科目：控制系統(300D)　　校系所組：交通大學電控工程研究所（甲組、乙組）
清華大學電機工程學系（甲組、丁組）

參考用

1. (11%) The DC motor variables and parameters are defined as follows:

$i(t)$ = armature current　　L = armature inductance
R = armature resistance　　$e(t)$ = applied voltage
K_b = back-emf constant　　$T_L(t)$ = load torque
K_i = torque constant　　$\omega(t)$ = rotor angular velocity
$\theta(t)$ = rotor angular displacement　　J = rotor inertia
B = viscos friction coefficient

(a) (5%) obtain its transfer function $\frac{\Theta(s)}{E(s)}$

(b) (6%) obtain its state-space equation with
x_1 : rotor angular displacement
x_2 : rotor angular speed, and
x_3 : armature current

2. (18 %) For a system as $G(s)=\frac{2(s+1)}{s^2(s+100)}$,

(a) (6%) plot its root locus,
(b) (6%) estimate all control gains to achieve $\zeta = 0.707$ with unit feedback, and
(c) (6%) if the system is with non-unit feedback $H(s) = 2$, determine its steady-state error e_{ss} with a unit-step function input.

3. (21%) For a plant as $G(s)=\frac{c}{s(s+a)(s+b)}$ with unit feedback,

(a) (7%) to achieve the closed-loop poles at $-d \pm je$ with a suitable gain K_1, determine the third closed-loop pole $(s+f)$ of the system,
(b) (7%) obtain the control gain K_2 to achieve critically damped system ($\zeta = 1$) for the dominant poles, and
(c) (7%) determine the coefficient g for a PD control $K_3(s+g)$ to achieve the closed-loop poles at $-2d \pm j2e$

注意：背面有試題

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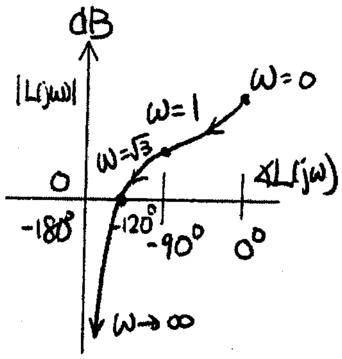
4. (27 %) The Nichols chart of the open-loop transfer function $L(j\omega)$ of a unity-feedback system is shown in the following.



(a) (10%) Determine the open-loop transfer function.

(b) (3 %) Let the input is unit-step. Find the closed-loop steady-state error in percentage.

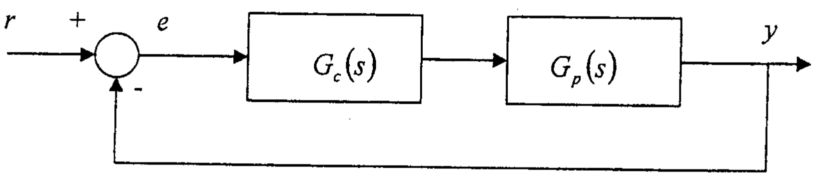
(c) (5 %) Plot the corresponding Nyquist plot of $L(j\omega)$, indicating all information from the Nichols chart. Is the system stable?

(d) (4 %) Determine the phase margin and gain margin and its corresponding frequencies.

(e) (3 %) A P controller is added to increase the phase margin to 90°. Find the controller and its corresponding gain-crossover frequency.

(f) (2 %) To reduce the closed-loop steady-state error by P controller, what will happen to its phase margin, why?

5. (23 %) Consider the following feedback system with the plant $G_p(s)$ and the controller $G_c(s)$.



Let $G_p(s)=\dfrac{1}{s^2(s+6)}$. You are asked to desired a PD controller $G_c(s)=K(s+z)$, where z>0.

(a) (8 %) Sketch the Nyquist plot for K>0 and z>0. Determine the range of z to stabilize the system.

(b) (5 %) Choose z=1. Find K and the corresponding gain crossover frequency so that the phase margin=45°

(c) (2 %) When $r(t)=e^{-t}$, what output will you expect in (c)?

(d) (5 %) Formulate the system by Controllability Canonical form. Let the state equation. $\begin{matrix}\dot{x}=\mathrm{A}x+\mathrm{B}r\\ y=\mathrm{C}x+\mathrm{D}r\end{matrix}$, where $x=[x_1 \quad x_2 \quad x_3]^T$ and $y=x_1$, $x_2=\dot{x}_1$, and $x_3=\dot{x}_2$. Find the corresponding A, B, C and D in terms of K and z.

(e) (3 %) Let $x=\mathrm{P}\bar{x}$. It exists a nonsingular matrix P to factorize A to be $\bar{\mathrm{A}}$, which is diagonal. Why do we have to transform A to be diagonal? What is the advantage?