EE160 Homework 3

Deadline: 2022-11-25, 23:59:59, Submit your homework on Blackboard
(Hint:You can use MATLAB to help you do the homework.)

1. Consider a unity negative feedback system with a loop transfer function (10')

$$L(s) = G_c(s)G(s) = \frac{10(1-s)}{(0.5s+3)(s+T)}$$

   (a) Sketch the root locus of the system by hand when T changes from 0 to $+\infty$. (4')

   (b) Determine the value of T when system is critically stable and critically damping. (3')

   (c) Calculate the unit step response in time domain of the system with $T = 20$. (3')

2. A control system with a PI-controller is shown in Figure 1.(10')

   (a) Let $K_I/K_P = 0.5$ and determine K_P so that dominant roots have the maximal damping ratio. (5')

   (b) Draw the step response of the system with K_P set to the value determined in part (a). (5')

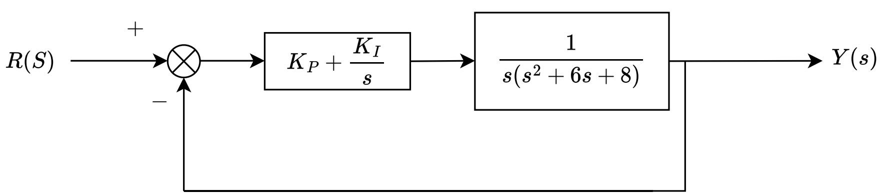

Figure 1: A control system with a PI controller

3. A control system with a PD-controller is shown in Figure 2. (20')

   (a) Given $K = 10$, if one wish the $P.O. \leq 16\%$, and the settling time is $T_s \leq 4s$ (2% of final value). Apply root locus to determine the control parameter K_P and K_D. (10')

   (b) Given the K_P and K_D obtained in question (a), sketch the root locus of the system when K changes from 0 to $-\infty$. (10')

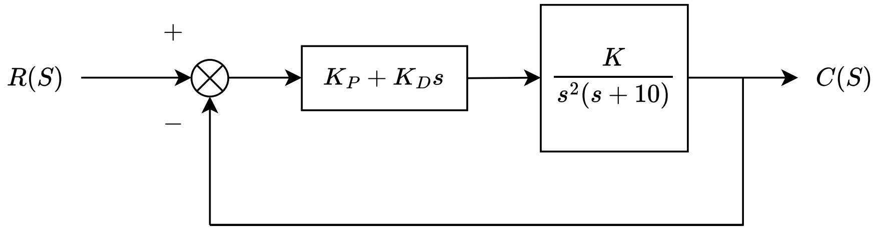

Figure 2: A control system with a PD controller

4. Consider a circuit system whose transfer function is $G(s)$, the high frequency gain of the system is $k_p = 1, (k_p = \lim_{s\to\infty} sG(s))$. We use a P-controller with proportional gain equals to K to control this system. The root locus of the system is given in in Figure 3.(15')

