淡江大學 102 學年度碩士班招生考試試題 35-1

系別：電機工程學系控制系統組　　科目：控制系統

考試日期:3月10日(星期日) 第2節　　本試題共　3　大題，　2　頁

本試題雙面印刷

1. Figure 1 below illustrates the automatic breaking control of a train, where $U_r(s)=\mathcal{L}[u_r(t)]$, $V(s)=\mathcal{L}[v(t)]$, u_r is the input voltage representing a desired train speed, and v is the actual train speed,. The amplifier gain is K=100, and the tachometer (velocity sensor) constant is K_g=0.15.
   a. (10%) Suppose that the braking action can be modeled by a transfer function of the form $G_B = \dfrac{F(s)}{E_B(s)} = \dfrac{C}{s+a}$, where $E_B(s)=\mathcal{L}[e_B(t)]$, $F(s)=\mathcal{L}[f(t)]$, $e_B(t)$ is the braking input and $f(t)$ is the resulting braking force. If $f(t)=100(1-e^{-10t})$ is measured with $e_B=u(t)$ (the unit step function), determine the constants a and C.
   b. (10%) The train has mass $M=5\times10^4$ and is assumed to be subjected to no other force than the braking force. What is the transfer function for the train, $G_T = \dfrac{V(s)}{F(s)}$?
   c. (10%) Determine the closed-loop transfer function $T_{cl} = \dfrac{V(s)}{U_r(s)}$.
   d. (10%) Let the input voltage be a step function $u_r(t)=Au(t)$. Determine the value of A if the steady state speed of the train (i.e., at time $t\to\infty$) is to be maintained at 20. (*Hint*: use the Final Value Theorem of Laplace transforms.)

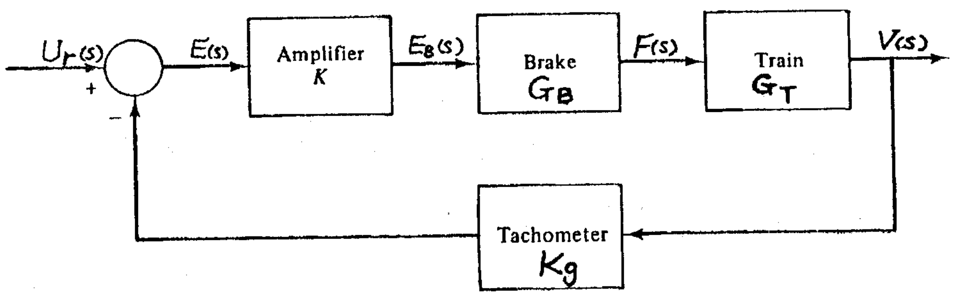

Figure 1 Automatic breaking control of train

2. A motor speed control system with PI control is depicted in the block diagram form in Figure 2. Before the controller was added and the loop was closed, the time response was recorded for a

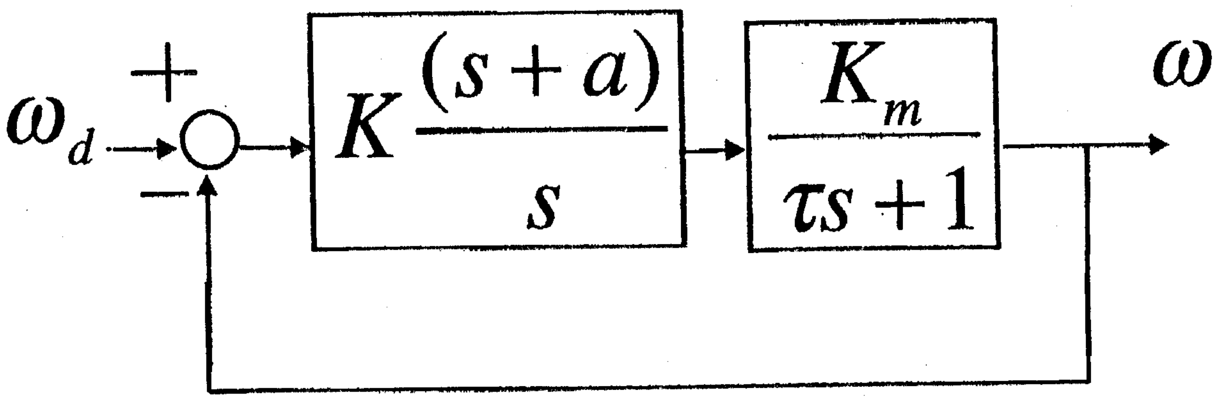

Figure 2 Motor speed control system.

