

Capítulo 8

Técnicas do Lugar das Raízes

Fig. 8.1

a. Sistema a malha fechada;
b. função de transferência equivalente

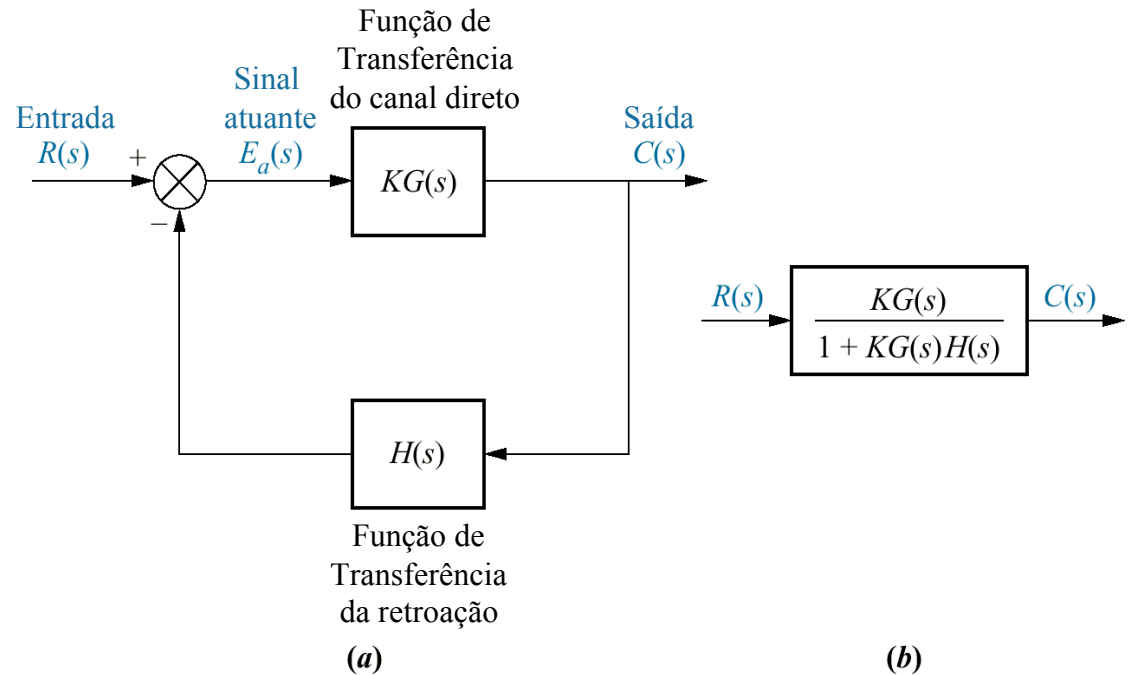


Fig. 8.2
 Representação
 vetorial de números
 complexos:
a. $s = \sigma + j\omega$;
b. $(s + a)$;
c. representação
 alternativa de
 $(s + a)$;
d. $(s + 7)|_{s \rightarrow 5 + j2}$

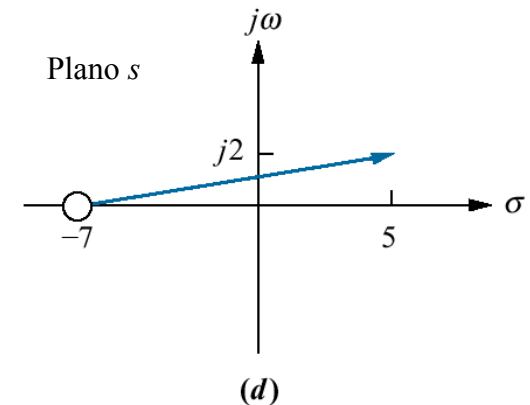
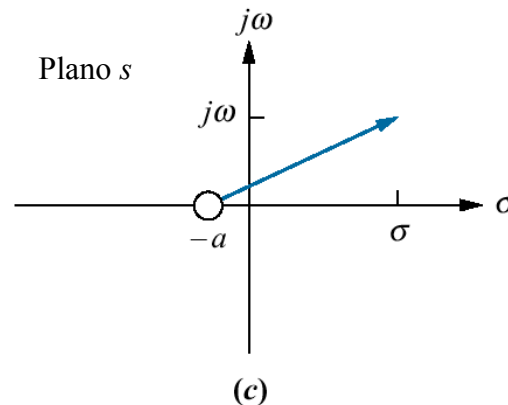
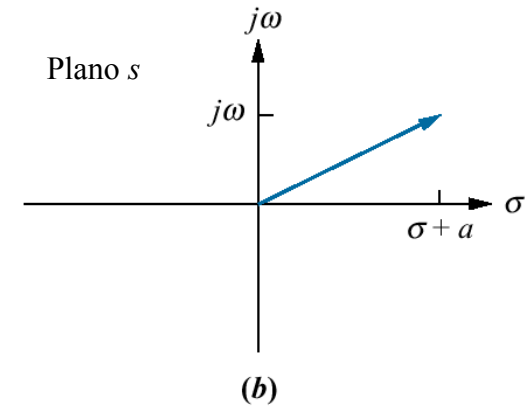
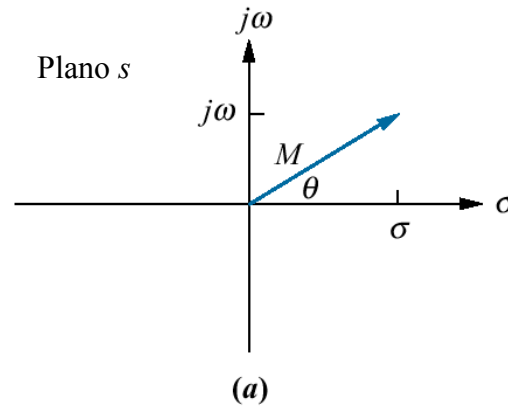


Fig. 8.3
 Representação
 vetorial da Eq. (8.7)

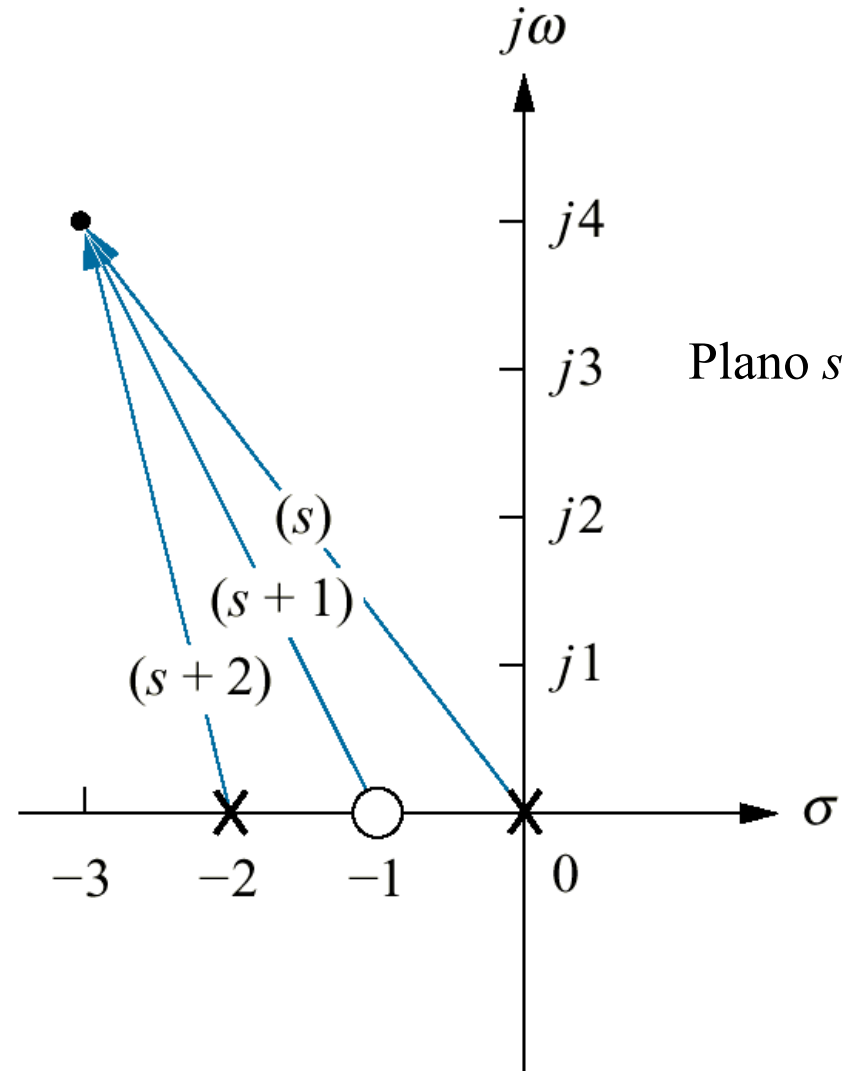


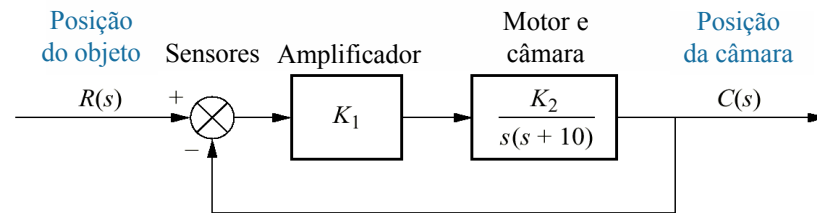
Fig. 8.4

- a. O sistema CameraMan® Presenter Camera rastreia automaticamente um objeto que utiliza sensores de infravermelho frontal e traseiro (o sensor frontal é também um microfone); comandos de rastreamento e de áudio são passados ao CameraMan através de um enlace de radiofrequência de uma unidade usada pelo objeto;
- b. diagrama de blocos;
- c. função de transferência a malha fechada

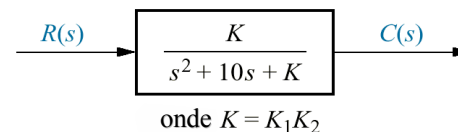
Cortesia de ParkerVision.



(a)



(b)



(c)

Tabela 8.1

Localização dos pólos como função do ganho do sistema da Fig. 8.4

K	Pólo 1	Pólo 2
0	-10	0
5	-9,47	-0,53
10	-8,87	-1,13
15	-8,16	-1,84
20	-7,24	-2,76
25	-5	-5
30	$-5 + j2,24$	$-5 - j2,24$
35	$-5 + j3,16$	$-5 - j3,16$
40	$-5 + j3,87$	$-5 - j3,87$
45	$-5 + j4,47$	$-5 - j4,47$
50	$-5 + j5$	$-5 - j5$

Fig. 8.5

a. Diagrama de pólos com base na tabela 8.1;
b. lugar das raízes

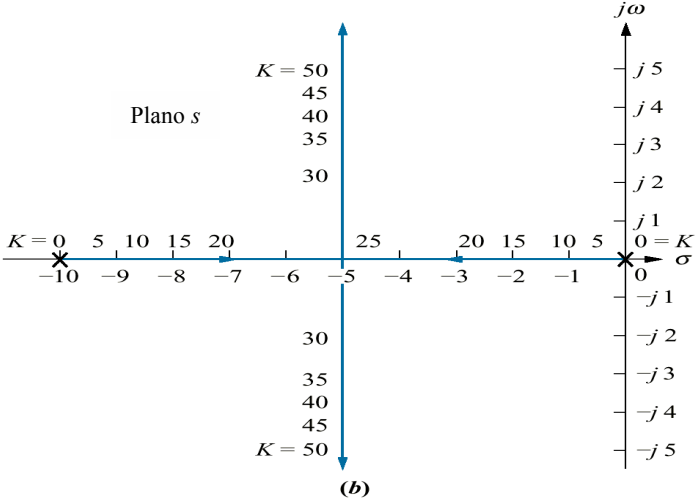
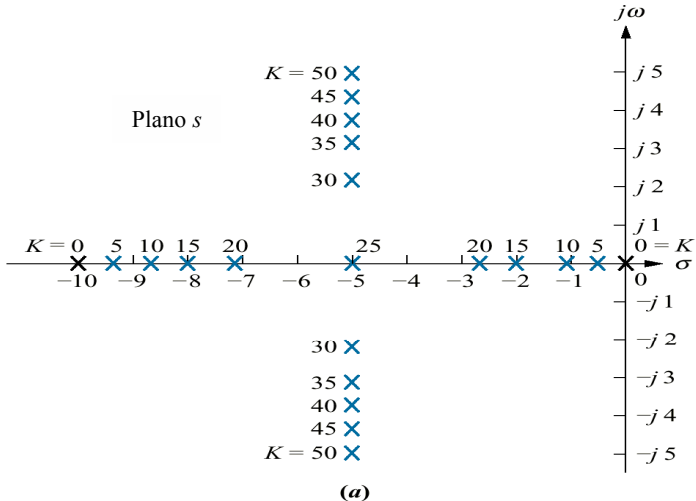
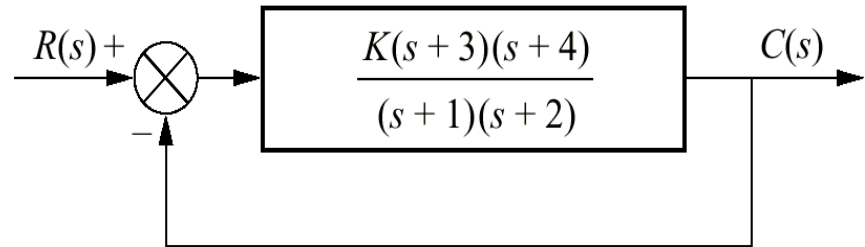
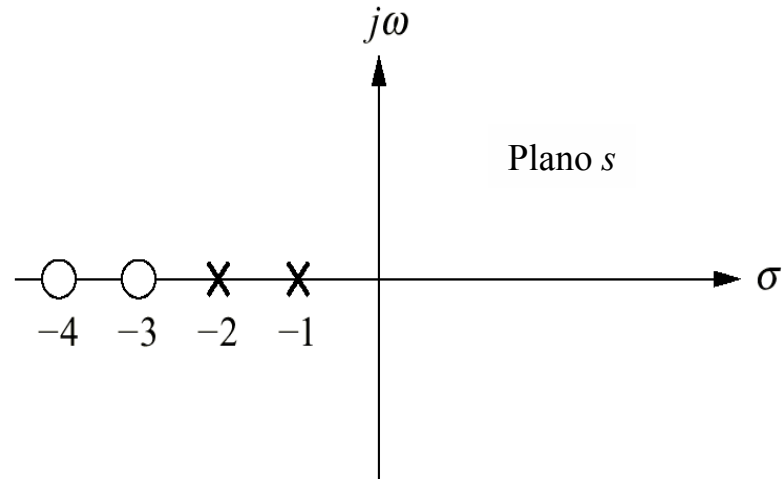


Fig. 8.6

- a. Sistema de Exemplo;
- b. diagrama de pólos e zeros de $G(s)$



(a)



(b)

Fig. 8.7

Representação vetorial de $G(s)$ com base na Fig. 8.6(a) em $-2 + j3$

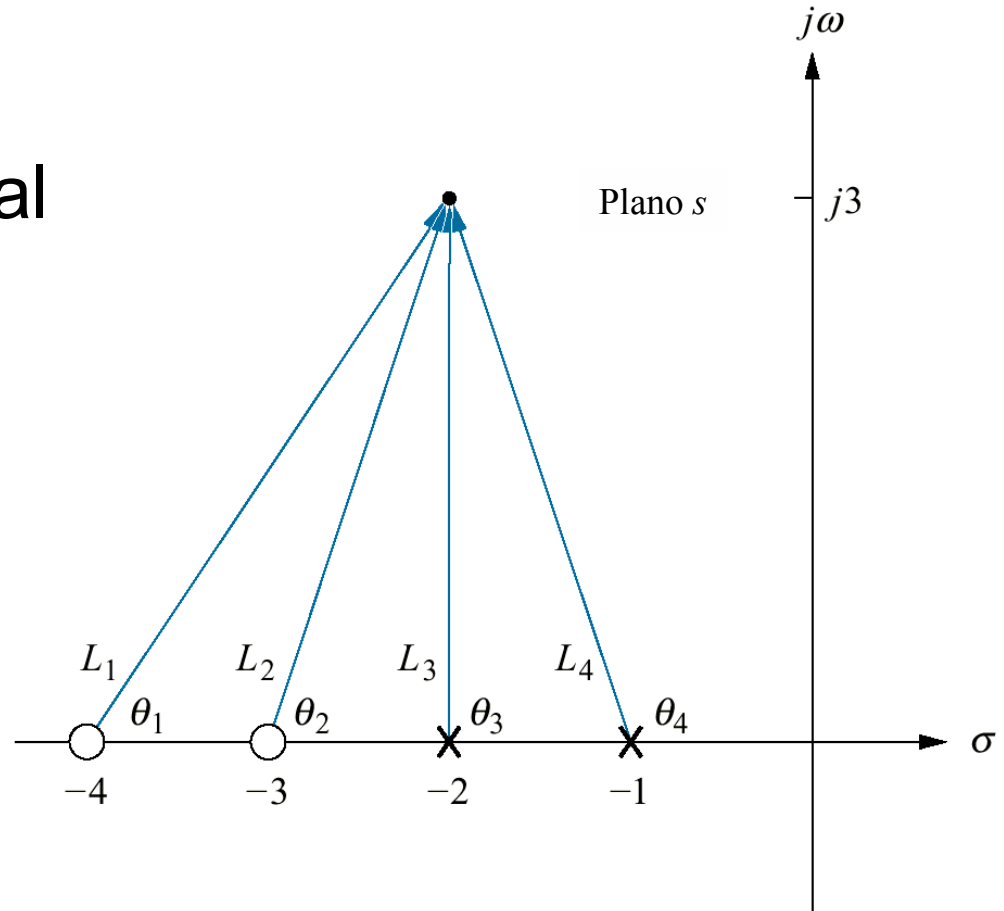


Fig. 8.8

Pólos e zeros de um sistema a malha aberta genérico com pontos de teste, P_i , no eixo real

