國立台灣科技大學九十五學年度碩士班招生試題

系所組別： 機械工程系碩士班丁組

科　　目： 線性系統控制

題目共四題，總分 100 分

1. Consider the unity feedback system shown in Fig. 1, the open-loop transfer function is $G(s)=\dfrac{(10-s)}{(s+2)(s+3)}$. To improve the steady state set-point tracking accuracy and maintain acceptable transient response, a PI controller $G_{c1}(s)=\dfrac{K(s+\alpha)}{s}$ is proposed. Suppose that α is selected as 2 to cancel one of the pole, and K is designed to be 1:
   - (a) Use the asymptotes to roughly sketch the Bode plots of $G_{c1}(s)G(s)$. Mark the phase margin and gain margin on the Bode plots, and estimate the phase margin. (10%)
   - (b) Suppose that K is to be tuned, draw the root locus of $G_{c1}(s)G(s)$. Give representations for the break-in and break-away points (if any), and the $j\omega$-axis crossing. Calculate the gain margin for K=1 using root locus results. (10%)
   - (c) A user conjectures that the zero at 10 is undesired, and proposes to add a pole at s=10 to the controller. Determine, and give explicit reasons, whether this suggestion should be accepted. (6%)
   - (d) An engineer modifies the design to a PID controller ($G_{c2}(s)=\dfrac{K(\beta s^2+\alpha s+1)}{s}$) to improve the rise time performance. Explain in terms of Bode plots and root locus why the rise time can be reduced, and comment on the drawbacks of this new design. (8%)

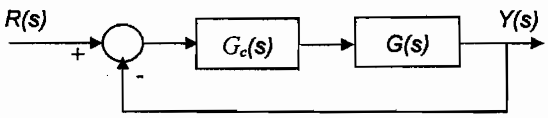

Figure 1: Unity feedback system structure

2. Consider the armature controlled DC motor driving a mechanical load through a gear set, as shown below. V is the input voltage, Ra, La are the armature resistance and inductance respectively. θ_m and θ_L are the angular position of the motor shaft and output shaft respectively, J_m and J_L are the moments of inertia, K is a rotational spring constant, and N_1, N_2 are the number of gears of the gear set. Find the governing equations based on the symbols given, and derive the transfer function $\dfrac{\theta_L(s)}{V(s)}$. The motor characteristics are given as the steady state load-speed curve at the operating voltage V_0. (16%)

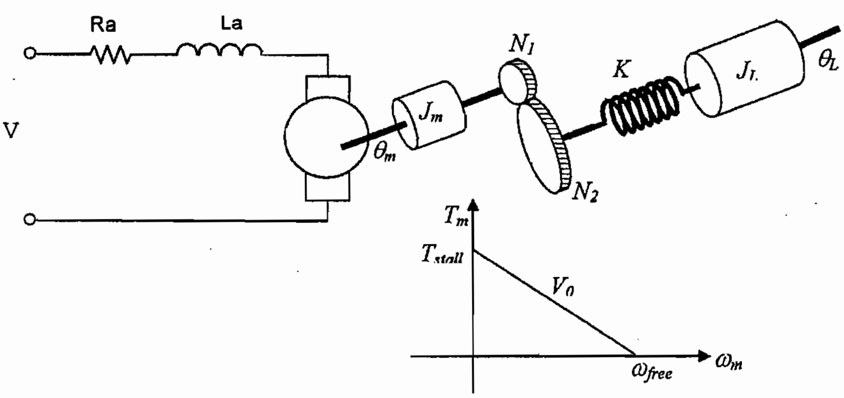

Figure 2

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3. Develop the state model based on state variables x_1 and x_2 of Fig.3. [25%]

(i) Design the state feedback controller so that the desired poles are $-2\pm 2j$.

(ii) Design the state feedback controller to minimize $J=\int_0^{\infty}(3x_1^2+7x_2^2+u^2)dt$.

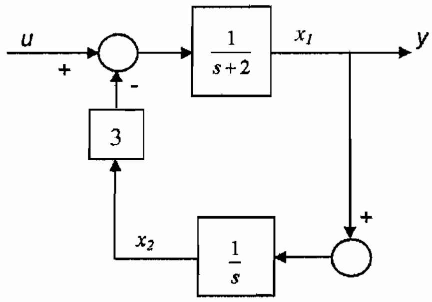

Figure 3

4. As Fig.1, $G=\dfrac{1}{S(S+2)}$. [25%]

(i) Design a suitable G_c so that the velocity error constant is 4 and the phase margin is 50°. Then, is it a phase-lead or phase-lag compensator?

(ii) Design a suitable G_c so that the system damping ratio is 0.5 and the natural frequency is 1*rad/sec*. Then, is it a phase-lead or phase-lag compensator?