Reduction of Multiple Subsystems – Fb Systems

(Ch. 5 of Nise's CSE Textbook and more)

Components used in Block Diagram Representations

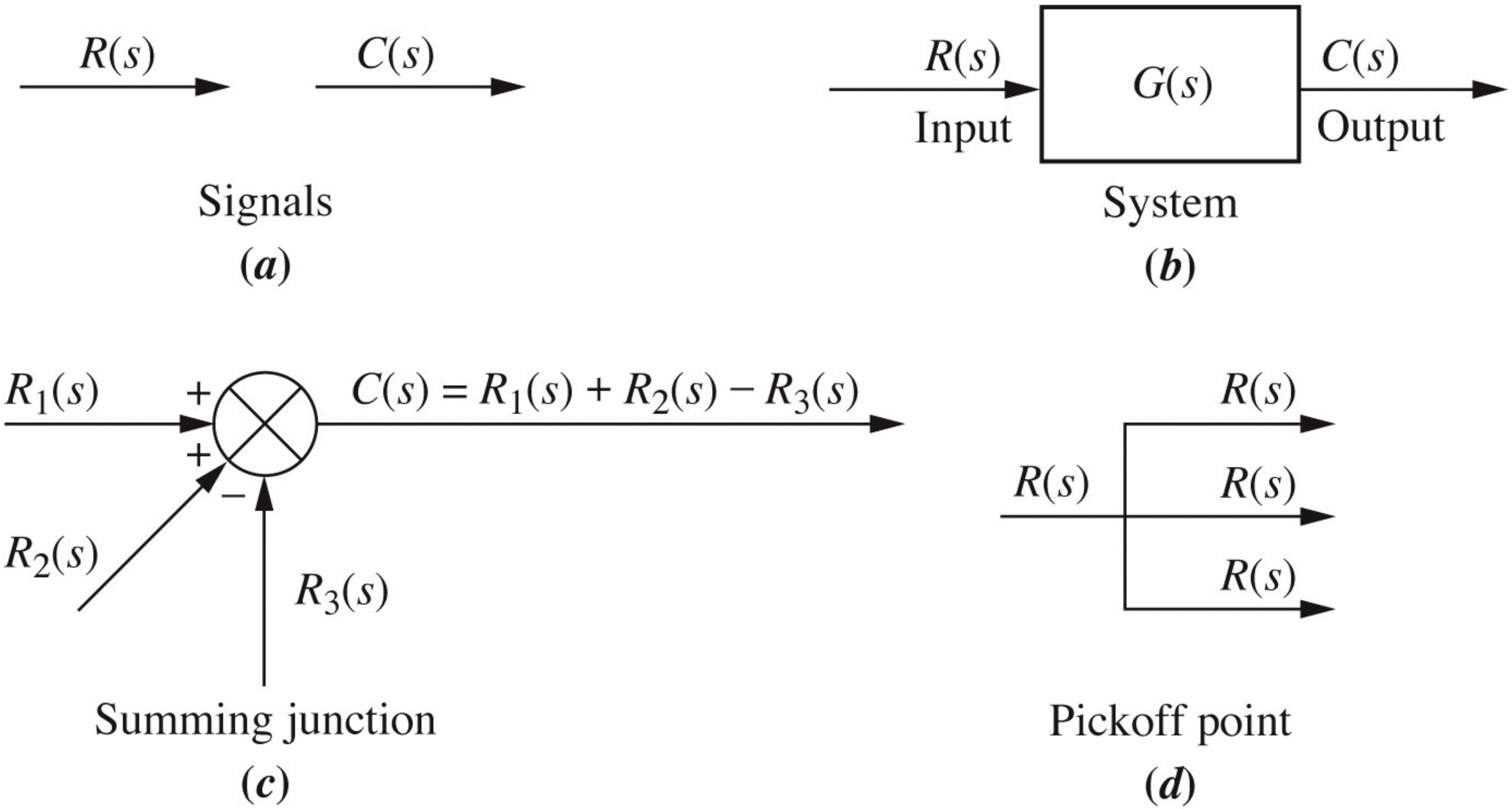


Figure 5.2

Cascade Connection