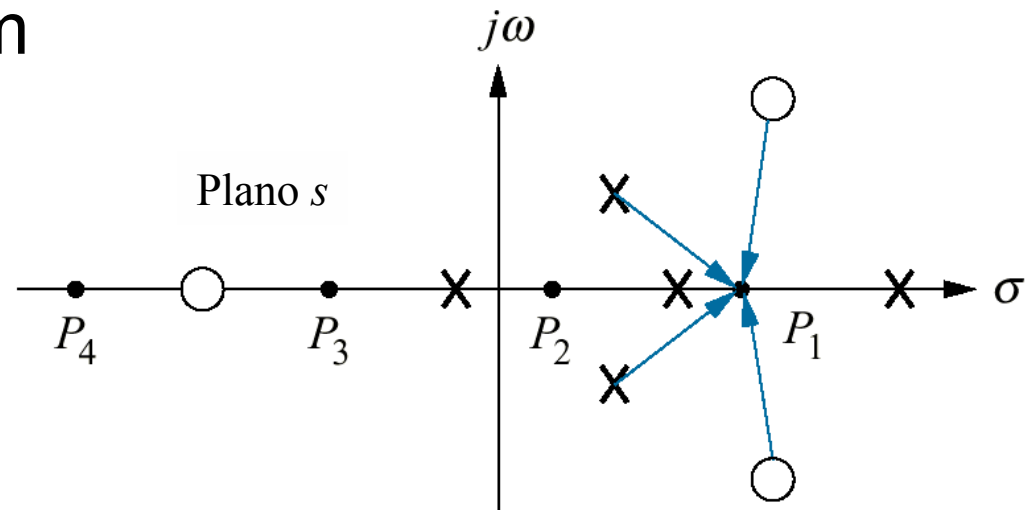


Fig. 8.9

Segmento do eixo real do lugar das raízes para o sistema da Fig. 8.6

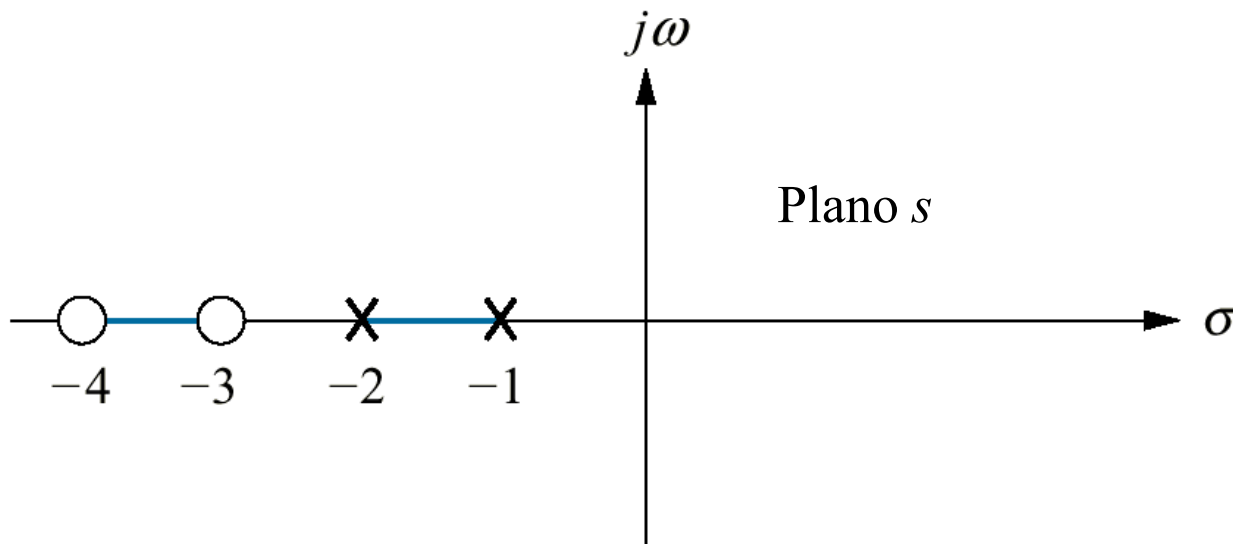


Fig. 8.10

Lugar das raízes completo para o sistema da Fig. 8.6

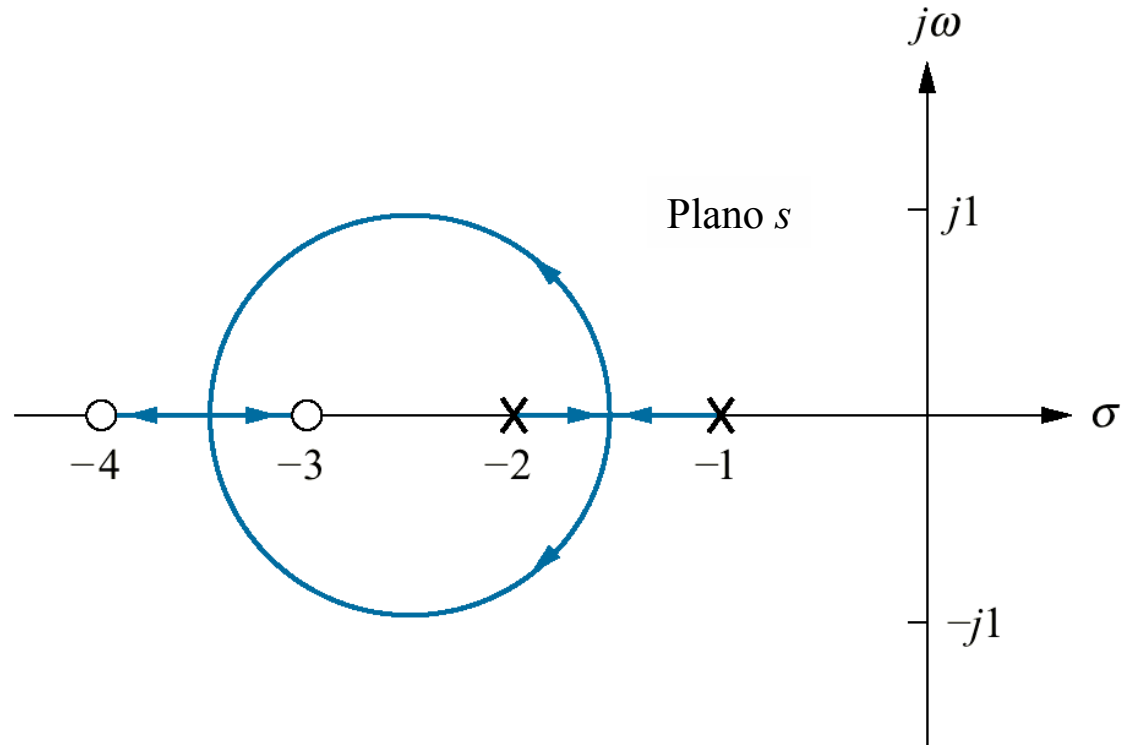


Fig. 8.11

Sistema para o Exemplo 8.2

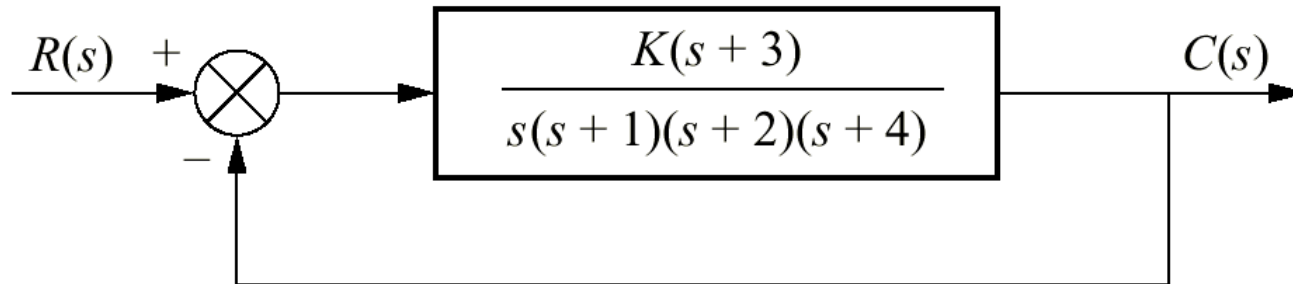


Fig. 8.12
 Lugar das raízes
 e assíntotas
 para o sistema
 da Fig. 8.11

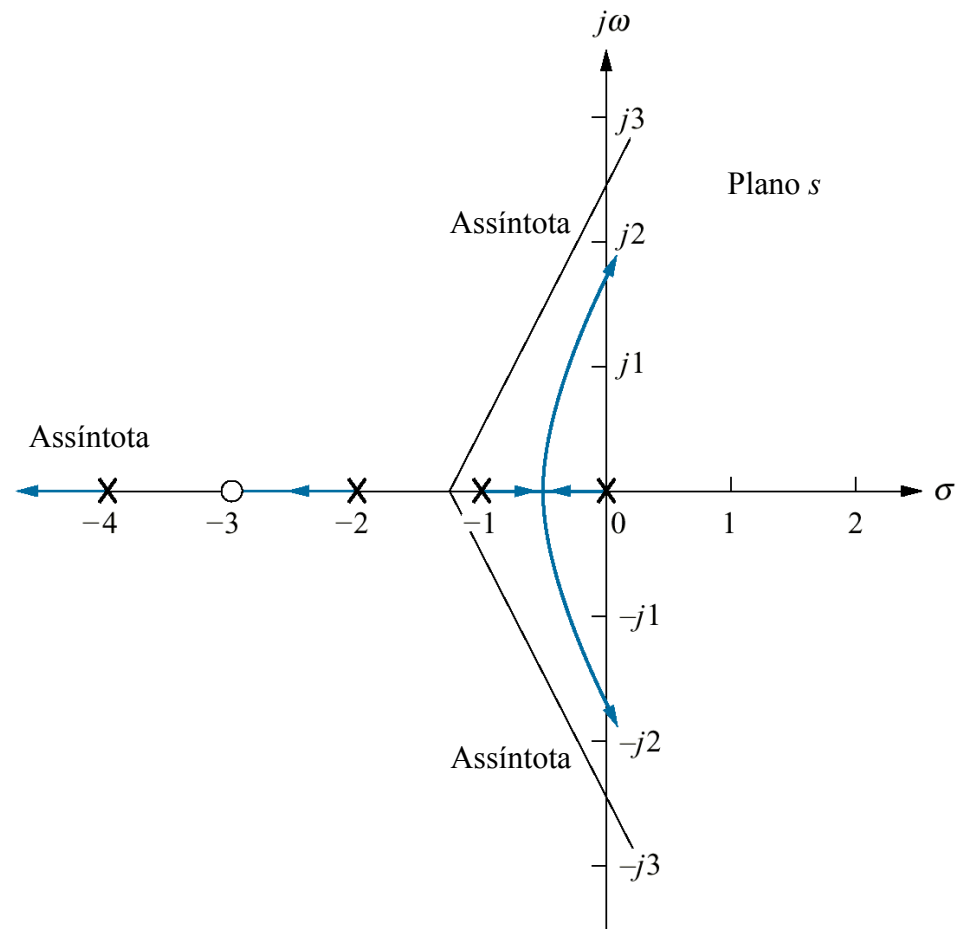


Fig. 8.13

Exemplo de lugar das raízes mostrando os pontos de saída ($-\sigma_1$) e entrada (σ_2) no eixo real

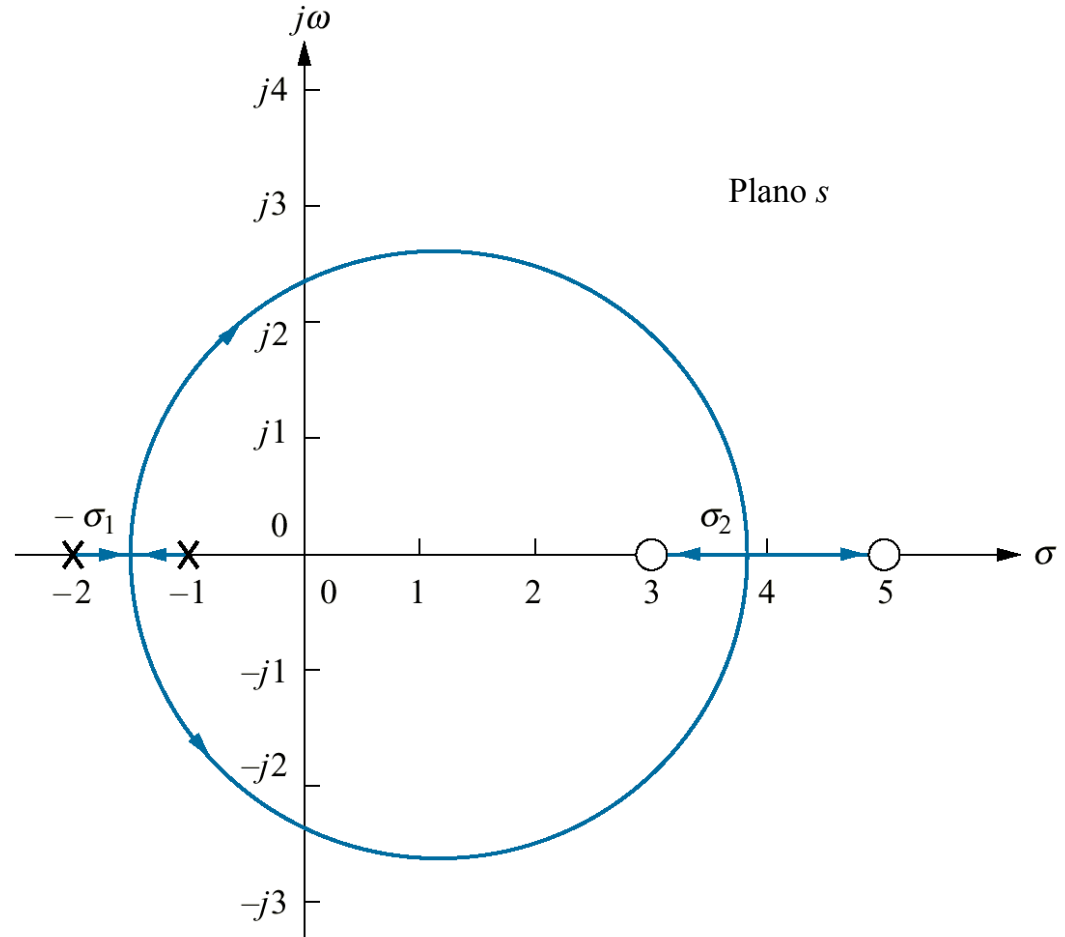


Fig. 8.14

Variação de ganho sobre o eixo real para o lugar das raízes da Fig. 8.13

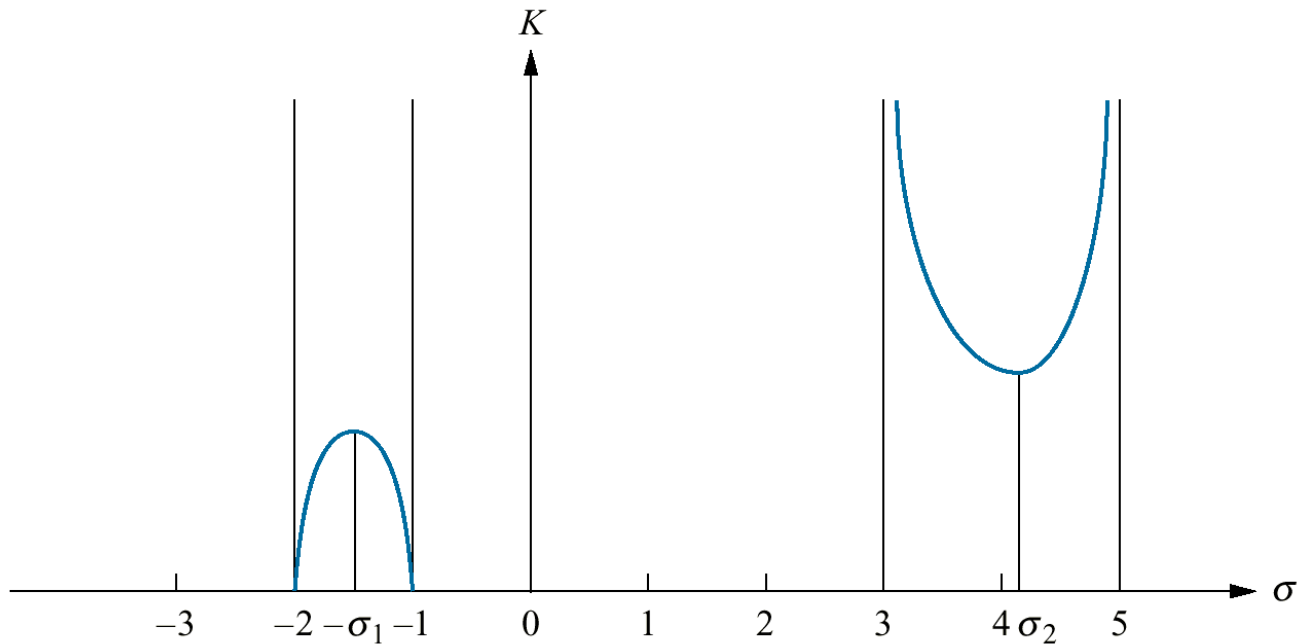


Fig. 8.15

Pólos e zeros a malha aberta e cálculos de:

- a. ângulo de saída;
- b. ângulo de chegada

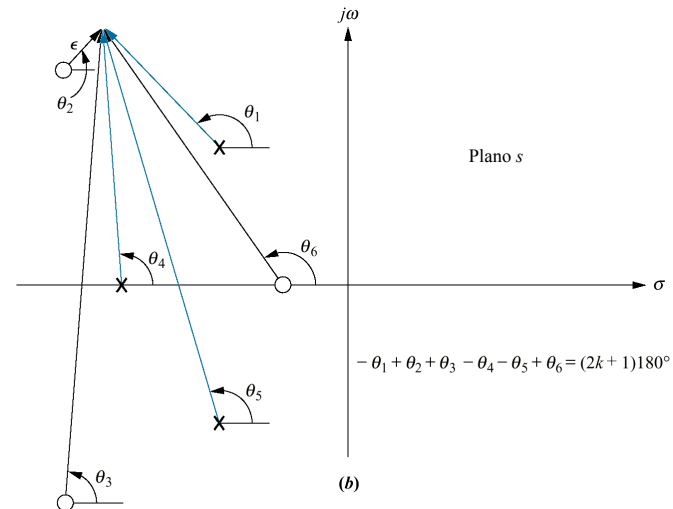
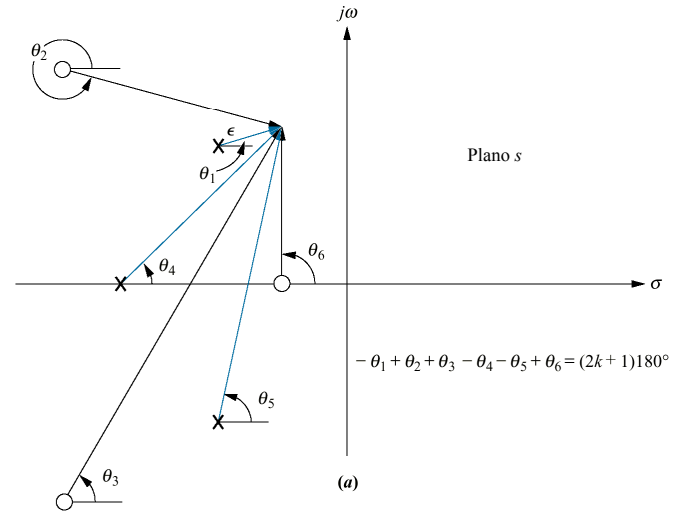


Fig. 8.16

Sistema com retroação unitária com pólos complexos

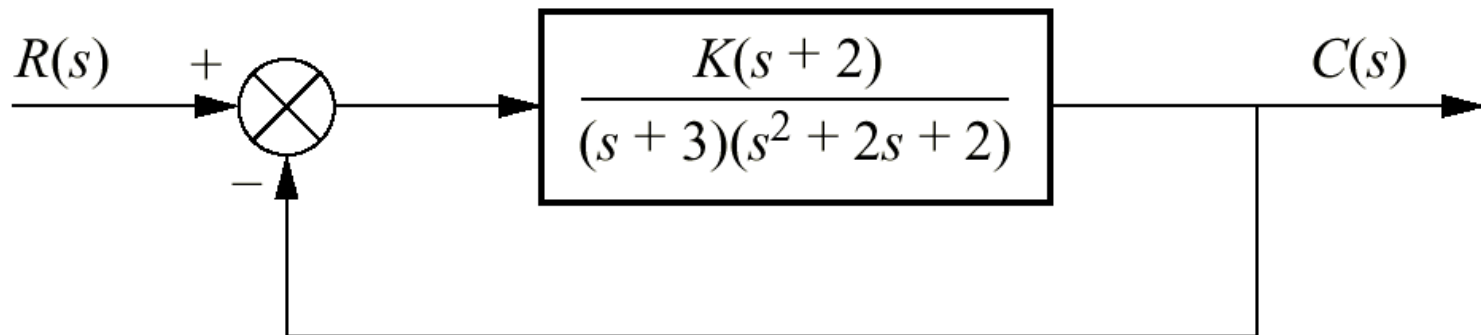


Fig. 8.17

Lugar das raízes para o sistema da Fig. 8.16 mostrando ângulo de saída

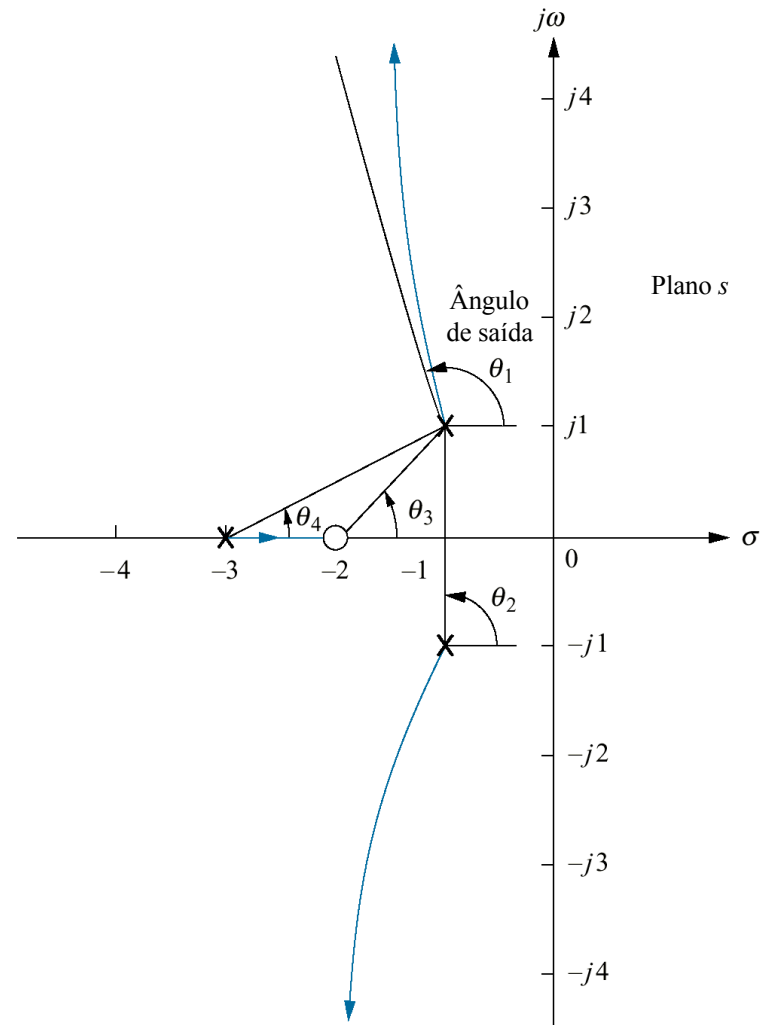


Fig. 8.18

Determinando e calibrando os pontos exatos no lugar das raízes da Fig. 8.12

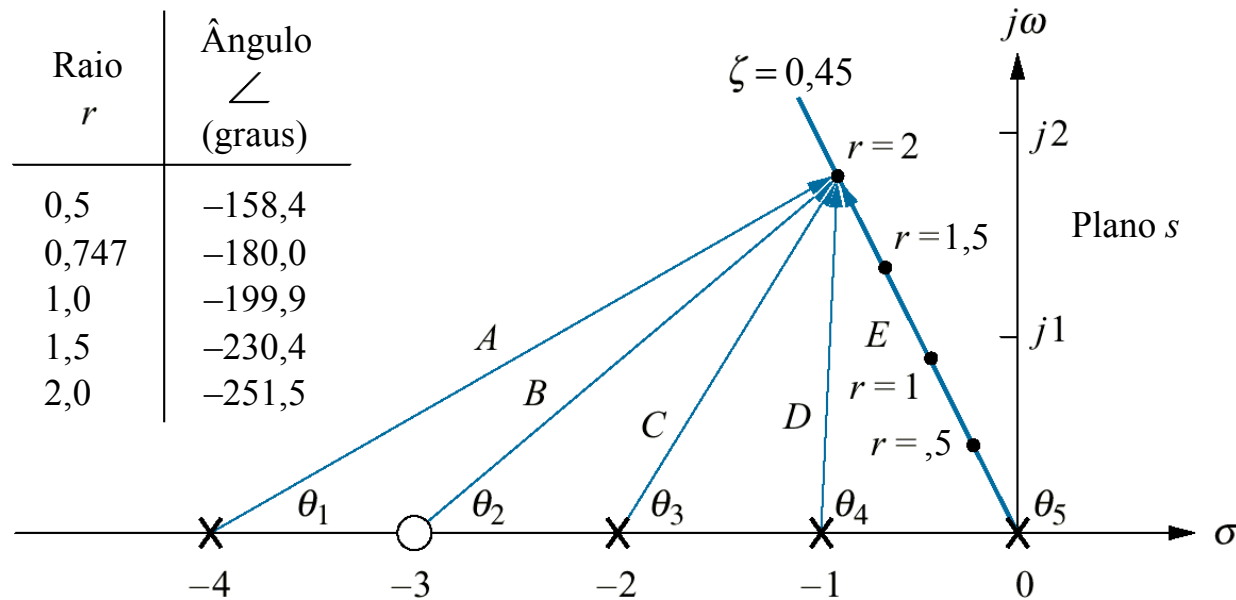
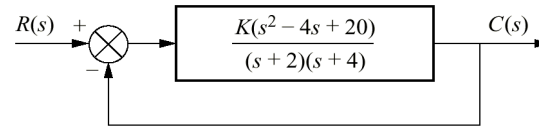
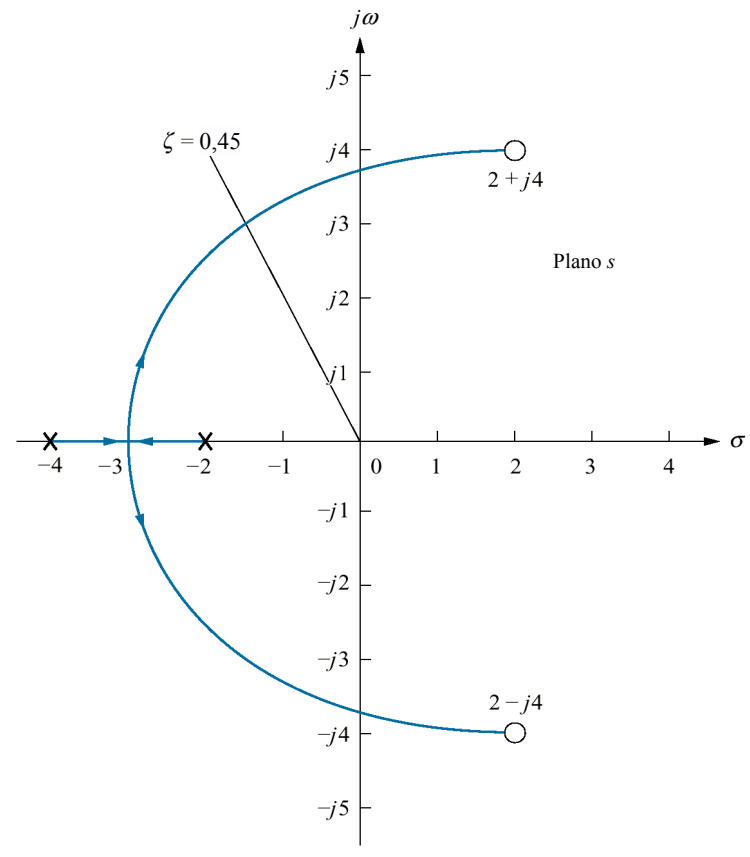


Fig. 8.19

- a. Sistema para o Exemplo 8.7;
- b. esboço do lugar das raízes



(a)



(b)

