Reduction of Multiple Subsystems

(Nise's Textbook Ch. 4)

Components used in Block Diagram Representations

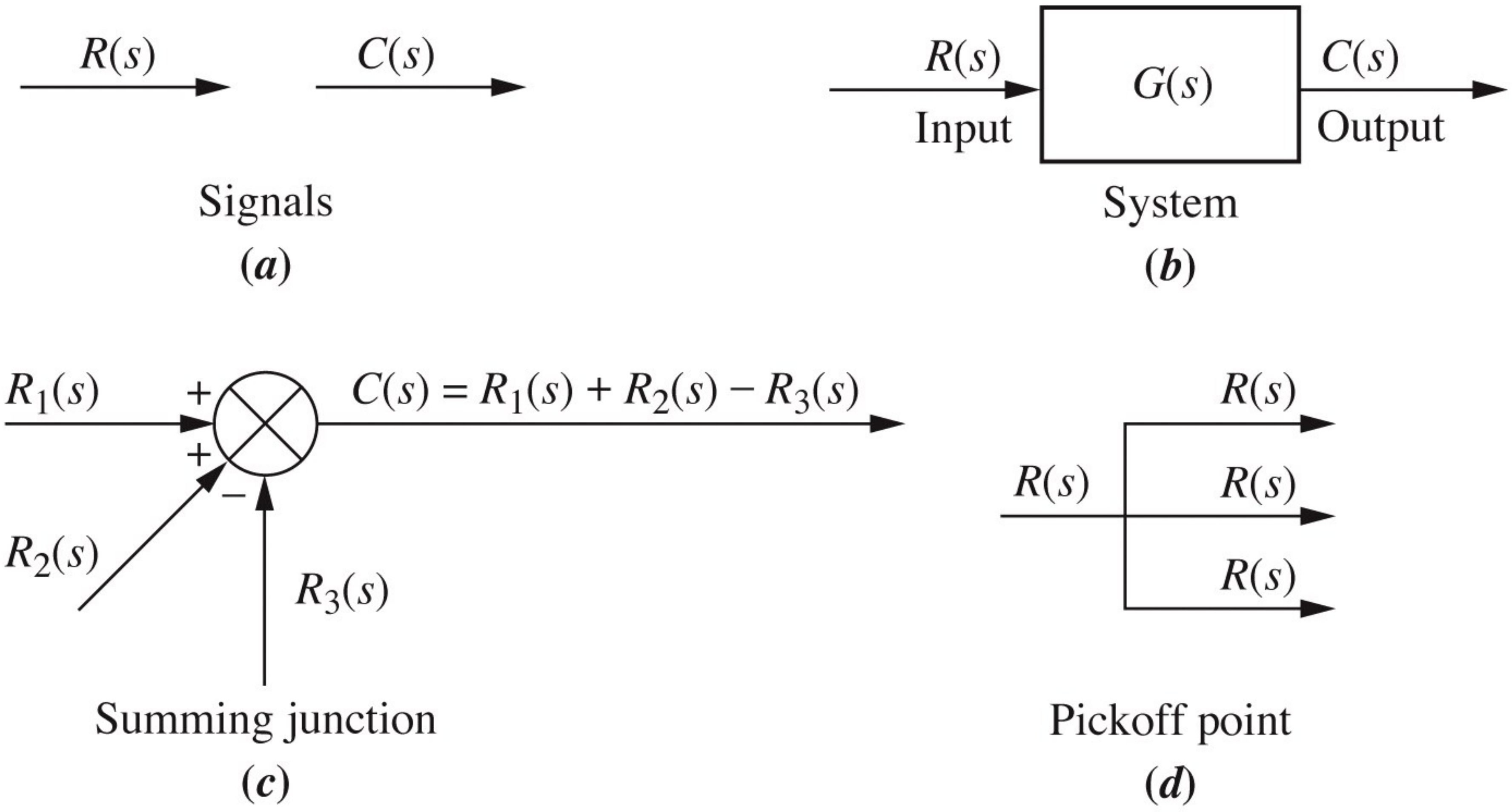


