

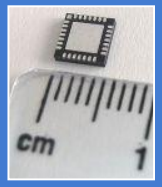

Dispositivos e Circuitos Eletrônicos Básicos

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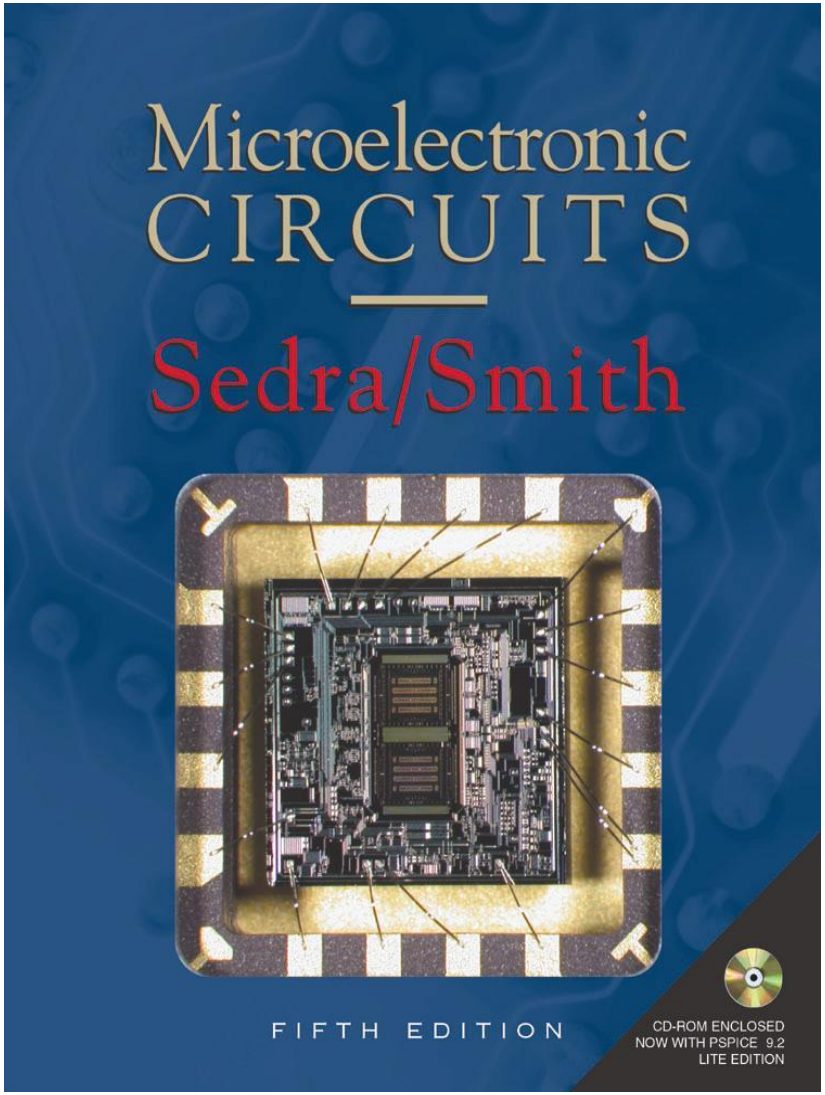


PowerPoint Overheads for

Sedra/Smith Microelectronic Circuits 5/e

Programa

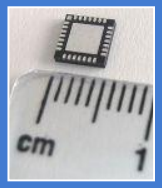
- **Introdução a Eletrônica *(Capítulo 1)***
- **Amplificadores Operacionais – AmpOp *(Capítulo 2)***
- **Diodos *(Capítulo 3)***
- **Transistores a Efeito de Campo – FET *(Capítulo 4)***
- **Transistores Bipolares de Junção – TBJ *(Capítulo 5)***
- **Outros Circuitos com Amp. Operacionais (Capítulos 12 e 13)**
- **Conversores de Dados - Uma Introdução (Capítulo 9)**

Avaliações

Avaliação	Data	Valor
Primeira Prova	23/09	25
Segunda Prova	04/11	25
Terceira Prova	07/12	25
Trabalho 1 - Simulação LTSpice		7,5
Trabalho 2 - Simulação LTSpice		7,5
Trabalho 3 - Simulação LTSpice		10
Total		100

Avaliação	Data	Valor
Quarta prova - Substitutiva	14/12	25
Exame especial	21/12	100





Dispositivos e Circuitos Eletrônicos Básicos

Introdução à Eletrônica

DEPARTAMENTO DE ENGENHARIA ELETRÔNICA
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Sumário

1. Sinais

2. Valor médio, Valor eficaz e potência média

3. Espectro de frequências de sinais

4. Sinais Digitais

5. Amplificadores

6. Modelos de Amplificadores

Sinal

Sinal: todo meio que contém informações de interesse

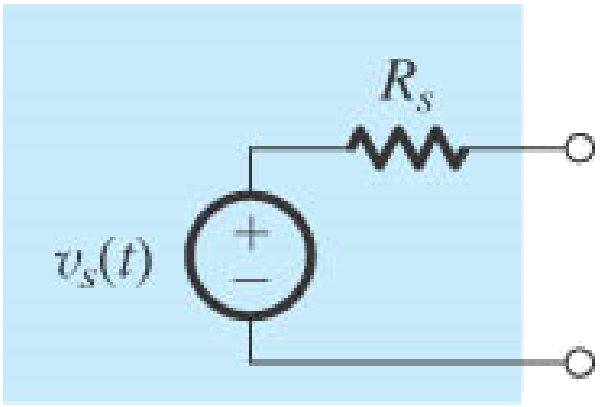
Exemplo: Informações sobre o tempo:

- Temperatura do ar
- Pressão
- Velocidade do vento

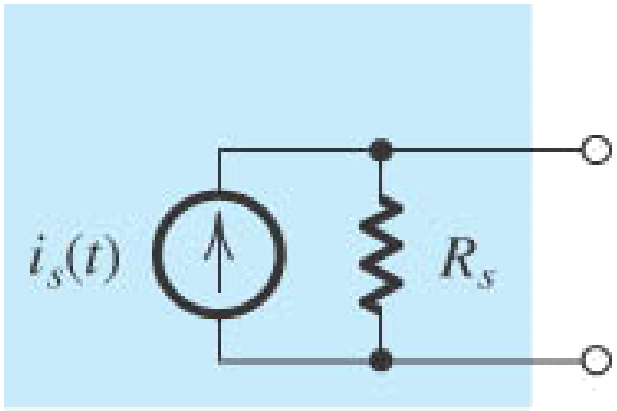
Exemplo: A voz de um narrador ao ler as notícias de um jornal produz um sinal acústico.

O microfone é um TRANSDUTOR, que converte este sinal para a forma elétrica.

Representações para sinais elétricos



(a)



(b)

$$v_s(t) = R_s i_s(t)$$

Figure 1.1 Two alternative representations of a signal source: **(a)** the Thévenin form, and **(b)** the Norton form.

Sinal no domínio do tempo

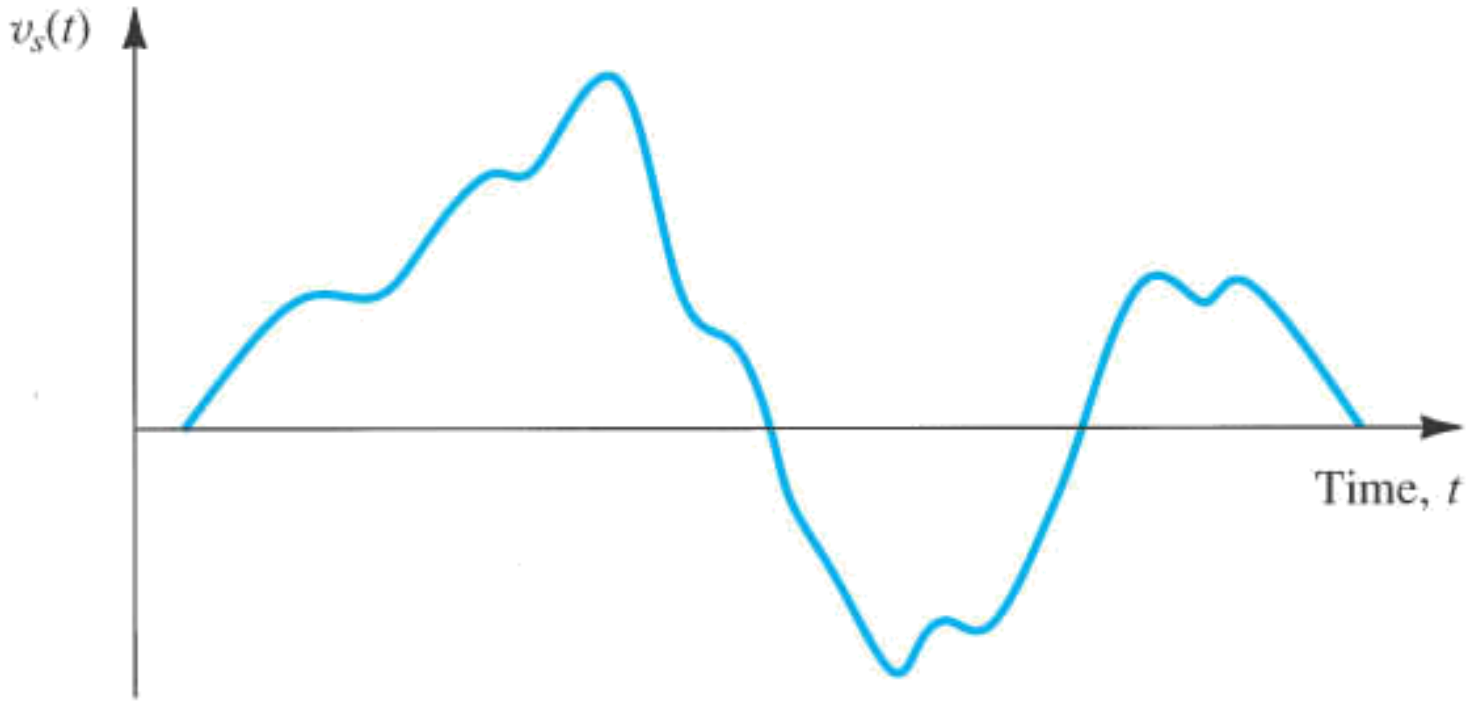


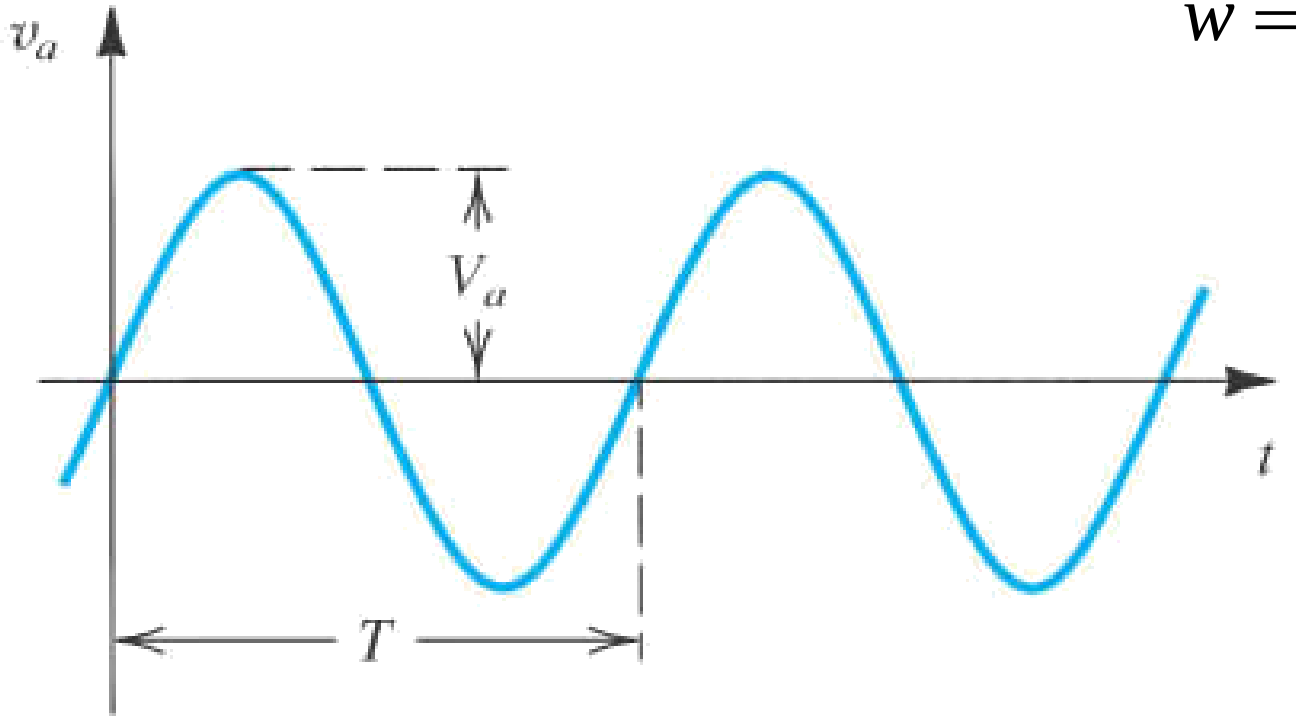
Figure 1.2 An arbitrary voltage signal $v_s(t)$.

Sinal senoidal

$$v_a(t) = V_a sen(wt)$$

Freqüência angular

$$w = 2\pi f \text{ rd/s}$$



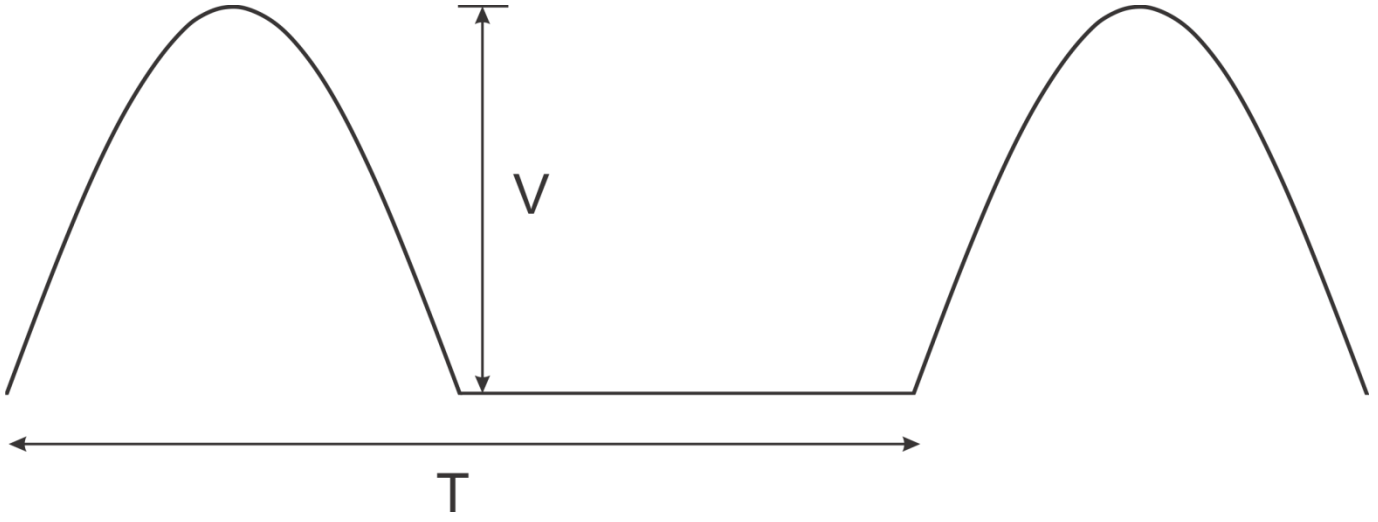
Freqüência

$$f = \frac{1}{T} \text{ Hz}$$

Figure 1.3 Sine-wave voltage signal of amplitude V_a and frequency $f = 1/T$ Hz. The angular frequency $v = 2\pi f$ rad/s.

