(1) (10%)

Please give a state-space representation, (A,B,C,D), of the transfer function (5%)

$$G(s) = \frac{s+4}{s^3+6s^2+11s+6}$$

Find the eigenvalues of A and the value of CAB. (5%)

(2) (10%)

Consider a unity feedback system where

$$G(s) = \frac{200}{s(s+15)}$$

is the controlled plant and

$$K(s) = \alpha\frac{s+z}{s+p}$$

is the compensator to be designed. Find the parameters of $K(s)$ such that the closed-loop system has the natural frequency $\omega_n = 20$ and the damping ratio $\zeta = 0.7$.

(3) (10%)

Find the transfer function, $\frac{V_2(s)}{V_1(s)} = k\frac{\tau_1 s+1}{\tau_2 s+1}$, of the network circuit shown in Fig.1. (5%) Draw the Bode diagram (only approximate curve, but having the information of k, τ_1 and τ_2) of the system while $R_1 = 9$, $R_2 = 1$ and $C = \frac{1}{9}$. (5%)

(4) (20%)

Design a feedback control system of Fig.2 that satisfies the following specifications:

a) settling time (i.e., within 2% of the final value) of the system ≤ 3 sec;

b) damping ratio of dominant poles ≥ 0.707;

c) Steady-state error for a ramp input = 12.5% of input magnitude.

Compute the desired parameter K_1. (5%)

Determine the region of the closed-loop poles in the complex plane for this design. (5%)

Draw a root locus plot as K varies, and then show the range which will satisfy the specifications. (10%)

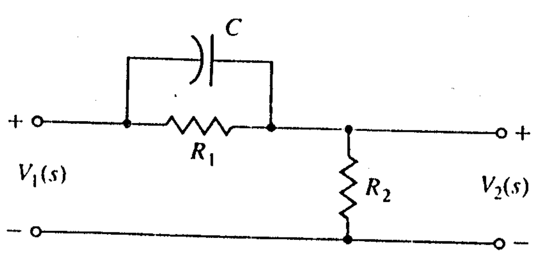


Fig. 1

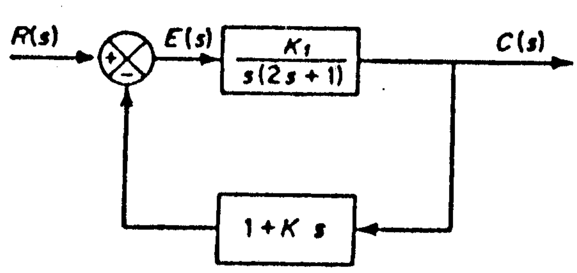


Fig. 2

(背面仍有題目,請繼續作答)

(15%) 5. A machine element is modeled for control purposes as two masses, a dashpot, and a spring sliding on a frictionless surface, as shown below. The compliance comes from such elements as lead screws, gears, belts, etc.

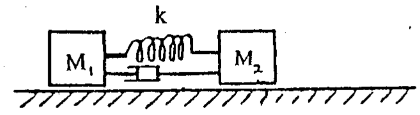


Figure 3 Machine Element Model

The goal is to control the position of M_2. The system is driven by a DC motor directly connected to M_1.

a) For modest sized motors, the motor can be considered as a torque source. Derive the transfer function between motor input and position of M_2 for the case in which there is no damping (these systems are normally very lightly damped). (5%)

b) Can the system be made asymptotically stable with pure derivative control (i.e., feedback of v_2)? (Take $k=M_1=M_2=1$ for this part.) (5%)

c) If a very large motor is used, the motor appears as a velocity source to the driven system. Discuss what the model would be like in this circumstance and whether control would be easier or more difficult. (5%)

(35%) 6. A second order linear time invariant plant is under proportional feedback control.

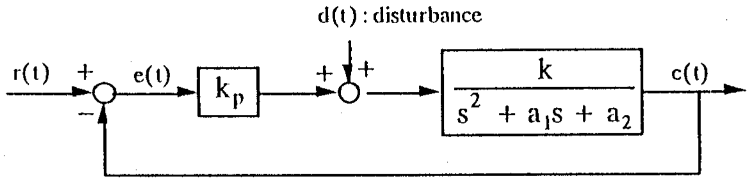


Figure 4

The unit step reference input response for this system, when the control gain k_p was set to 8, is shown in the figure below. (Assume that the disturbance was constant during the test.)

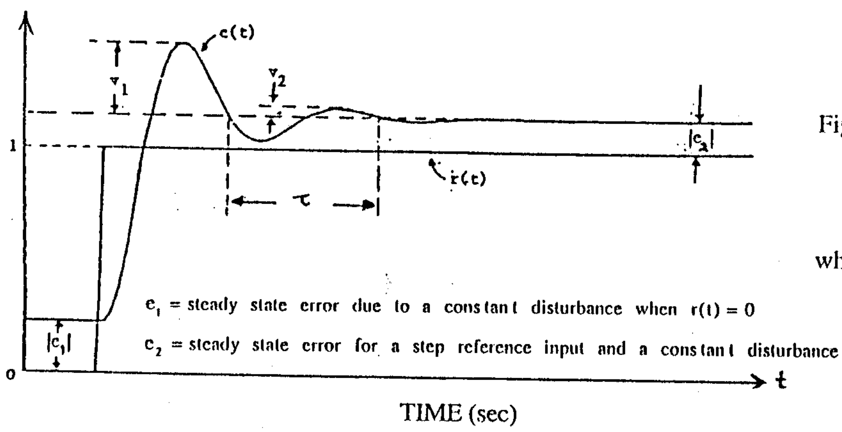


Figure 5

where $e_1 = -0.23$, $e_2 = -0.15$

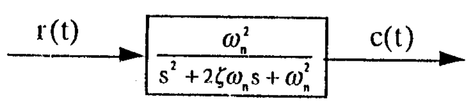
$\tau = \frac{2}{3}\pi$ sec , $\frac{v_2}{v_1} = e^{\frac{-2\pi}{3}}$

a) Find the plant open loop poles. (20%)

b) You are requested to design a new feedback control system for this plant with the following specifications: (15%)

   i) The steady state error for a step reference input and a constant disturbance must be zero.

   ii) The unit step reference input response pattern of the closed loop system should be similar (but not necessarily equal) to the response pattern of the following second order system when $c(0)=0$, $d(t)=0$.



$\zeta = 0.7$, $\omega_n = 4$ $\sec^{-1}$

Figure 6

<u>Hints</u>: The similar response pattern referred to in this problem means that both systems should have the same closed loop zeros and that the dominant poles should be equal. You may consider ideal proportional, derivative and integral action in cascade (series) or in minor loop configurations, whichever satisfies the control specifications given above.