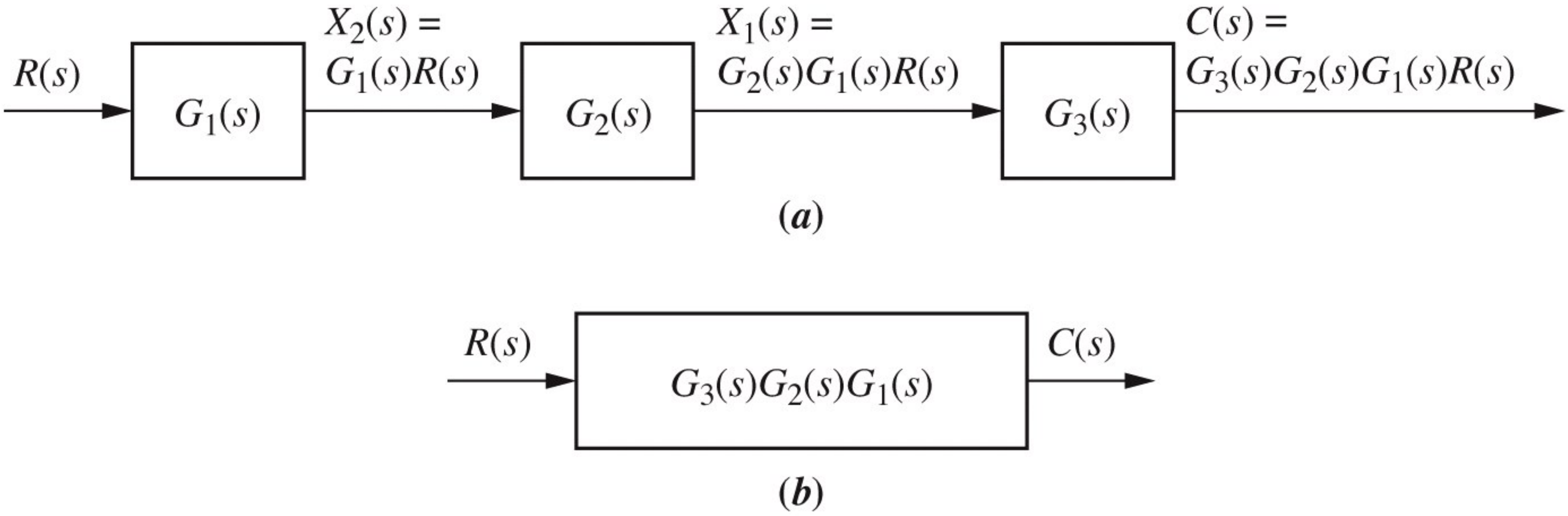


Figure 5.3

Unloading Issue Explained

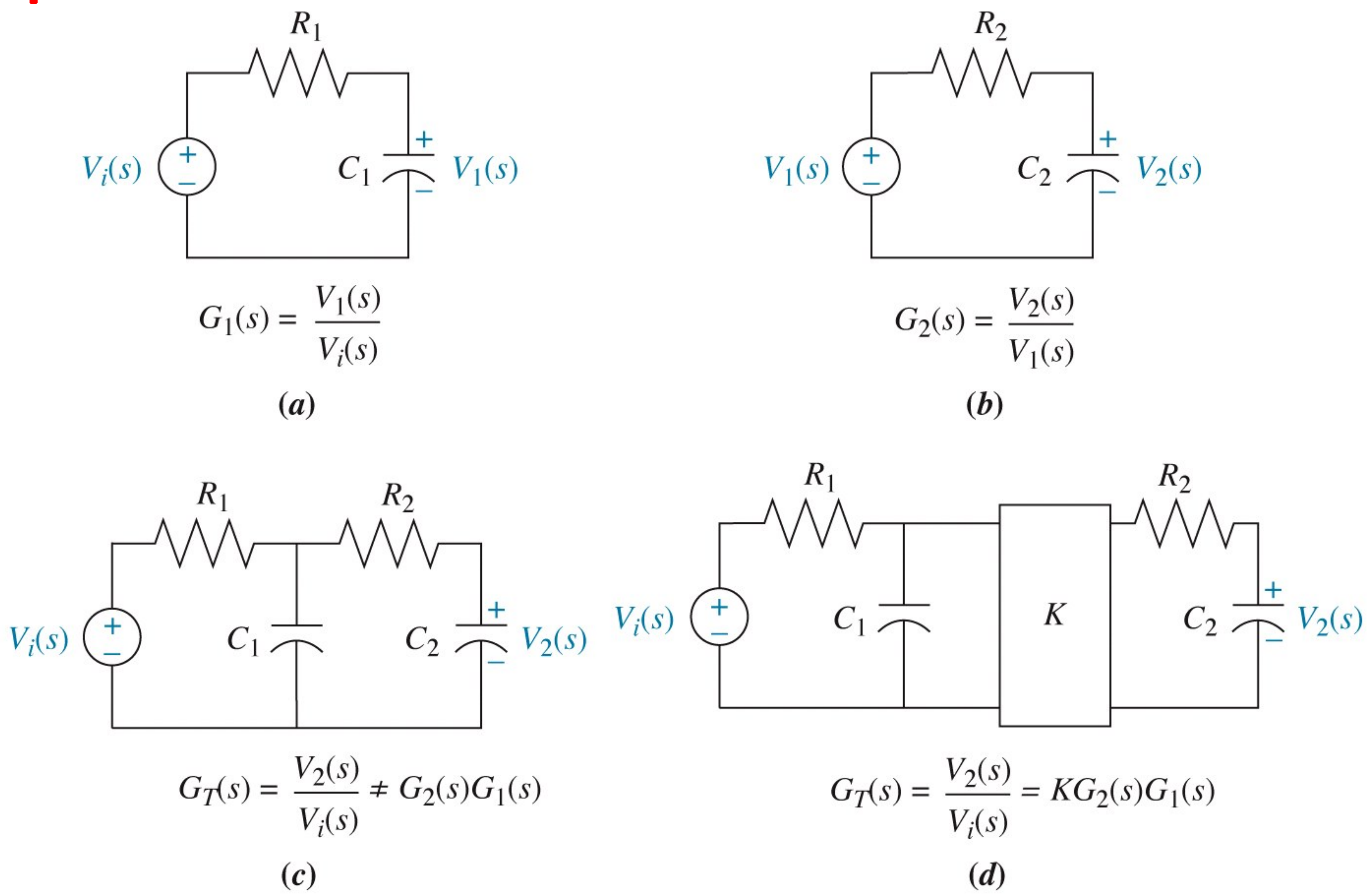
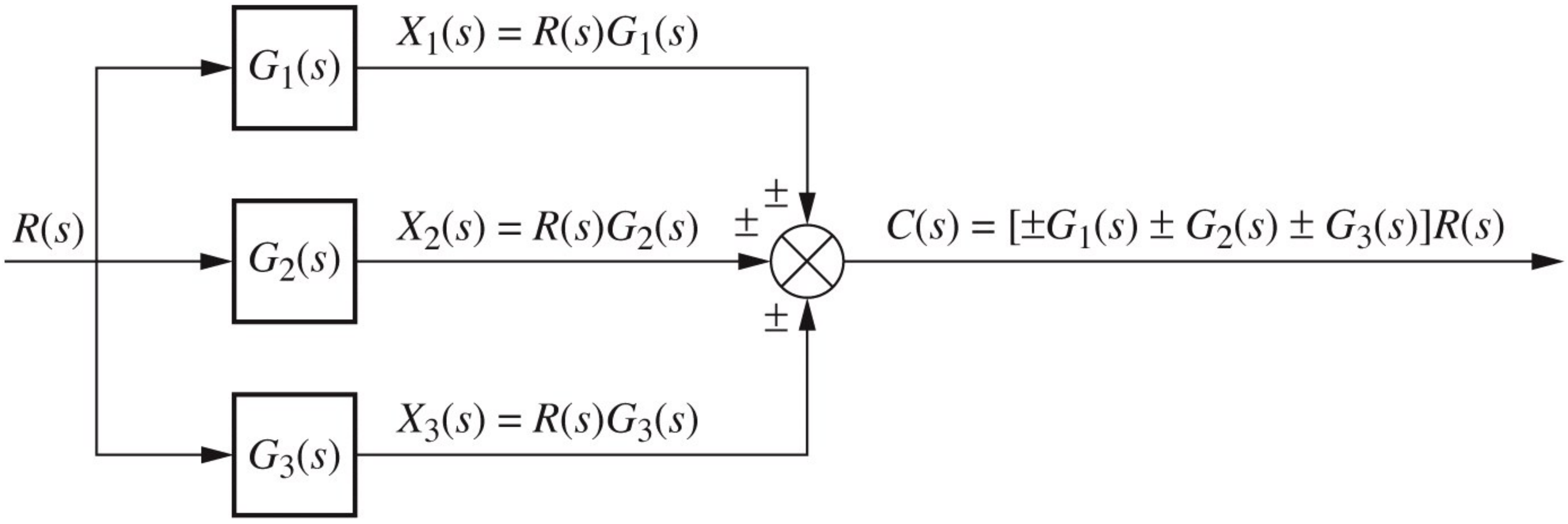
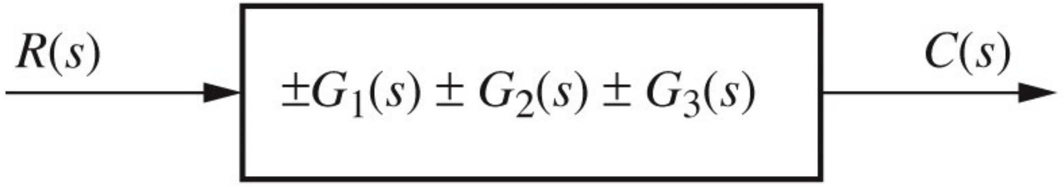