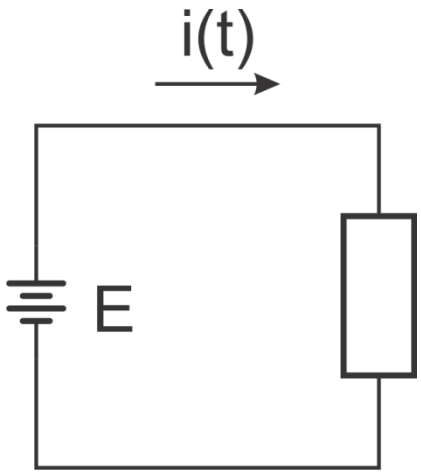
Valor médio de um sinal

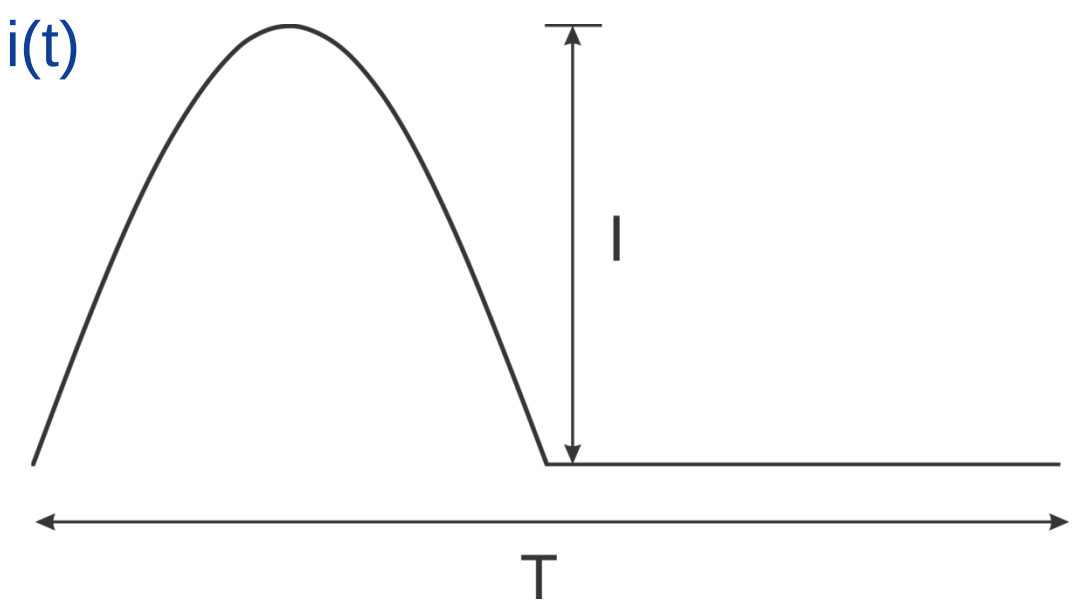
$$X_m = \frac{1}{T}\int_{c}^{c+T} x(t)dt$$



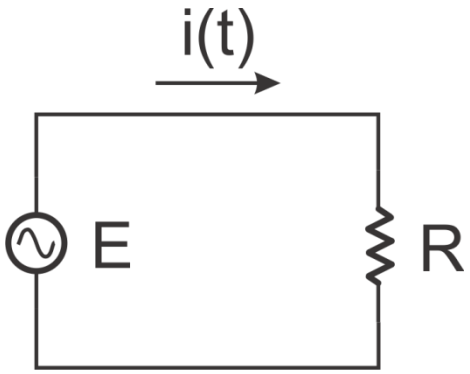
Potência média

$$P = \frac{1}{T}\int_{c}^{c+T} p(t)dt = \frac{1}{T}\int_{c}^{c+T} v(t)i(t)dt$$





Valor Eficaz



$$P = \frac{1}{T}\int_{c}^{c+T} v(t)i(t)dt = \frac{1}{R}\left[\frac{1}{T}\int_{c}^{c+T} v^2(t)dt\right] = \frac{V_{ef}^2}{R}$$

$$V_{ef} = \sqrt{\frac{1}{T}\int_{c}^{c+T} v^2(t)dt}$$

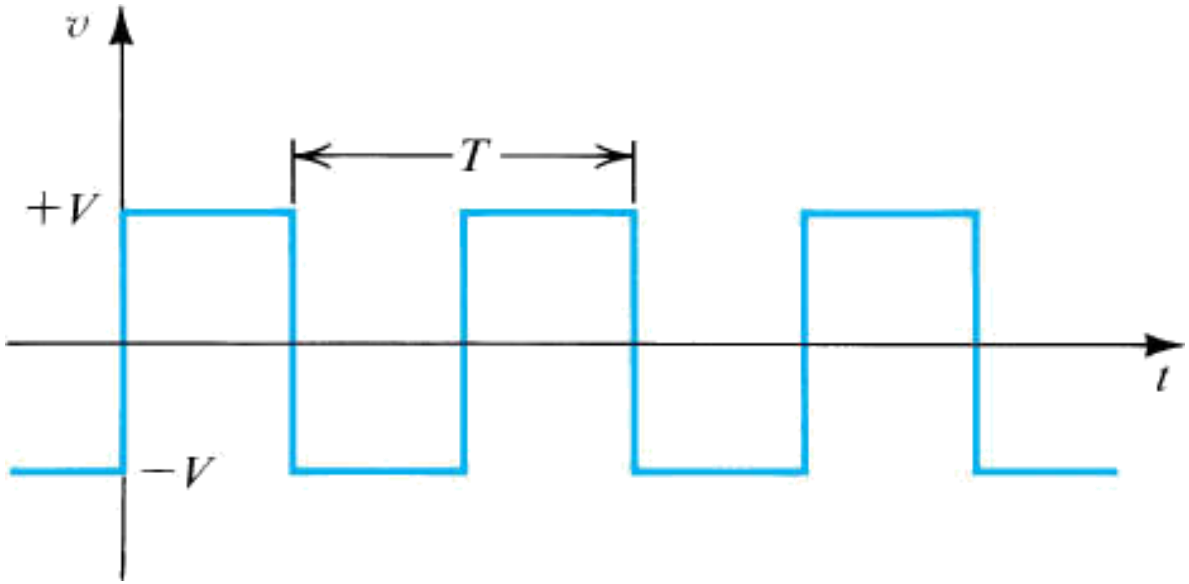
Série de Fourier

$$x(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos \frac{2\pi}{T} nt + b_n \sin \frac{2\pi}{T} nt)$$

$$a_n = \frac{2}{T} \int_{c}^{c+T} x(t) \cos(\frac{2\pi}{T} nt) dt$$

$$b_n = \frac{2}{T} \int_{c}^{c+T} x(t) \sin(\frac{2\pi}{T} nt) dt$$

Sinal Quadrado



Série de Fourier:

$$v(t) = \frac{4V}{\pi}\left(\sin w_0 t + \frac{1}{3}\sin 3w_0 t + \frac{1}{5}\sin 5w_0 t + \frac{1}{7}\sin 7w_0 t \ldots\right)$$

Figure 1.4 A symmetrical square-wave signal of amplitude *V*.

Espectro de um sinal quadrado

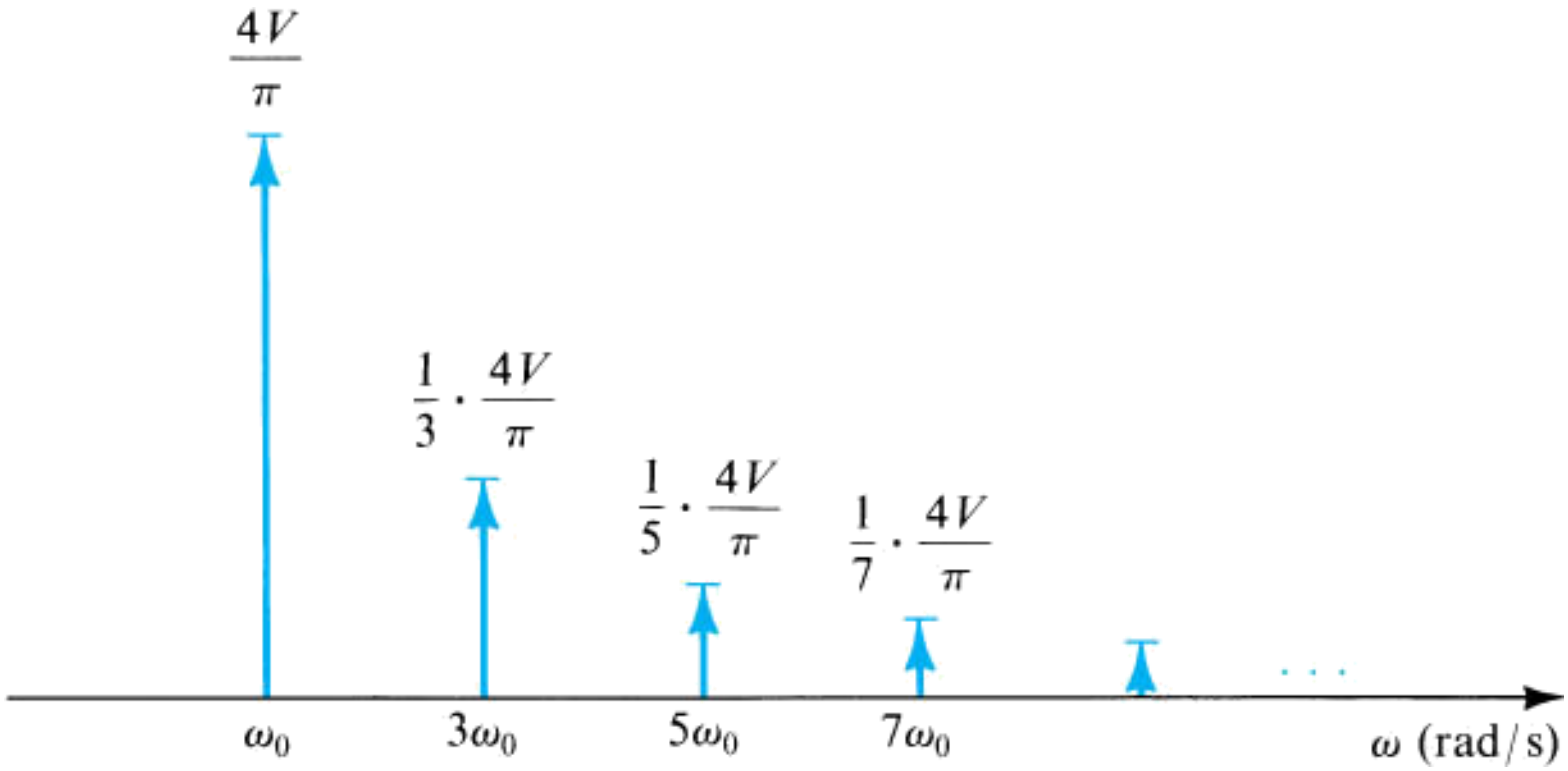
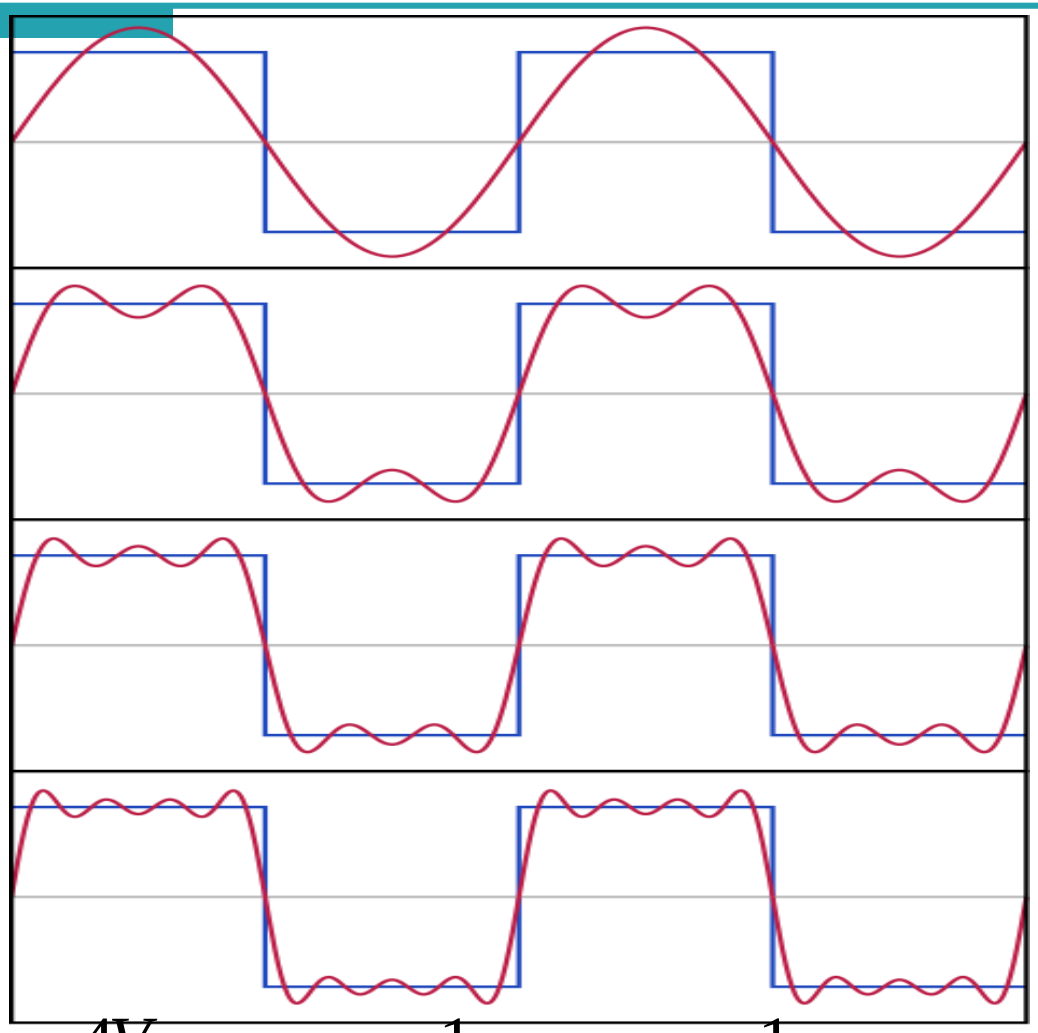


Figure 1.5 The frequency spectrum (also known as the line spectrum) of the periodic square wave of Fig. 1.4.

