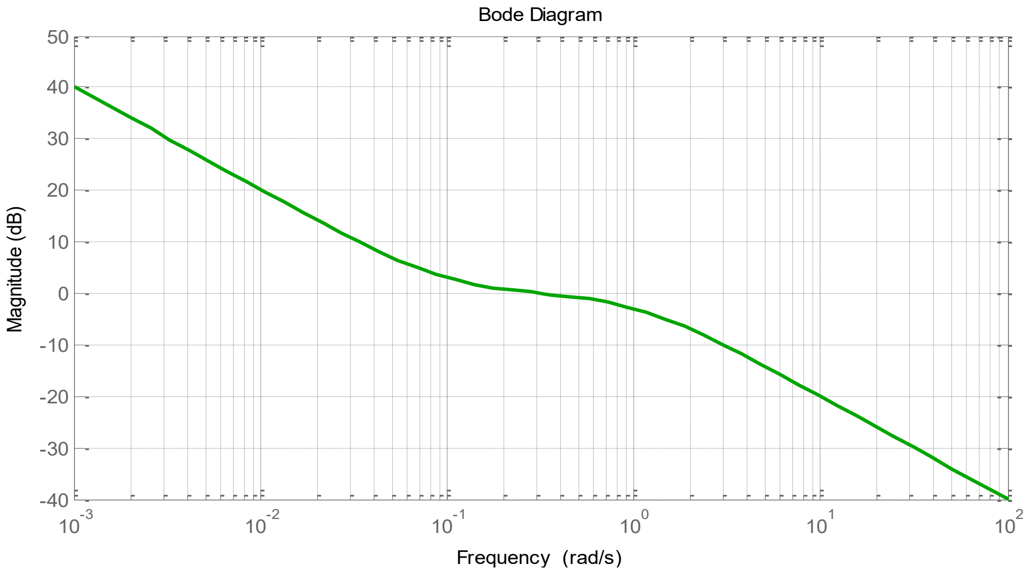

Figure 5: Bode magnitude plot of a system.

a. Obtain the open-loop transfer function ($G(s)$) of system (All necessary explanations are expected to be made).

b. Draw the Bode phase plot of system asymptotically. Calculate the gain margin and phase margin.

c. In the closed-loop if the system output is measured with L seconds delay, calculate the critical value of the parameter $\boldsymbol{L}$ that causes the closed-loop system to be unstable.