12.1 Consider the following open-loop TF, where $G(s)=Y(s)/U(s)$

i. $G(s)=\dfrac{(s+3)}{(s+4)^2}$ ii. $G(s)=\dfrac{s}{(s+5)(s+7)}$

iii. $G(s)=\dfrac{20s(s+7)}{(s+3)(s+7)(s+9)}$ iv. $G(s)=\dfrac{30(s+2)(s+3)}{(s+4)(s+5)(s+6)}$

v. $G(s)=\dfrac{s^2+8s+15}{(s^2+4s+10)(s^2+3s+12)}$

For each of these TF, do the following

a. Draw the signal-flow graph in phase-variable form
b. Add state-variable feedback to the signal-flow graph
c. For each closed-loop signal-flow graph, write the state equations
d. Write, by inspection, the closed-loop TF $T(s)$ for your closed-loop signal-flow graphs
e. Verify your answers for $T(s)$ by finding the closed-loop TF from the state equations and Eq.3.73

12.2 The following open-loop TF can be represented by signal-flow graphs in cascade form

i. $G(s)=\dfrac{30(s+2)(s+7)}{s(s+3)(s+5)}$ ii. $G(s)=\dfrac{5(s^2+3s+7)}{(s+2)(s^2+2s+10)}$

For each, do the following

a. Draw the signal-flow graph and show the state variable feedback
b. Find the closed-loop TF with state variable feedback

Solution

12.3 The following open-loop TF can be represented by signal-flow graphs in parallel form

a. $G(s)=\dfrac{50(s^2+7s+25)}{s(s+10)(s+20)}$ b. $G(s)=\dfrac{50(s+3)(s+4)}{(s+5)(s+6)(s+7)}$

For each, do the following

a. Draw the signal-flow graph and show the state variable feedback
b. Find the closed-loop TF with state variable feedback

12.4 Given the following open-loop plant

$$G(s)=\frac{20}{(s+2)(s+4)(s+8)}$$

design a controller to yield a $\%OS=4.32\%$ and $T_s=4s$. Place the third pole 10 times as far from the imaginary axis as the dominant pole pair. Use the phase variables for state-variable feedback

12.5 Section 12.2 showed that controller design is easier to implement if the uncompensated system is represented in phase-variable form with its typical lower companion matrix. We alluded to the fact that the design can just as easily progress using the controller canonical form with its upper companion matrix

a. Redo the general controller design covered in Section 12.2, assuming that the plant is represented in controller canonical form rather than phase-variable form
b. Apply your derivation to the system

$$G(s)=\frac{20(s+5)}{s(s+1)(s+4)},\quad \%OS=9.5\%,\quad T_s=0.74s$$

if the uncompensated plant is represented in controller canonical form

12.6 Given the following open-loop plant

$$G(s)=\frac{100(s+2)(s+20)}{(s+1)(s+3)(s+4)}$$

design a controller to yield 15% overshoot with a peak time of $0.5s$. Use the controller canonical form for state-variable feedback

12.7 Given the following open-loop plant

$$G(s) = \frac{20(s+2)}{s(s+5)(s+7)}$$

design a controller to yield $\%OS = 10\%$ and $T_s = 2s$. Place the third pole 10 times as far from the imaginary axis as the dominant pole pair. Use the phase variables for state-variable feedback

12.8 Given the following open-loop plant

$$G(s) = \frac{20}{(s+2)(s+4)(s+8)}$$

design a controller to yield a $\%OS = 4.32\%$ and $T_s = 4s$. Place the third pole 10 times as far from the imaginary axis as the dominant pole pair. Use the cascade form for state-variable feedback

12.18 If an open-loop plant

$$G(s) = \frac{100}{s(s+5)(s+9)}$$

is represented in parallel form, design a controller to yield a closed-loop response of 15% overshoot and a peak time of $0.2s$. Design the controller by first transforming the plant to controller canonical form

12.20 Consider the plant

$$G(s) = \frac{1}{s(s+3)(s+7)}$$

whose state variables are not available. Design an observer for the observer canonical variables to yield a transient response described by $\zeta = 0.4$ and $\omega_n = 75$. Place the third pole 10 times farther from the imaginary axis than the dominant poles