Figure 5.2

Cascade Connection

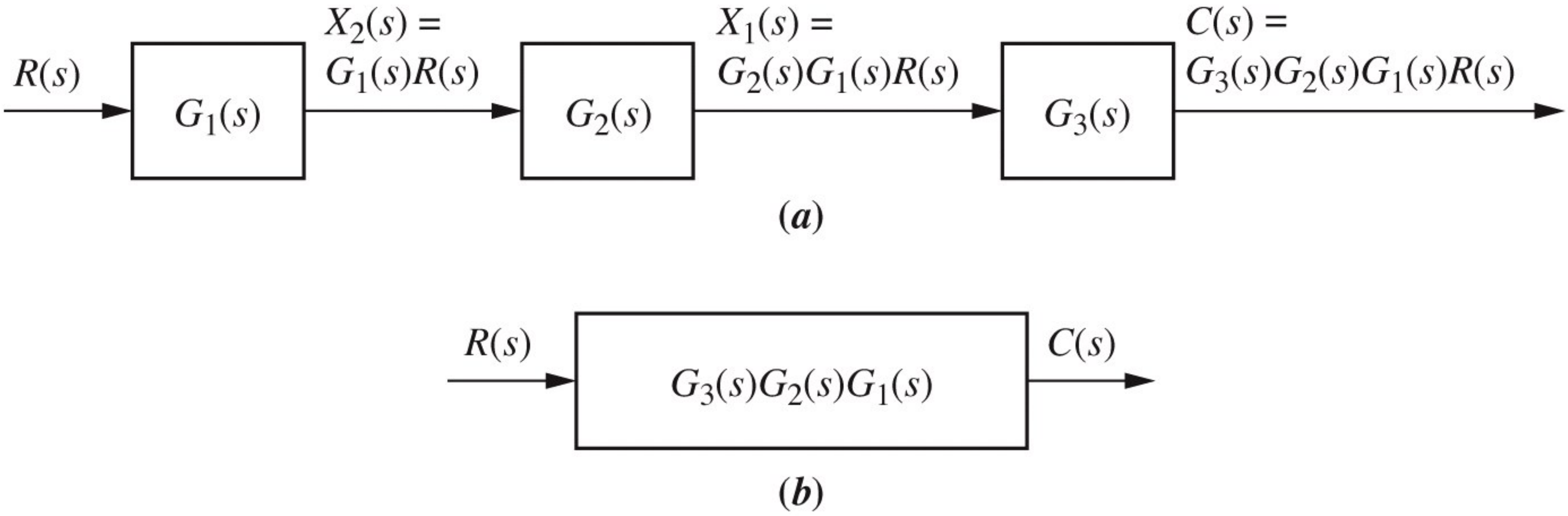


Figure 5.3

Unloading Issue Explained