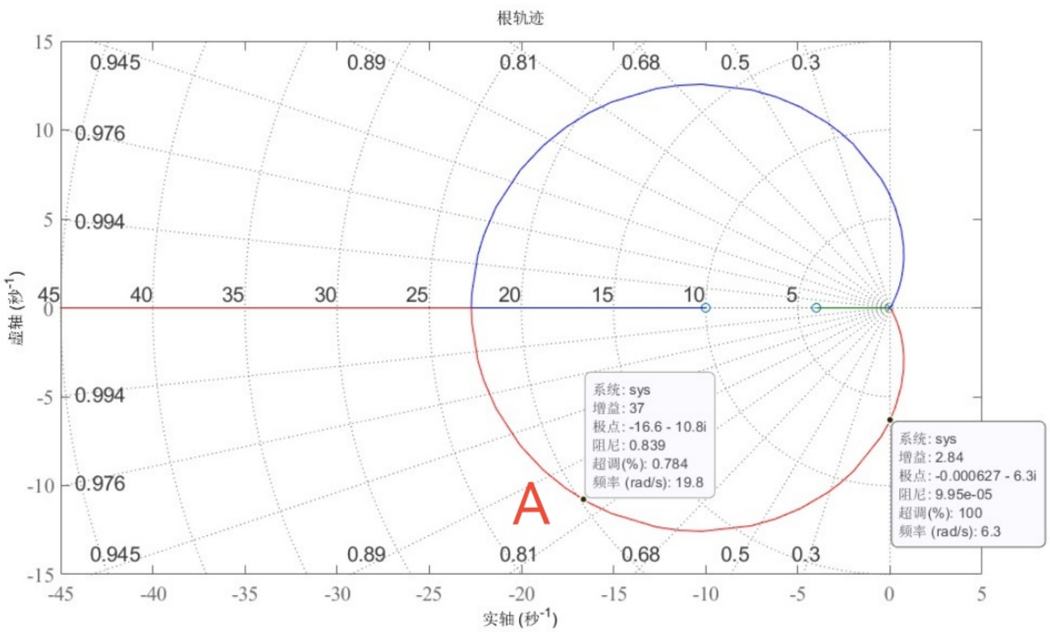

Figure 3: The root locus of the circuit system

(a) Determine the range of K which can stabilize the system.(4')

(b) Derive the transfer function of the system. (3')

(c) For point A in the graph, if there is a 10% change (including positive change and negative change) in K, determine the root sensitivity for point A.(8')

5. (20')

(a) Sketch the Bode plot for the following loop transfer function(6')

$$G_c(s)G(s) = \frac{5(s^2 + 6s + 8)}{(s + 2.5)^2}$$

(b) Use the Bode plot in Figure 4. Derive the transfer function for the open loop system. The initial phase is 0°. $\omega_1 = 0.32, \omega_2 = 4.76, \omega_3 = 50, \omega_4 = 100$(8')

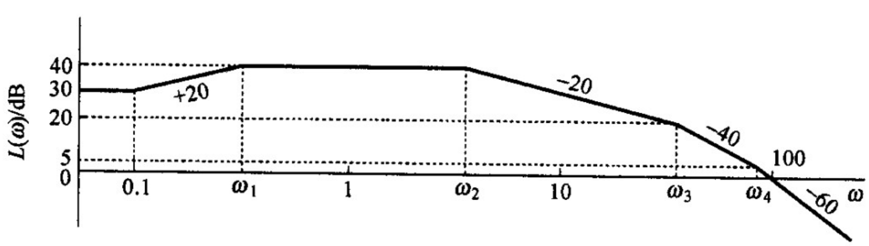

Figure 4: A control system

(c) Sketch the logarithmic-magnitude versus phase angle curve for (b)(6')

6. A model of an automobile course control system is shown in Figure 5, where $K = 5.6$. (15')

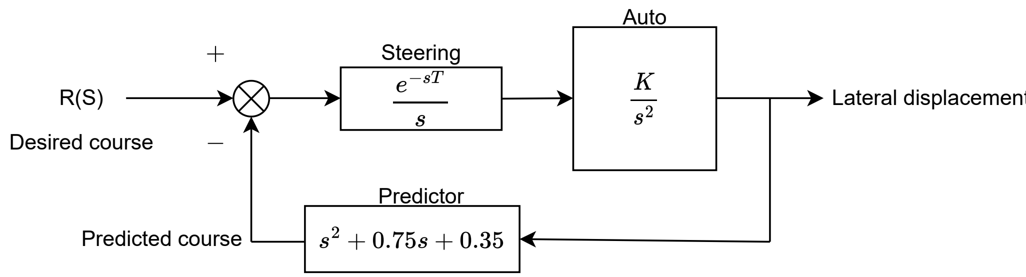

Figure 5: automobile and driver control

(a) Derive the transfer function, show the bode plot and find the gain and phase margin when the reaction time $T = 0$. (5')