Espectro de um sinal quadrado



Fundamental

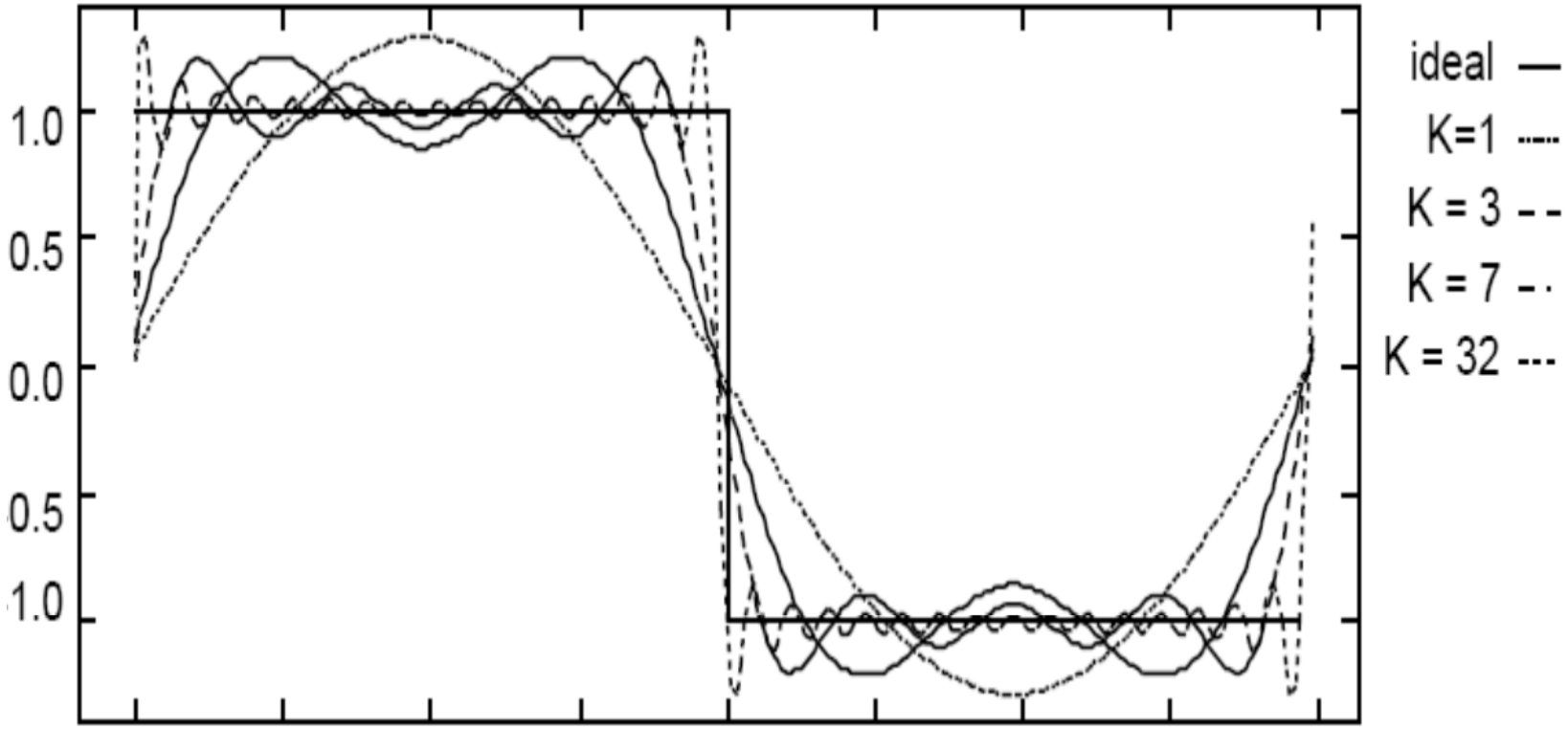
Fundamental +
3^0 harmônico

Fundamental +
$3^0 + 5^0$ harmônico

Fundamental +
$3^0 + 5^0 + 7^0$ harmônico

$$v(t) = \frac{4V}{\pi}\left(\sin w_0 t + \frac{1}{3}\sin 3w_0 t + \frac{1}{5}\sin 5w_0 t + \frac{1}{7}\sin 7w_0 t \ldots\right)$$

Espectro de um sinal quadrado



$$v(t) = \frac{4V}{\pi}\left(\sin w_0 t + \frac{1}{3}\sin 3w_0 t + \frac{1}{5}\sin 5w_0 t + \frac{1}{7}\sin 7w_0 t \ldots\right)$$

Espectro de frequências de sinais não periódicos

Sinais de áudio:

espectro de freqüências compreendido entre 20 Hz e 20KHz.

Sinal de vídeo analógico:

espectro de freqüências compreendido entre 0 Hz e 4,5 MHz.

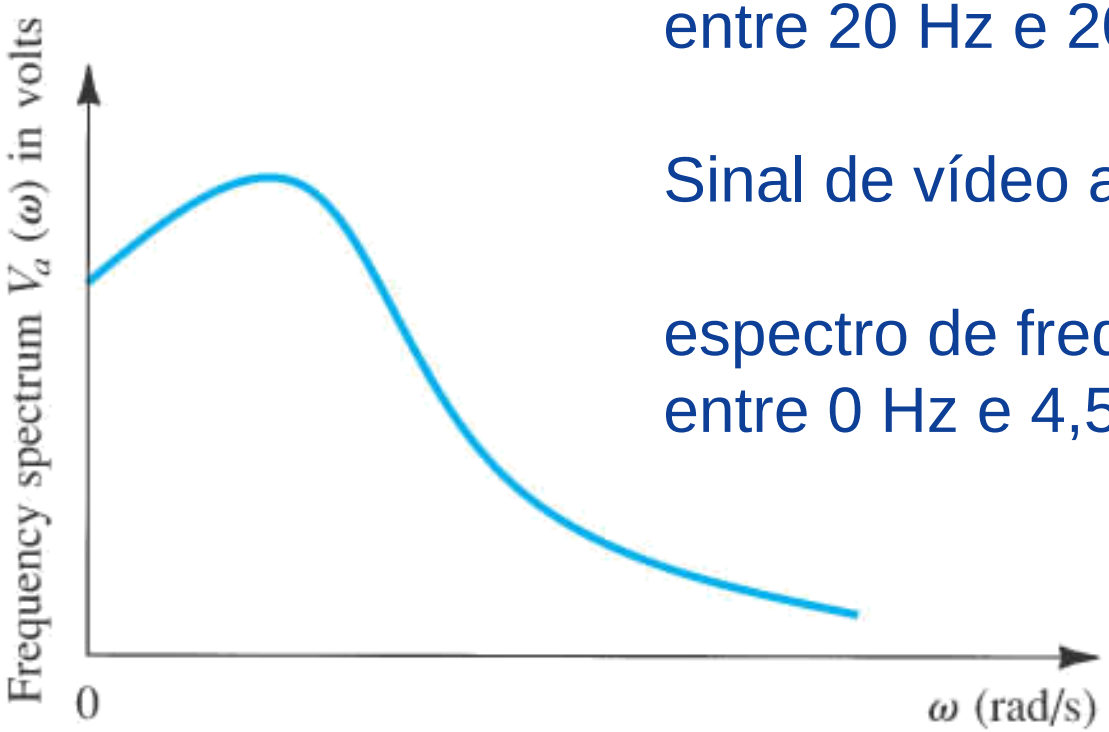
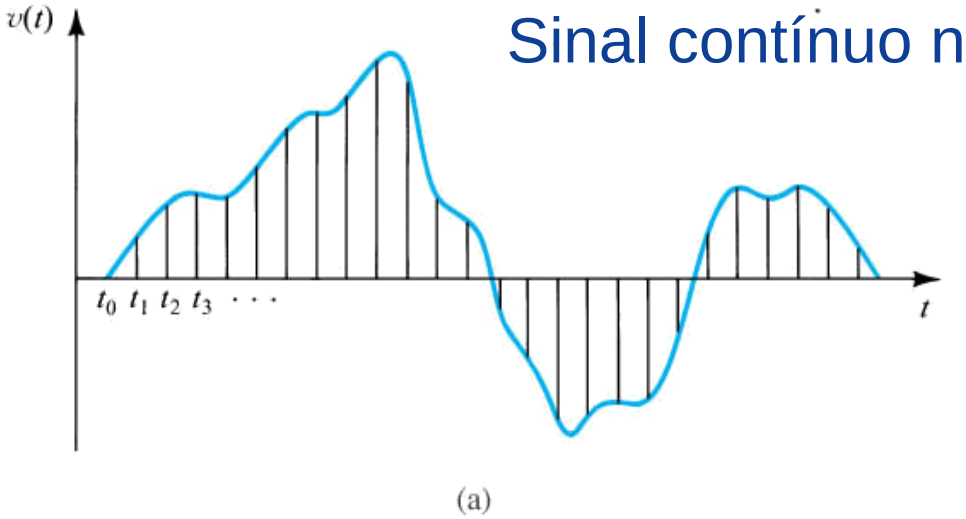


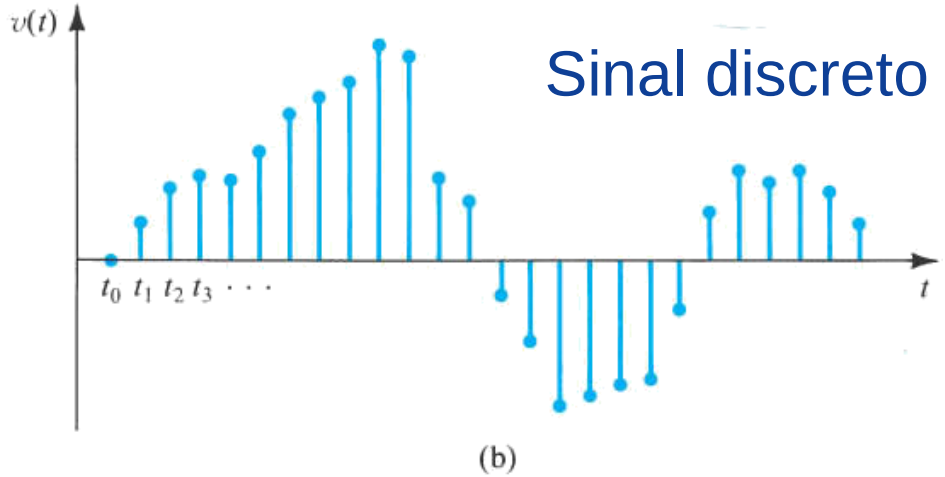
Figure 1.6 The frequency spectrum of an arbitrary waveform such as that in Fig. 1.2.

Sinais Analógicos x sinais digitais



Sinal contínuo no tempo ou sinal analógico

Eletrônica analógica



Sinal discreto no tempo

Eletrônica digital

Figure 1.7 Sampling the continuous-time analog signal in **(a)** results in the discrete-time signal in **(b).**

Sinal Digital Binário

Números representados na base 2

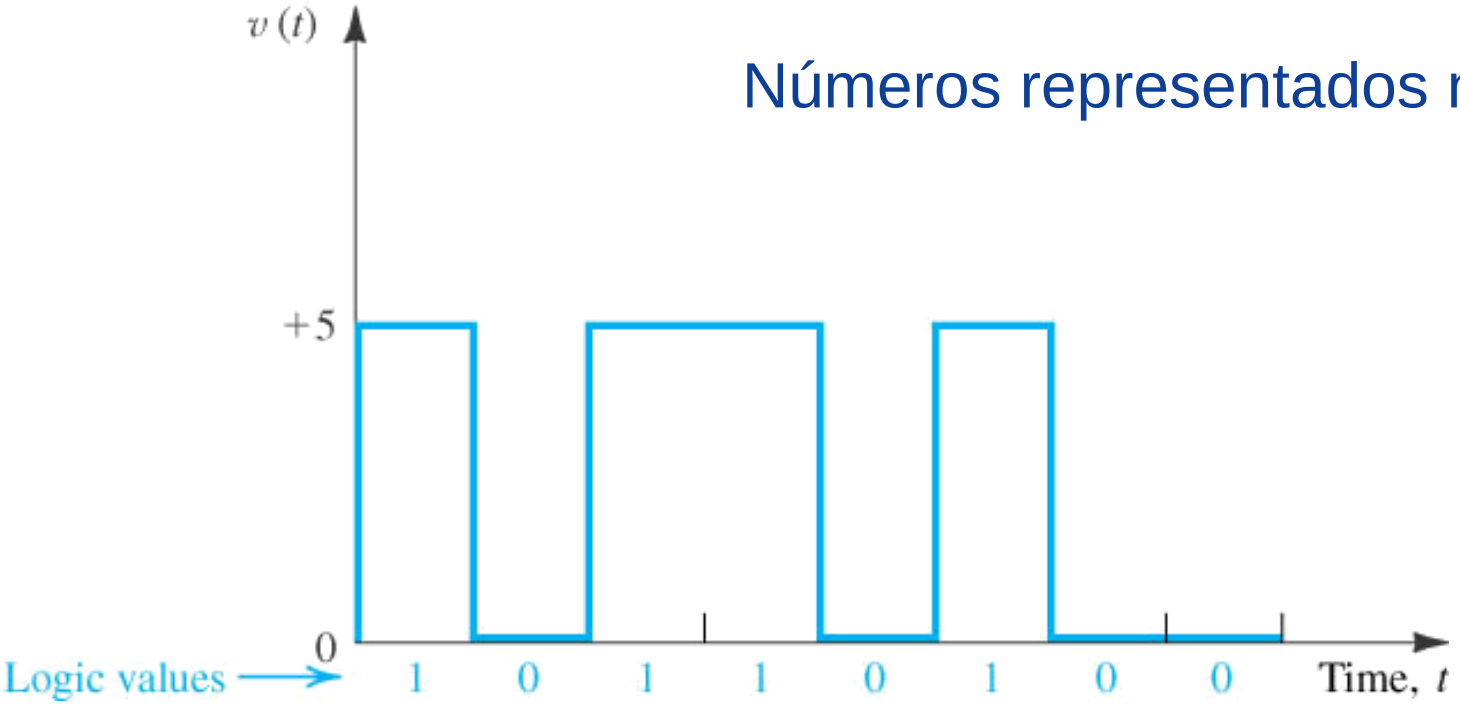
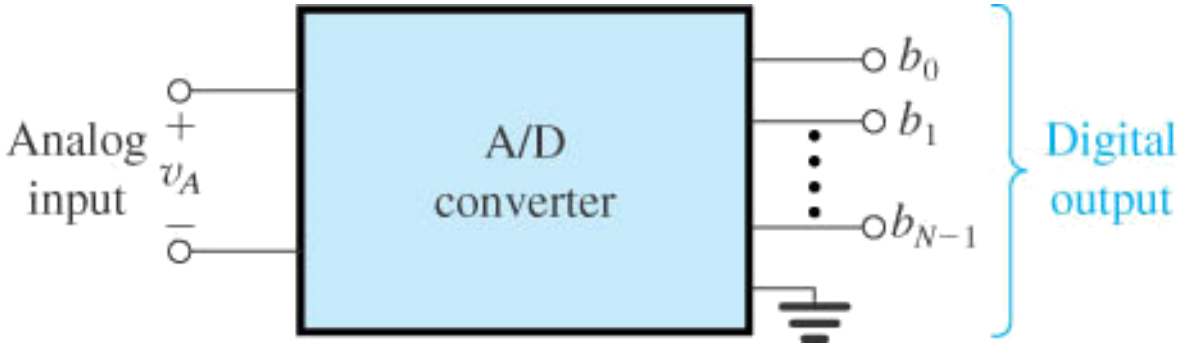


Figure 1.8 Variation of a particular binary digital signal with time.