Fig. 8.20

Fazendo aproximação de segunda ordem

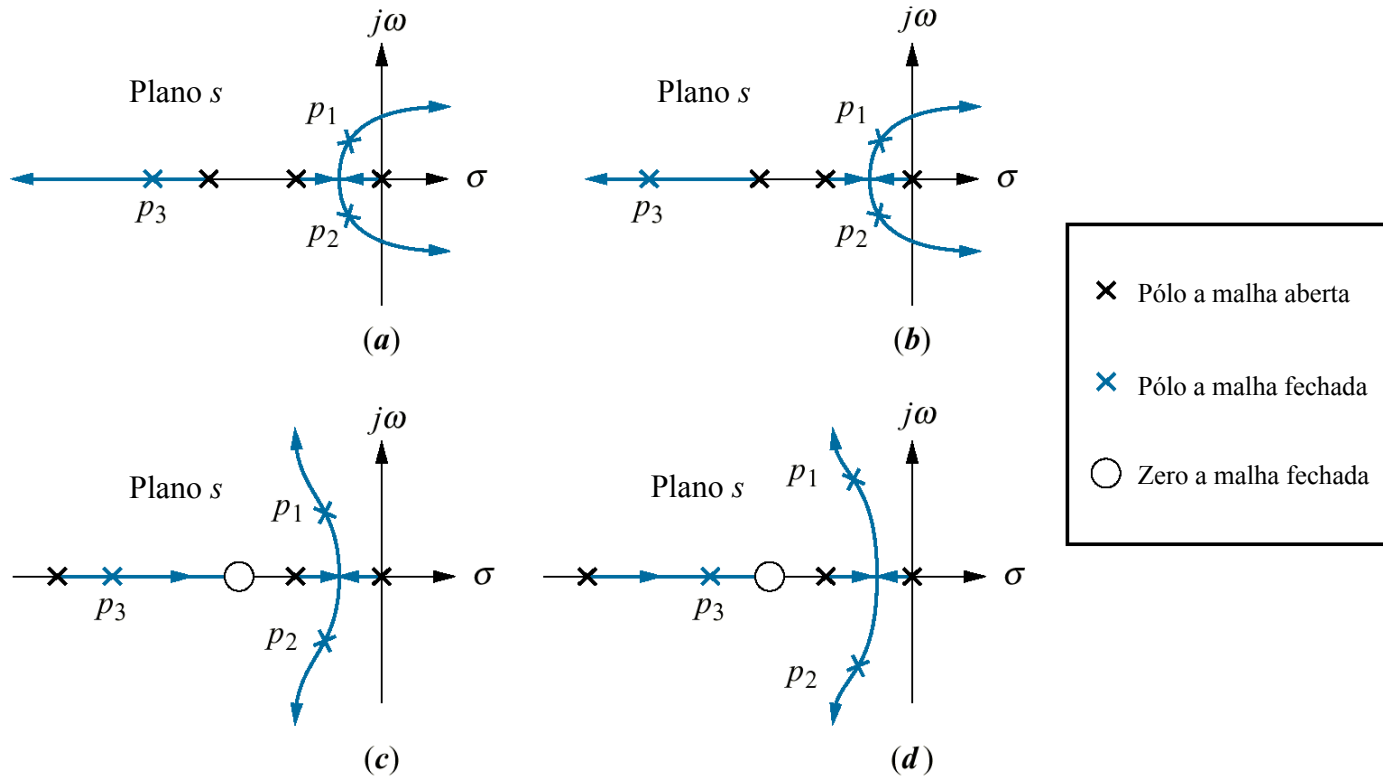


Fig. 8.21
Sistema para o
Exemplo 8.8

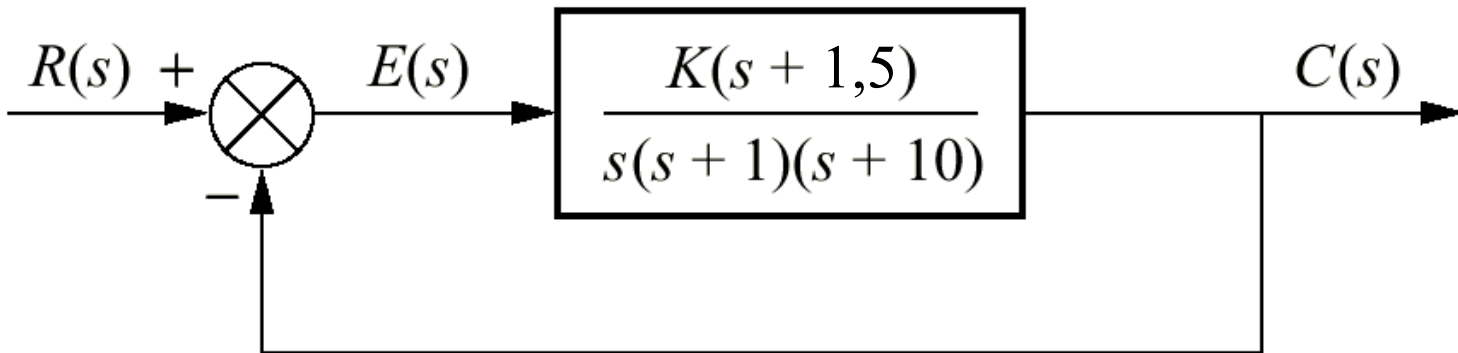


Fig. 8.22
Lugar das raízes
para o Exemplo 8.8

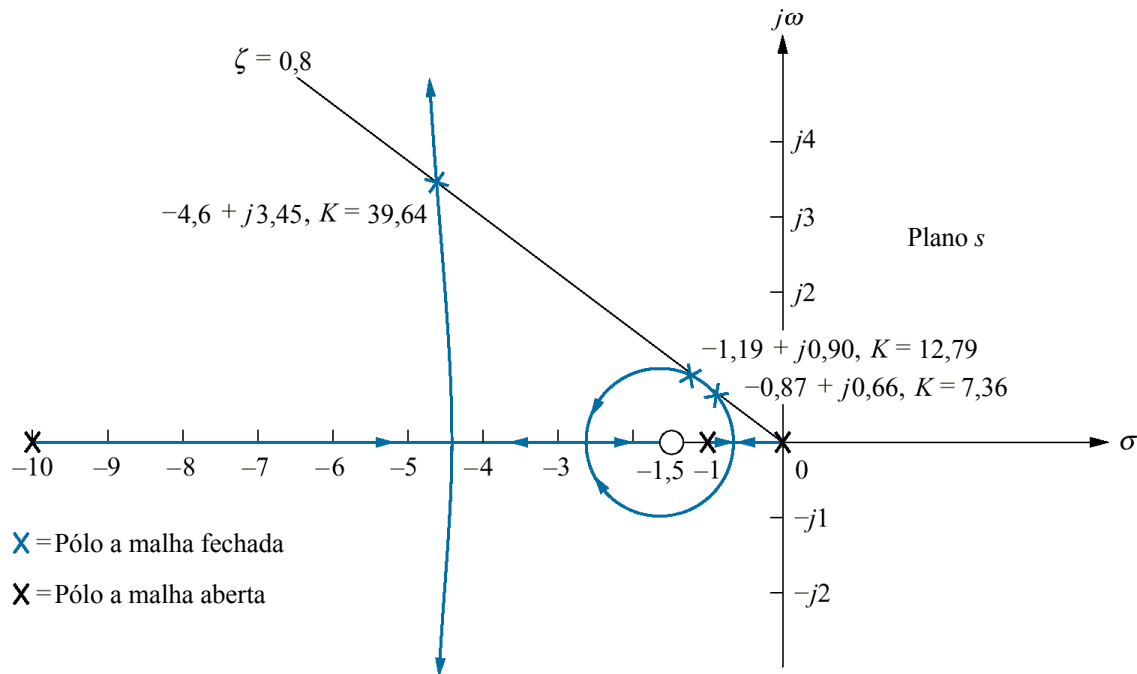


Fig. 8.23

Respostas da segunda e terceira ordem para o Exemplo 8.8:

- a. Caso 2;
- b. Caso 3

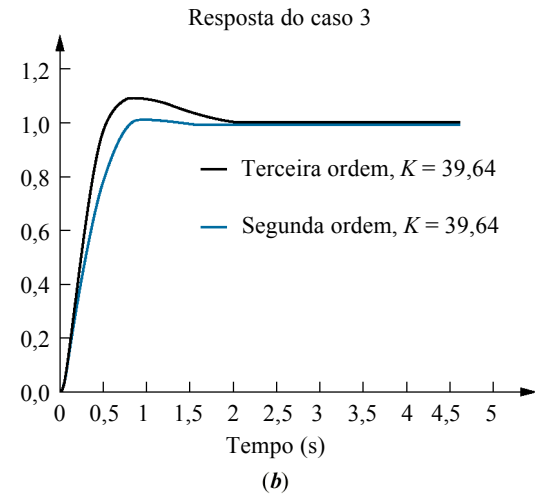
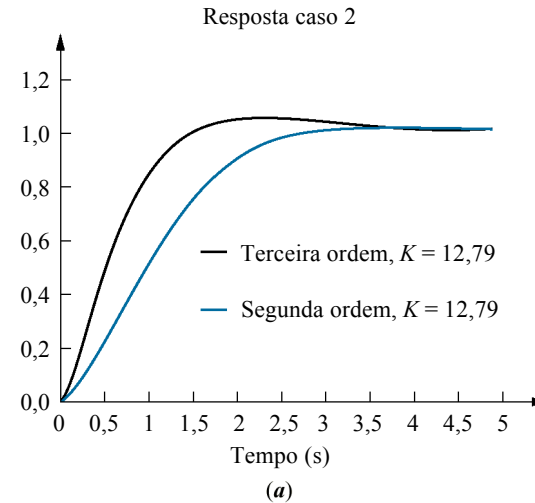


Fig. 8.24

Sistema que requer um lugar das raízes calibrado em valores p_1 como parâmetro

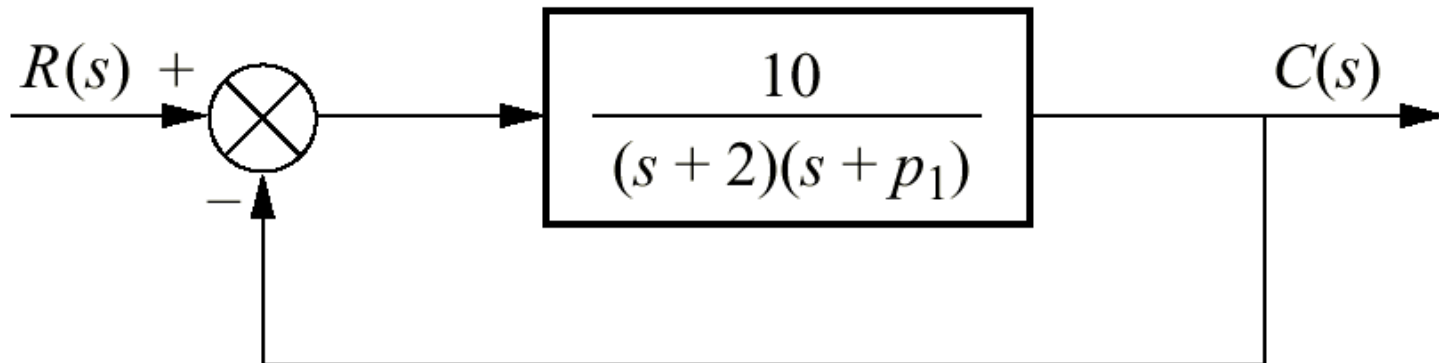


Fig. 8.25

Lugar das raízes para o sistema da Fig. 8.24, tendo p_1 como parâmetro

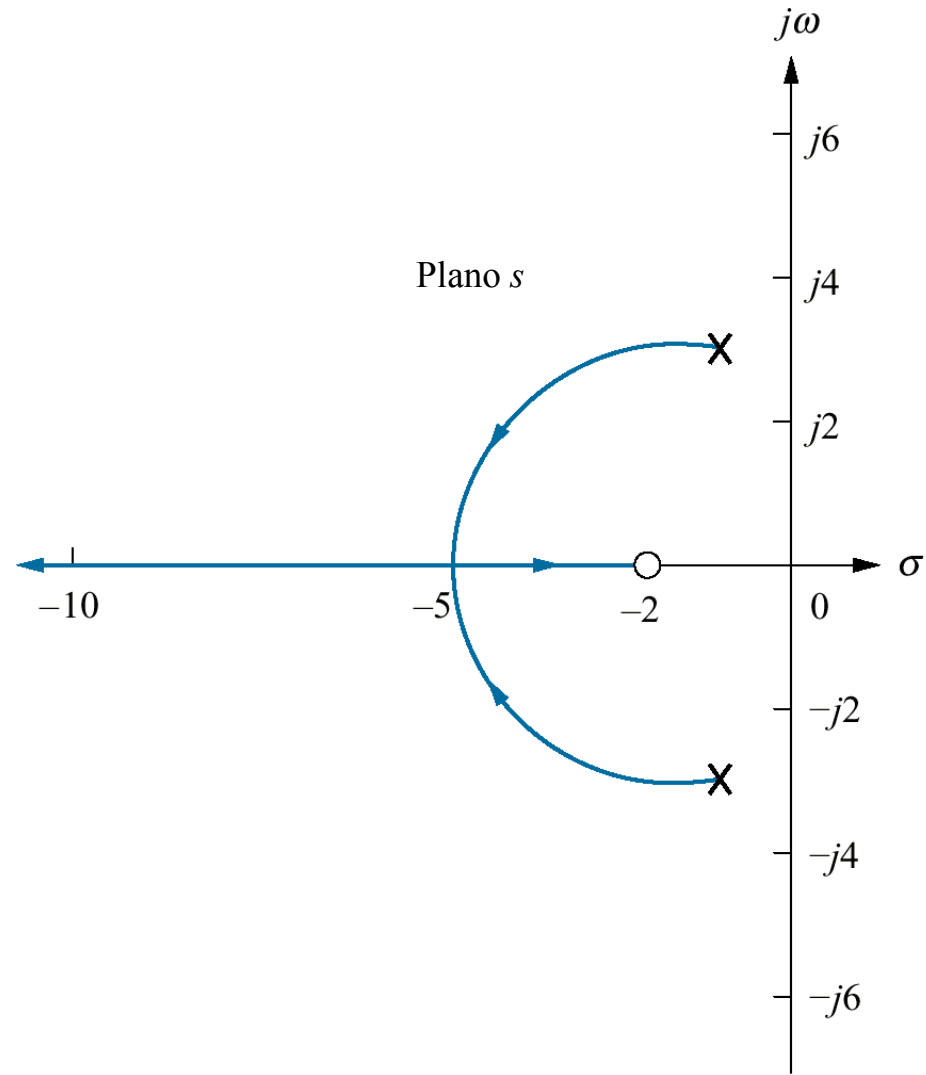


Fig. 8.26

Sistema com retroação positiva

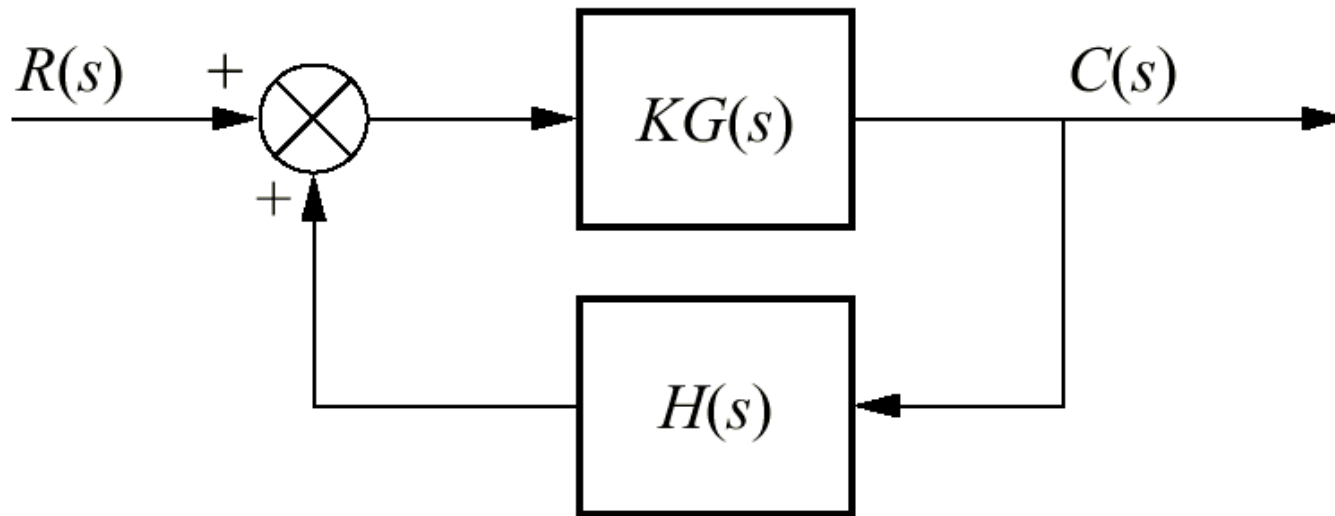
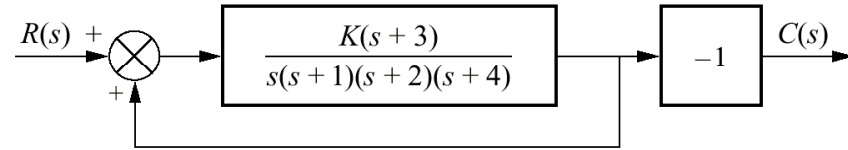
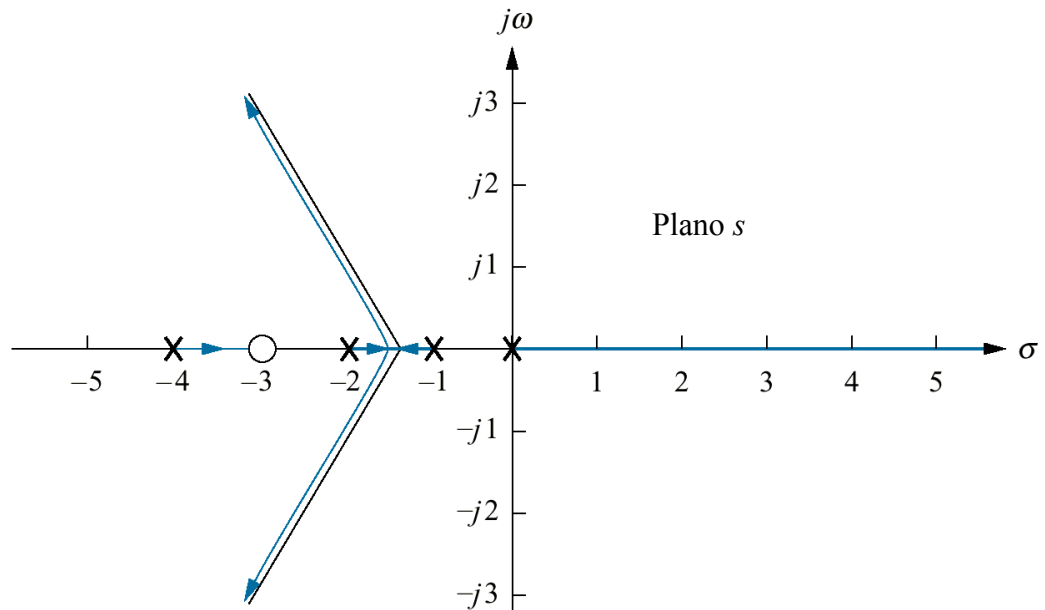


Fig. 8.27

a. Sistema com retroação positiva equivalente para o Exemplo 8.9;
 b. lugar das raízes



(a)



(b)

Fig. 8.28

Porção do lugar das raízes para o sistema de controle de antena

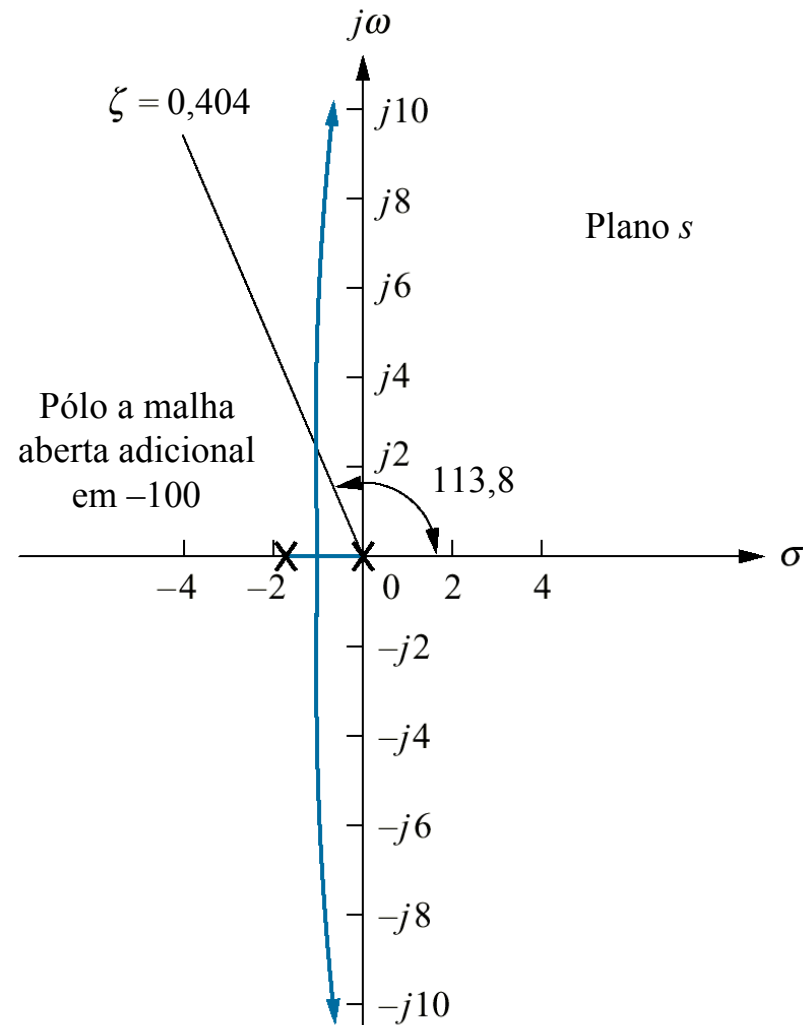


Fig. 8.29
Resposta ao degrau do sistema de controle de antena com ajuste de ganho