Figure 5.4

Parallel Connection



(*a*)



(*b*)

Figure 5.5

Feedback Connection

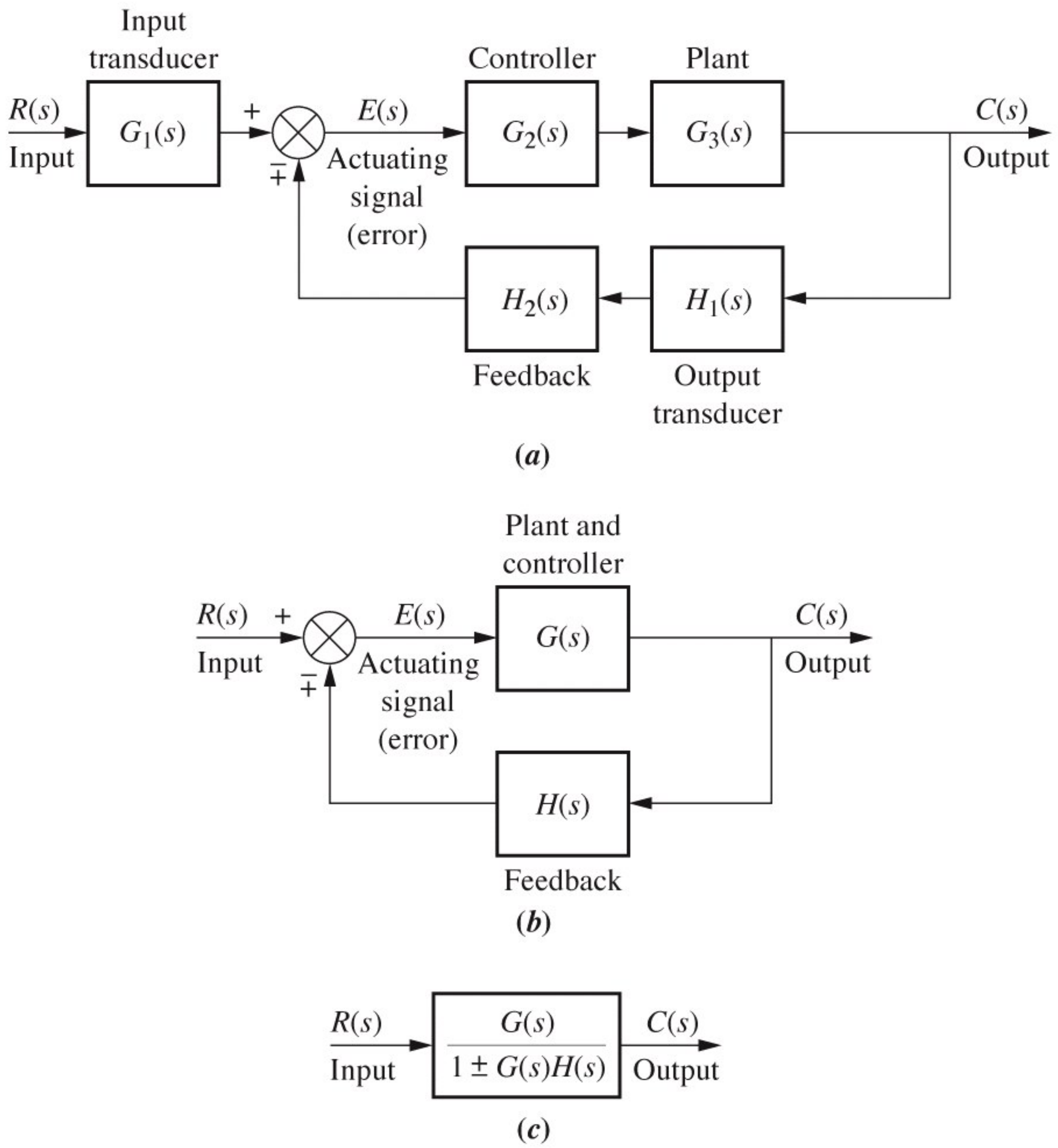
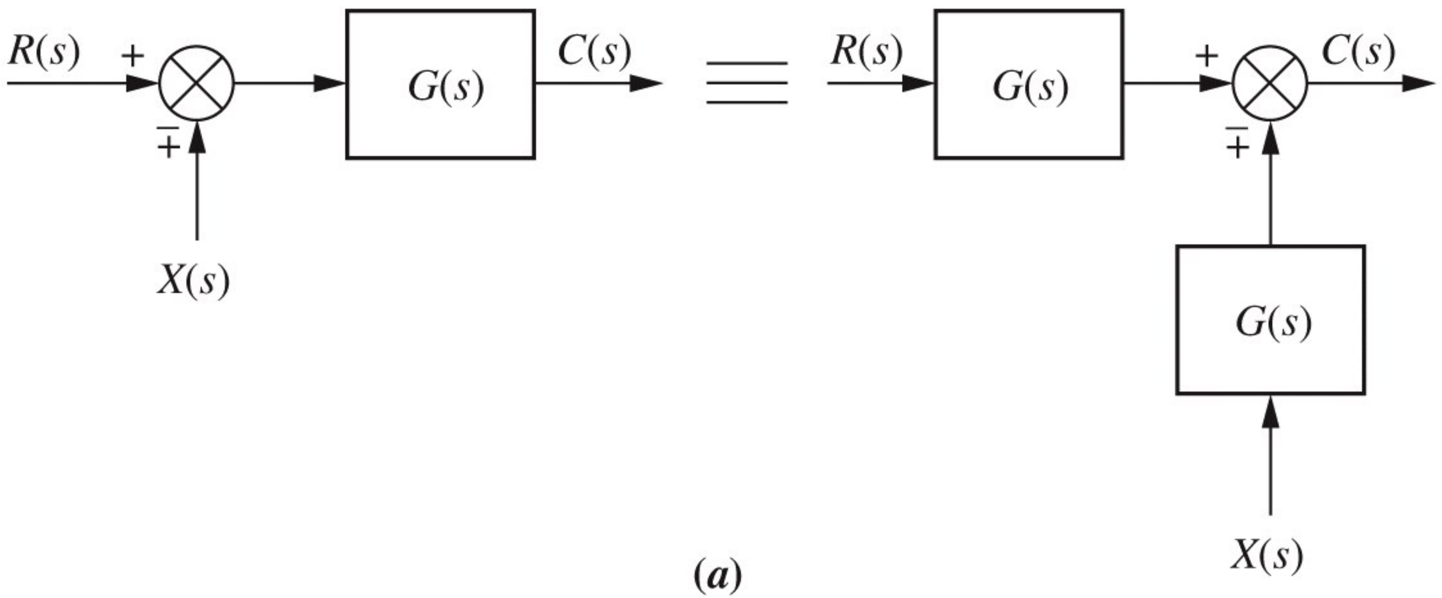
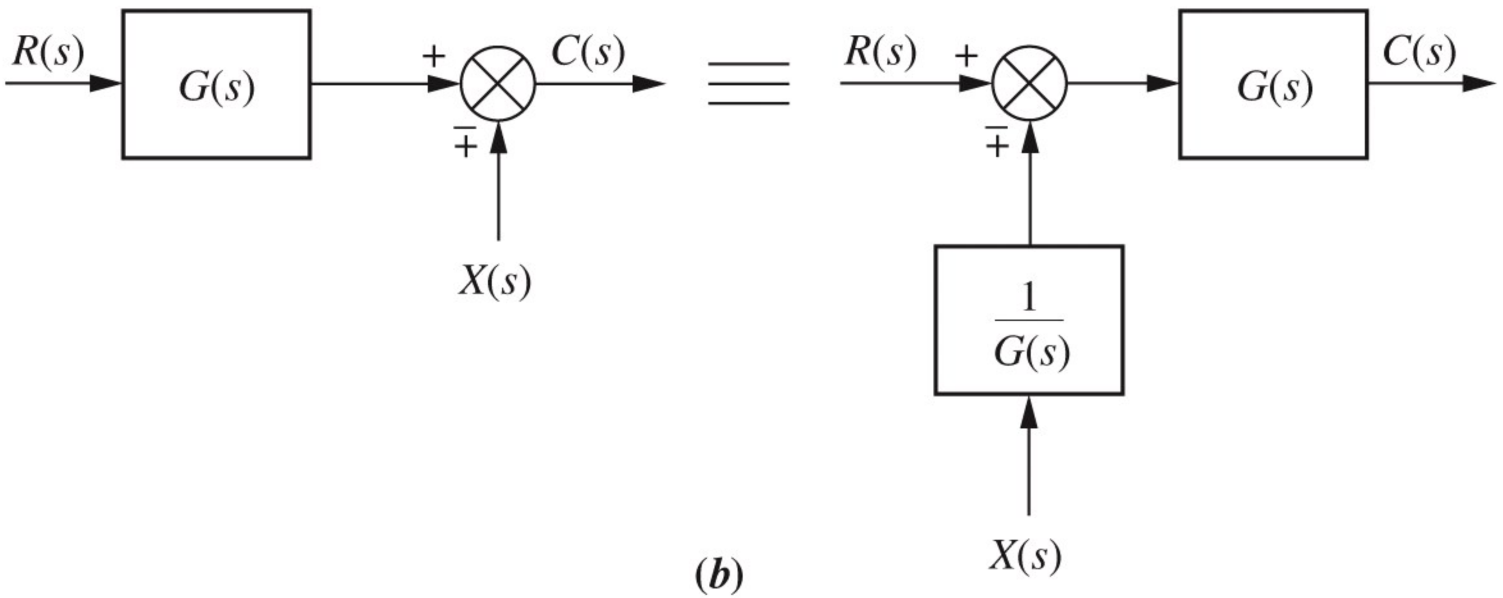


