Problem I (40%). For the third-order system:

$$G(s) = \frac{32000}{s(s+8)(s+40)}$$

(a) Use Bode plot sketches to design a compensator so that PM > 45° and ω_{BW}>15 rad/sec, where PM stands for phase margin and ω_{BW} is the closed-loop bandwidth (25%). (b) Verify your design by drawing compensated Bode plots. Refine and verify your design again if necessary (15%).

Problem II (40%). Consider the plant dynamics described by

$$\dot{x} = \begin{bmatrix} 0 & 2 \\ 5 & -4 \end{bmatrix} x + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u$$
$$y = [1 \quad 2]x$$

1. Draw a block diagram for the plant with one integrator for each state variable (5%).
2. Find the transfer function using matrix algebra (5%).
3. Find the closed-loop characteristic equation if the feedback is (a) $u = Ky$ (5%) (b) $u = -[K_1 \quad K_2]x$ (5%)
4. Design an operational amplifier circuit to realize the plant dynamics. Perform a circuit analysis to show that the transfer function is indeed identical (20%).

Problem III (20%). Bode's gain-phase relationship states that for any stable minimum-phase transfer function $G(j\omega)$, the phase of $G(j\omega)$ is uniquely related to the magnitude of $G(j\omega)$, by

$$\angle G(j\omega) = \frac{1}{\pi}\int_{-\infty}^{+\infty} \frac{dM}{du} W(u)du \text{ (in radians)},$$

where

M = log magnitude = ln $|G(j\omega)|$,

u = normalized frequency = ln (ω/ω_0),

dM/du ≈ slope n, the slope of $G(j\omega)$ in units of decade of amplitude per decade of frequency,

$W(u) = \ln(\coth|u|/2) \approx \pi^2\delta(u)/2$.

Use it to explain why it is desirable to have $n = -1$ for ω around ω_c, the crossover frequency for about a decade. Give a numerical example.

試題隨卷繳回