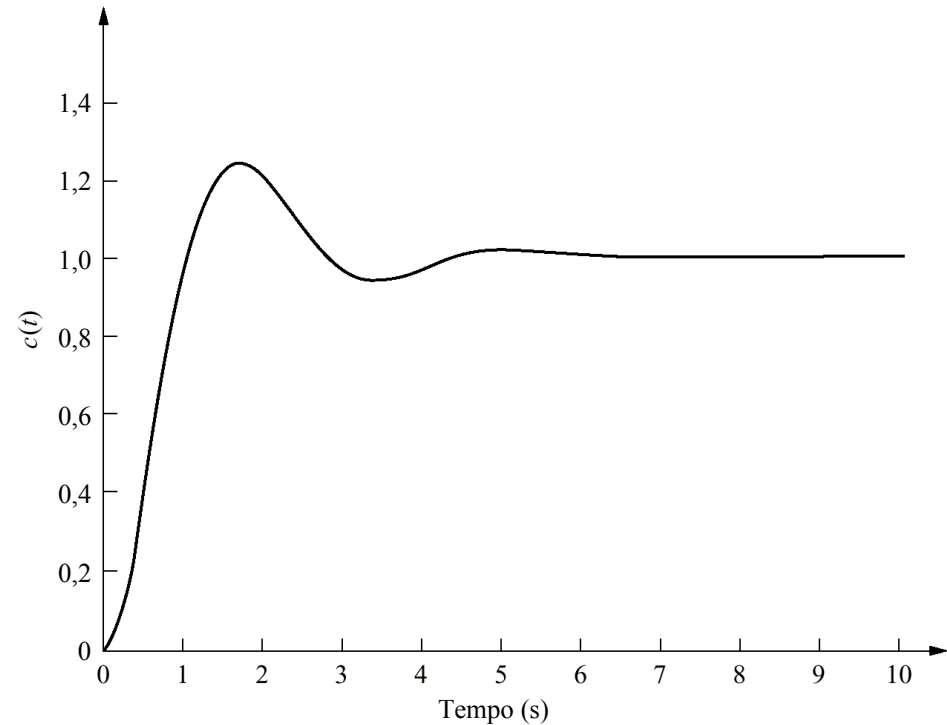


Fig. 8.30

Lugar das raízes da malha de controle de arfagem sem retroação de velocidade, veículo UFSS

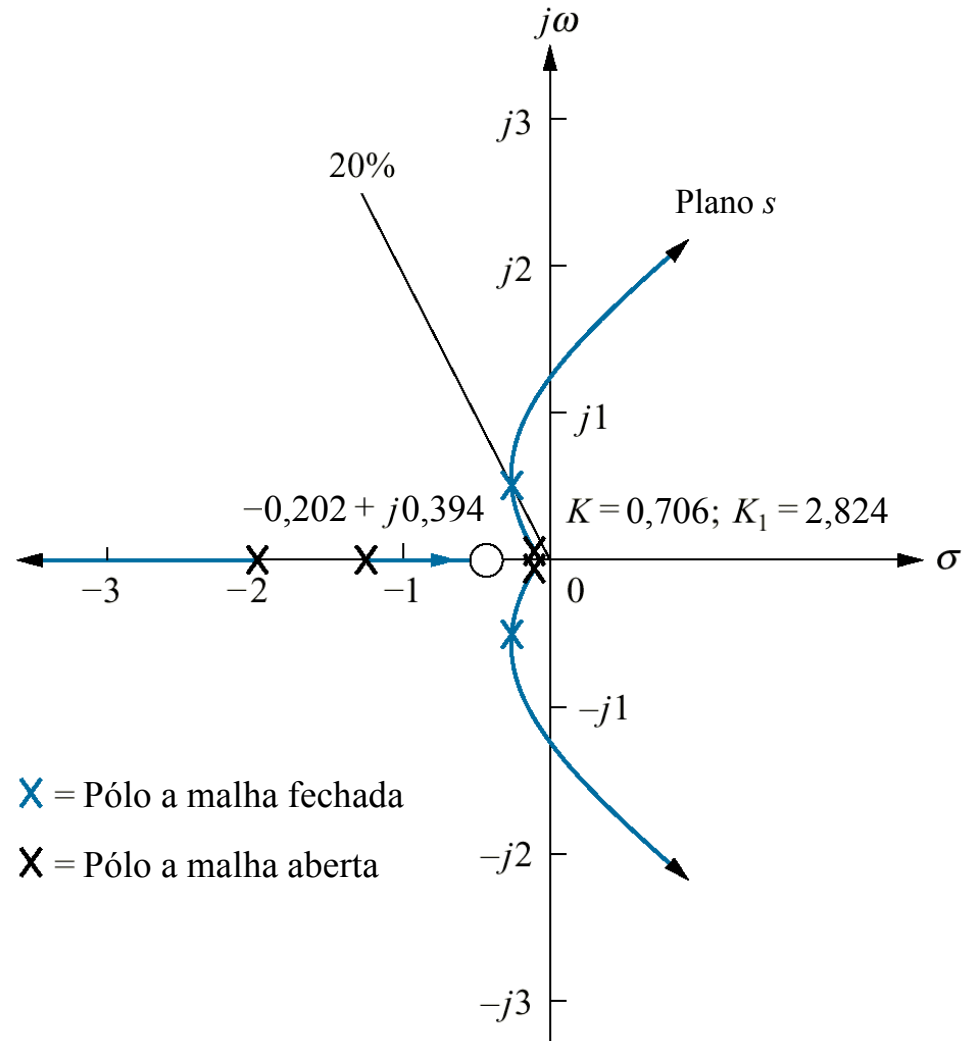


Fig. 8.31

Simulação em computador da resposta ao degrau da malha de controle de arfagem sem retroação de velocidade, veículo UFSS

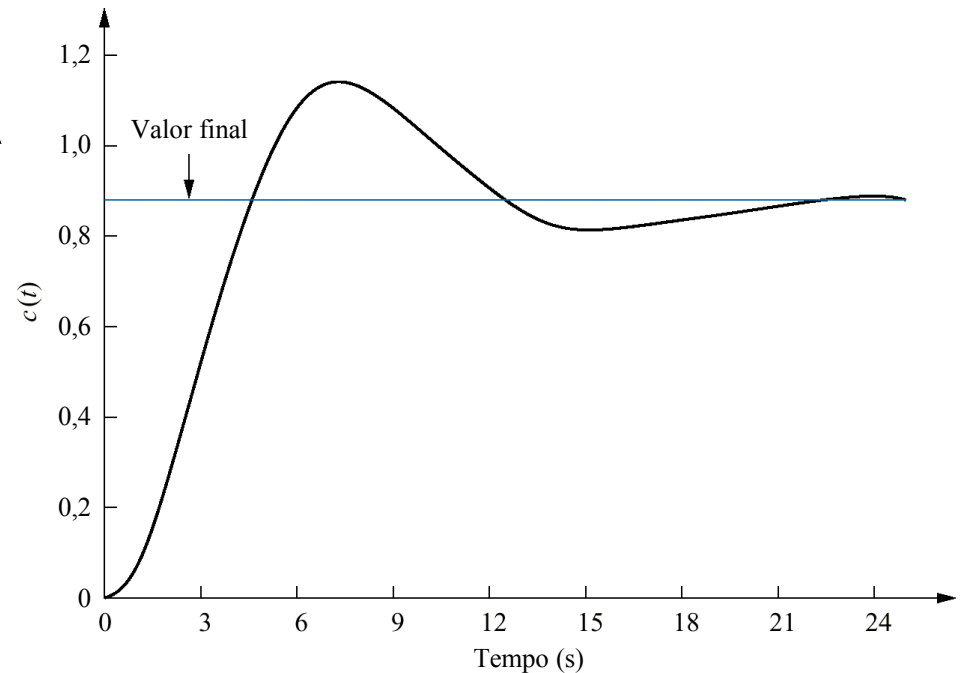


Fig. 8.32

Lugar das raízes da malha de controle de arfagem com retroação de velocidade, veículo UFSS

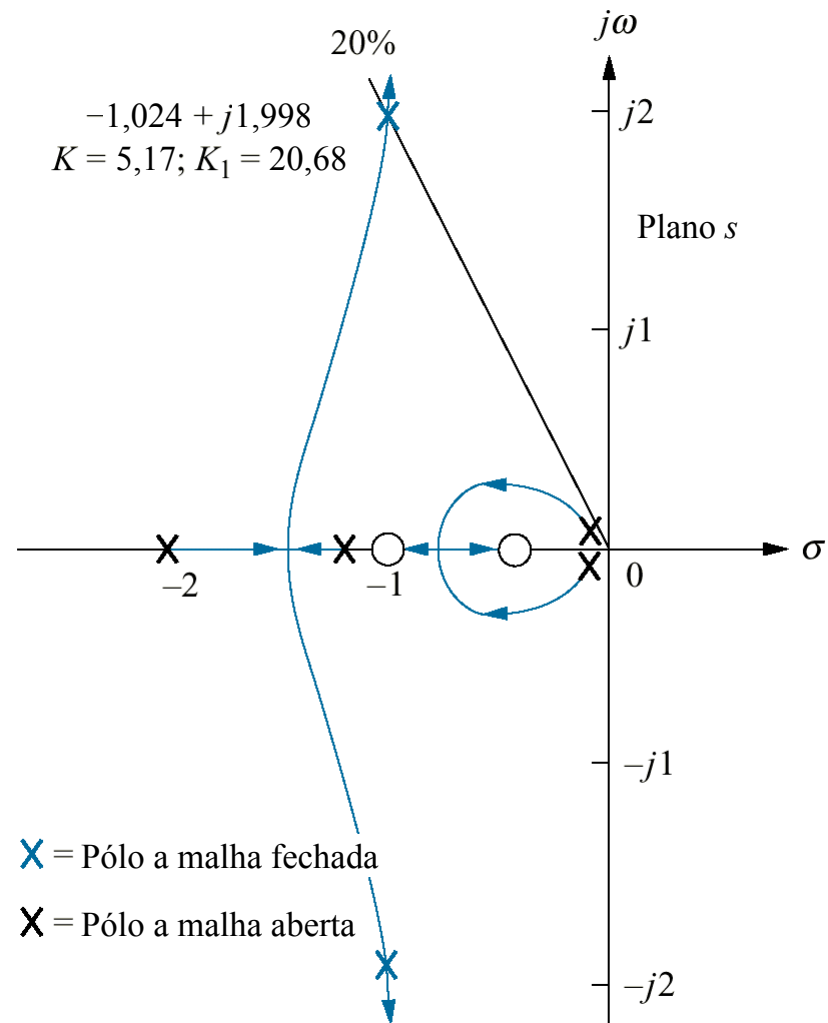


Fig. 8.33

Simulação em computador de resposta ao degrau da malha de controle de arfagem com retroação de velocidade, veículo UFSS