(b) Find the phase margin when the reaction time is $T = 0.15s$. (5')

(c) Find the new gain that will let the system in (b) to be borderline stable ($P.M. = 0°$). (5')

7. Anesthesia is used in surgery to induce unconsciousness. One problem with drug-induced unconsciousness is differences in patient responsiveness. Furthermore, the patient response changes during an operation. A model of drug-induced anesthesia control is formulated with a feedback control system when the open-loop transfer function $L(s) = G(s)H(s)$ and $F(s) = 1+G(s)H(s)$. If we use a PD-controller $G_c(s) = K(s + z), z > 0$ to control this system. Setting $K = 5$, the Nyquist plot of the feedback system is shown in Figure 6, in which the poles of the open-loop system are -1 and -3.(10')

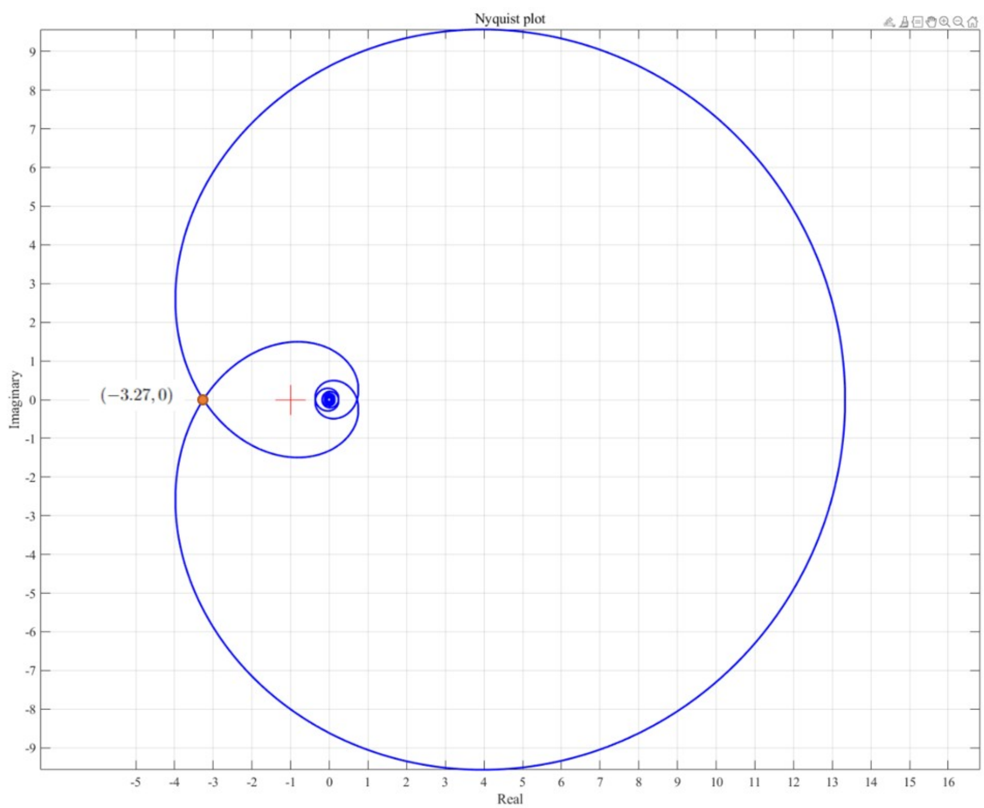

Figure 6: Nyquist plot for control of blood pressure with anesthesia

(a) Judge whether the system shown in Figure 6 is stable? Give reasons to explain it.(3')

(b) Determine the range of K such that the closed-loop system is to be stable.(You can neglect the inner loop) (4')

(c) Assume that the system has a time-delay T. Should we increase or decrease the time delay by setting $K = 5$? Give reasons.(3')