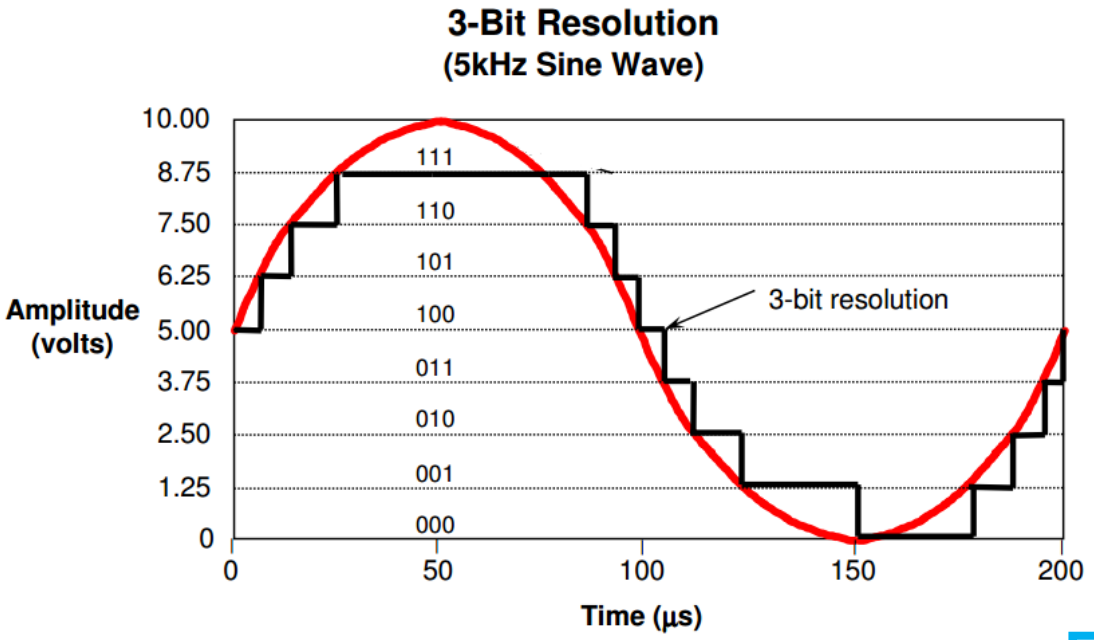
Conversor Analógico Digital



$$D = b_0 2^0 + b_1 2^1 + b_2 2^2 + \ldots + b_{N-1} 2^{N-1}$$

Figure 1.9 Block-diagram representation of the analog-to-digital converter (ADC).

Conversor Analógico Digital



V_{FSR} - Full scale range

$1\,LSB = \frac{V_{FSR}}{2^n}$ Resolução

$V_{FSV} = (1 - 2^{-n})V_{FSR}$ Full scale value

- Conversor A/D de 3 bits com V_{FSR} = 10V.

  LSB = 1,25V

  V_{FSV} = 8,75V

- Conversor A/D de 12 bits com V_{FSR} = 10V.

  LSB = 2,44 mV

  V_{FSV}=9,9976V

Amplificadores de Sinais

Os transdutores muitas vezes fornecem sinais na faixa de alguns micro-volts ou mili-volts.

Se:

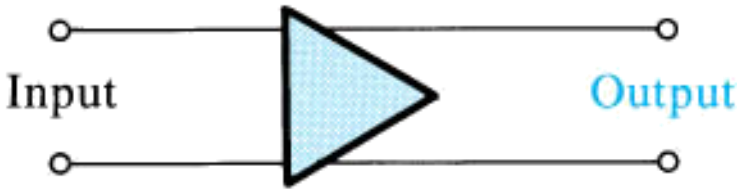
$$v_o(t) = Av_i(t)$$

O amplificador é linear.

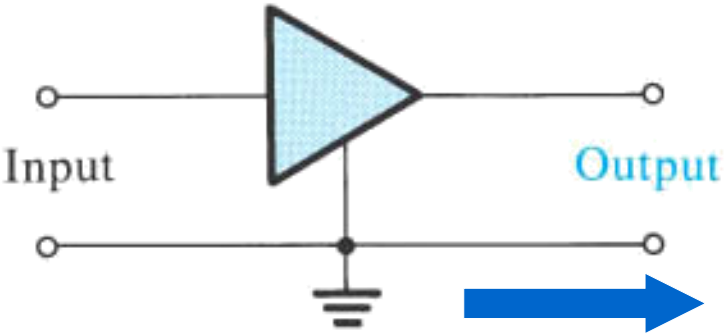
A – ganho do amplificador

Caso contrário dizemos que o amplificador introduz DISTORÇÃO.

Amplificadores de sinais



(a)

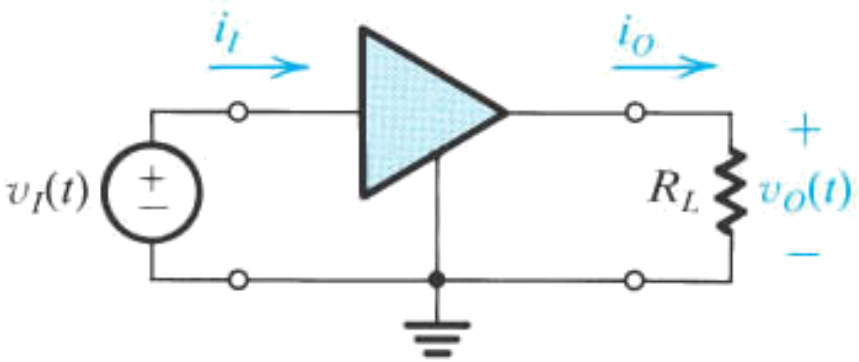


Terra do circuito

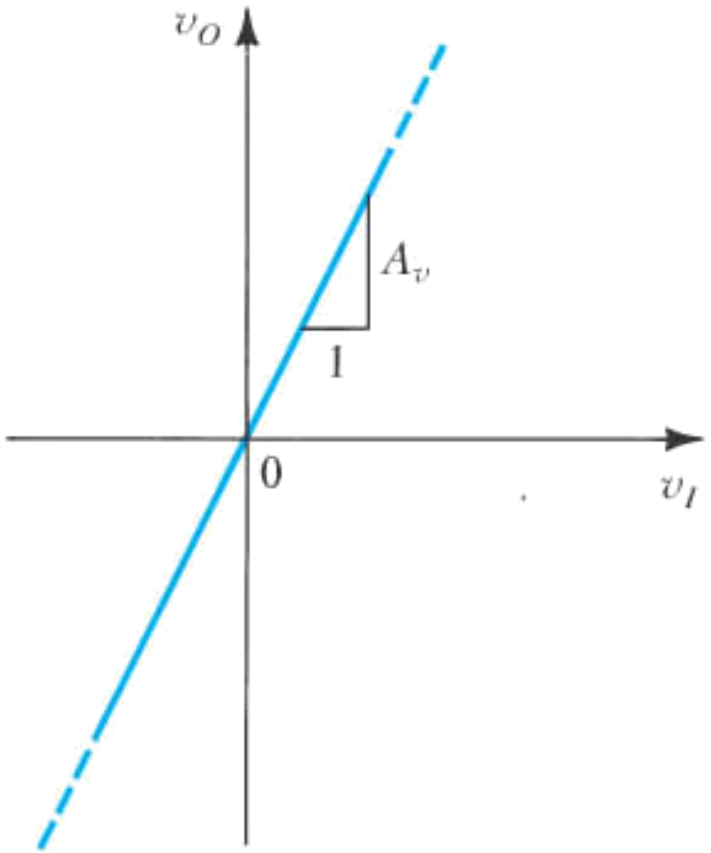
(b)

Figure 1.10 **(a)** Circuit symbol for amplifier. **(b)** An amplifier with a common terminal (ground) between the input and output ports.

Amplificador de tensão



(a)



(b)

Ganho de tensão: $A_v = \dfrac{v_O}{v_I}$

Figure 1.11 **(a)** A voltage amplifier fed with a signal $v_I(t)$ and connected to a load resistance R_L. **(b)** Transfer characteristic of a linear voltage amplifier with voltage gain A_v.

Ganho de Potência e ganho de corrente

ganho de corrente: $A_i = \frac{i_O}{i_I}$

ganho de potência: $A_p = \frac{v_O i_O}{v_I i_I} = A_v A_i$

Ganhos em Decibéis

$$A_v(db) = 20 \log | A_v |$$

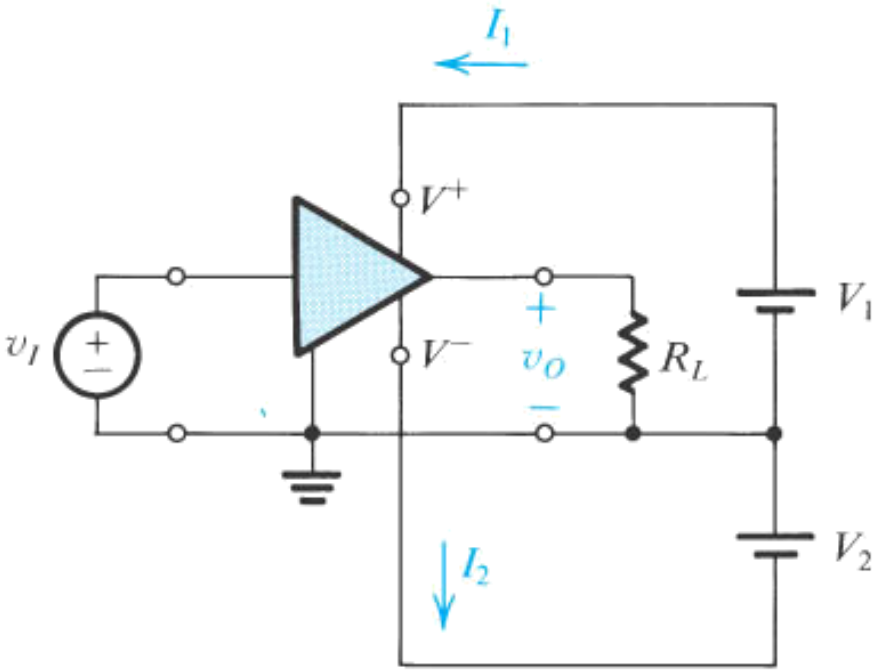
$$A_i(db) = 20 \log | A_i |$$

$$A_p(db) = 10 \log | A_p |$$

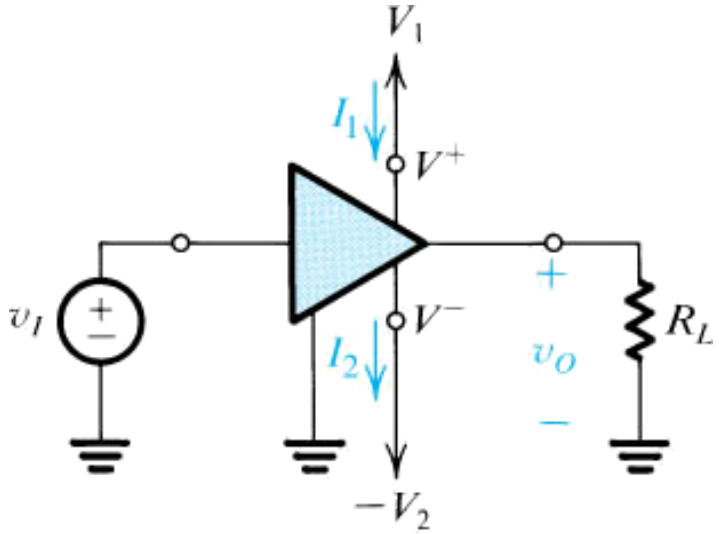
Fontes de Alimentação

$$P_{dc} = V_1 I_1 + V_2 I_2$$

$$P_{dc} + P_I = P_L + P_{dissipada}$$



(a)



(b)

$$\eta = \frac{P_L}{P_{dc}} \times 100\%$$

Figure 1.12 An amplifier that requires two dc supplies (shown as batteries) for operation.