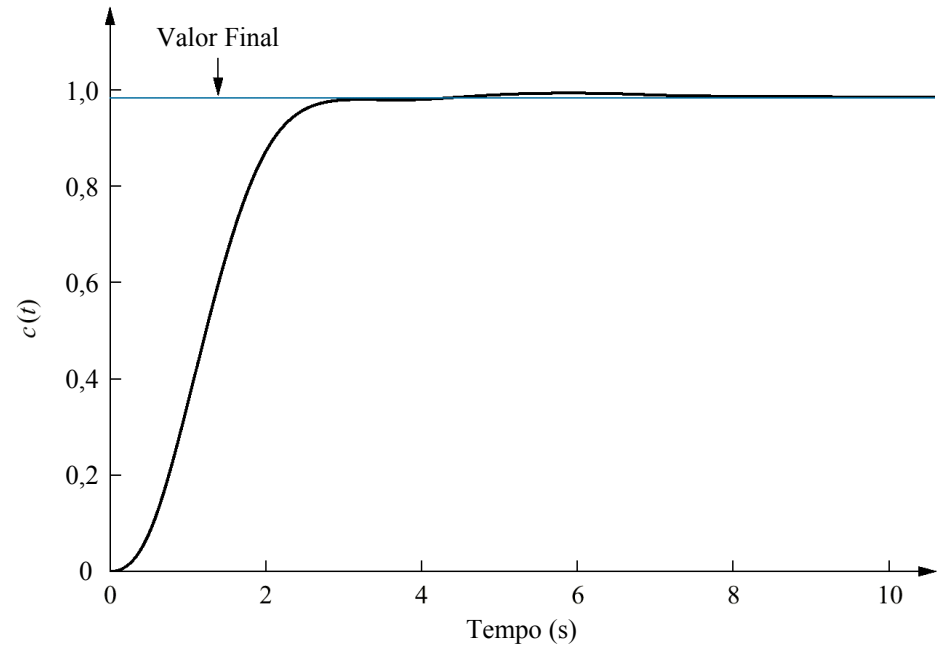


Fig. P8.1

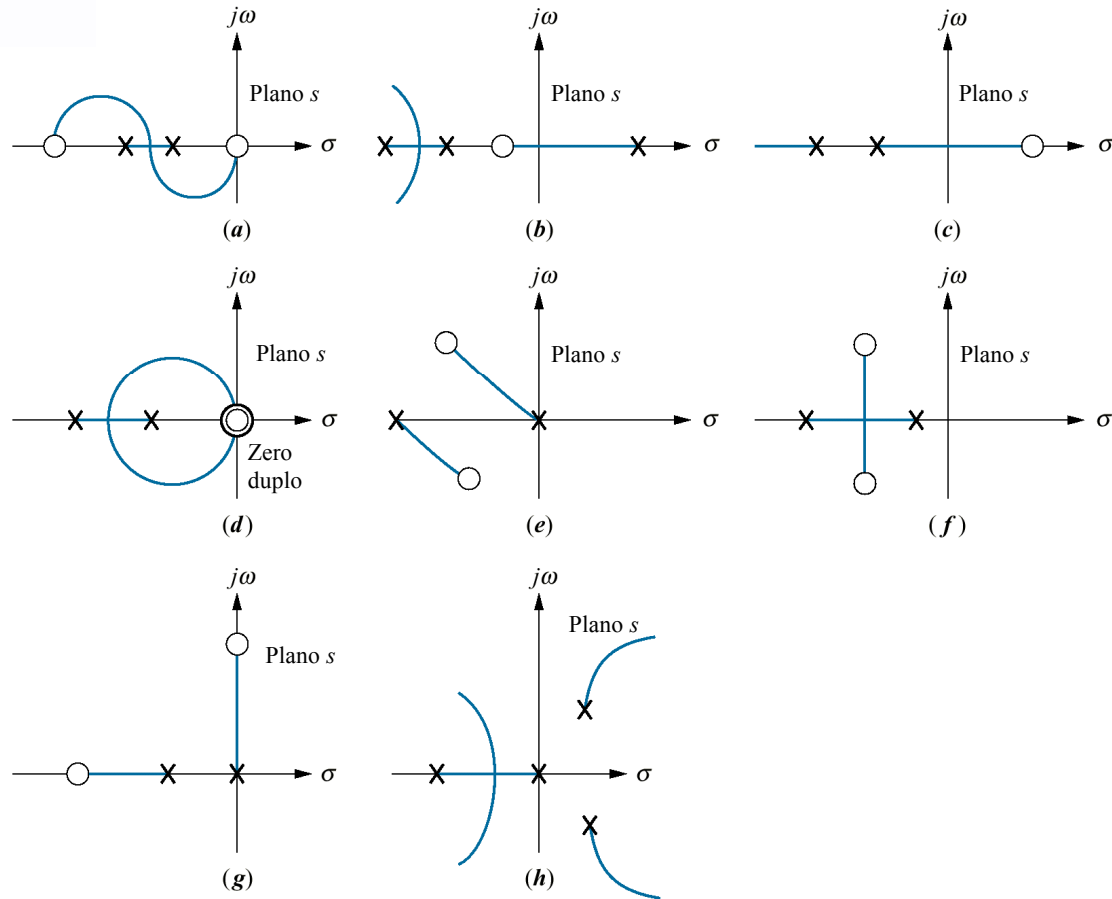


Fig. P8.2

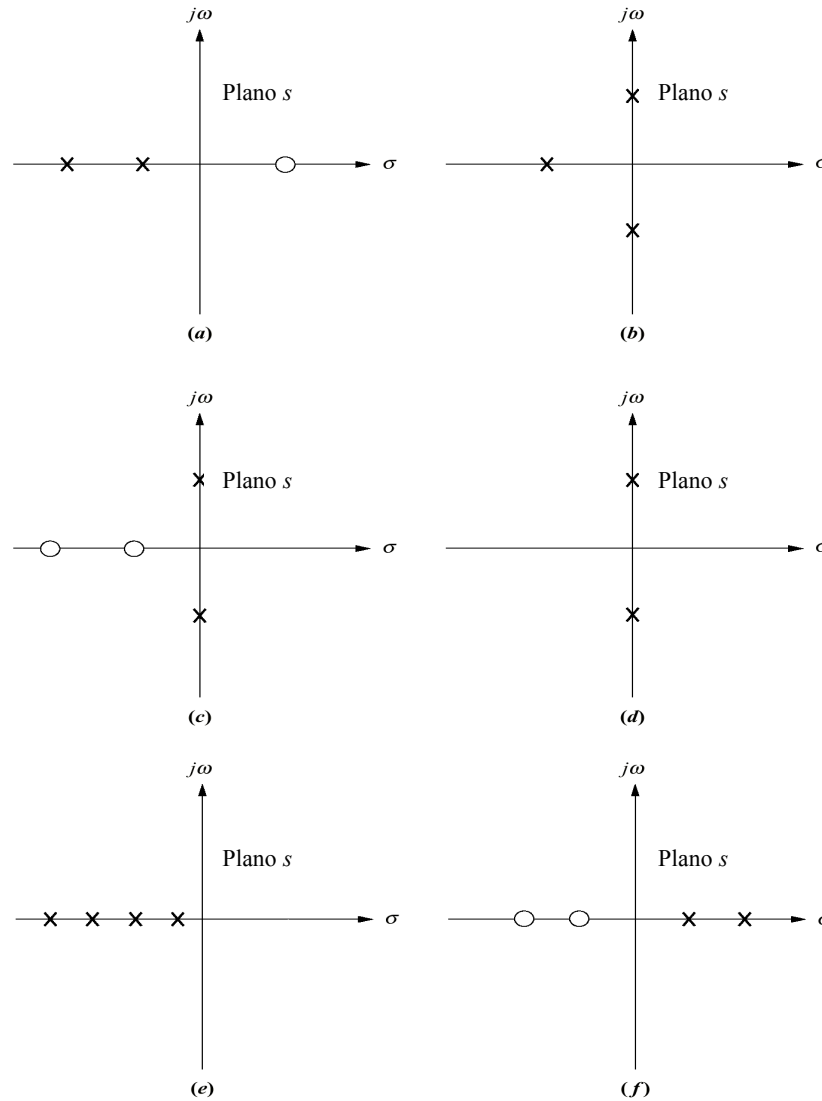


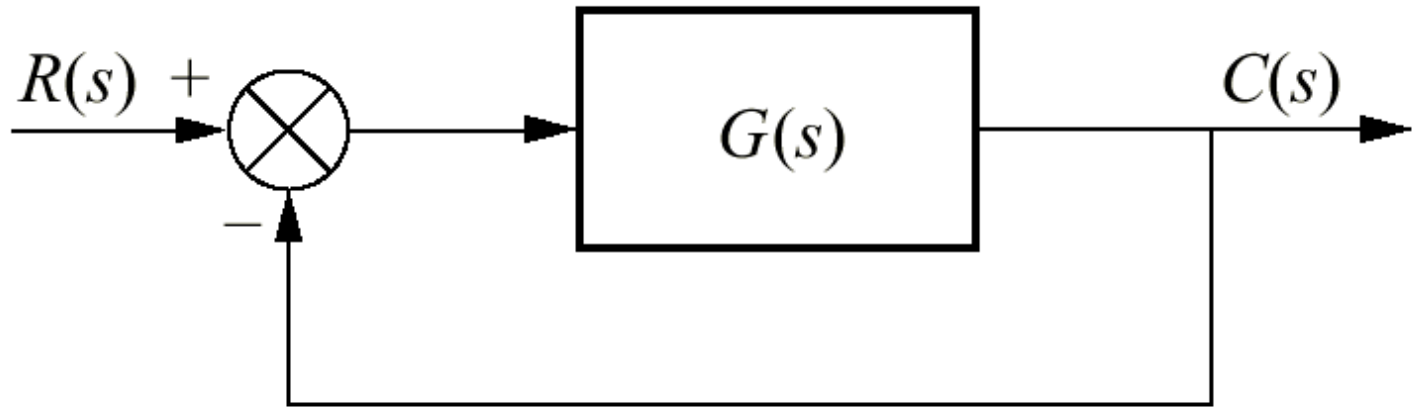
Fig. P8.3

Fig. P8.4

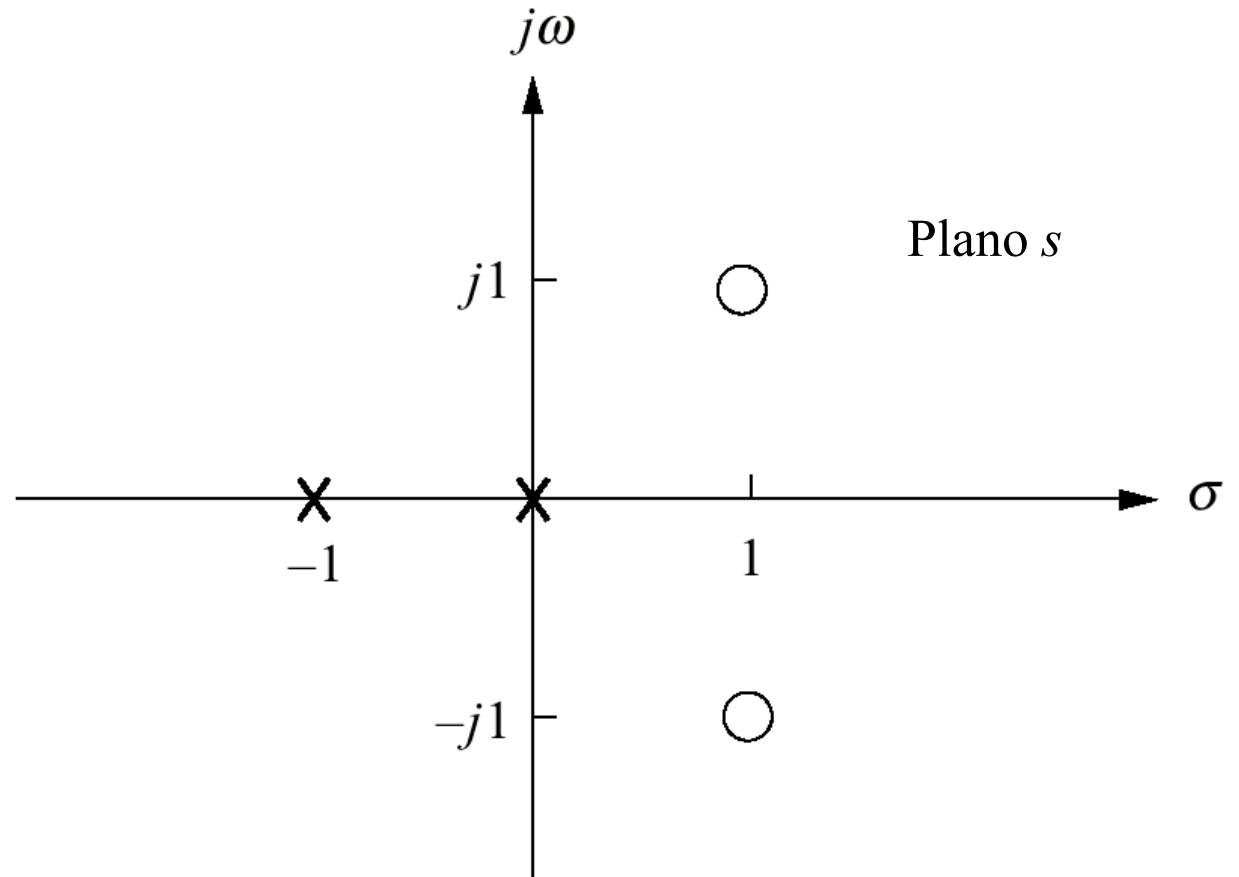


Fig. P8.5

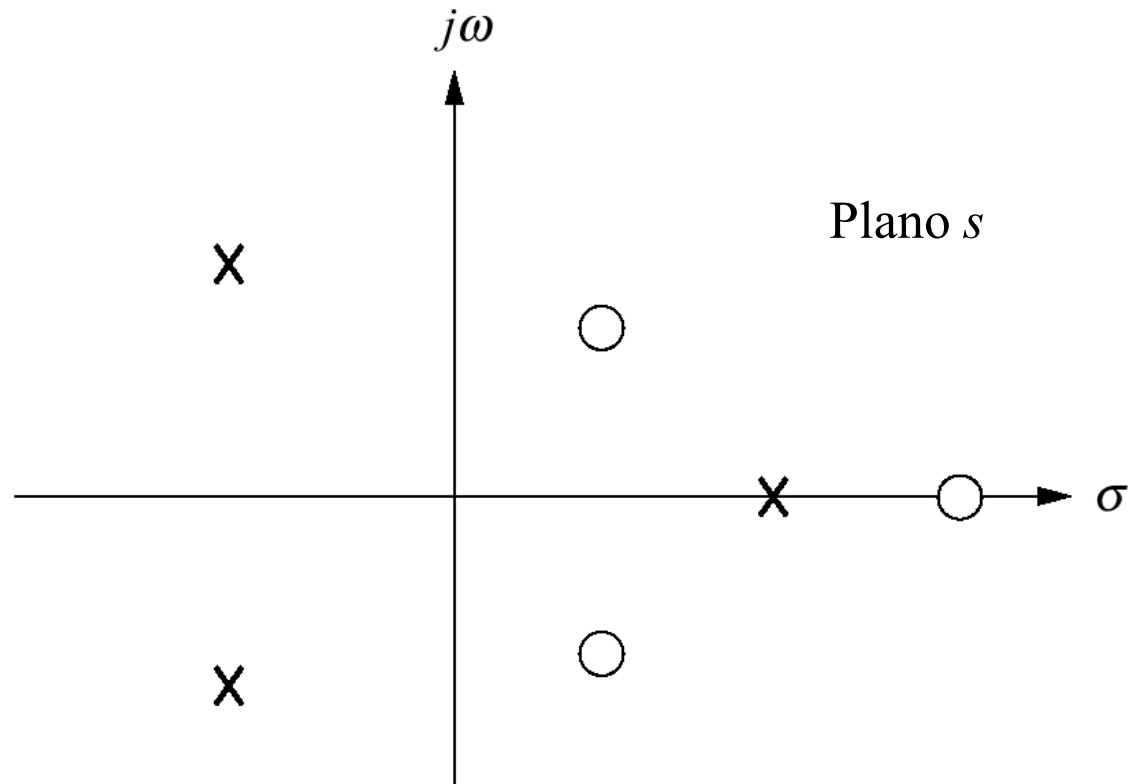


Fig. P8.6

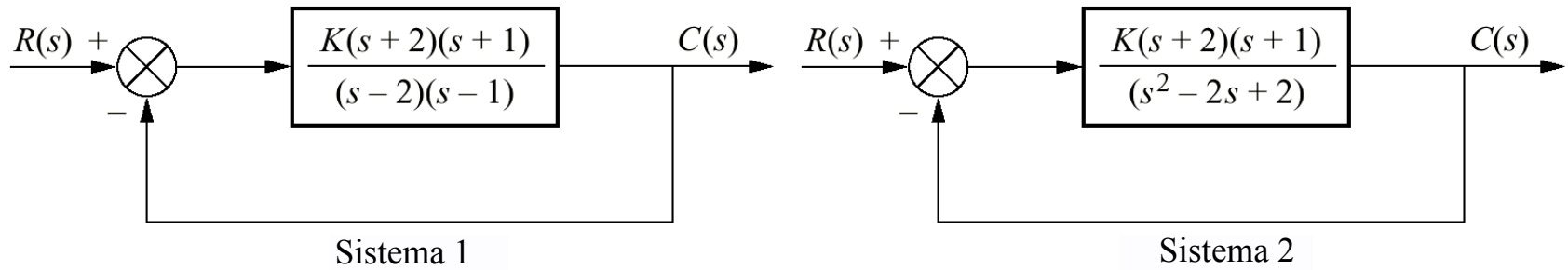


Fig. P8.7

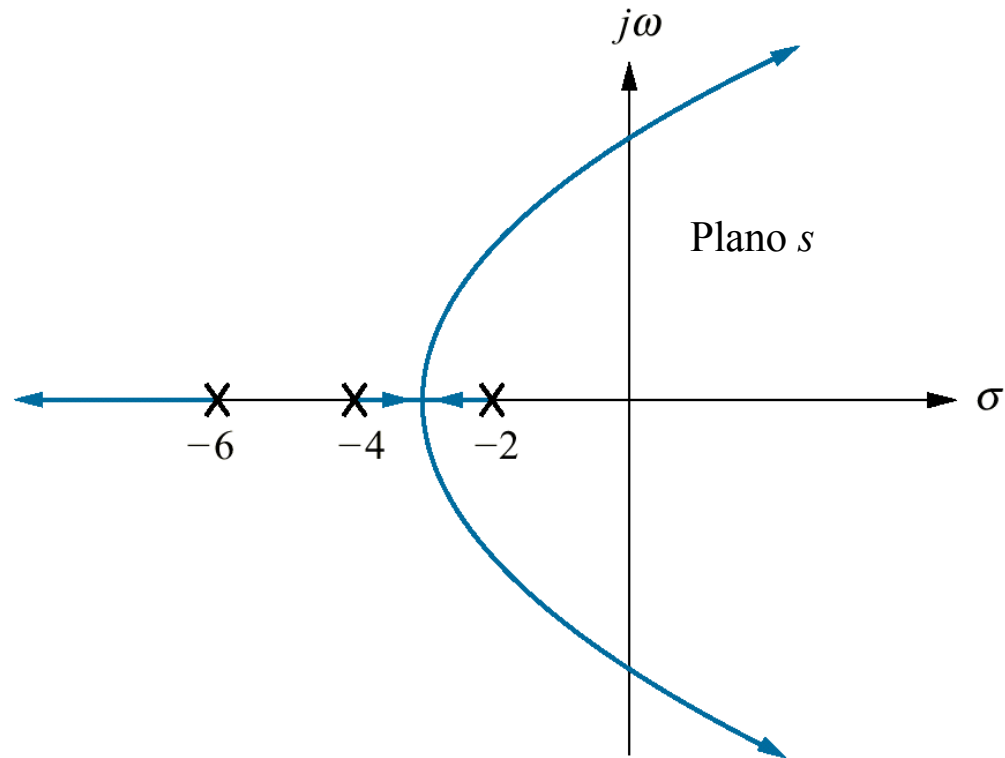
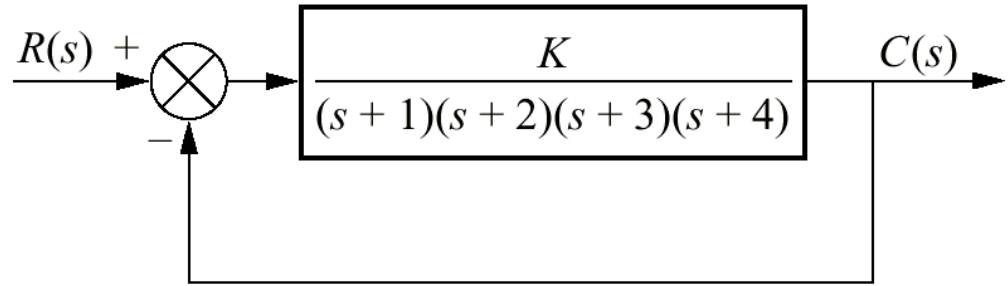
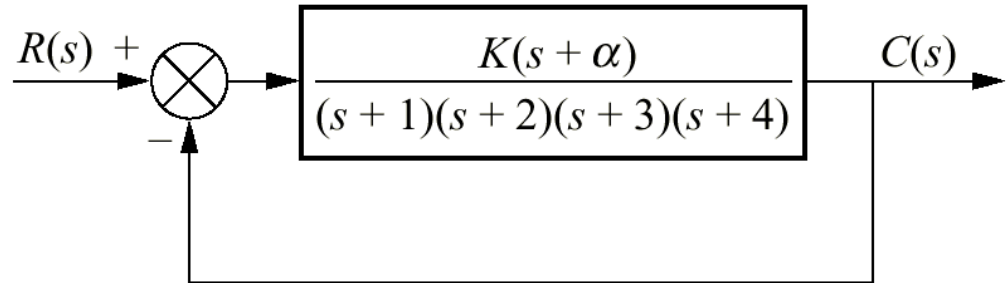


Fig. P8.8



(a)



(b)

