國　立　清　華　大　學　命　題　紙

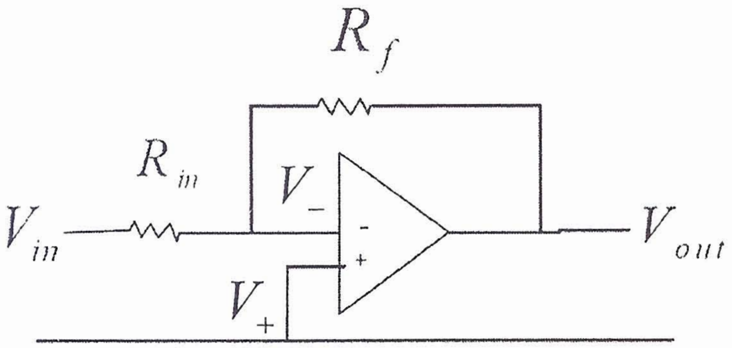
95學年度　動力機械工程學系（所）＿乙＿組碩士班入學考試

科目　控制系統　科目代碼　1601　共＿3＿頁第＿1＿頁　*請在【答案卷卡】內作答

1. A more realistic model of an op amplifier for the following circuitry is given by the two equations below.

   (1) $V_{out} = \dfrac{10^7}{s+1}(V_+ - V_-)$

   (2) The current into the positive port of op (i_+) = The current into the negative port of op (i_-) = 0

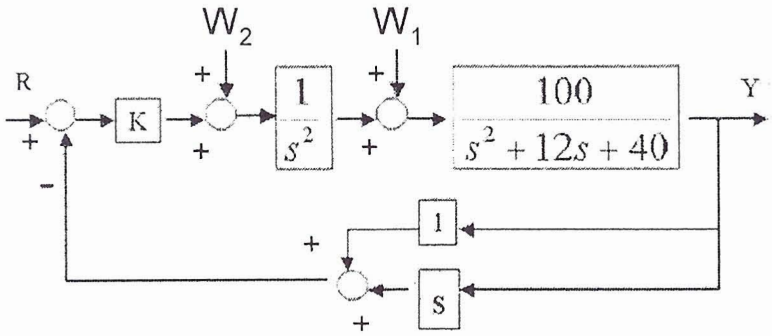


   (a) Find the transfer function $\dfrac{V_{out}}{V_{in}}$ based on the op realistic model as shown above. (5 %)

   (b) What is the circuit bandwidth (real frequency where the magnitude of the transfer function is half of low-frequency gain.) (5%)

2. (a) Sketch the root locus with respect to K for the following system. Be sure to give the (i) asymptotes(5%), (ii) Break-in/Breakaway points(5%), (iii) departure angles(5%), and (iv) imaginary-axis crossings (5%). Based on above information, sketch the root locus(5%).

   (b) What is the steady state response in y for a constant unit disturbanceW_1? (Assume K=1) (5%)



   (c) Based on the Ziegler-Nichols Tuning method (Table 4.2 on the next page), design a PID controller $G_c(s)$ instead of proportional controller K. (10%)

TABLE 4.2 Ziegler–Nichols Tuning for the Regulator $D(s) = K(1 + 1/T_I s + T_D s)$, Based on a Stability Boundary

Type of Controller	*Optimum Gain*
Proportional	$K = 0.5K_u$
PI	$K = 0.45K_u$ $T_I = 1/1.2P_u$
PID	$K = 0.6K_u$ $T_I = \frac{1}{2}P_u$ $T_D = \frac{1}{8}P_u$

3. Consider a negative unit-feedback system with open-loop transfer function G(s) as

$$G(s) = \frac{1000K}{s(s+10)(s+100)}$$

(a) Draw the Bode plot for $G(j\omega)$ assuming K=1. (10%)

(b) Is the system stable for K=1? Find GM(gain margin) and PM(phase margin) from the Bode plot in (a). (10%)

(c) Draw the Nyquist plot for G(s) and determine the range of K to ensure the stability of the system. (10%)

4. Consider a linear time-invariant system with dynamic equation

$$\dddot{y}(t) + 6\ddot{y}(t) + 11\dot{y}(t) + 6y(t) = u(t)$$

(a) Find the state-space representation, $\dot{X}(t) = AX(t) + bu(t)$ and $y(t) = cX(t)$, of the dynamic equation in control canonical form, where the state vector $X(t)$ and the state variables $x_1(t)$, $x_2(t)$, and $x_3(t)$ are defined respectively as

$$X(t) = [x_1(t)\, x_2(t)\, x_3(t)]^T,\quad x_1(t) = y(t),\quad x_2(t) = \dot{y}(t), \text{ and } x_3(t) = \ddot{y}(t). \quad (5\%)$$

(b) Test the controllability and the observability for the state-space representation obtained in (a). (5%)

(c) Design a state feedback gain k such that the poles of the system can be assigned to be –1, -3 and –5 after the state feedback $u(t)=kX(t)+r(t)$. (5%)

(d) Modify the parameter c in the state-space representation obtained in (a) so that the new state-space representation has the same dynamic response as the following dynamic equation.

$$\dddot{y}(t) + 6\ddot{y}(t) + 11\dot{y}(t) + 6y(t) = 3\dot{u}(t) + 2u(t) \qquad (5\%)$$