Saturação do Amplificador

Para não ocorrer distorção:

$$\frac{L_-}{A_v} \leq v_I \leq \frac{L_+}{A_v}$$

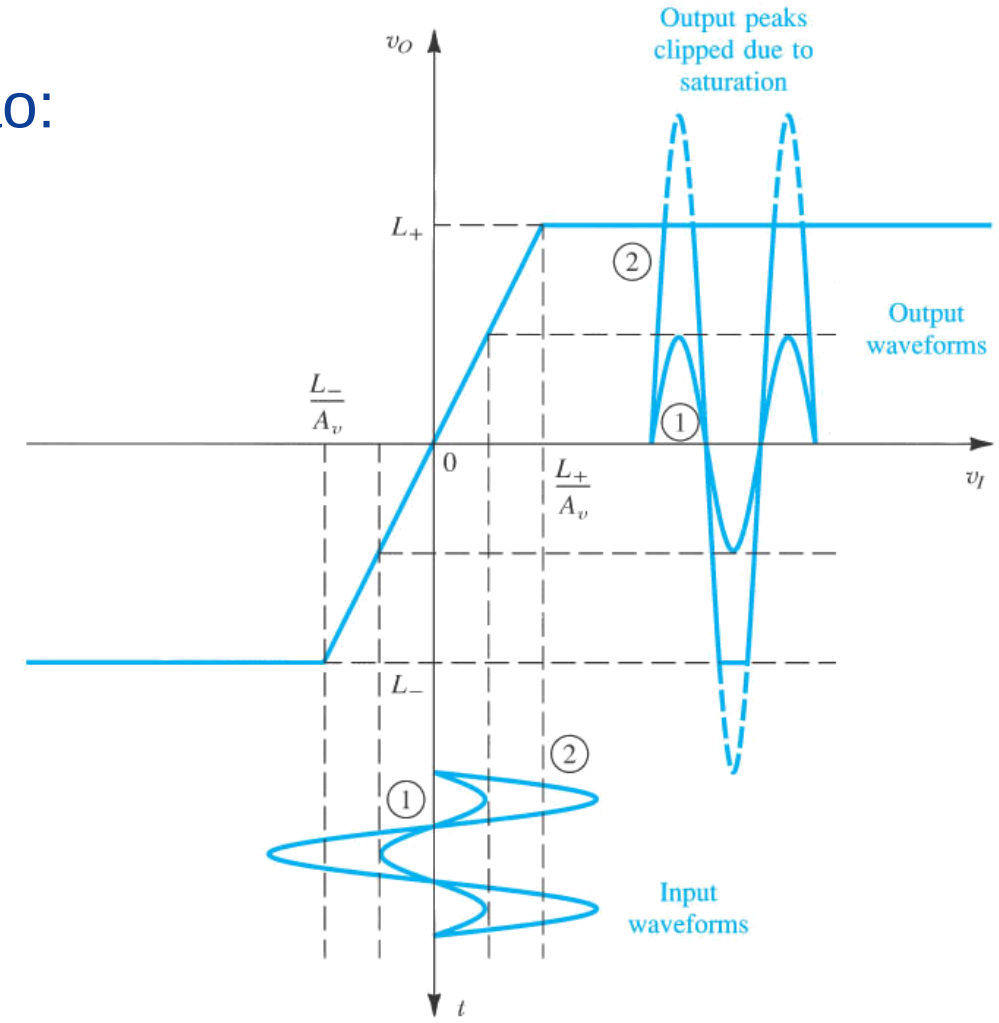
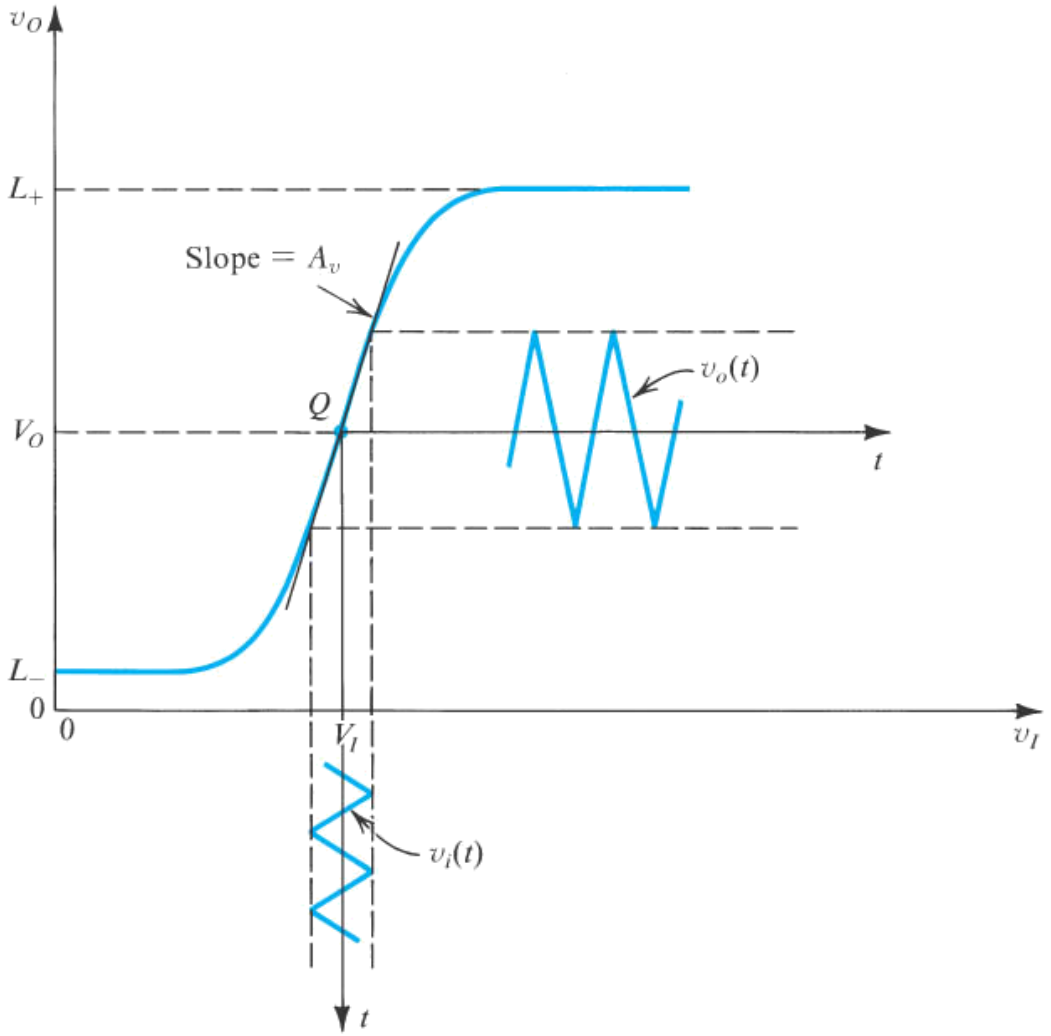
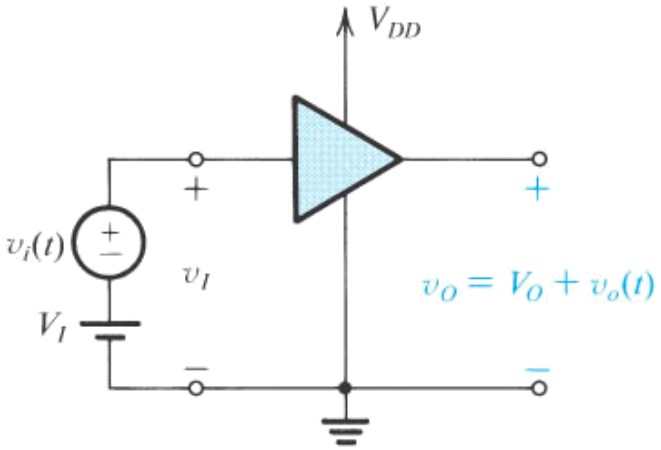


Figure 1.13 An amplifier transfer characteristic that is linear except for output saturation.

Característica de transferência não linear e polarização



(a)



(b)

Convenção de símbolos

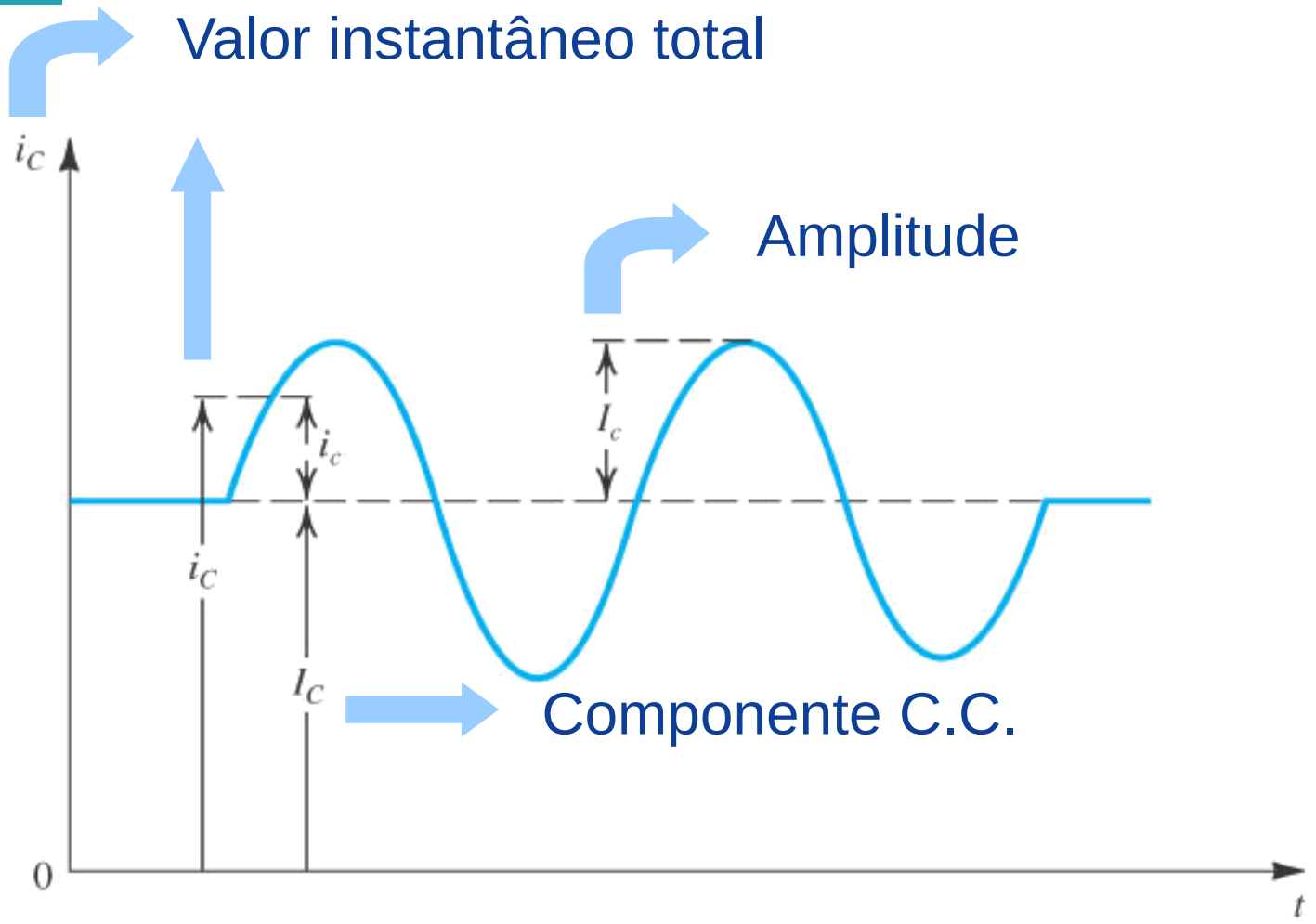
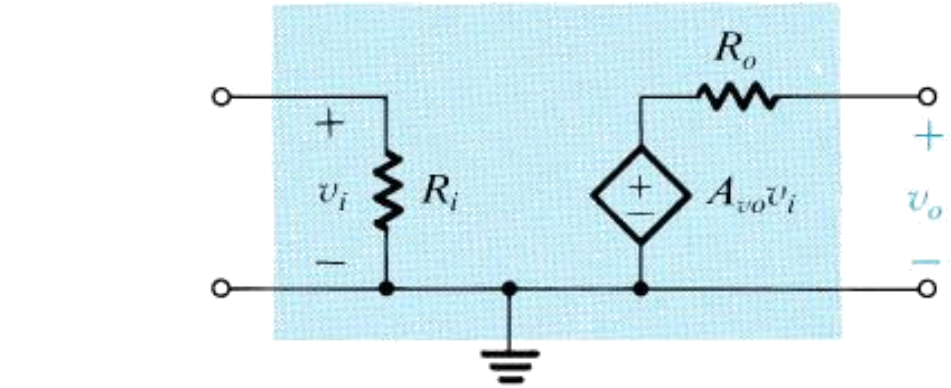
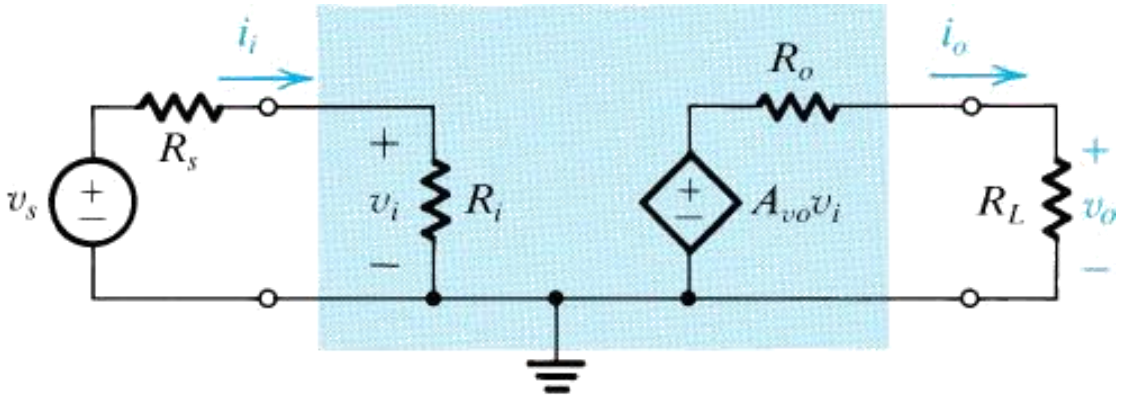


Figure 1.16 Symbol convention employed throughout the book.

Amplificadores de tensão



(a)



(b)

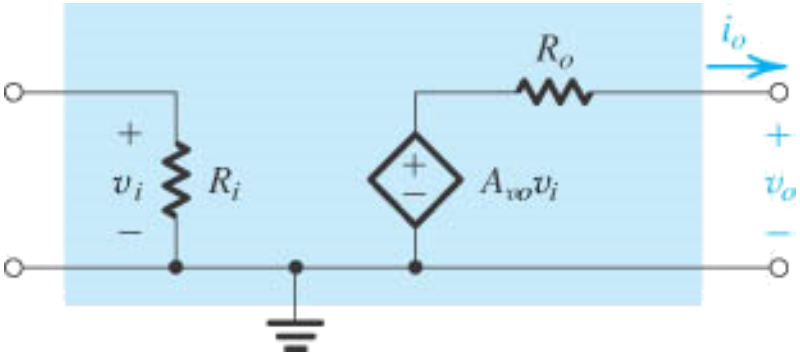
$$\frac{v_o}{v_i} =$$

$$\frac{v_o}{v_i} =$$

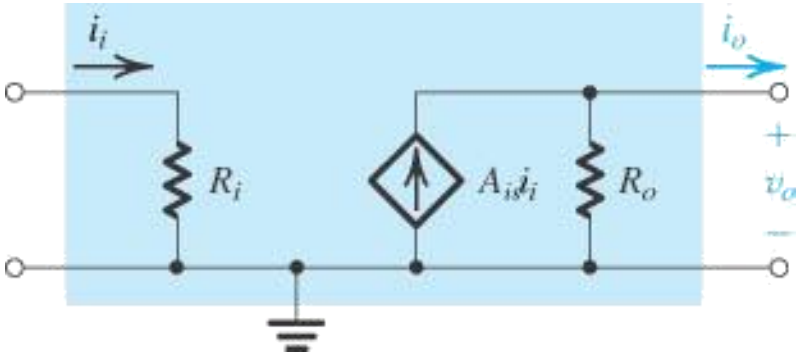
$$\frac{v_o}{v_s} =$$

Figure 1.17 **(a)** Circuit model for the voltage amplifier. **(b)** The voltage amplifier with input signal source and load.

