科目：控制系統(500E)　　校系所組：交大電子研究所(乙組)
交大電控工程研究所(乙組、丙組)
清大電機工程學系(甲組、丁組)
清大動力機械工程學系(乙組)

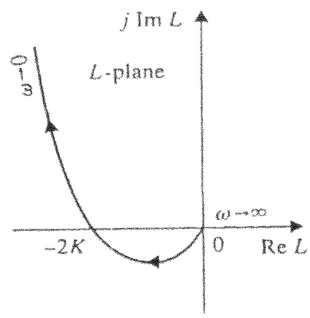
1. (15 %) A system is ruled by the differential equation $\ddot{x}(t)+3\dot{x}(t)-4x(t)=\dot{u}(t)-4u(t)$.

   (a). (3 %) What input will let $x(t)=0, \forall t \geq 0$, assuming zero initial conditions? Why?

   (b). (7 %) The initial condition $x(0)=1$ and $\dot{x}(0)=0$. What are the zero-input response, zero-state response and total response for a unit-step input? Observing the total response, what conclusion can be made?

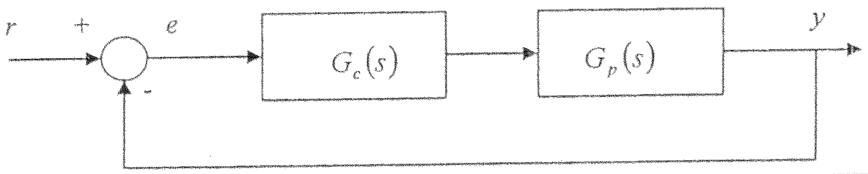
   (c). (5 %) Find the relationship of the initial values $x(0)$ and $\dot{x}(0)$ such that $x(t)$ won't blow up for a unit-step input $u(t)=u_s(t)$.

2. (25 %) A smart engineer like you performs an experiment to test the frequency response of an open loop function, $L(j\omega)$, in a unity-feedback system. You already have the knowledge that $L(j\omega)$ is minimum-phase and has <u>multiple zeros</u> if exists and K>0. The right figure is the Nyquist plot. The intersection of the Nyquist plat and real-axis occurs when $\omega=1$.



   (a) (5 %) When K=1/2, what information you got from this Nyquist plot?
   (b) (10 %) Find out possible $L(s)$ with minimum order.
   (c) (10 %) Plot its root locus, including the angels of departure, breakaway points, the frequency at $j\omega$-axis, and the stability region of K.

3. (10%) Consider the following feedback system with the plant $G_p(s)$ and the controller $G_c(s)$, where $G_p(s)=\dfrac{1}{(s-1)(s+1)}$. You are free to design the controller with the spec. that the maximum overshoot is less than 5% and steady-state error for a unit-step input is less than 0.01. No credit will be given without explanation how you choose the controller and the design procedure.



注意：背面有試題

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4. (12 %) For a DC motor with the following parameters:

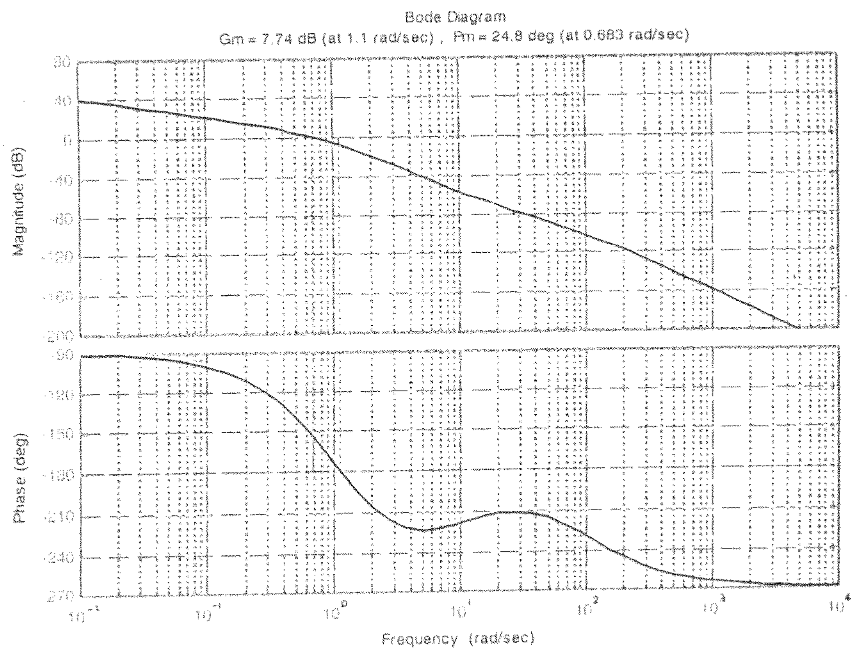
J: rotor inertia
B: viscous-friction coefficient
K_t: motor torque constant, and $T = K_t \cdot i$
R, L: armature current and inductance
K_b: back-emf constant
K_θ, K_ω: displacement and velocity sensor gains
θ, ω: rotor angular displacement and velocity