Figure 5.6

Moving Blocks to get Familiar Forms-1



(a)



(b)

Moving Blocks to get Familiar Forms-2

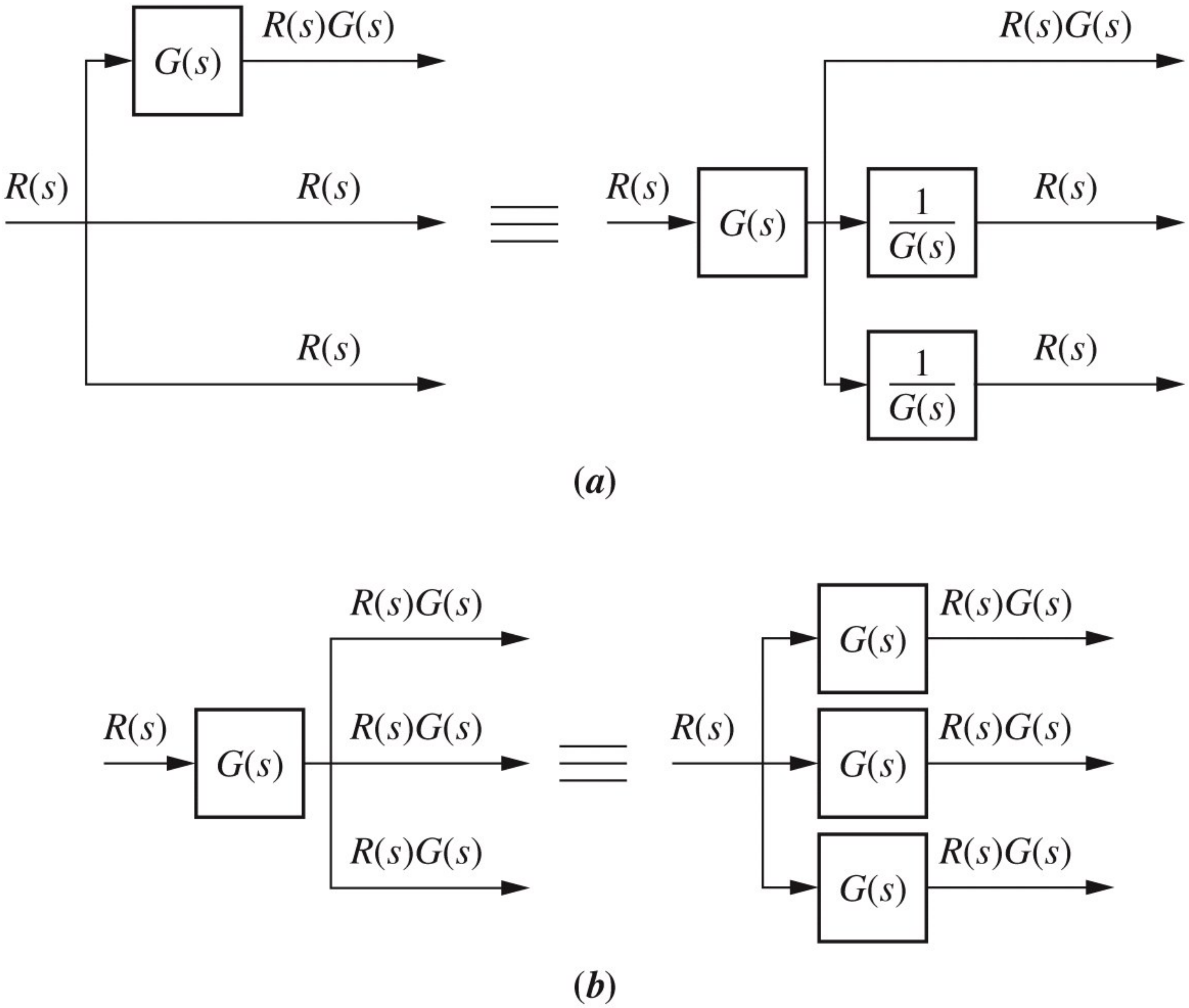