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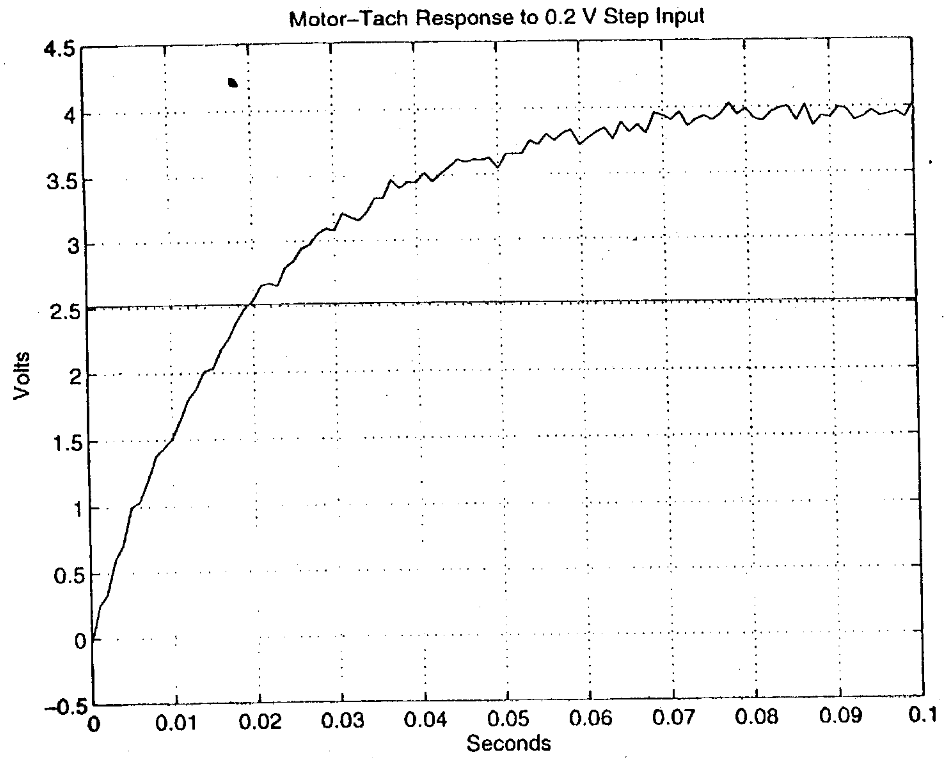
step input of magnitude 0.2 V to the motor-tach system.

a. (10 %) Determine the parameters τ and K_m from the recorded time response as shown in Figure 3. To read the data shown, 0.01 s is an acceptable accuracy for time and 0.5 V is an



acceptable accuracy for voltage.

Figure 3 Time response

b. (10 %) Determine the desired closed-loop poles that achieve a damping ratio of 0.707 and a settling time of 0.02 second.

c. (10 %) Using the angle criterion, determine the location of the controller zero (i.e. the value of a) to obtain the desired closed-loop poles.

d. (5 %) Determine the gain K to obtain the desired closed-loop poles.

e. (10 %) Sketch the root locus. Indicate any open-loop poles and zeros, along with the closed-loop poles obtained in step b, in your sketch. You do not need to calculate the breakaway and break-in points in this step.

f. (5 %) Calculate the real-axis breakaway and break-in points of the root locus.

3. (10%) Find a state space representation for the transfer function

$$G(s)=\begin{bmatrix} \dfrac{-(12s+6)}{3s+34} & \dfrac{22s+23}{3s+34} \end{bmatrix}$$