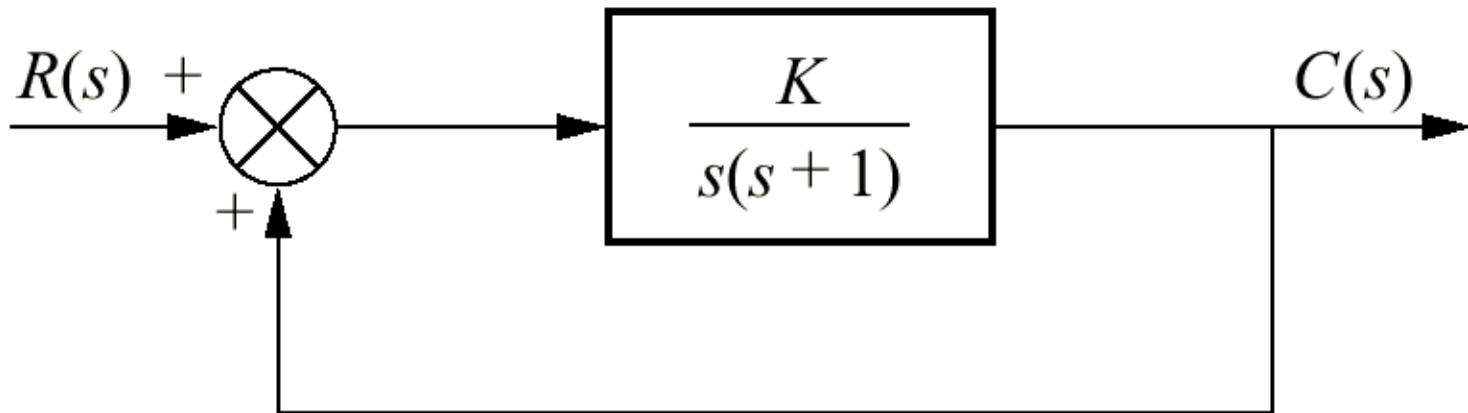
Fig. P8.9

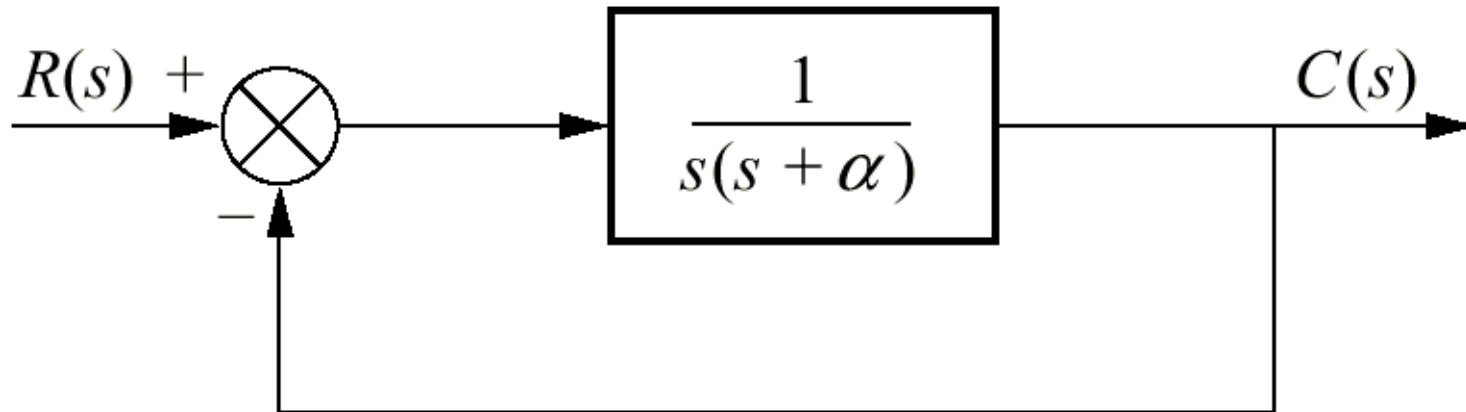
Fig. P8.10

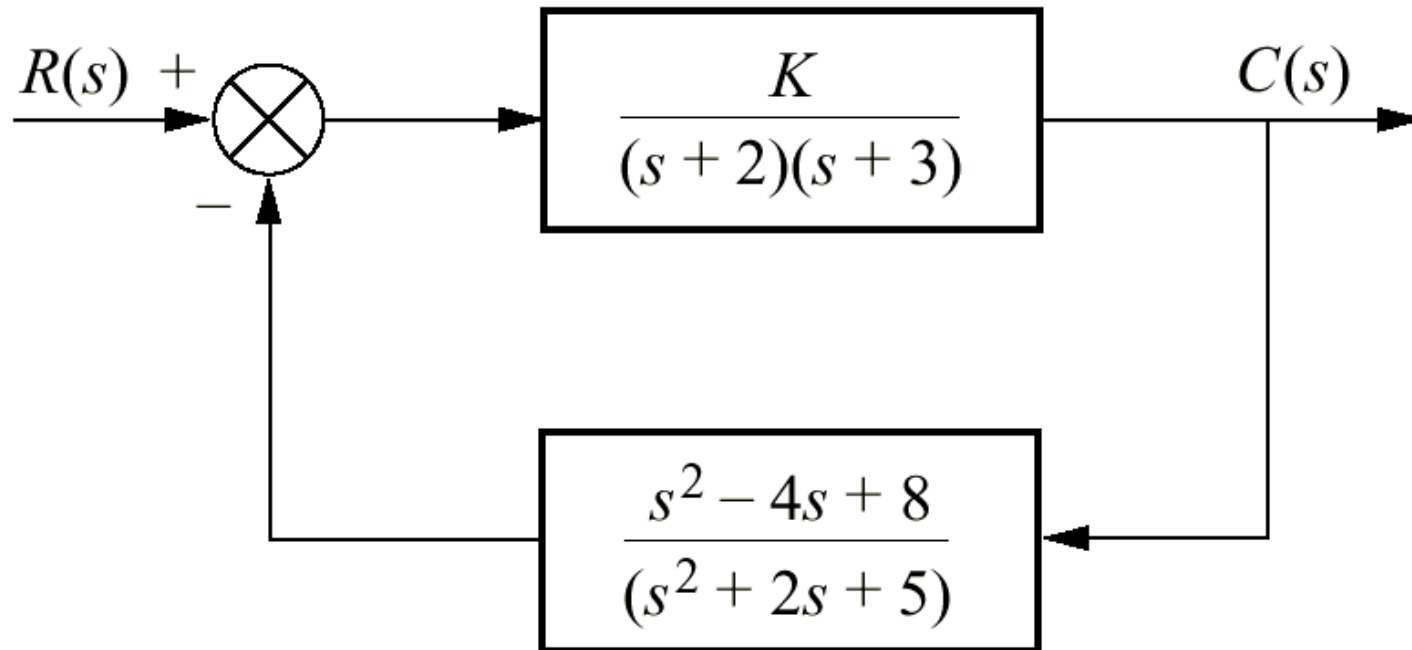
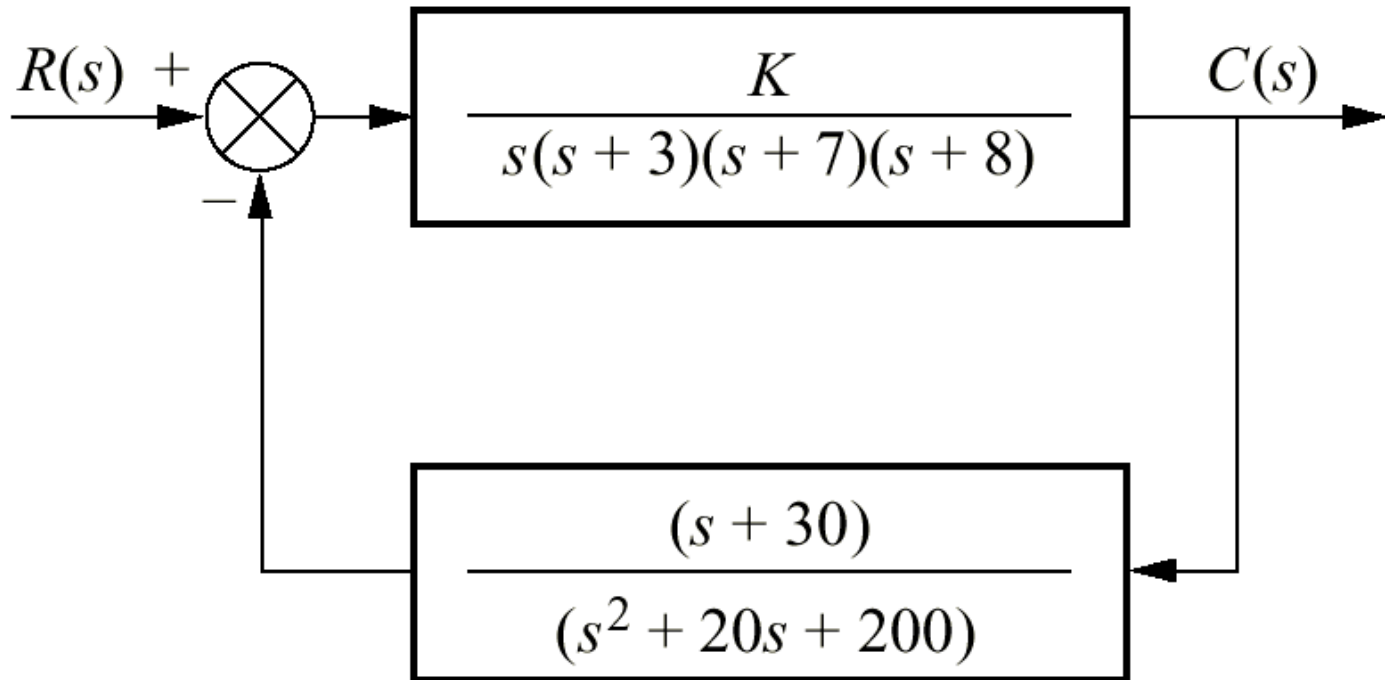
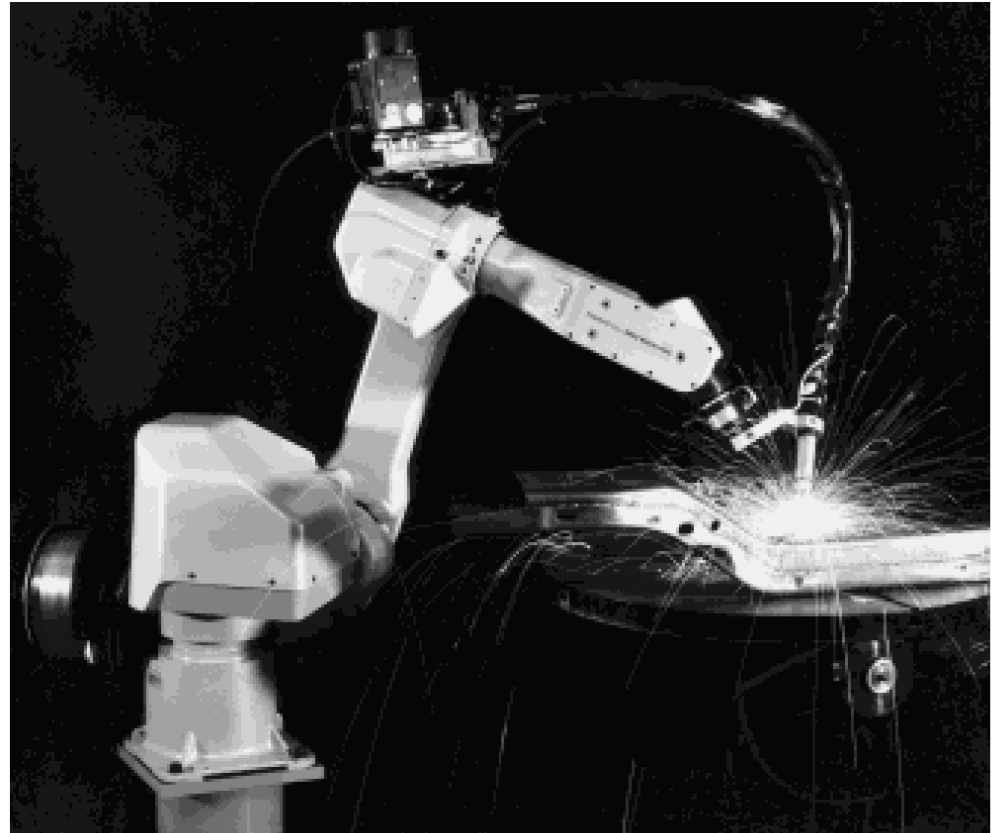
Fig. P8.11

Fig. P8.12

Cortesia de FANUC Robotics.

Fig. P8.13

a. Robô equipado para executar solda a arco;
(*continua*)

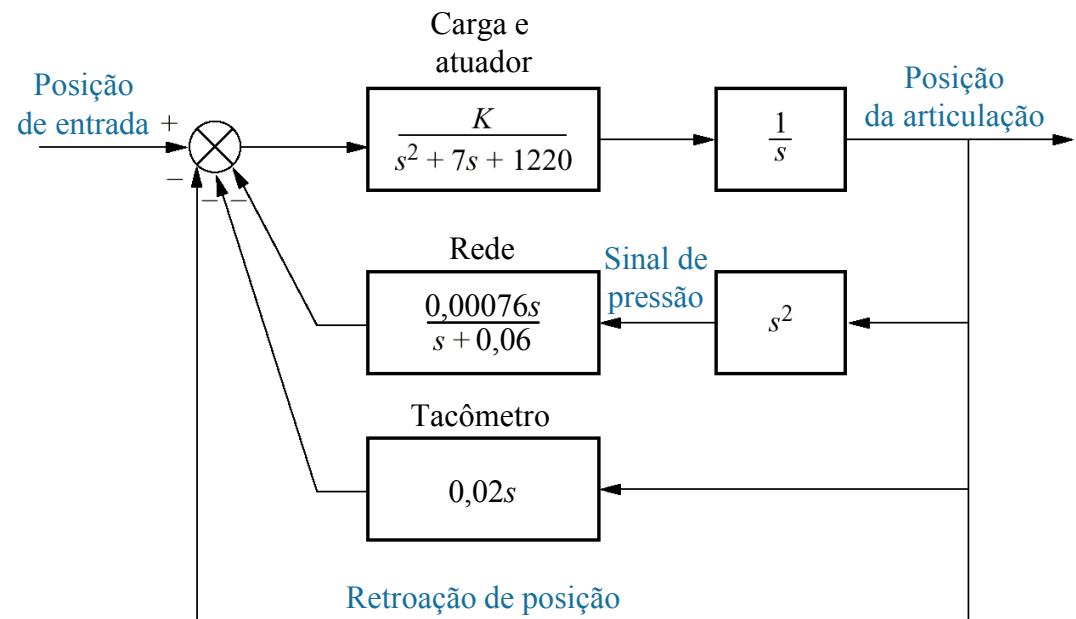


(a)

Fig. P8.13

(continuação)

b. diagrama de blocos para o sistema de movimento em balanço

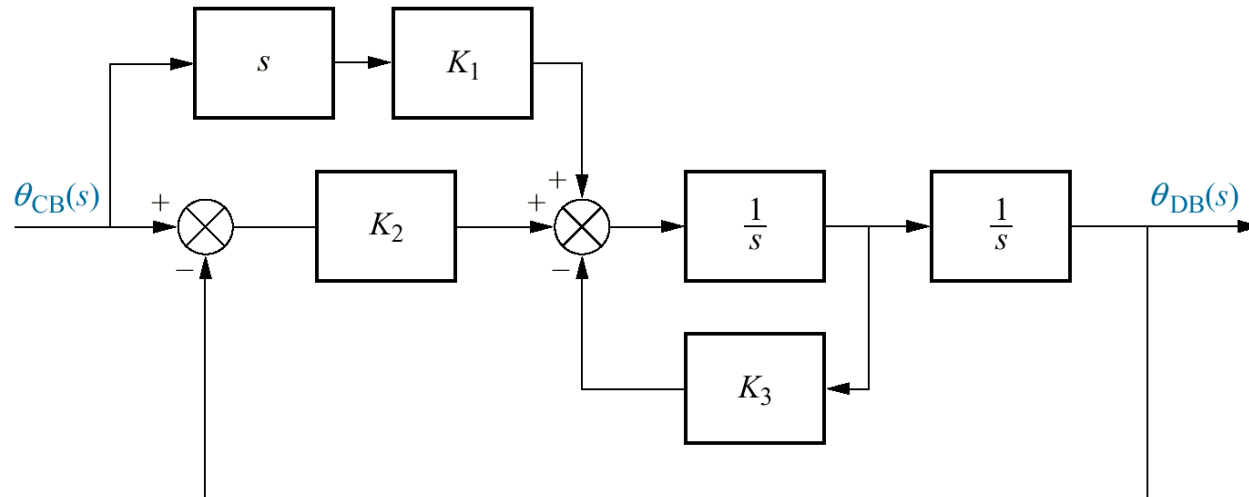


(b)

© 1967 H.L. Hardy.

Fig. P8.14

Diagrama de blocos do suavizador



© 1985 Rockwell International.