(a) (2 %) write equations for (i) the motor circuit with the input voltage $e(t)$ and (ii) the motor motion with the torque $T(t)$

(b) (3 %) from the measurements $y_1 = K_\theta \cdot \theta$ and $y_2 = K_\omega \cdot \omega$ from the encoder and the generator, respectively, obtain its state-space equation matrices (*A, B, C, D*) with the state $x = [\theta \quad \omega \quad i]^T$, and

(c) (7 %) by neglecting the armature inductance, determine the controller so that $u = -K_1 \cdot y_1 - K_2 \cdot y_2$ leads to system poles at $p_{1,2} = -a$ with the state $x = [\theta \quad \omega]^T$.

5. (12 %) By observing the Bode plot of a plant as shown below,



(a) (4 %) estimate its transfer function,

(b) (4 %) estimate its steady-state output $y(t)$ with the input $u(t) = \sin 0.2t$ ($t >> 0$), and

(c) (4 %) estimate its steady-state output $y(t)$ of its closed-loop unit-feedback system with the command $r(t) = \sin 0.2t$ (K=1).

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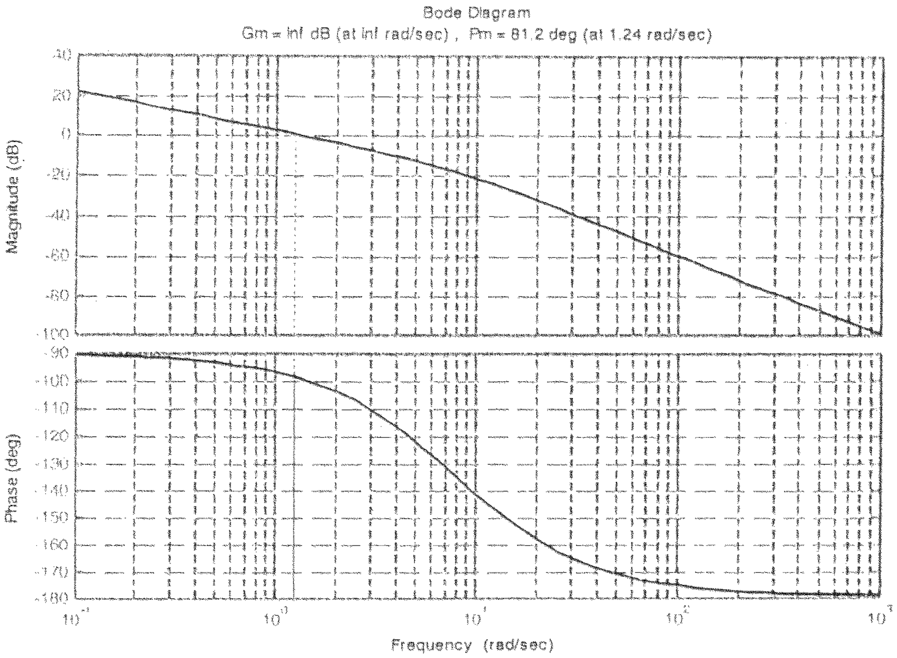
6. (26 %) The Bode plot of a plant $G(s)=\frac{10}{s(s+8)}$ is shown as below



design suitable controllers (lead, lag, or lead-lag) to meet the following specifications :

(a) (7 %) $K_a(s)$ to achieve (i) $K_v = 80\sec^{-1}$ and (ii) PM $\approx 60^o$,

(b) (7 %) $K_b(s)$ to achieve (i) $\omega_g \geq 8 \cdot rad/\sec$ and (ii) PM $\approx 60^o$,

(ω_g :gain crossover frequency)

(c) (7 %) $K_c(s)$ to achieve (i) $K_v = 80\sec^{-1}$, (ii) PM $\approx 60^o$, and

(iii) $\omega_g \geq 8 \cdot rad/\sec$, and

(d) (5 %) by sketching the Nyquist plot of the lead controller $K_{lead}(s) = K\frac{1+aTs}{1+Ts}$,

prove that the maximum phase lead provided by the controller is

$\phi_m = \sin^{-1}\frac{a-1}{a+1}$.