EE 231 **Exam#2** **March 14, 1989**

75 minutes

1. The field of a DC servomotor is excited by means of a DC amplifier with gain $K_A = 90$ volts/volt as shown in Figure 1. The field has an inductance of $L = 2$ Henry's, and a resistance of $R = 50$ ohms.

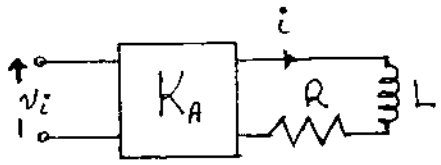

Figure 1:

(a) Calculate the time constant of this system. (5pts.)

(b) Determine the 5% settling time for a unit step input voltage. (5pts.)

To improve the time behavior of the system, a voltage proportional to the field current is fed-back to the amplifier input as shown in Figure 2.

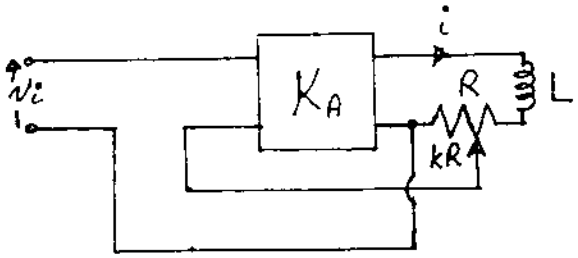

Figure 2:

(c) Determine the feedback proportionality constant k to reduce the time constant to 4 milliseconds. (10pts.)

(d) Find the sensitivity of the transfer function with respect to k for the k determined in part (1c) and for $\omega = 50$. (10pts.)

(e) Determine the steady state error voltage when the input voltage is a unit step. (5pts.)

2. A feedback system employing an output rate damping is shown in Figure 3.

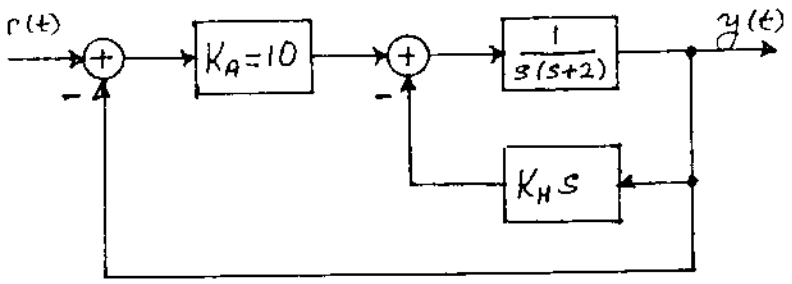

Figure 3:

(a) In the absence of the derivative feedback ($K_H = 0$), determine the damping ratio, the natural frequency, the rise time and the 2% settling time for the unit step response. (10pts.)

(b) Calculate the steady state error (with $K_H = 0$) resulting from a unit ramp input.(5pts.)

(c) Determine the derivative feedback constant K_H which will give a damping ratio equal to 0.6. (10pts.)

(d) Determine the steady state error to a unit ramp input with this value of K_H. (5pts.)

(e) Compute the parameters K_A and K_H again to maintain a damping ratio of 0.6, while reducing the steady state error to a unit ramp input to the value calculated in part (2b). (15pts.)

3. A system oscillates with a frequency ω, if it has poles at $s_{1,2} = \pm j\omega$ and no right half-plane poles. For the system shown in Figure 4, choose K and T, so that the system oscillates with frequency $\omega = 3$ rad/sec. (20pts.)

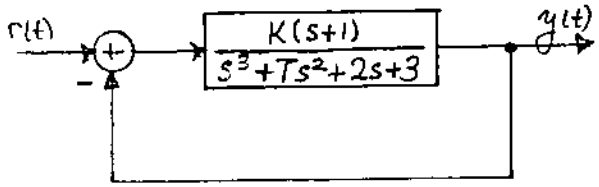

Figure 4:

EE231

EXAM #2
ANSWERS

#1 a,, Time constant = 40 μsec.

b,, 5% settling time $t_s = 120$ μsec

c, $k = 0.1$

d,, $S_k^{R/V_i} = \frac{9\sqrt{26}}{52}$

e,, $e_{ss} = 0.1$

#2 a,, $\zeta = \frac{\sqrt{10}}{10} \approx 0.316$; $\omega_n = \sqrt{10} \approx 3.162$

$t_r = 0.631$ sec 2% settling time $t_s = 4$ sec

b,, $e_{ss} = 0.2$

c, $K_H \approx 1.795$

d,, $e_{ss} = 0.379$

e,, $K_H = 5.2$, $K_A = 36$

#3 $K = 7$, $T = 10/9$