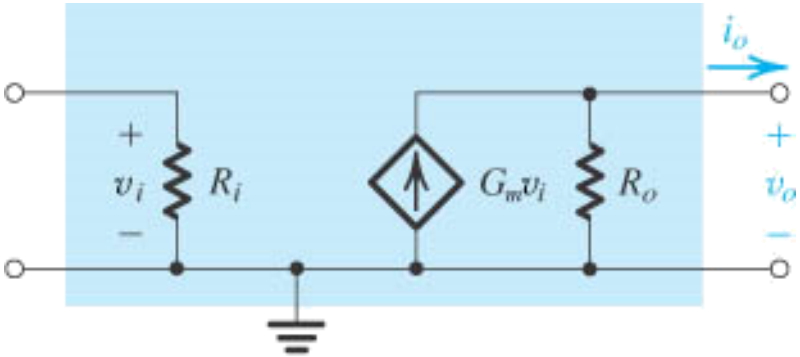
Os quatro tipos de amplificadores



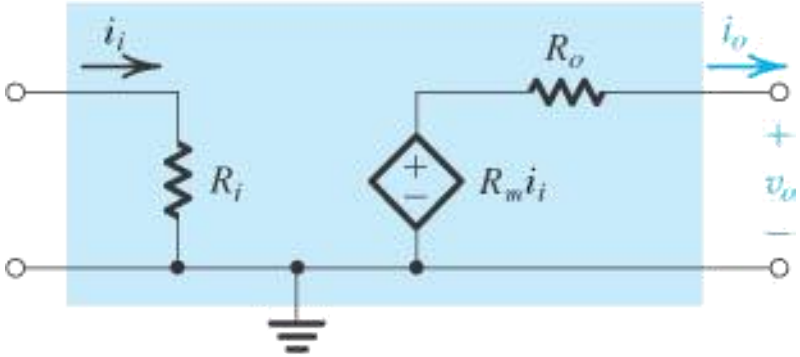
Amplificador de tensão



Amplificador de corrente



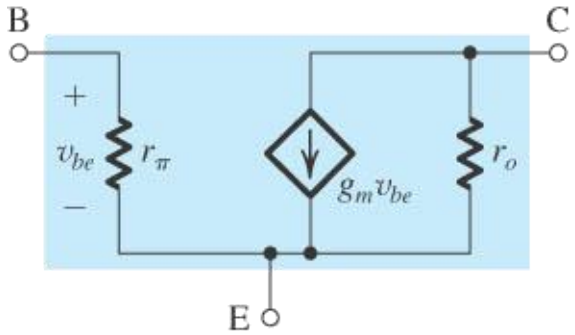
Amplificador de transcondutância



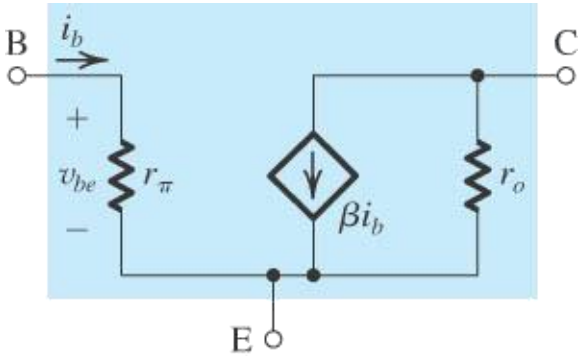
Amplificador de transresistência

Table 1.1 The Four Amplifier Types

O transistor bipolar

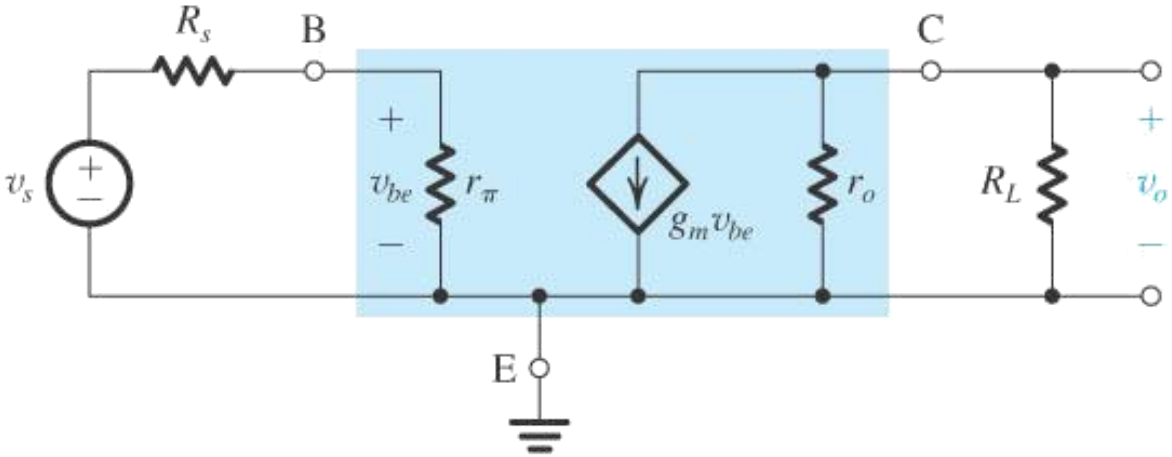


(a)



(c)

$$R_S = 5K\Omega \quad r_\pi = 2{,}5K\Omega \quad g_m = 40mA/V \quad r_o = 100\,K\Omega \quad R_L = 5K\Omega$$



(b)

$$\frac{v_O}{v_S} = ?$$

Exercício 1.20

Determine a resistência de entrada do amplificador, R_{in}.

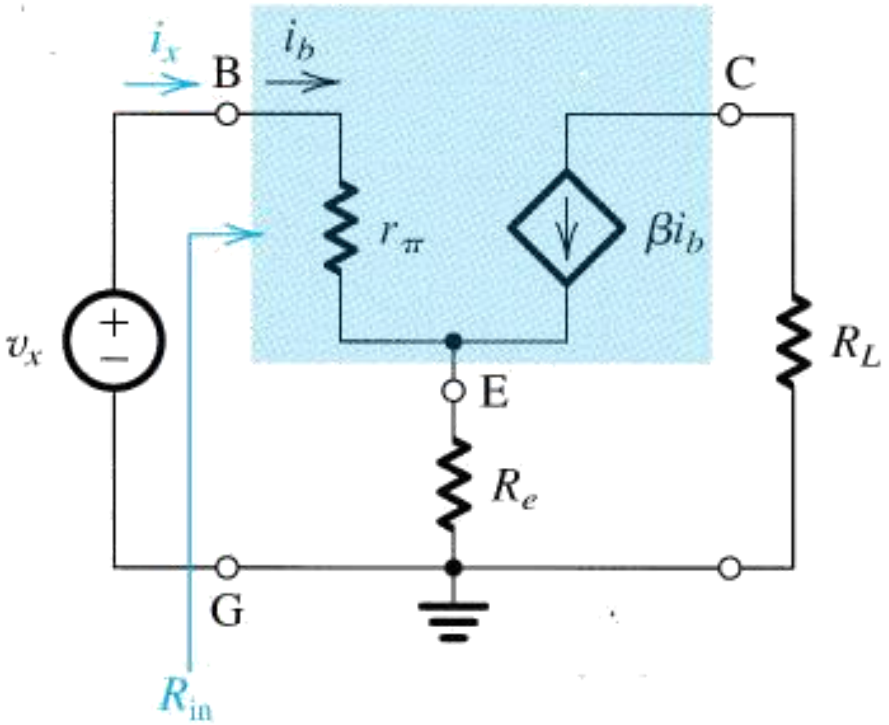


Figure E1.20

Resposta em frequência

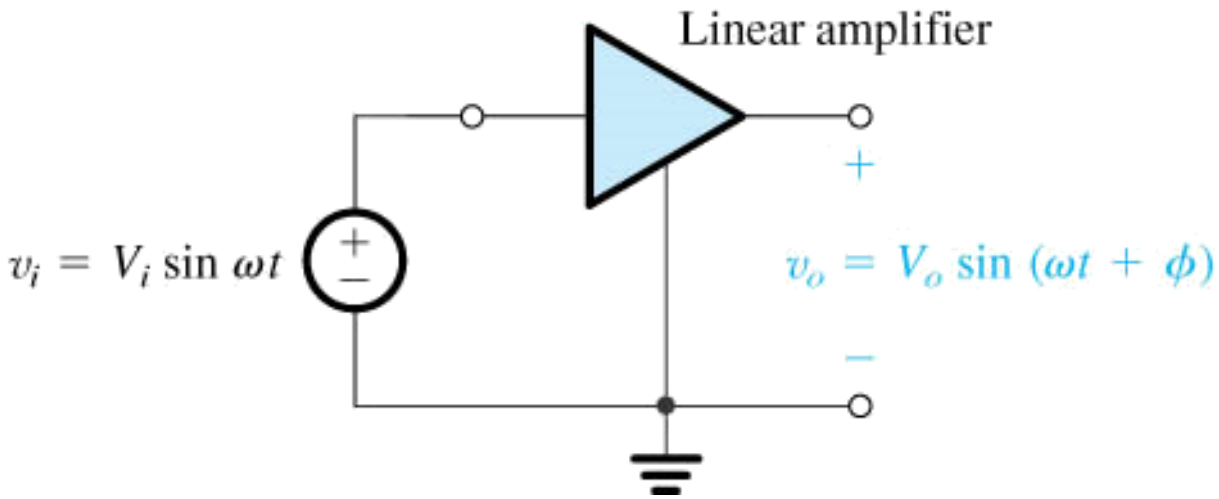


Figure 1.20 Measuring the frequency response of a linear amplifier. At the test frequency *v*, the amplifier gain is characterized by its magnitude (V_o/V_i) and phase *f*.

Resposta em frequência – Curva de módulo

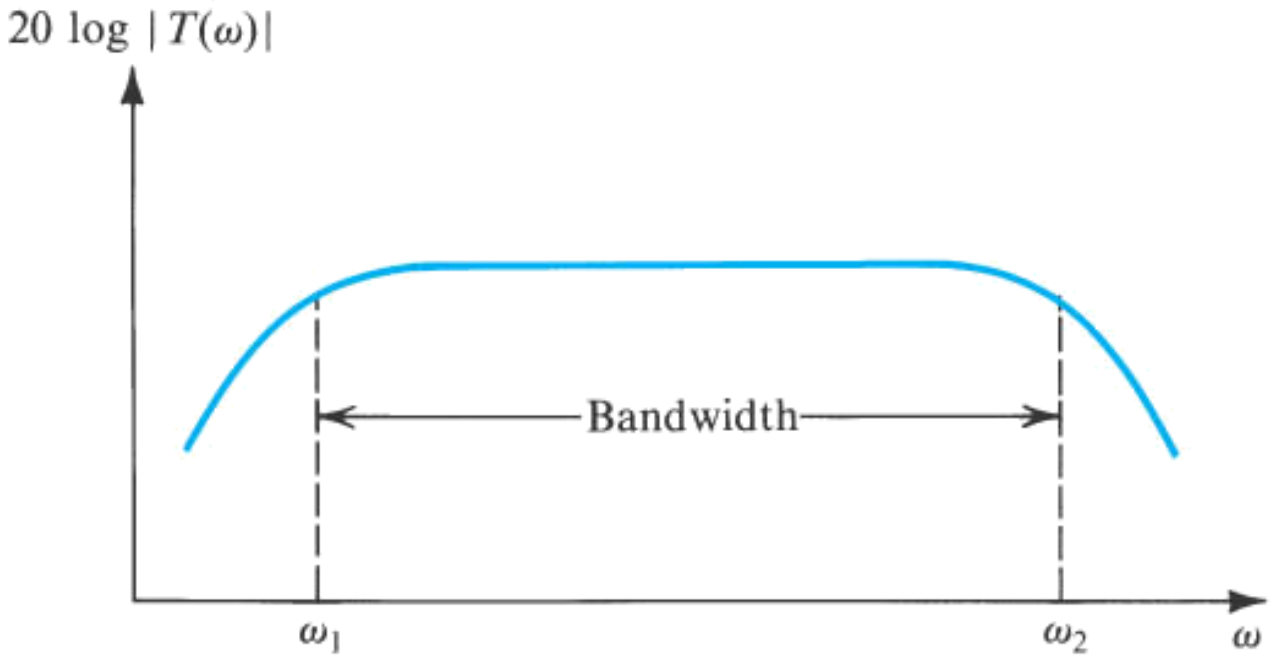
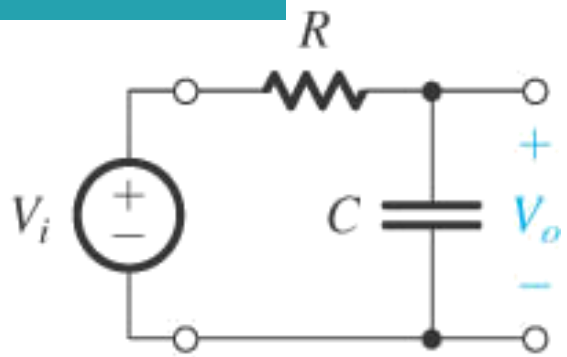


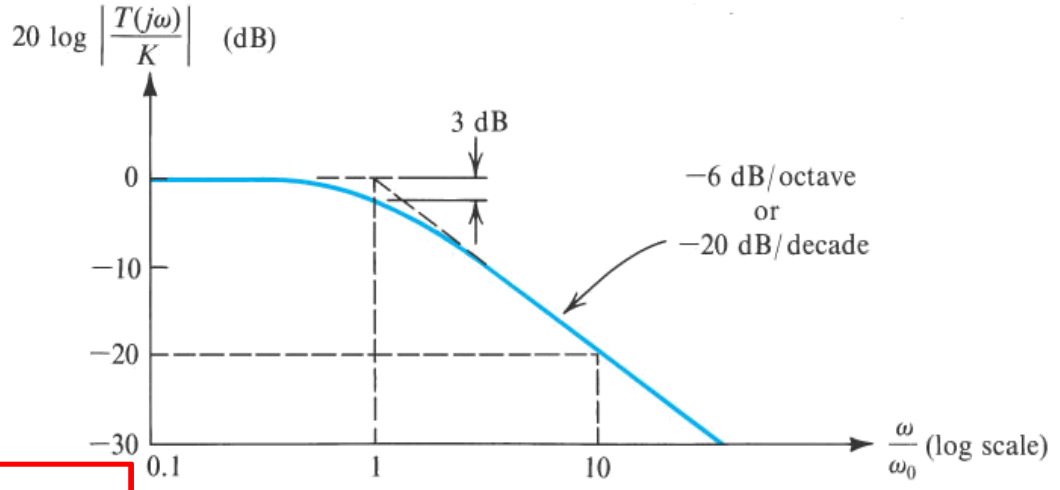
Figure 1.21 Typical magnitude response of an amplifier. $|T(v)|$ is the magnitude of the amplifier transfer function—that is, the ratio of the output $V_o(v)$ to the input $V_i(v)$.