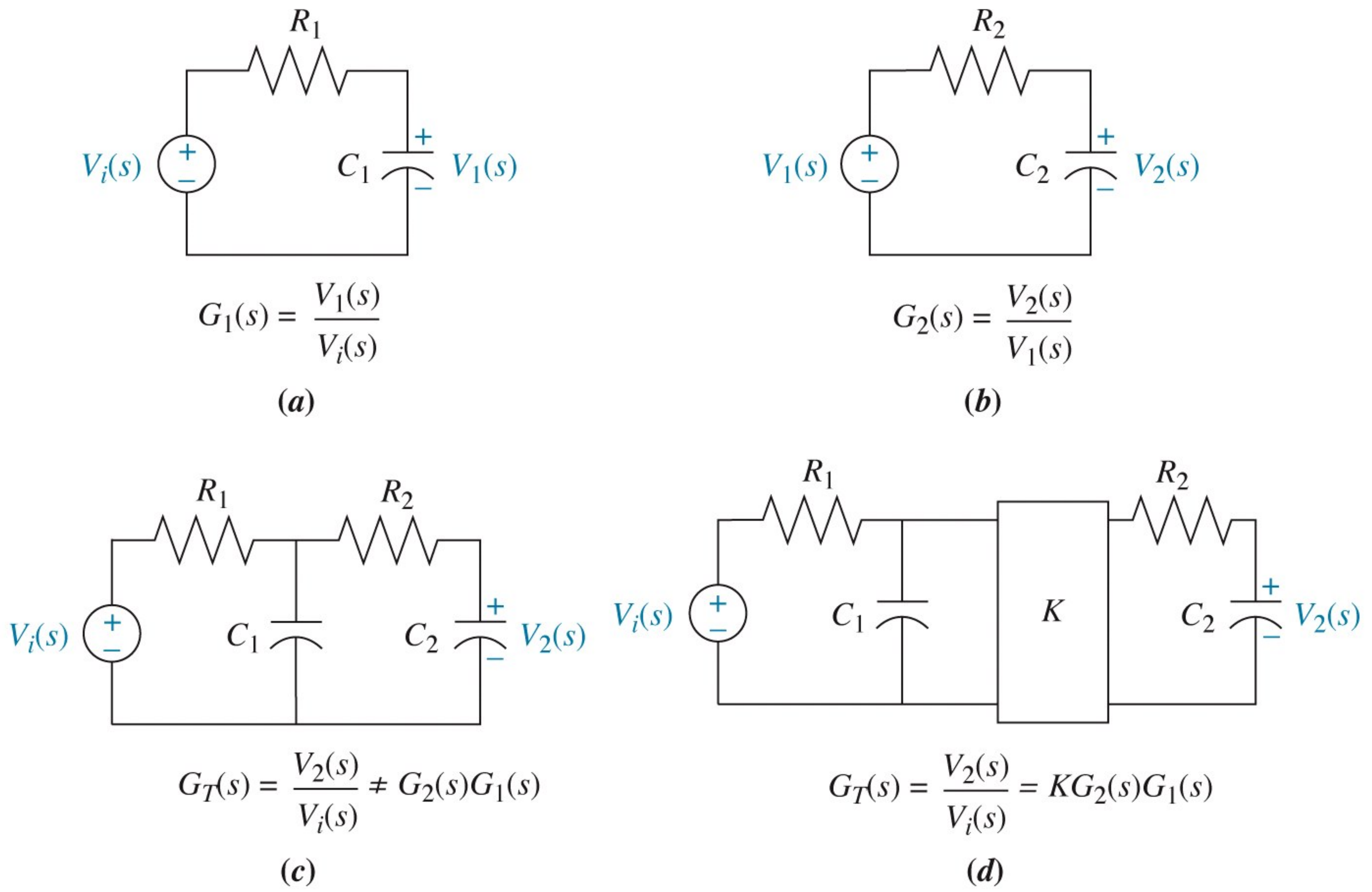


Figure 5.4

Parallel Connection

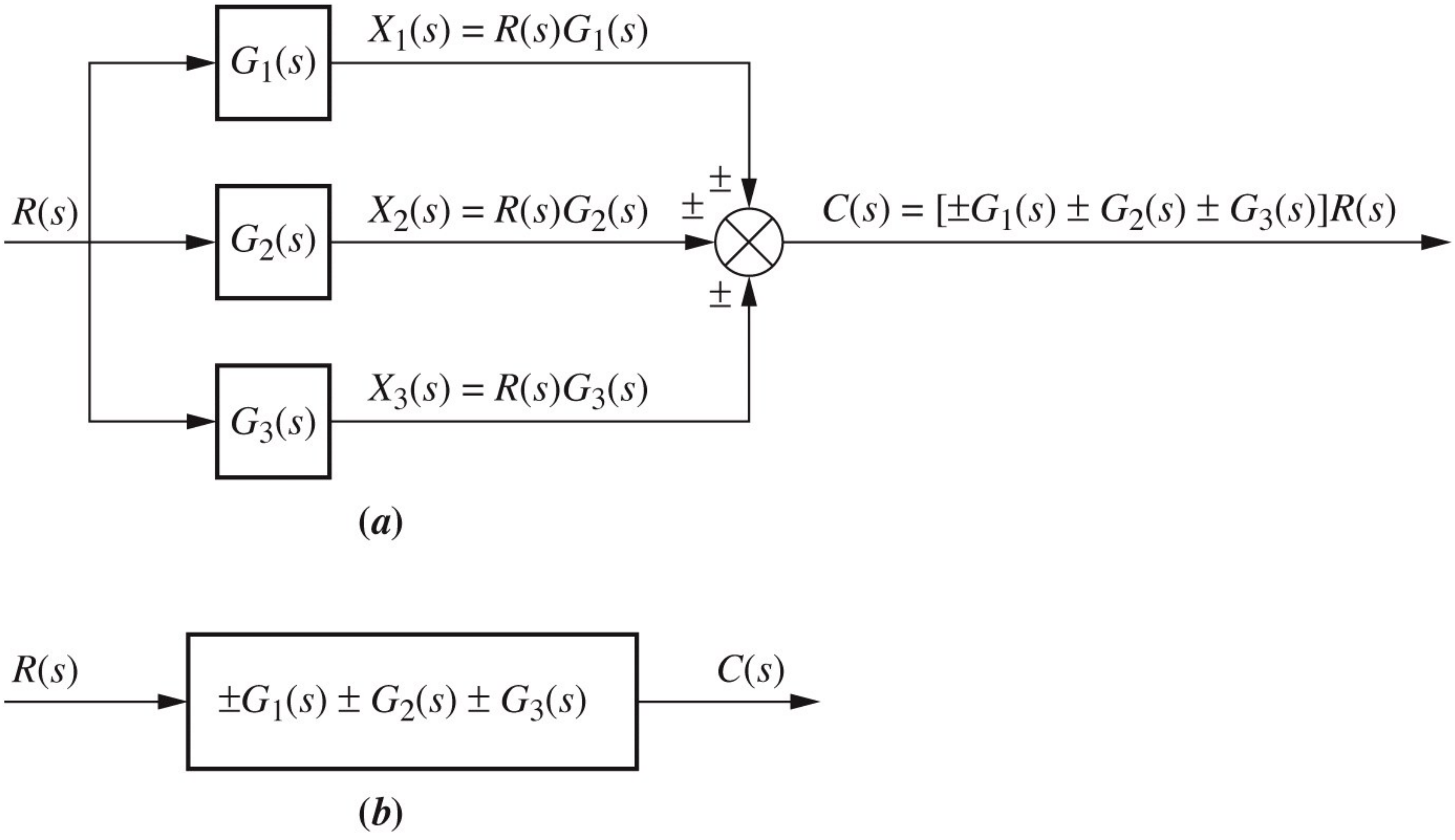


Figure 5.5