Figure 5.8

Example-1

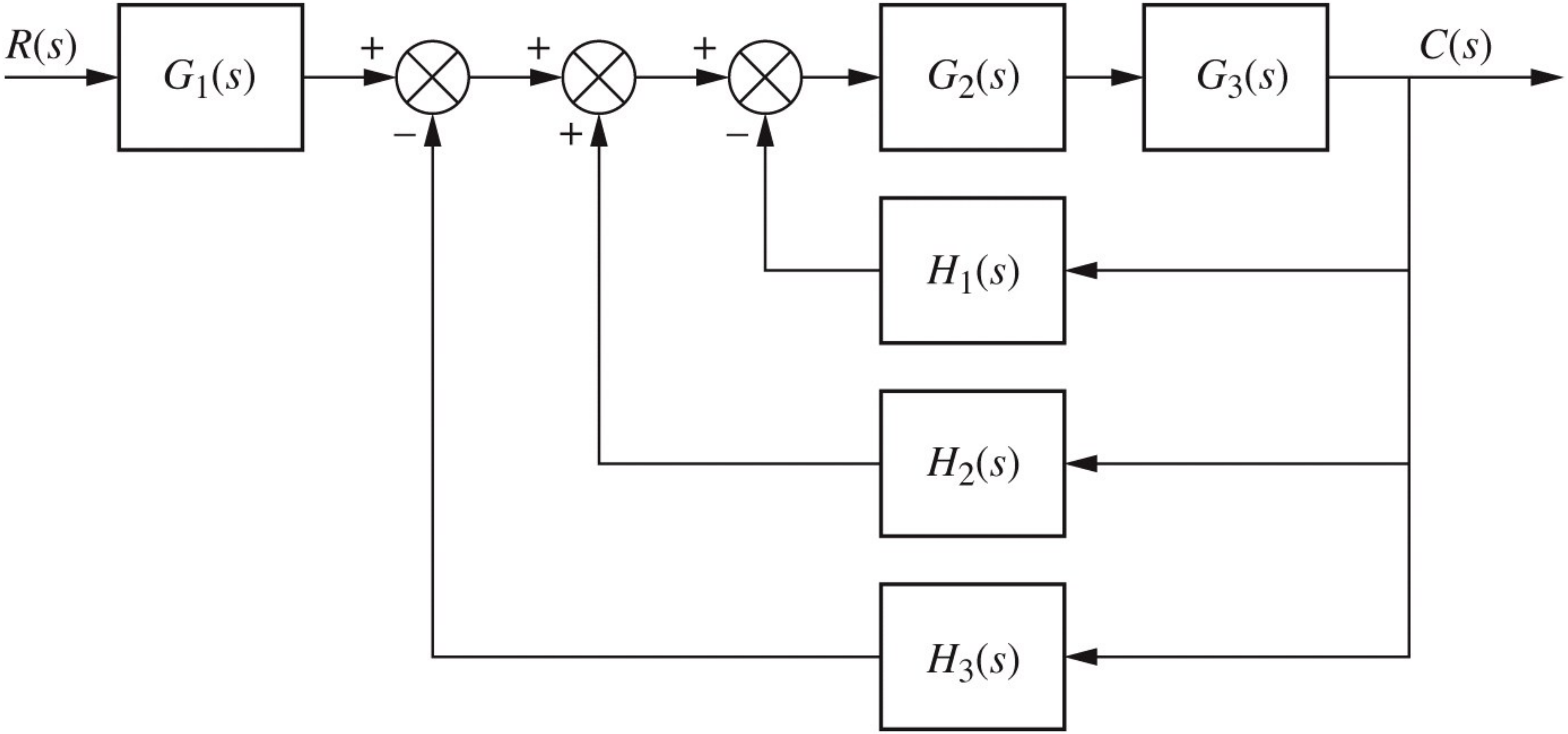


Figure 5.9

Example-1, *conts.*