Resposta em frequência – Passa baixa

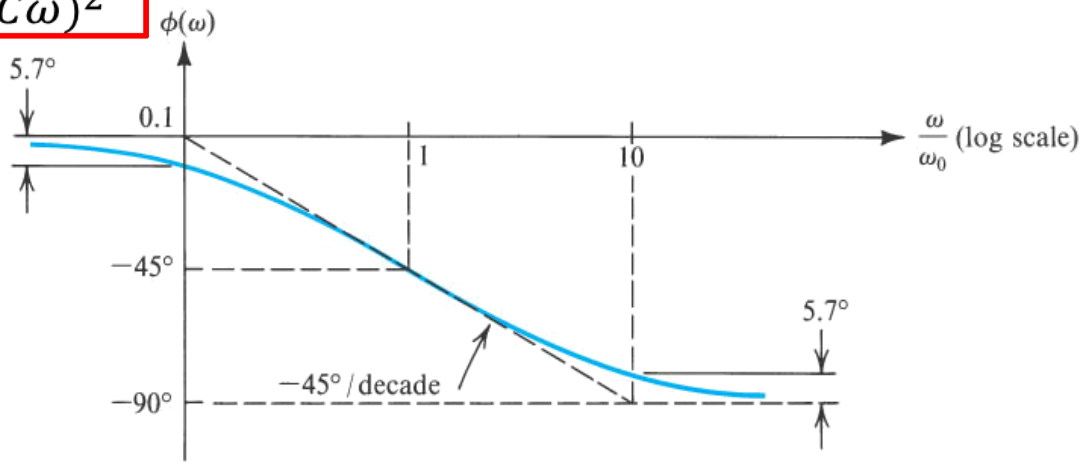


(a)

$$|T(j\omega)| = \left|\frac{V_o(j\omega)}{V_i(j\omega)}\right| = \frac{1}{\sqrt{1+(RC\omega)^2}}$$

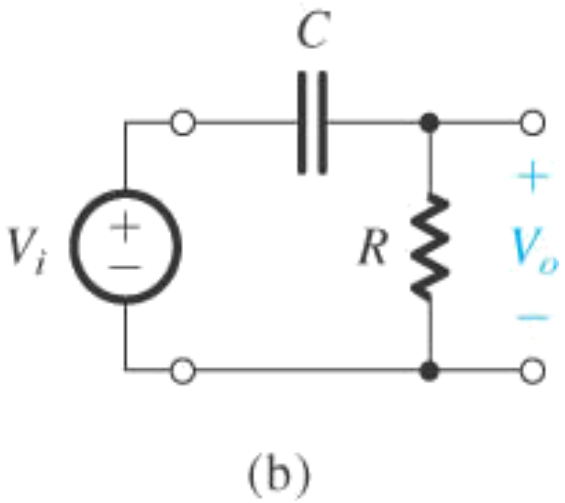


(a)

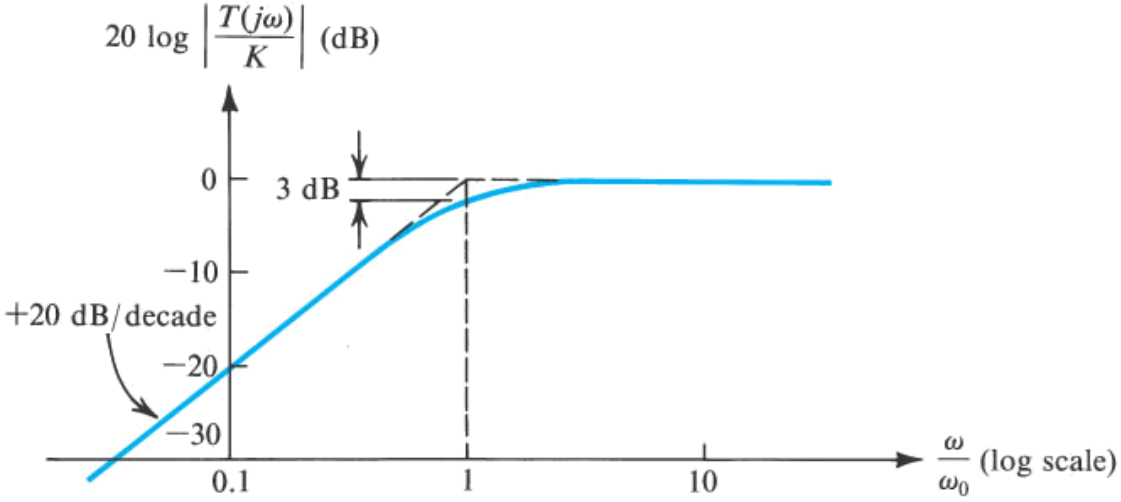


(b)

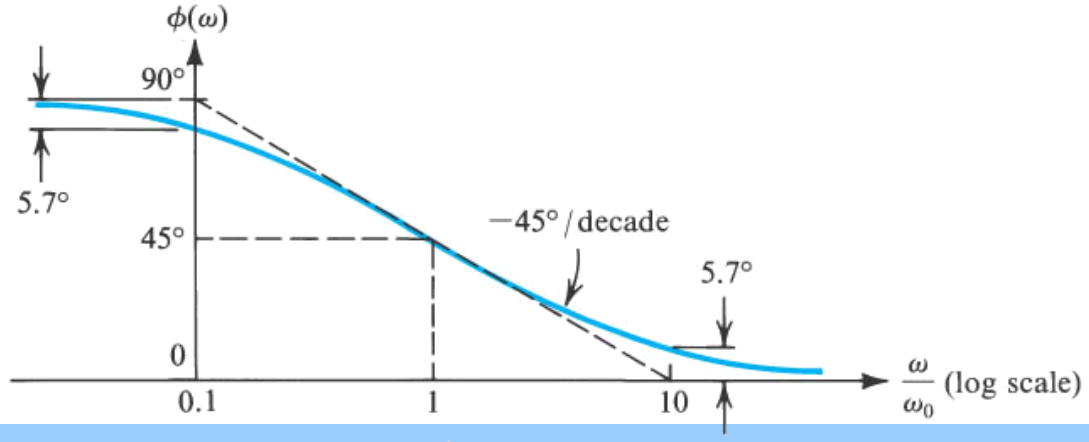
Resposta em frequência – Passa Alta



(b)



(a)



(b)

Lista de Exercício da Unidade I

- Sedra - Microeletrônica 5/e

  Capítulo 1

  - 1.1,1.2,1.5,1.8,1.9 e 1.11

- E 1.6, 1.10, 1.15, 1.16 e 1.17 desta apresentação.

Exercício 1.6

Determine expressões para V_O e R_O.

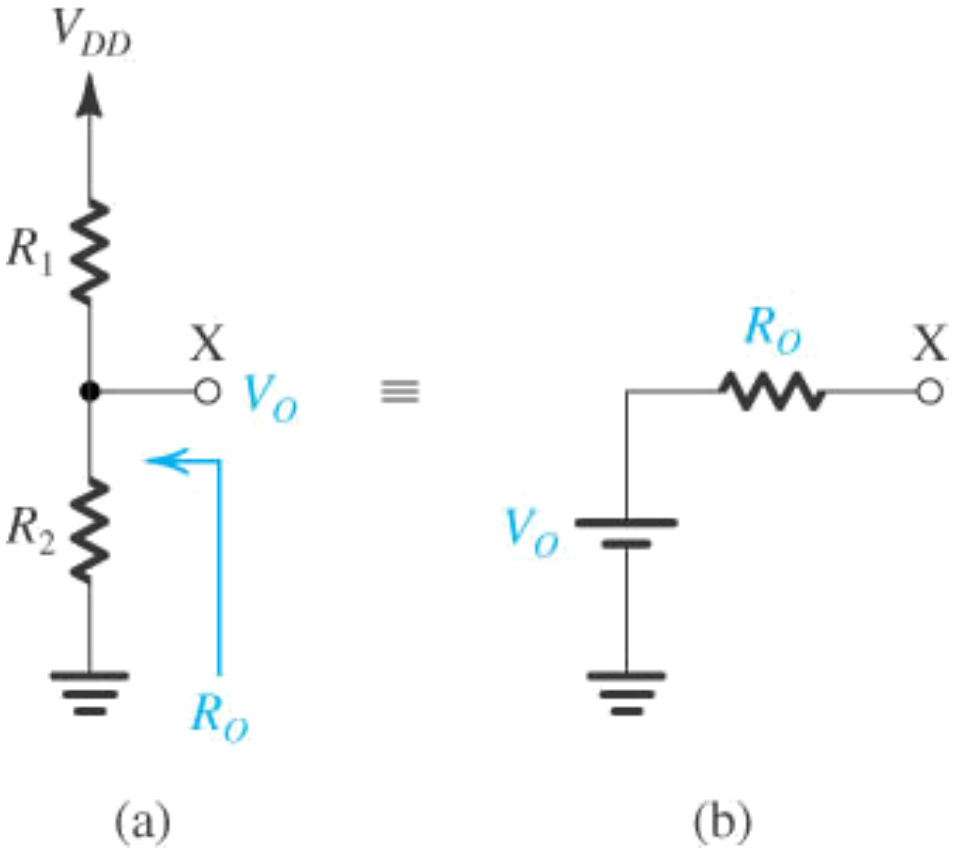


Figure P1.6

Problema 1.10

Divisores de Corrente

Determine expressões para as correntes I_1 e I_2.

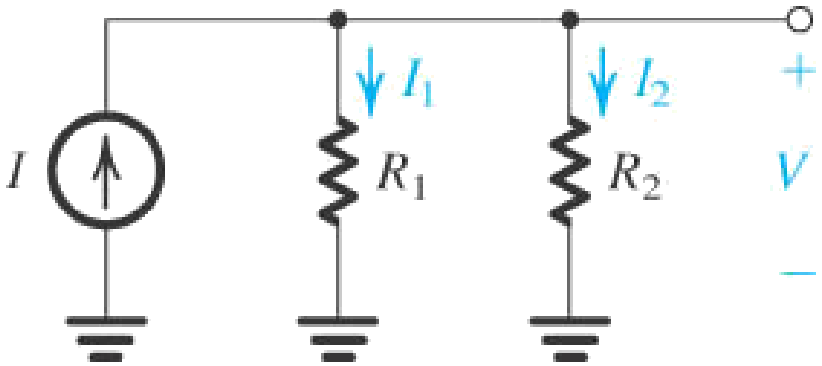


Figure P1.10

Problema 1.15

Aplique repetidamente o teorema de Thévenin e determine o circuito equivalente de Thévenin do nó 4 para terra.

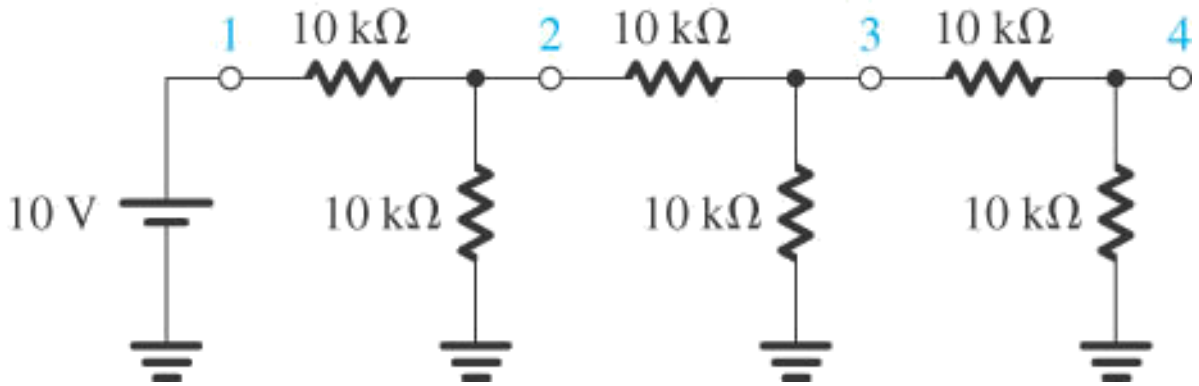


Figure P1.15

Problema 1.16

Determine as correntes no circuito e a tensão no nó comum usando dois métodos:

1 – Chame de I_1 e I_2 as correntes nos resistores R_1 e R_2 respectivamente. Escreva duas equações de malhas.

2 – Chame de V a tensão no nó comum. Escreva uma equação de nó.

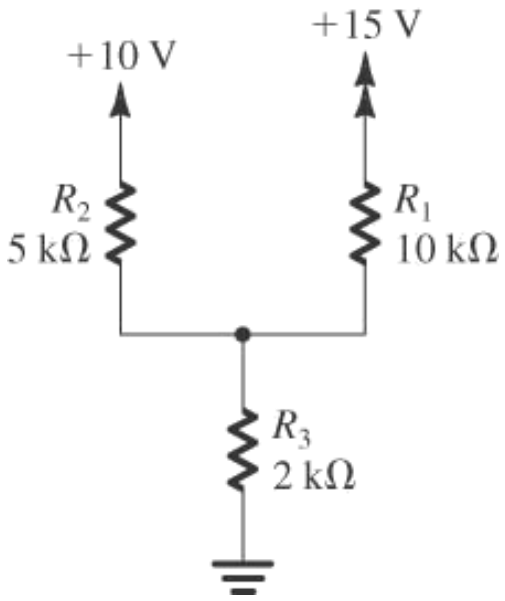


Figure P1.16

Problema 1.17

Determine a corrente e tensão no resistor R5.