Feedback Connection

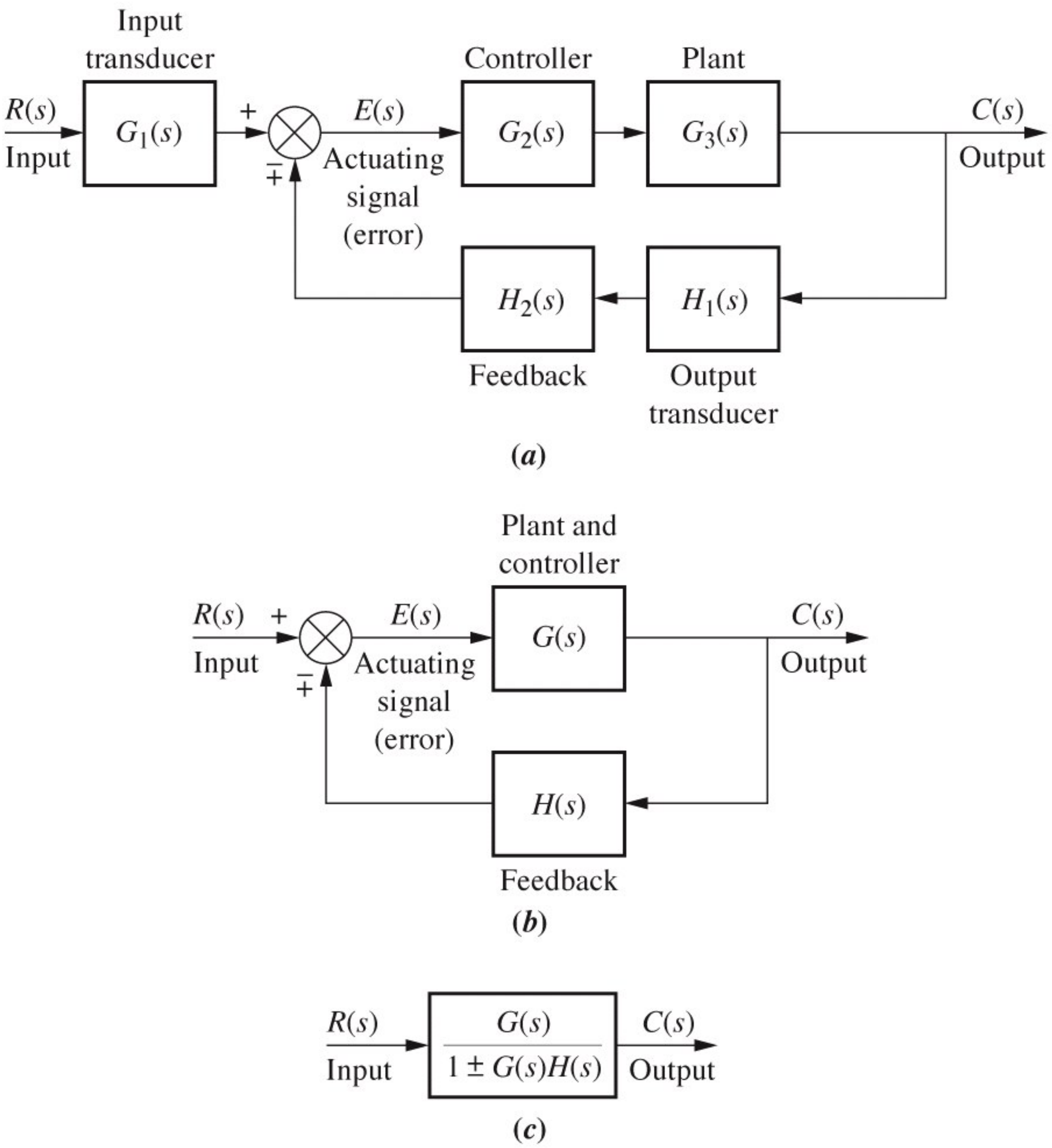
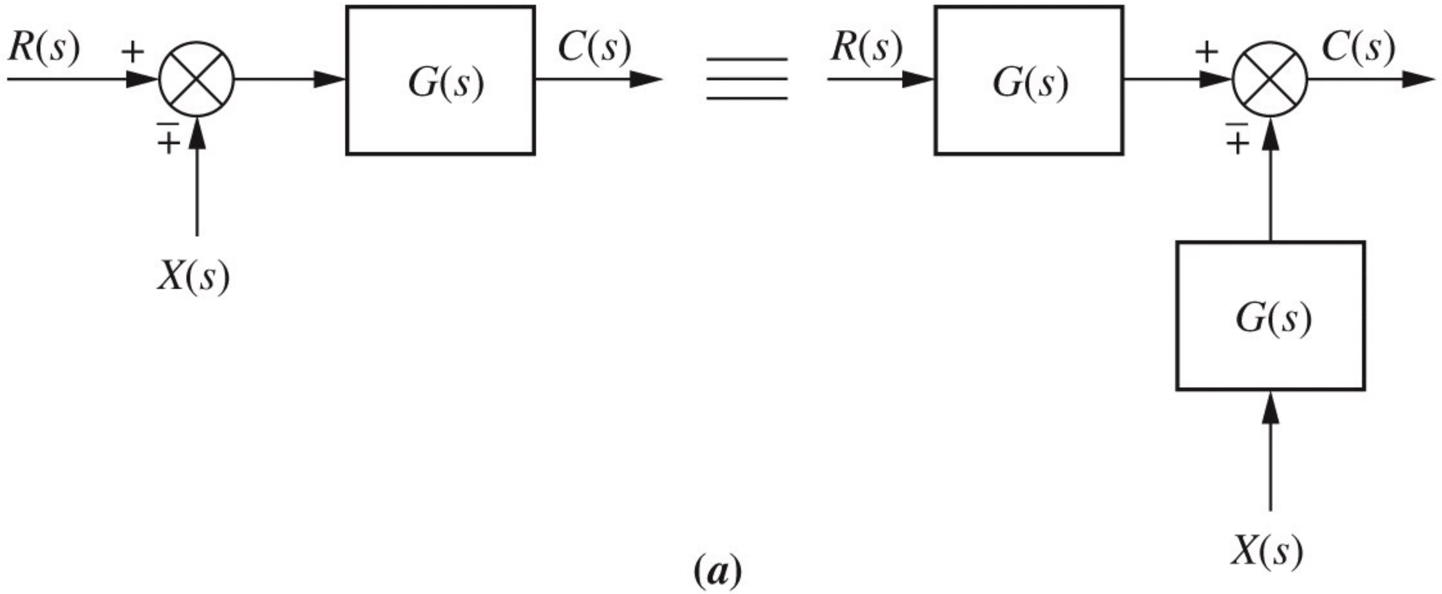
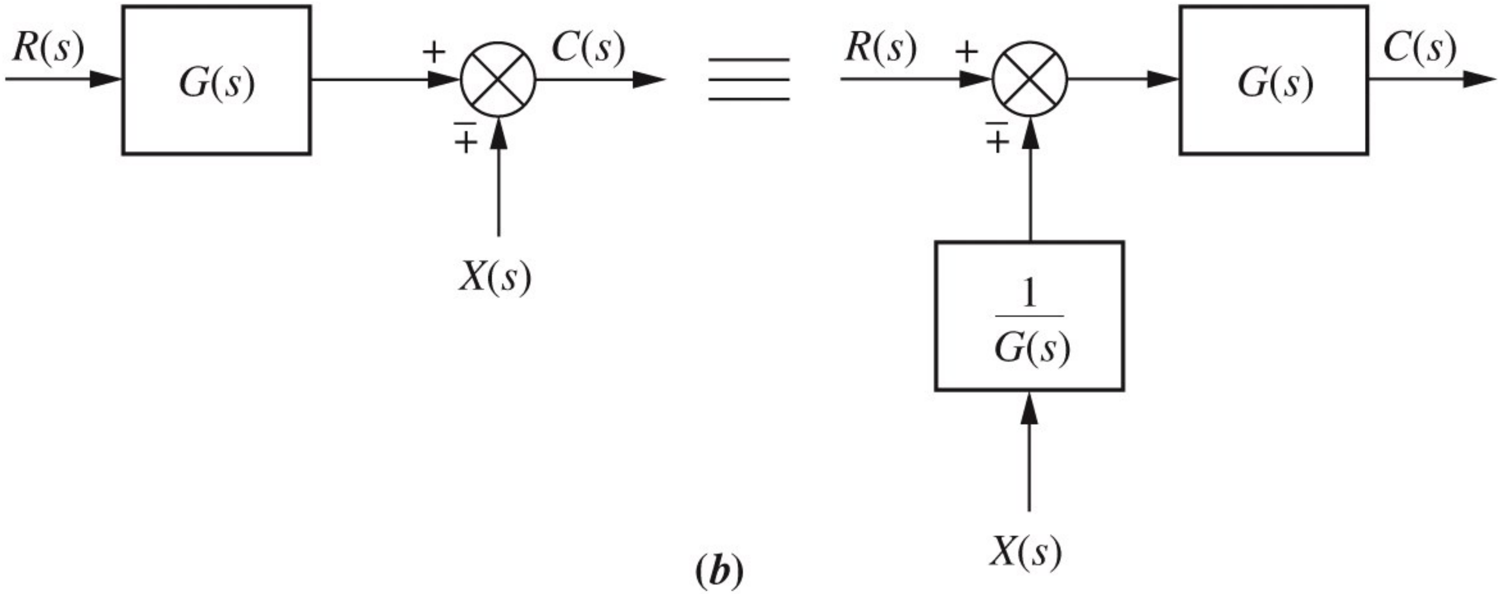