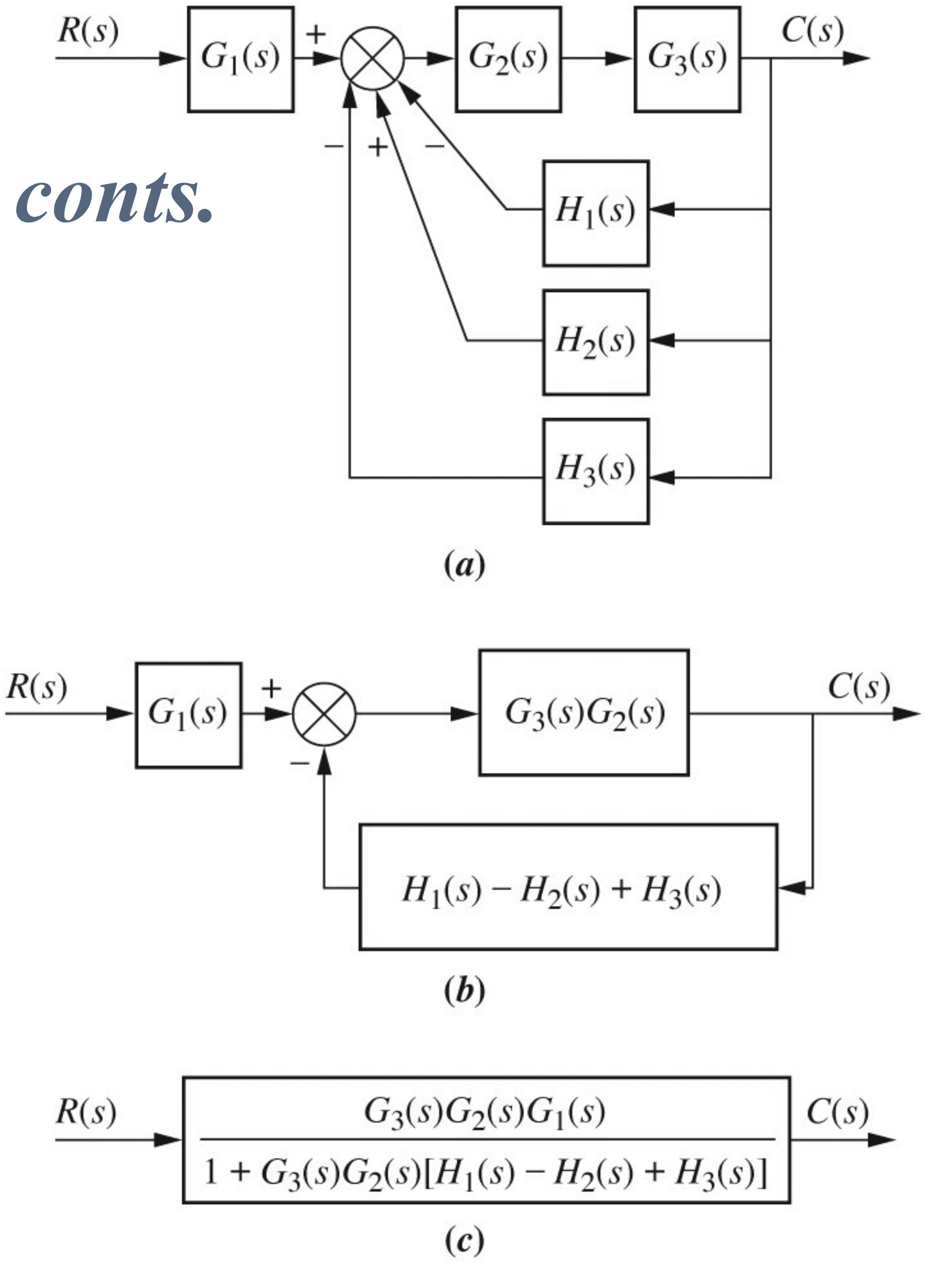


Figure 5.10

Example-2

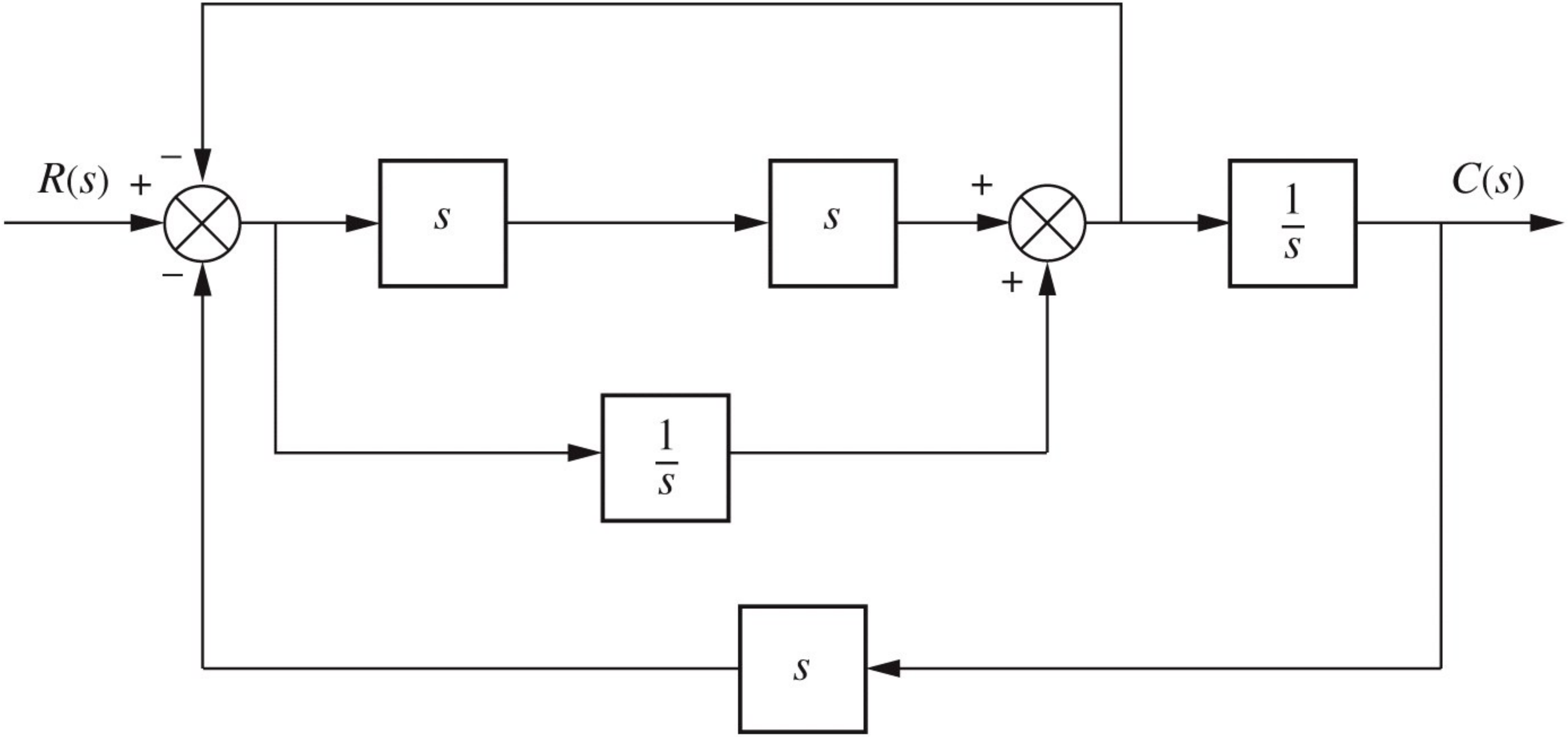
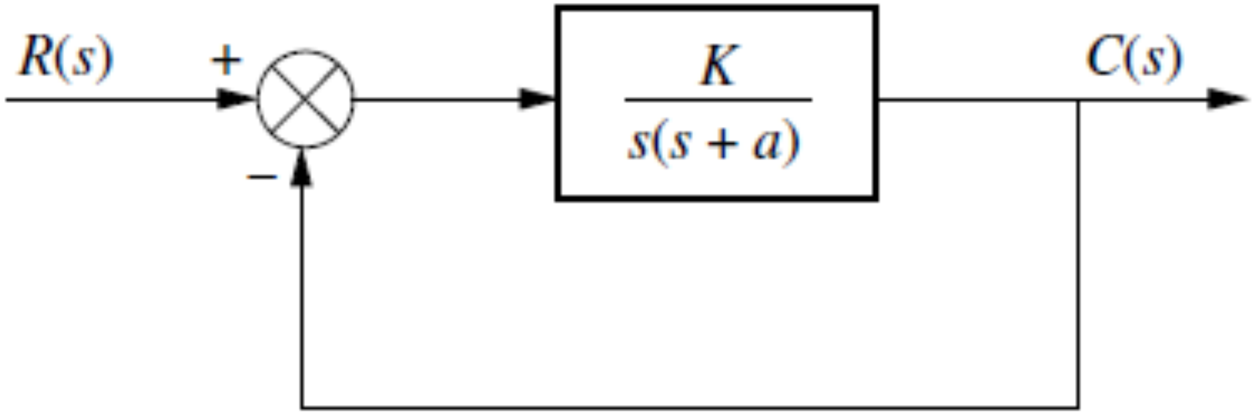


