本試題是否可以使用計算機： ☑可使用 ， □不可使用 （請命題老師勾選）

1. (24%) Is each of the following four statements true or false? State your reasoning.

(a) Adding a pole to the system has the general effect of pushing the root loci to the right, whereas adding a zero pushes the loci to the left. (4%)

(b) The general effect of adding a pole to the loop transfer function is to make the closed-loop system less stable while decreasing the bandwidth. (4%)

(c) Feedback system can be only used to stabilize system, speed up transient response, and improve steady-state characteristics. For disturbance and sensitivity to parameter variations, it does not work. Also, the feedback system with the PI controller can improve transient properties. (4%)

(d) For an unstable feedback system, all the close-loop poles must be in the right-hand plane. (4%)

(e) The maximum overshot of a unit-step response of the second-order prototype system will never exceed 100 percent when the damping ratio and the natural undamped frequency are all positive. (4%)

(f) Increasing the undamped natural frequency will generally reduce the settling time of the step response. (4%)

2. (26%) The DC motor has the armature driven by the electric circuit shown in the following Fig. 1. It is standard to relate the torque T developed in the rotor in terms of the armature current i_a and a torque constant K_t, and to express the voltage generated as a result of rotation in terms of the shaft's rotational velocity $\dot{\theta}_m$ and an electric or electromotive force constant K_e. Thus

$$T = k_t i_a \ \ \& \ \ e = k_e \dot{\theta}_m .$$

Now, assume the rotor has inertia J_m, friction coefficient b, and disturbance $w = 0$.

(a) Find a transfer function of the DC motor relating the output shaft's rotation θ_m to the input voltage v_a? (10%)

(b) If, a normalized function of above transfer function is

$$\frac{\theta_m(s)}{v_a(s)} = K_G G(s) = \frac{1}{s(s+c)},$$

then sketch a root locus with respect to the proportional feedback control with $c = 3$. (8%)

(c) If the control system is a unity feedback loop, find the root locus versus c. (8%)

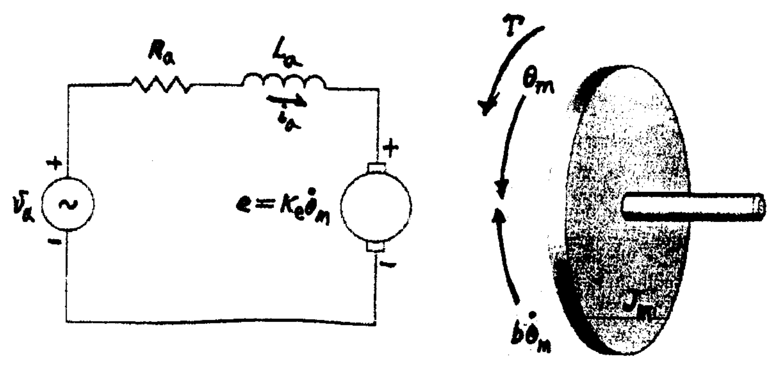


Fig. 1

（背面仍有題目,請繼續作答）

3. (20%) Specification of control system design might require things like this

(i) Steady state error for a ramp input $\leq 10\ \%$,

(ii) Rise time of the system ≤ 0.3 Sec.,

(iii) Settling time of the system ≤ 3 Sec., and

(iv) Damping ratio of dominant roots ≥ 0.707.

Using root-locus methods, find the range of the gain K for which the system in the Fig. 2 can achieve above specifications. The reference input $r(t)$ is a unit ramp.

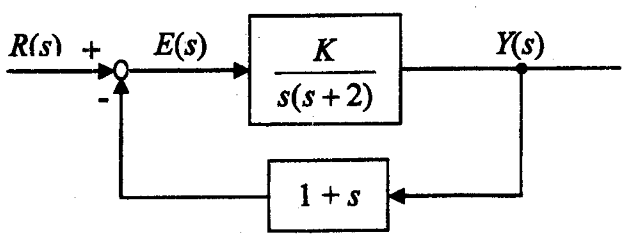


Fig. 2

4. (30%) The two transfer functions are

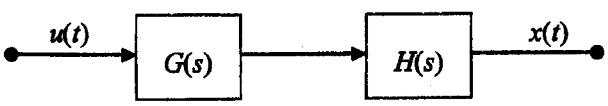
$$G(s)=\frac{10000K}{(s+10)^2},\qquad H(s)=\frac{1}{s+100}$$

(a) Draw the Bode Plot of the open-loop system $G(s)H(s)$ as $K=2$ (See Fig. 3(a).) What kind of the filter? Bandwidth? DC gain? (6%)

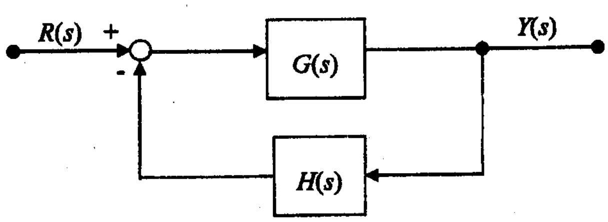
(b) Find the steady-state output $x_{ss}(t)$ of the system $G(s)H(s)$ (also $K=2$) if the input $u(t)=10\cos(1t+\pi/3)+10\cos(1000t)$, as shown in Fig. 3(a). Also, to figure out an approximated $x_{ss}(t)$ by using the Bode Plot of the system $G(s)H(s)$. (8%)

(c) Now, a single-feedback-loop control system is shown in Fig. 3(b). To find the gain and phase margins of the feedback control system between $Y(s)$ and $R(s)$ by using the Bode Plot of the system $G(s)H(s)$. Also, determine the range of K for the stability by using the gain margin. (8%)

(d) Sketch Nyquist Plot for the range of $\omega=0$ to ∞. (8%)



(a)



(b)

Fig. 3