Figure 5.6

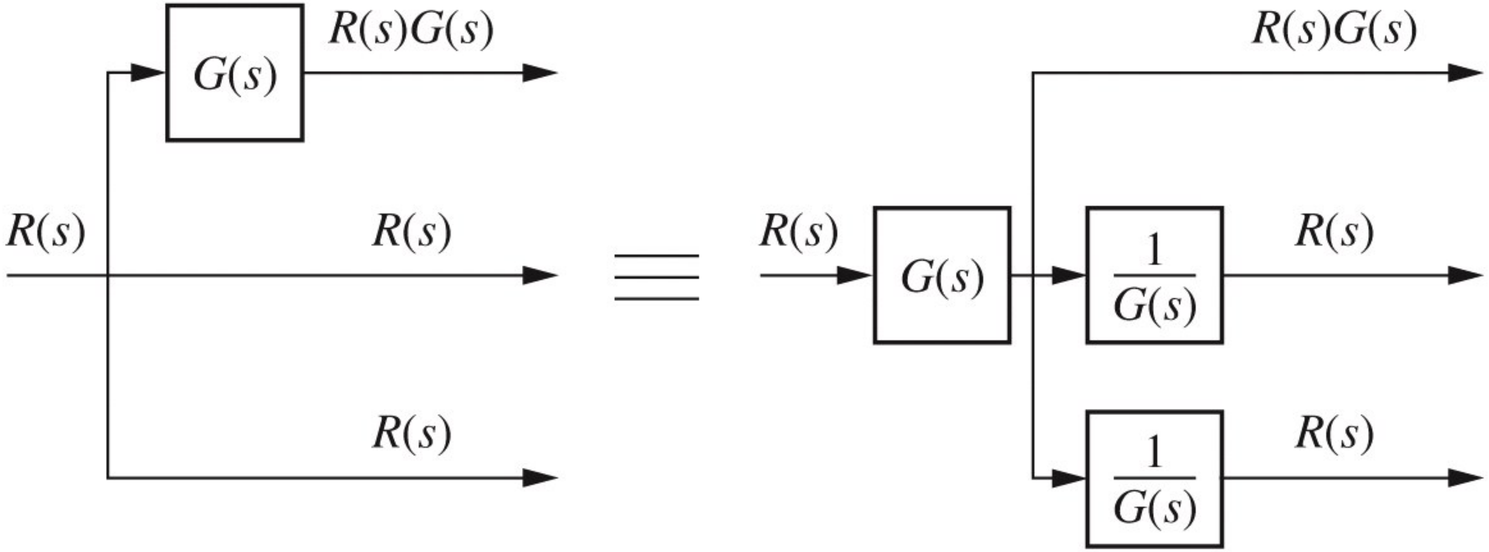
Moving Blocks to get Familiar Forms-1



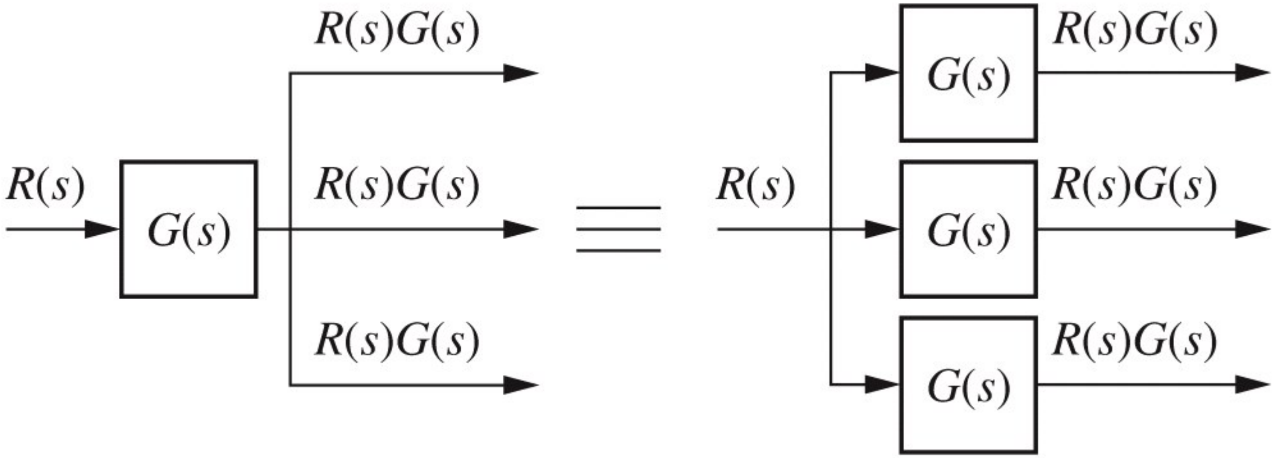
(a)



(b)


R(s)G(s)
G(s)
R(s)
R(s)
R(s)
R(s)G(s)
R(s)
G(s)
1/G(s)
R(s)
1/G(s)
R(s)