Figure 5.13

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

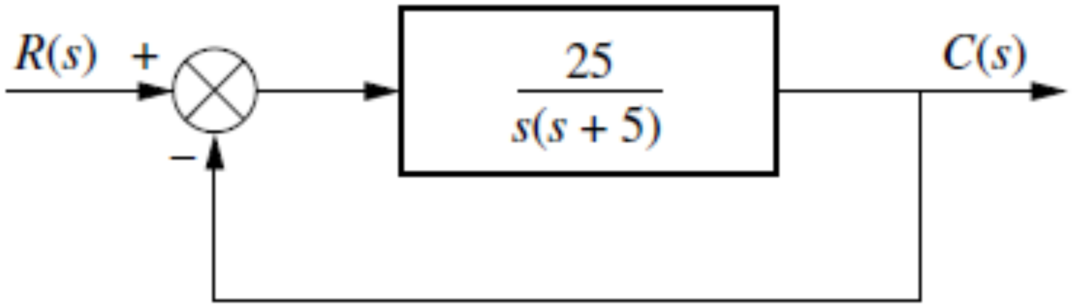
$$s_{1,2} = -\frac{a}{2} \pm \frac{\sqrt{a^2 - 4K}}{2}$$

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

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

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

$$2\zeta\omega_n = 5$$

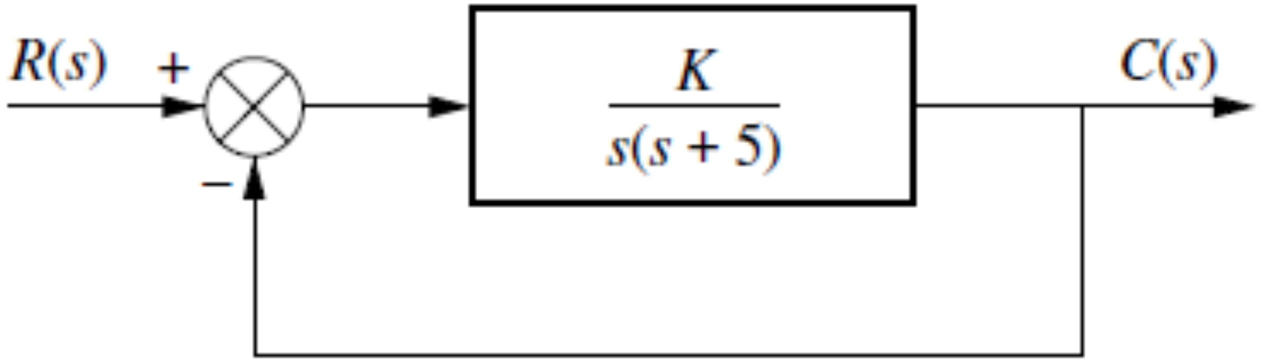
$$\zeta = 0.5$$

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

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

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

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

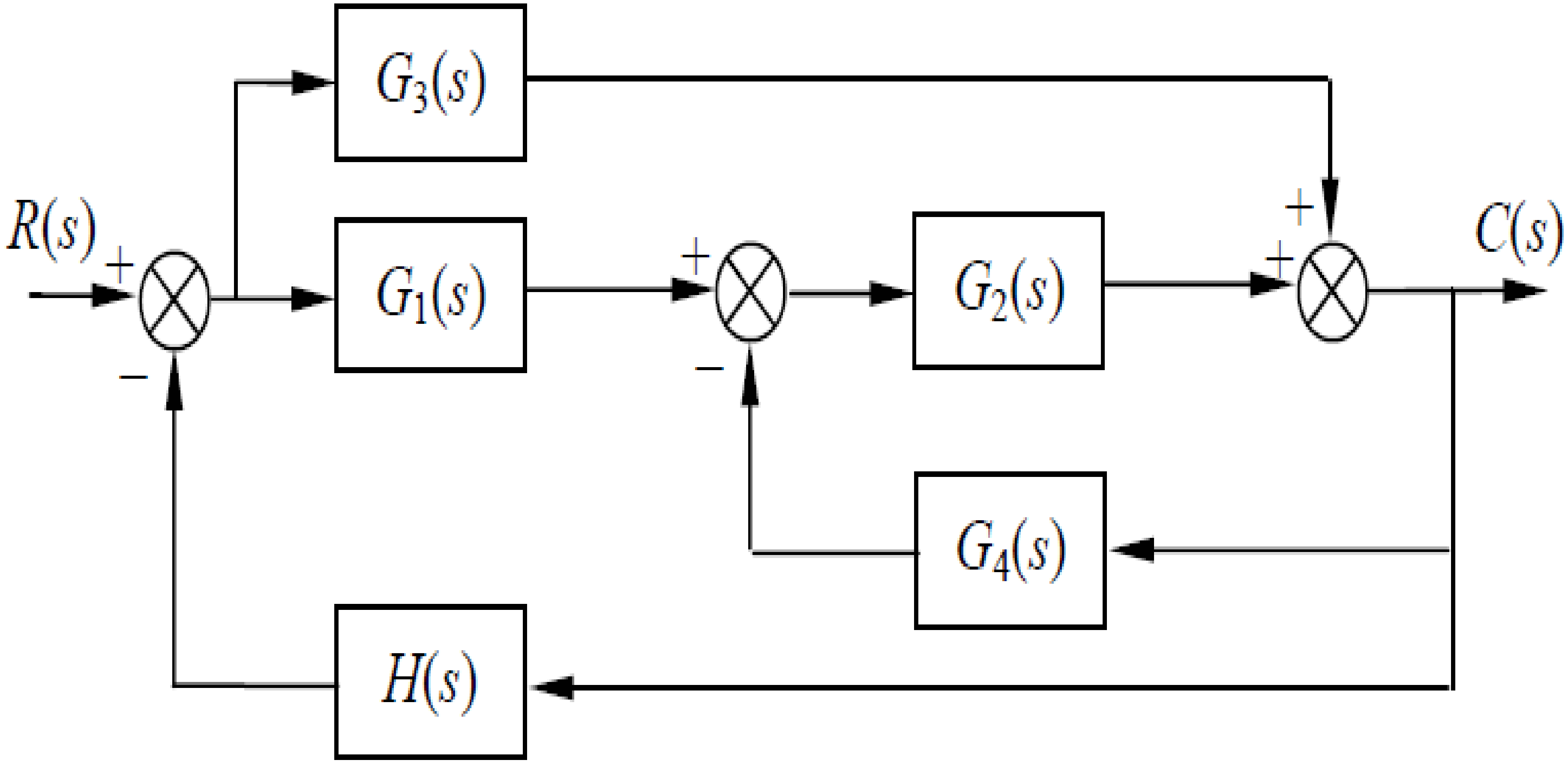
