淡江大學九十一學年度碩士班招生考試試題

系別：航空太空工程學系　　　　科目：自 動 控 制

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1. (30%) Consider the unit feedback systems shown below, Figure 1a is a simple second order system. In Figure 1b, an amplifier in the forward path and a minor-loop using rate feedback are incorporated into the system. The plant and the rate feedback transfer functions are

$$G(s) = \frac{8}{s(s+2)} \quad ; \quad H(s) = K_r s \quad , \quad K_r > 0$$

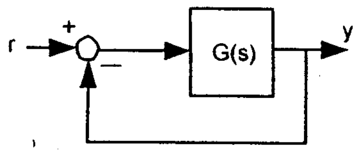

Figure 1a

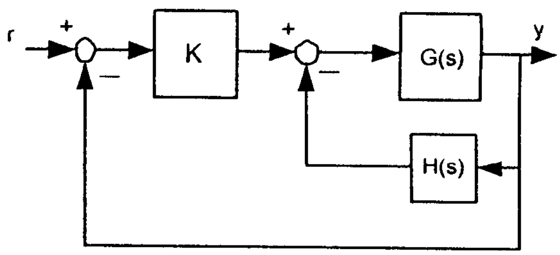

Figure 1b

(a) Determine the equivalent damping factor and natural frequency of the unit feedback system shown in Figure 1a. Also determine the steady-state error resulting from a unit-ramp input. (10%)

(b) In Figure 1b, the rate feedback is used to increase the system damping. Determine the rate feedback gain K_r so that the damping factor of the system will be increased to 0.7 (assume the amplifier gain $K = 1$). What is the steady-state error to unit-ramp input with this setting of the rate feedback. (10%)

(c) In part (b), the steady-state error is increased. Determine the amplifier gain K and the rate feedback gain K_r so that the steady-steady error to unit-ramp input can be reduced to the same value as in part (a), while the damping factor is maintained at 0.7. (10%)

2. (25%) A simple model of a bus suspension system is shown in Figure 2, where m is the mass of the bus, k is the spring constant, b is the damping constant of the dash pot, u is the displacement of the wheel (road height), and y is the displacement of the mass (the height of the bus). From force balance, the system can be represented as

$$m\frac{d^2y}{dt^2} + b\frac{dy}{dt} + ky = b\frac{du}{dt} + ku$$

Assume $m = 1$, $b = 2$, $k = 2$

(a) (5%) Find the transfer function of the system from the road height u to the height of the bus y.

(b) (5%) Find poles and zeros of the system.

(c) (5%) Express the dynamic system in state space form, *i.e.* express the system in the form

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx + Du \end{aligned}$$

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(d) (3%) Find the eigenvalues of the system matrix A in (c).

(e) (7%) Find the transfer function of the system using the results of (c), (*i.e.*, compute the transfer function using A, B, C, D matrices). Is it the same as the result that you get in (a) ? Why ?

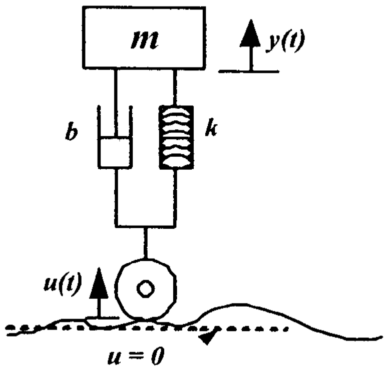

Figure 2. Bus Suspension System

3. (20%)The plant transfer function of a unit feedback system is

$$G(s) = \frac{K(s+1)}{s(s-1)}$$

(a) Sketch the root locus plot with K as a variable parameter.(5%)

(b) Is the system stable for all values of K ? If not, determine the range of K for stable system operation.(5%)

(c) Find the marginal value of K which causes sustained oscillations and the frequency of these oscillations.(5%)

(d) From the root locus plot, determine the value of K such that the resulting system has a settling time of 4 sec. What are the corresponding values of the roots?(5%)

4. (10%) A simple system with time delay is shown in Figure 3. The plant and the delay transfer functions are

$$G(s) = \frac{1}{s(s+1)} \quad ; \quad G_d(s) = e^{-sT}$$

where T is the delay time. Determine the maximum value of the delay time T for the system to be stable.

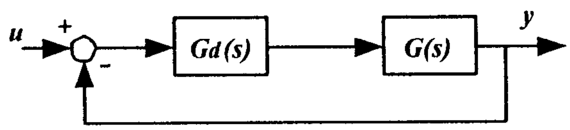

Figure 3. A simple system with time delay

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5. (15%) Describe/explain/answer the following terms/questions.

   (a) Gain margin, Phase margin (3%)

   (b) Nyquist stability criterion (3%)

   (c) General effect of incorporating a lead compensator into a system. (3%)

   (d) General effect of incorporating a lag compensator into a system. (3%)

   (e) Rise time, Peak overshoot, Settling time. (3%)