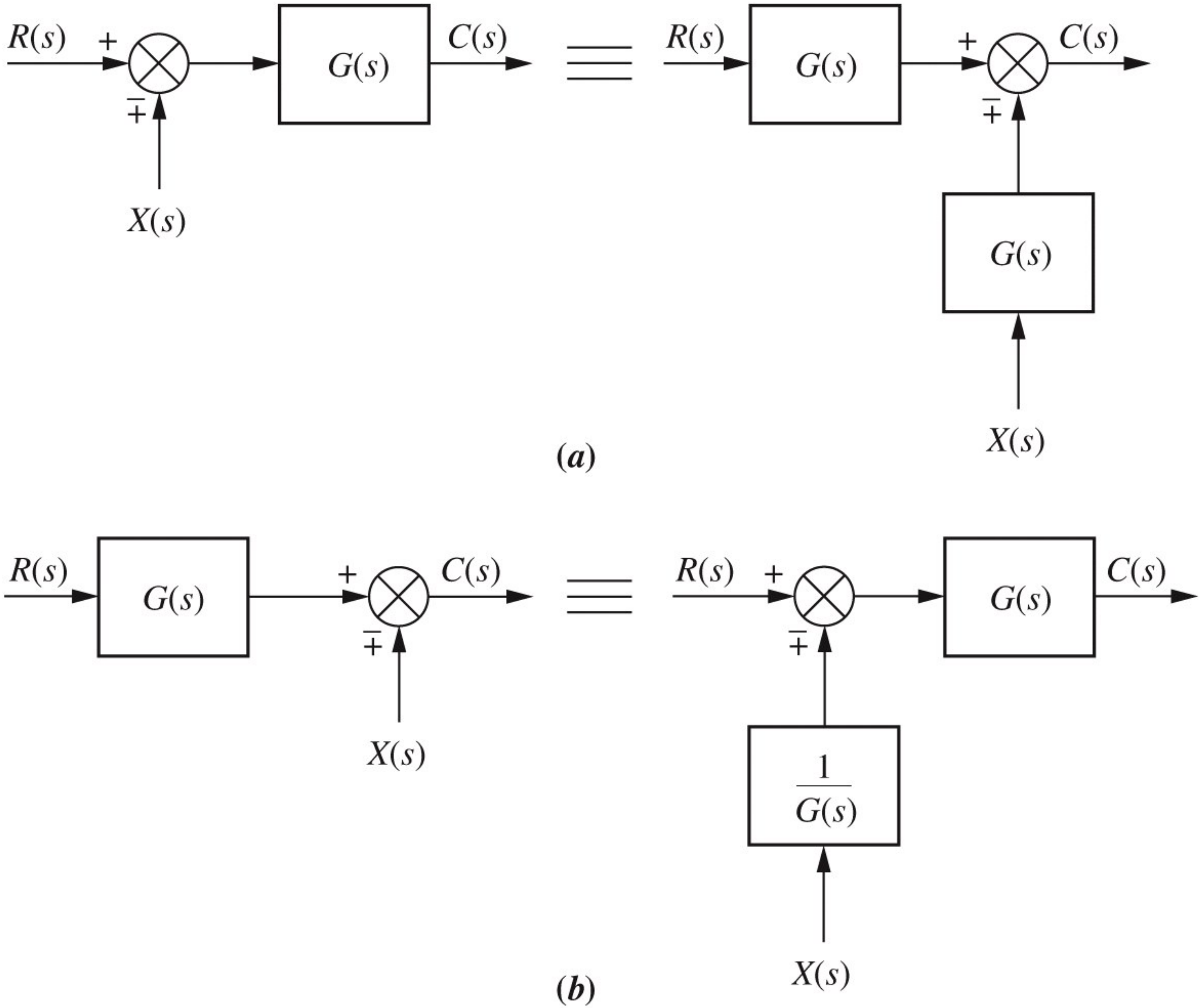
(*a*)


R(s)G(s)
R(s)
G(s)
R(s)G(s)
R(s)G(s)
G(s)
R(s)G(s)
R(s)
G(s)
R(s)G(s)
G(s)
R(s)G(s)

(*b*)

Figure 5.8

Moving Blocks to get Familiar Forms-2



Example-1

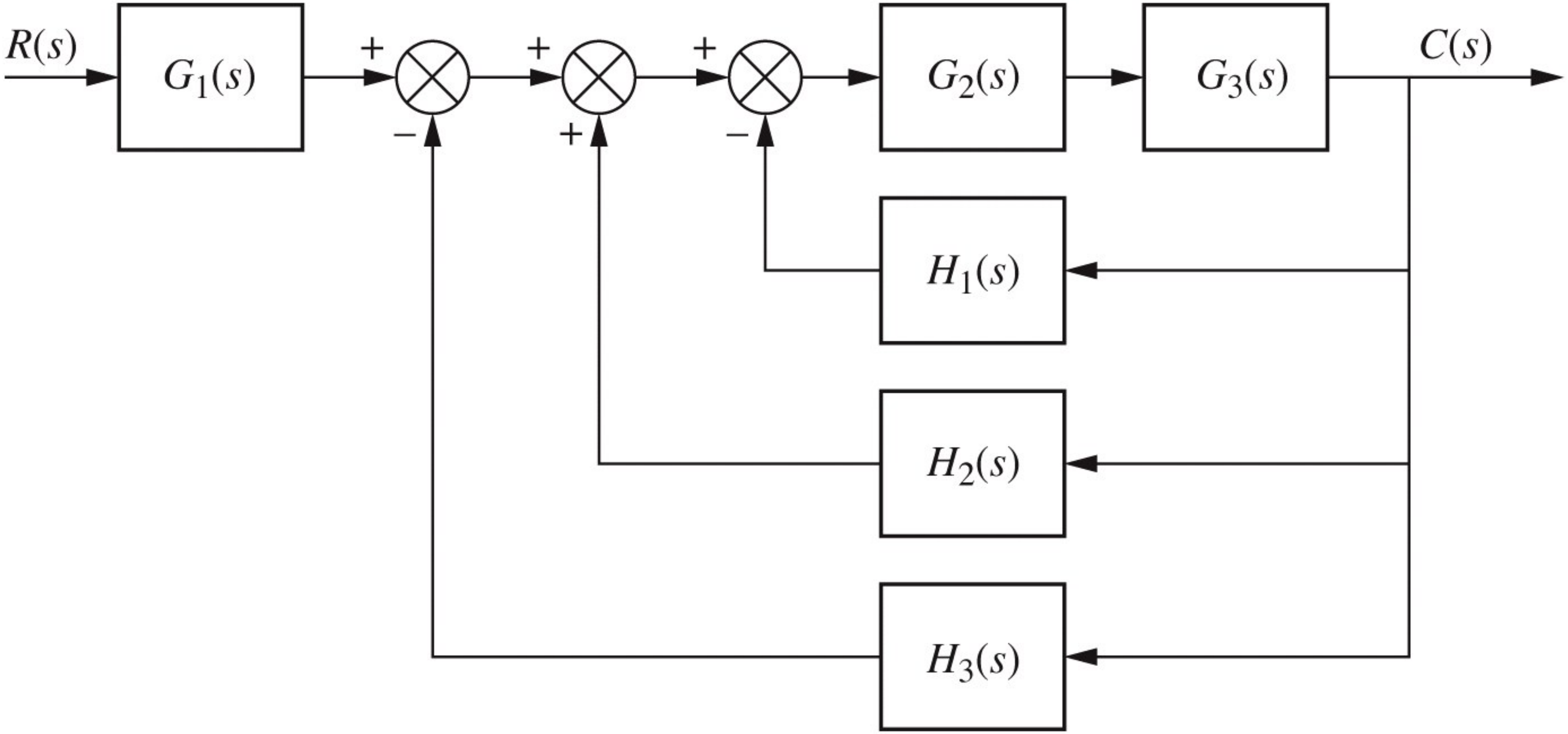
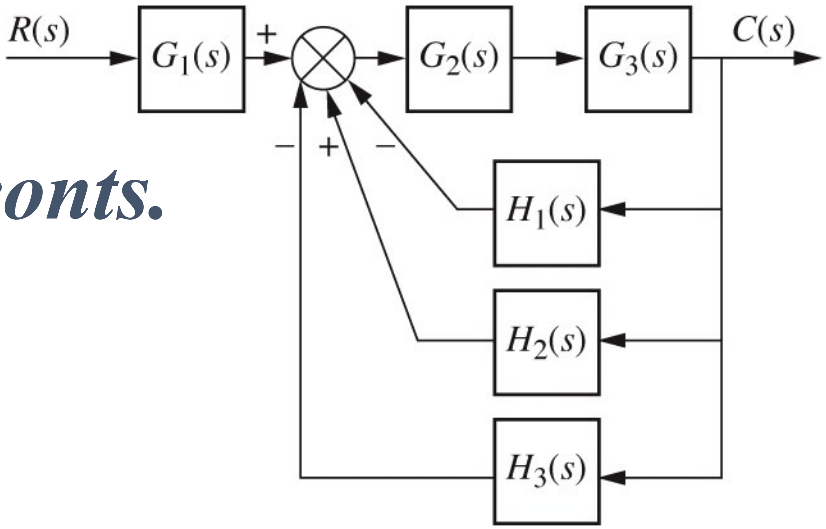
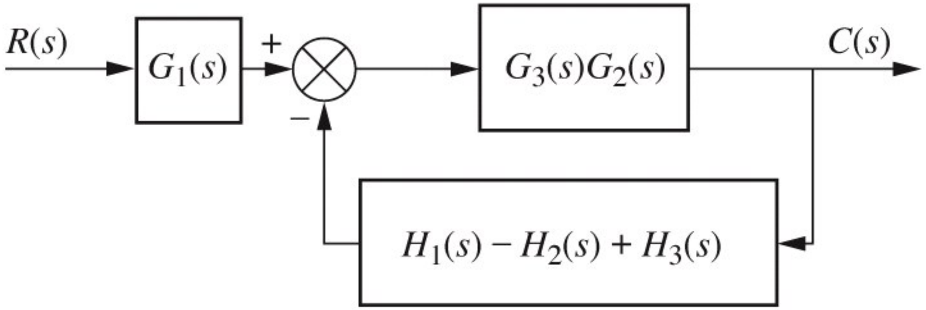