$$T(s) = \frac{K}{s^2 + 5s + K} \qquad 2\zeta\omega_n = 5 \qquad \omega_n = \sqrt{K} \qquad \zeta = \frac{5}{2\sqrt{K}}$$

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.

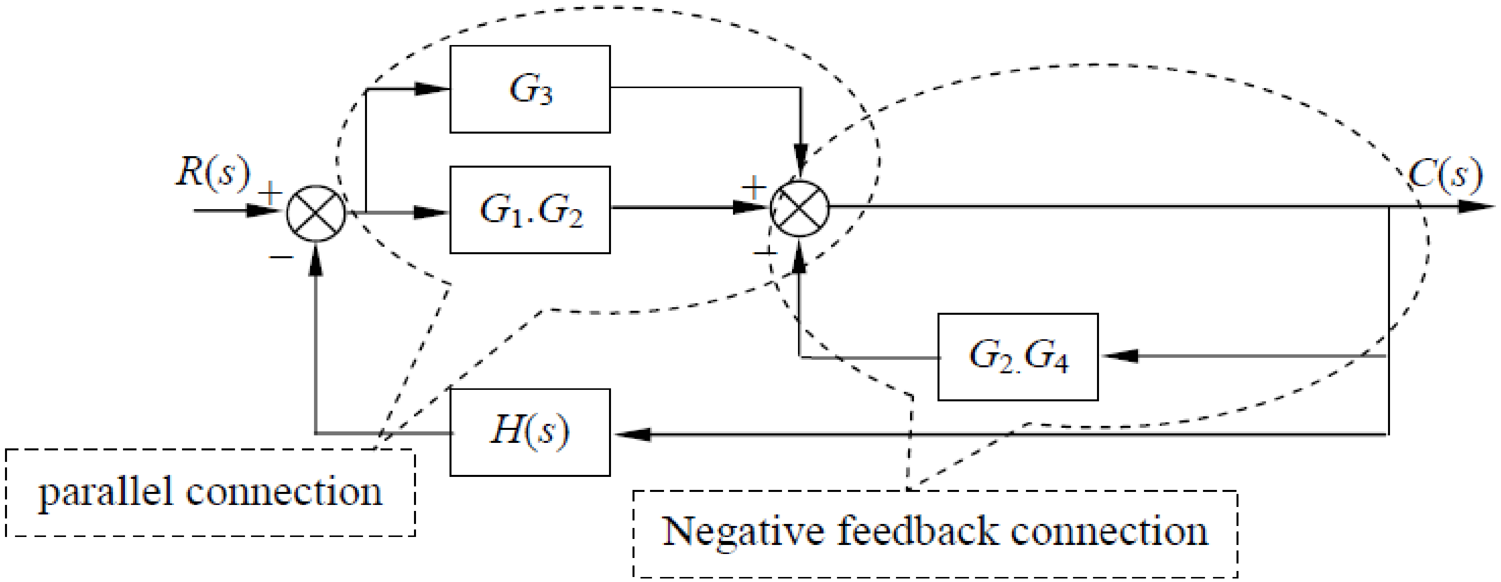
Example-8

Obtain the transfer function of C(s) / R(s) for the control system given below.

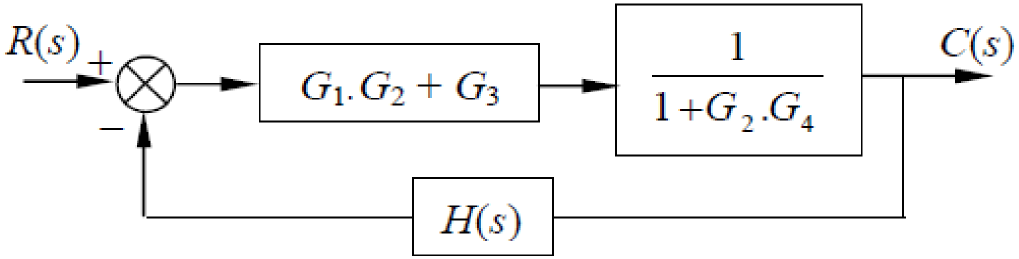


Solution

Move $G_2(s)$ to the left past the summing junction to combine two summing junctions:



Now, the simplified configuration becomes just a standard negative feedback configuration:



Consequently, the transfer function can be found as

$$\frac{C(s)}{R(s)} = \frac{G_1(s).G_2(s) + G_3(s)}{1 + G_2(s).G_4(s) + H(s).[G_1(s).G_2(s) + G_3(s)]}$$