Fig. P8.15

a. Amortecedor de vibração ativo ((c)1992 AIAA);
b. diagrama de blocos do sistema de controle

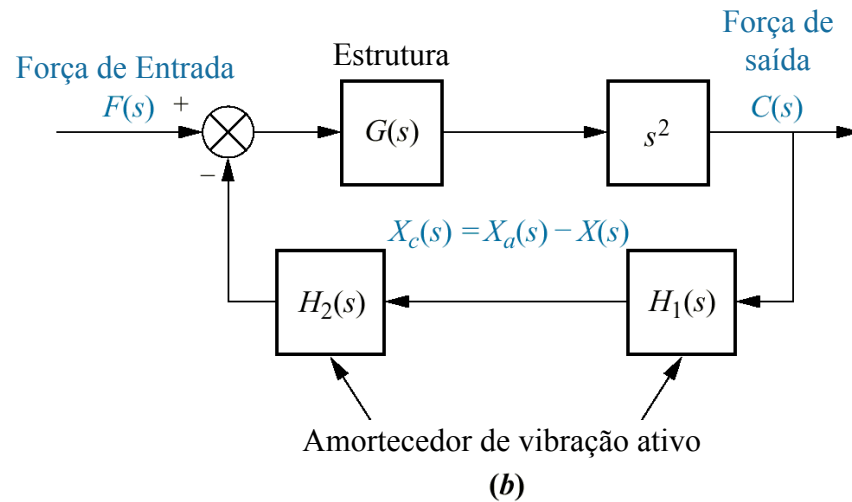
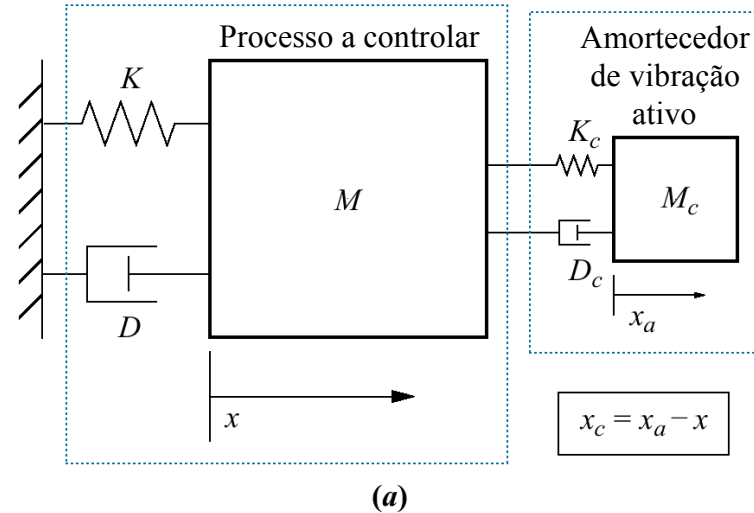


Fig. P8.16

Acionador de disco flexível:

a. representação física;

b. diagrama de blocos

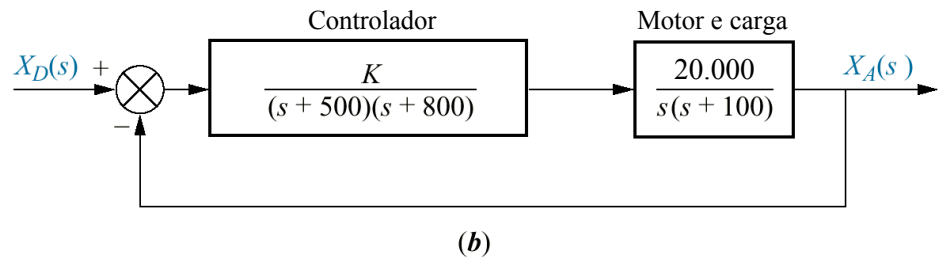
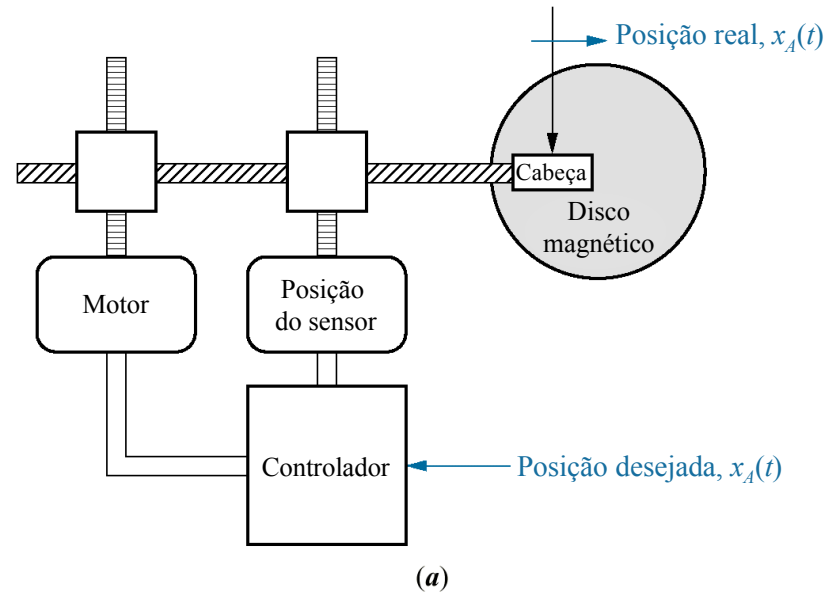


Fig. P8.17

Diagrama de blocos simplificado do servomecanismo da pupila do olho humano

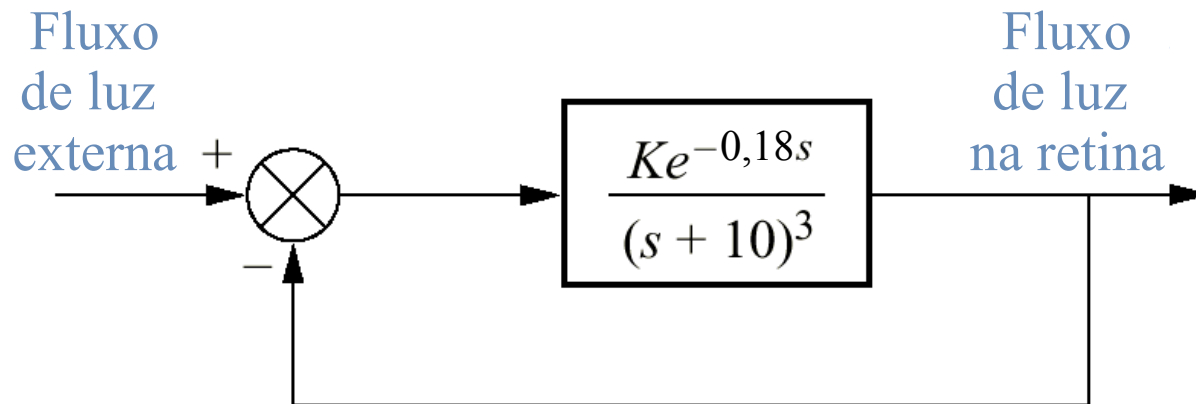
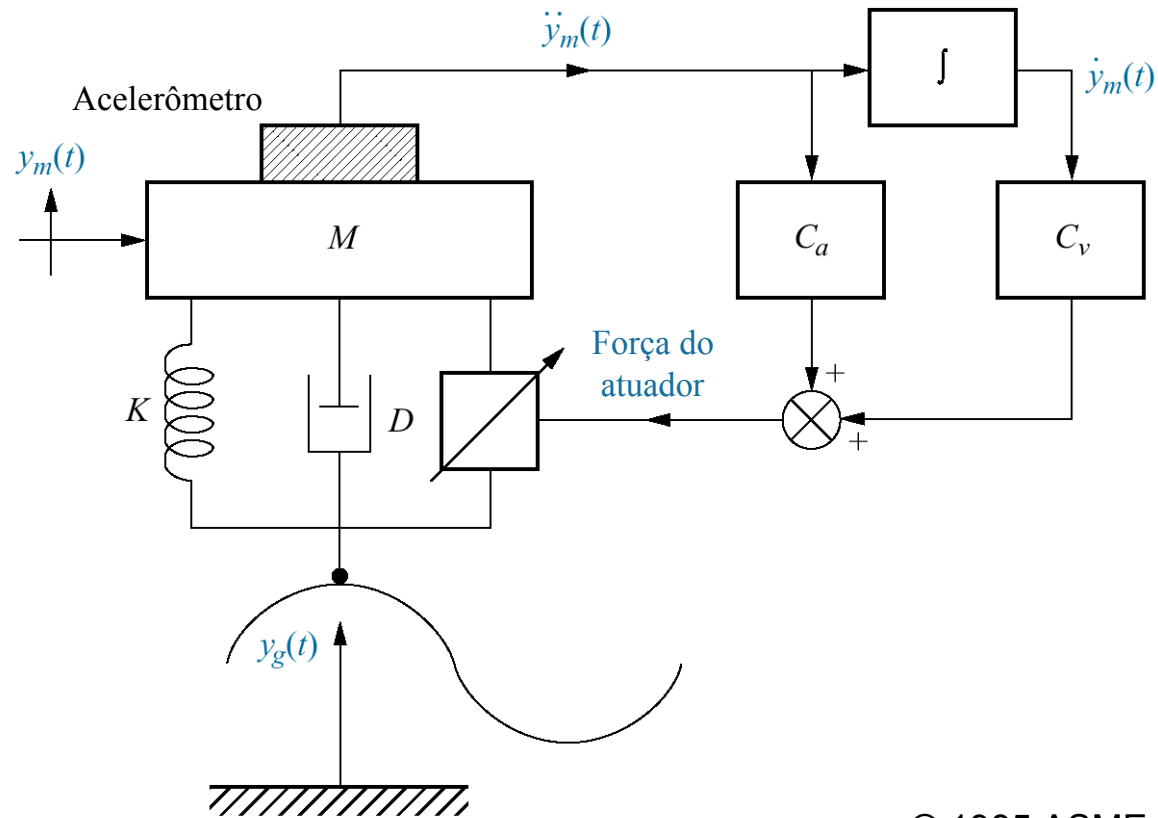


Fig. P8.18
Sistema de suspensão ativa



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Fig. P8.19

Malha de estabilização em arfagem do avião F4-E

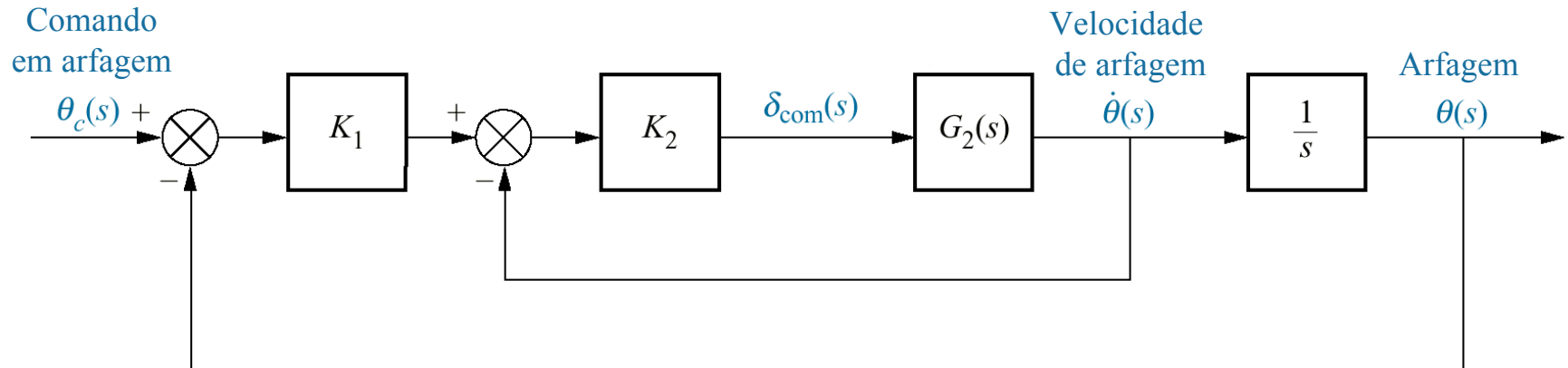


Fig. P8.20

Sistema de controle de atitude segundo o eixo de arfagem utilizando volante de inércia

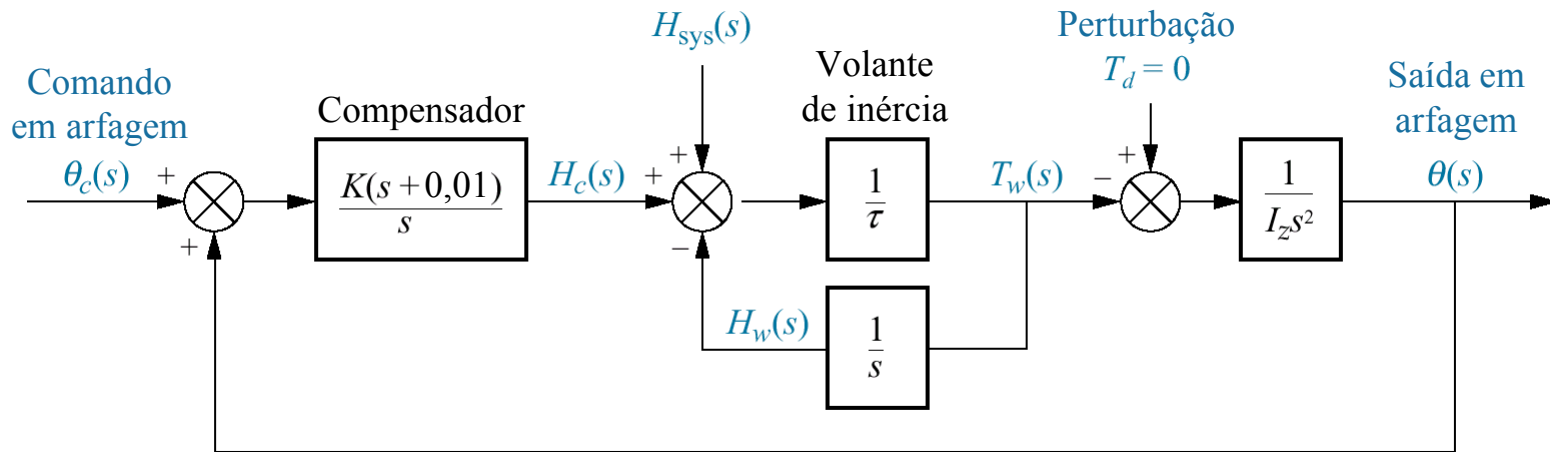
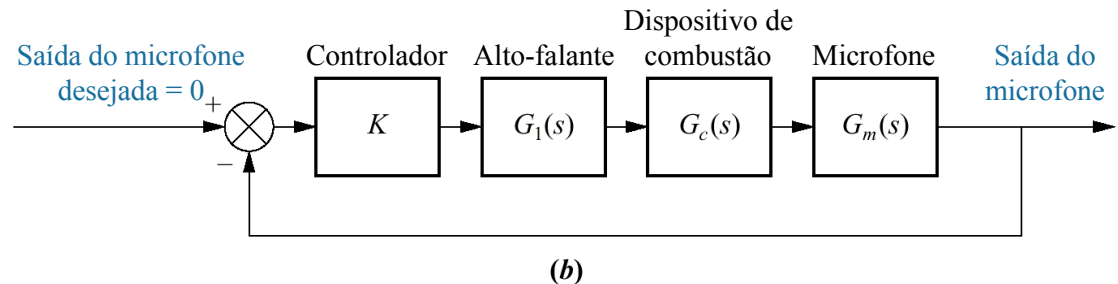
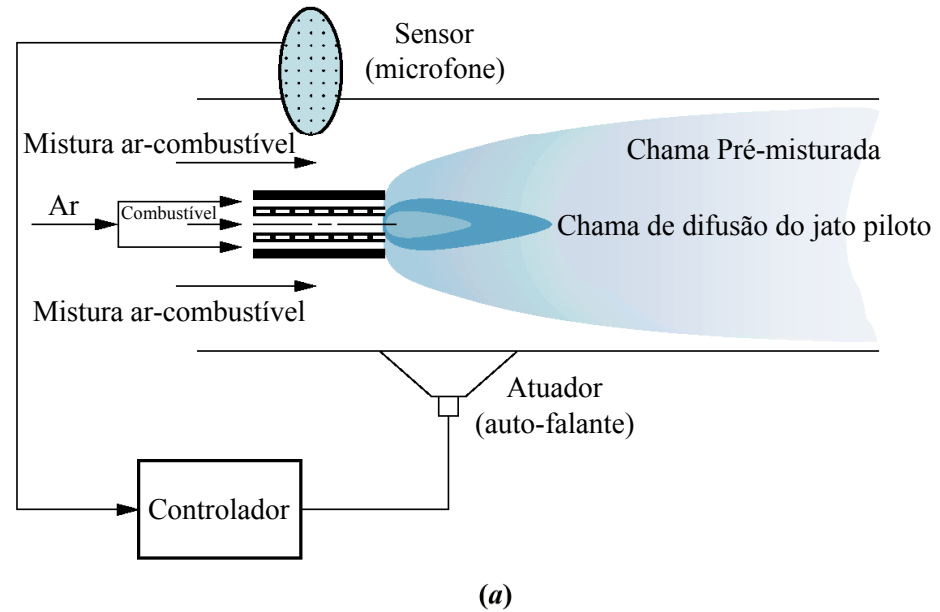


Fig. P8.21

a. Dispositivo de combustão;

b. diagrama de blocos

((c)1995 IEEE)
(continuação)



© Jim Corwin/ Photo Researchers

Fig. P8.22
a. Aerogeradores produzindo eletricidade próximo a Palm Springs, California;



(a)

Fig. P8.22
 (continuação)
b. Malha de controle para uma turbina de aerogerador controlada com velocidade constante em arfagem;
c. trem de acionamento
 ((c)1998 IEEE)