Figure 5.9

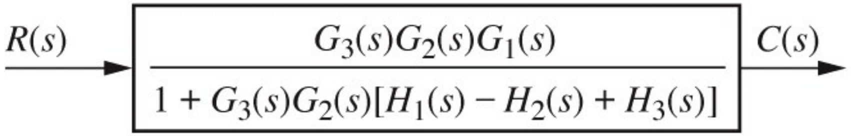
Example-1, *conts.*



(*a*)



(*b*)



(*c*)

Figure 5.10

Example-2

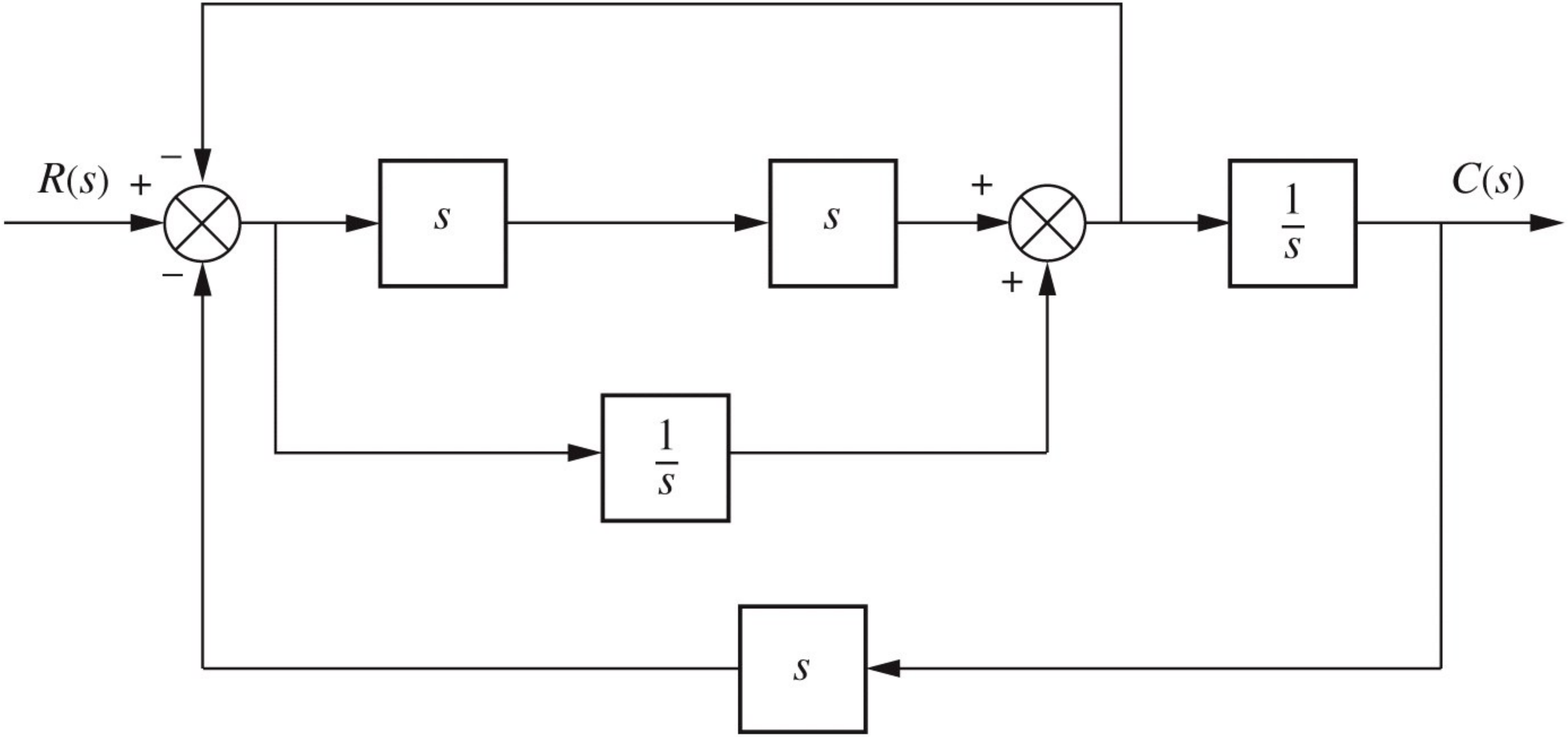
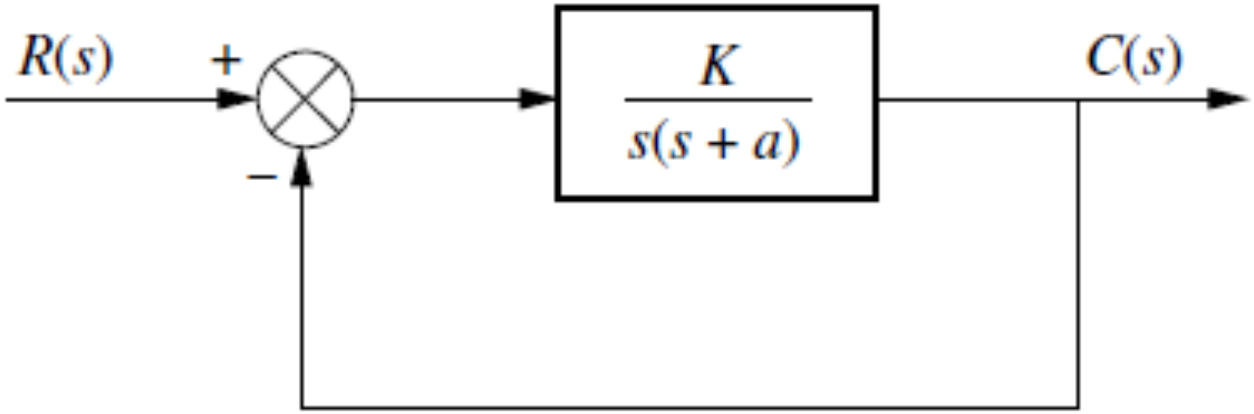


