國立臺灣科技大學

九十一學年度碩士班招生考試試題

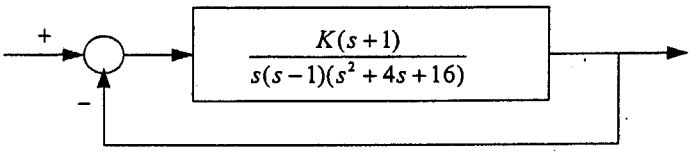
系所組別： 工程技術研究所自動化及控制學程丙組

科　目： 控制系統

總分 100 分

1. (15%)

An open-loop transfer function of an airplane with an autopilot in the longitudinal mode is



Such a system containing an open-loop pole in the right-half plane may be conditionally stable.

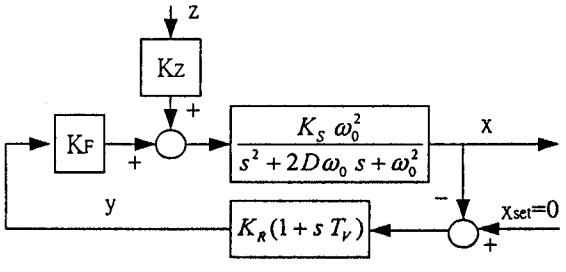
(a) Please sketch the root loci. (8%)

(b) Find the range of gain K for stable. (7%)

Note: $(3s^4+10s^3+21s^2+24s-16)=3(s+0.76+j2.16)(s+0.76-j2.16)(s+2.26)(s-0.45)$,

2. (25%)

A ship is fitted with stabilizers to achieve an active control to reduce ship's rolling motion. Disturbance z caused by waves makes the ship rolling. The stabilizer's angle y is controlled to keep ship's rolling angle $x = 0$. The block diagram is shown in Fig. 1.



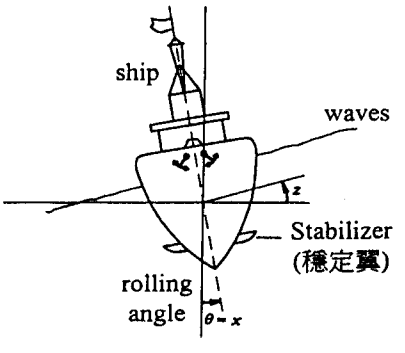


Fig. 1

(a) Please derive the transfer function of disturbance $G_{Sz}(s)=\frac{X(s)}{Z(s)}$, and solve the rolling angle $x(t)$ as $z(t)=\delta(t)$, where $\delta(t)$ is a impulse function. (6%)

(b) Solve the rolling angle $x(t)$ as $z(t)=\begin{cases} Z_0\cos\omega_0 t & for\ t>0 \\ 0 & for\ t\le 0 \end{cases}$ with initial values of $x(t)=0,\ \dot{x}(t)=0$ (9%)

(c) In the closed-loop control system, a PD-controller, $K_R(1+s\,T_V)$, is used to control the stabilizer. Please solve the control parameters of the PD-controller, K_R and T_V, to make the damping ratio D_C and the natural frequency ω_{0C} of the close-loop system keeping $D_C=0.707,\ \omega_{0C}=10\,s^{-1}$, where

$D=0.1;\ \omega_0=2\,s^{-1};\ K_SK_Z=1;\ \frac{K_F}{K_Z}=3;\ Z_0=4^\circ$. (10%)

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3. (15%)

A position control system is shown in Fig. 2(A), which control parameter K_V can be designed to satisfy the required control performance. If the control performance in such a system still cannot satisfy the requirement, an inner loop velocity feedback can be used as shown in Fig. 2(B).

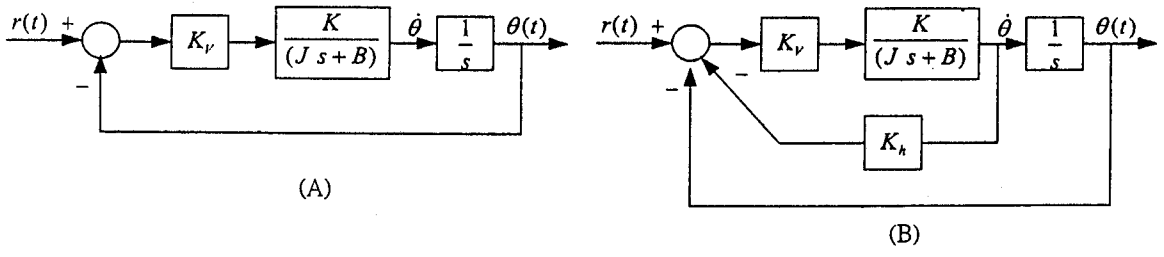

Fig. 2

(a) Please derive the closed-loop transfer functions for the above two control systems (6%)

(b) Please discuss the influence of the additional velocity feedback in the position control system (4%)

(c) If a differentiator is used for the feedback of velocity signals, please explain what problem will appear, and how to improve it? (5%)

4. (15%)

A unit feedback system as shown in Fig. 3 is controlled by a compensator $C(s) = \alpha \frac{s+z}{s+p}$.

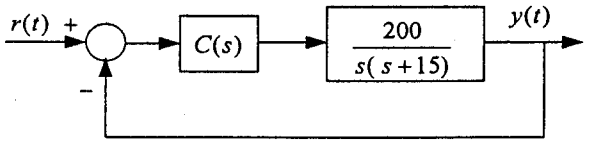

Fig. 3

Please find the control parameters of $C(s)$ to achieve the natural frequency $\omega_n = 20$ rad/s and the damping ratio $\varsigma = 0.7$ of the closed-loop control system. (15%)

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5. (15%)

Consider a system $\dot{\mathbf{x}} = \mathbf{A}\,\mathbf{x} + \mathbf{B}\,u$

where $\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$ $\mathbf{B} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

(a) Please show if this control system is controllable. (5%)

(b) By using the state feedback control $u = -\mathbf{K}\mathbf{x}$, the closed-loop poles at $s = -2 \pm j4$ and $s = -10$ are desired. Please determine the state feedback gain matrix $\mathbf{K}$. (10%)

6. (15%)

Consider a delayed system shown in Fig. 4,

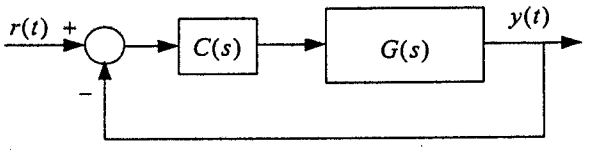

Fig. 4

where $G(s) = \dfrac{\sqrt{5}}{s(s+2)}$ and $C(s) = e^{-Ts}$. Please find the maximum time delay T with the closed-loop stability. (15%)