Figure 5.13

Analysis and Design of Feedback Systems: An Introduction

- Consider the system shown in the figure below, which can model a control system such as the antenna azimuth position control system.



- The closed-loop transfer function is

$$T(s) = \frac{K}{s^2 + as + K}$$

where K models the amplifier gain, that is, the ratio of the output voltage to the input voltage.

Analysis and Design of Feedback Systems: An Introduction *cntd*.

$$T(s) = \frac{K}{s^2 + as + K}$$

For K between 0 and $a^2/4$, the system is overdamped with <u>real</u> poles located at

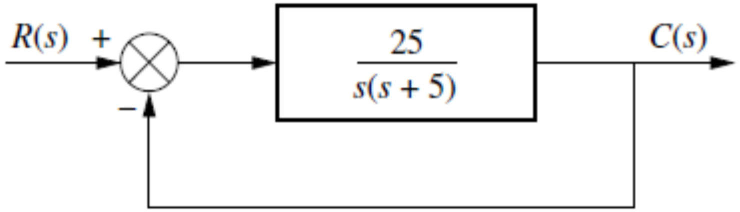
$$s_{1,2} = -\frac{a}{2} \pm \frac{\sqrt{a^2 - 4K}}{2}$$

For gains above $a^2/4$, the system is underdamped, with <u>complex poles</u> located at

$$s_{1,2} = -\frac{a}{2} \pm j\frac{\sqrt{4K - a^2}}{2}$$

For gains above $a^2/4$, as K increases, the real part remains constant and the imaginary part increases. Thus, the peak time decreases and the percent overshoot increases, while the settling time remains constant.

Example-6



For the system find the peak time, percent overshoot, and settling time.

The closed-loop transfer function of the system is

$$T(s) = \frac{25}{s^2 + 5s + 25}$$

$$\omega_n = \sqrt{25} = 5$$

$$2\zeta\omega_n = 5$$

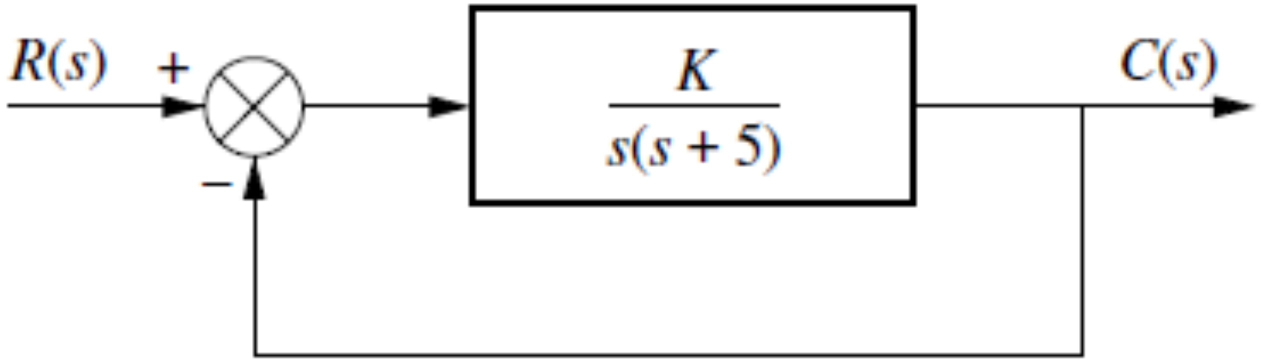
$$\zeta = 0.5$$

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = 0.726 \text{ second}$$

$$\%OS = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \times 100 = 16.303$$

$$T_s = \frac{4}{\zeta\omega_n} = 1.6 \text{ seconds}$$

Example-7



Design the value of gain, *K*, for the feedback control system so that the system will respond with a 10% overshoot.

The closed-loop transfer function of the system is

$$T(s) = \frac{K}{s^2 + 5s + K} \qquad 2\zeta\omega_n = 5 \qquad \omega_n = \sqrt{K} \qquad \zeta = \frac{5}{2\sqrt{K}}$$

A 10% overshoot implies that $\zeta = 0.591$. Thus, $K = 17.9$.

Although we are able to design for percent overshoot in this problem, we could not have selected settling time as a design criterion because, regardless of the value of *K*, the real parts, -2.5, of the poles of the system remain the same.