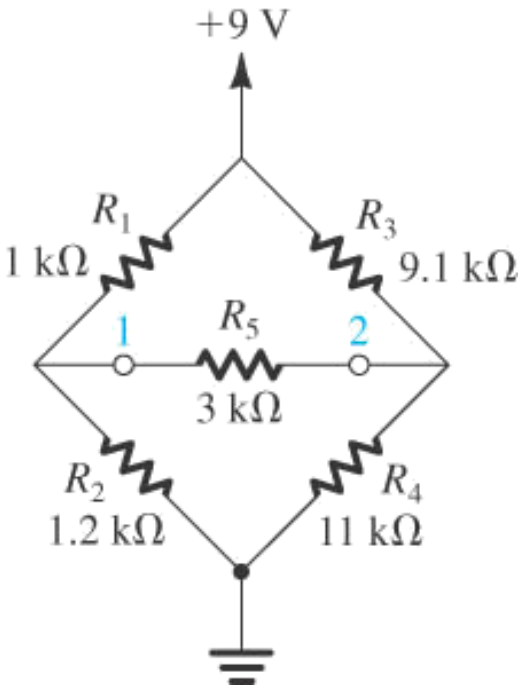


Figure P1.17

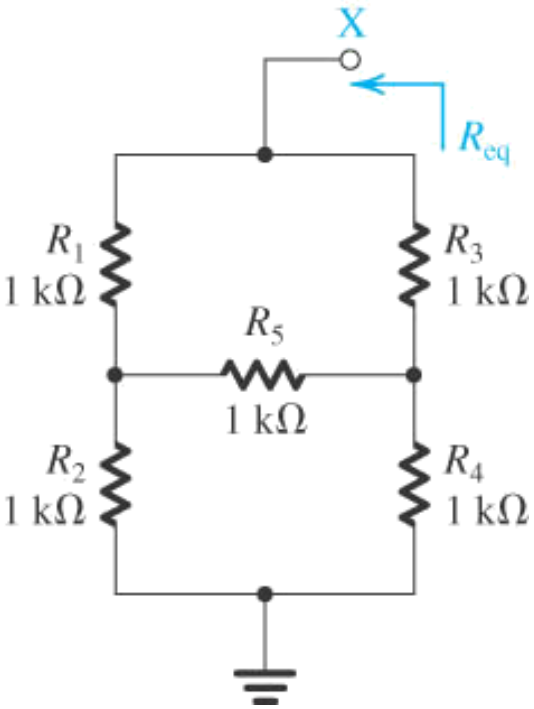


Figure P1.18

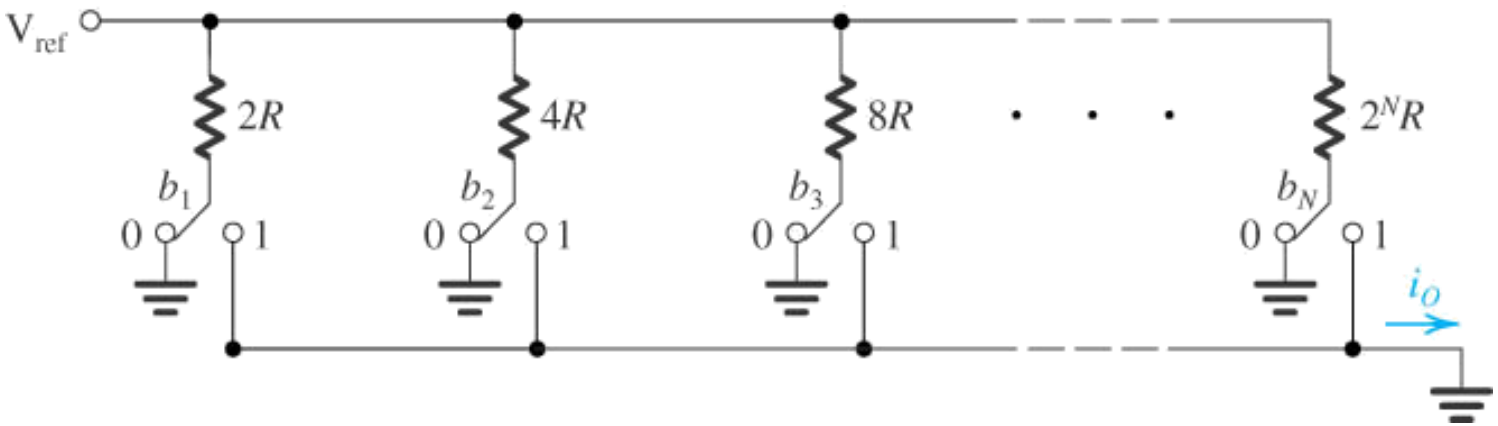


Figure P1.37

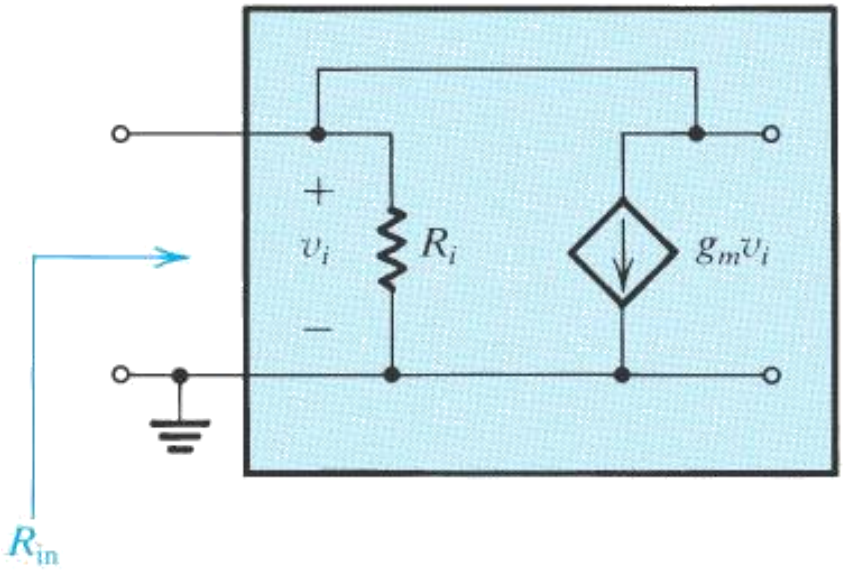


Figure P1.58

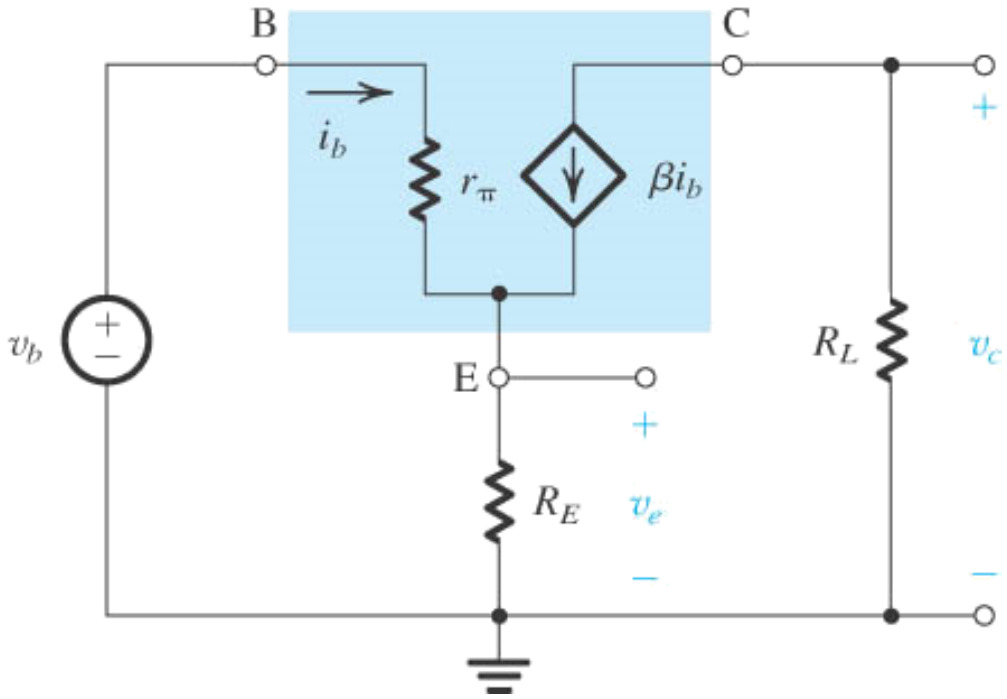
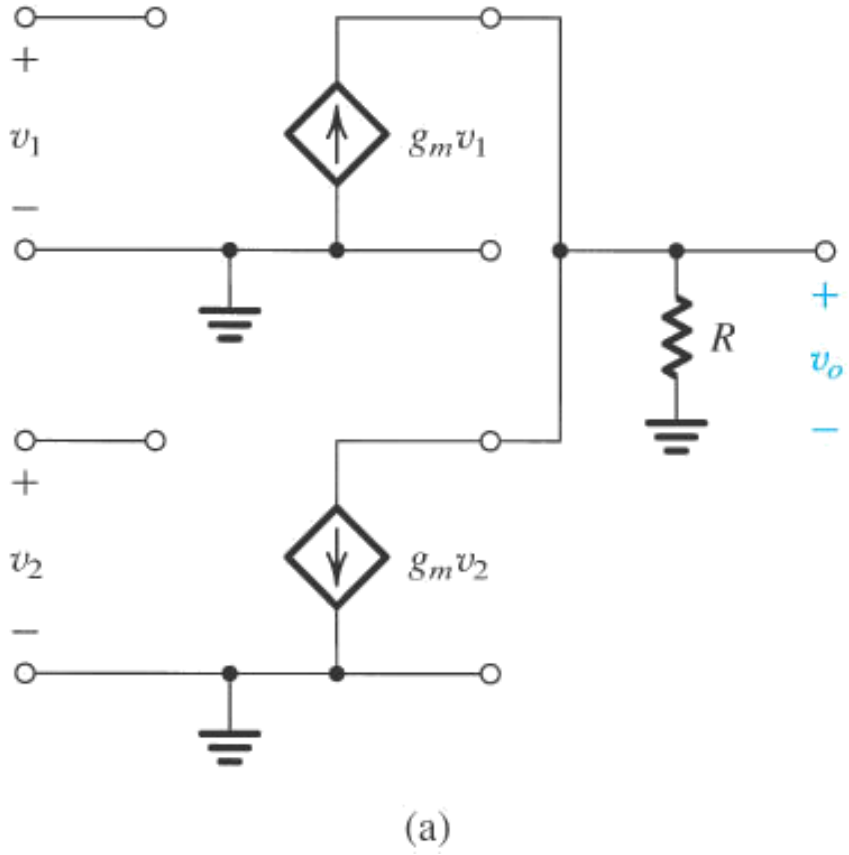
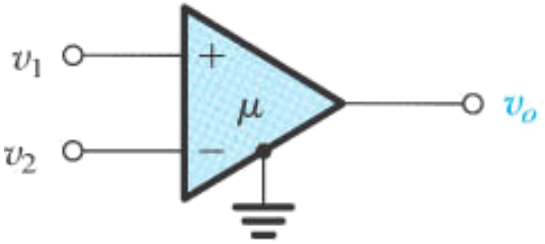


Figure P1.63



(a)



(b)

Figure P1.65

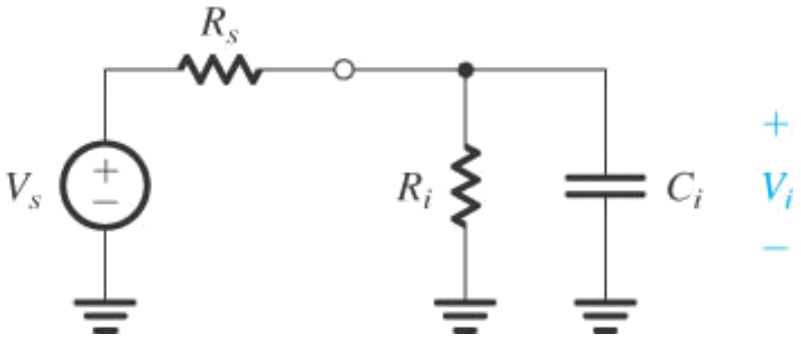


Figure P1.67

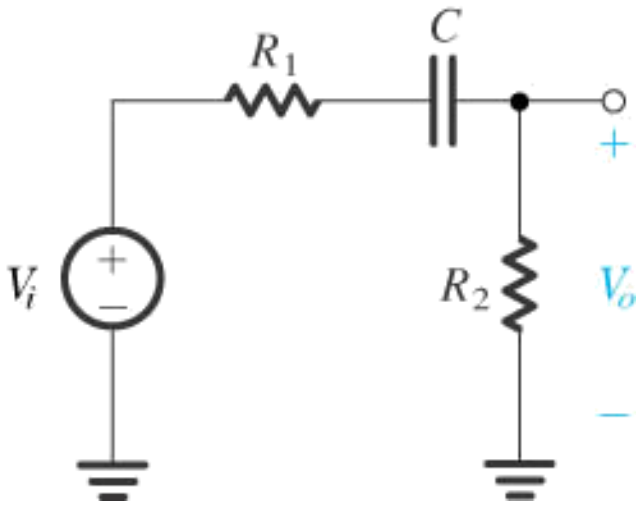


Figure P1.68

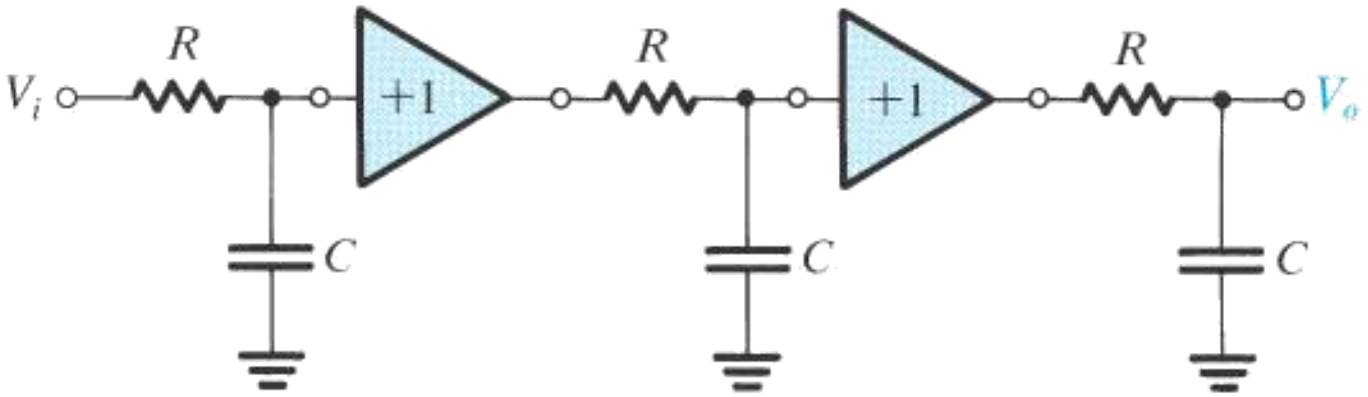


Figure P1.72

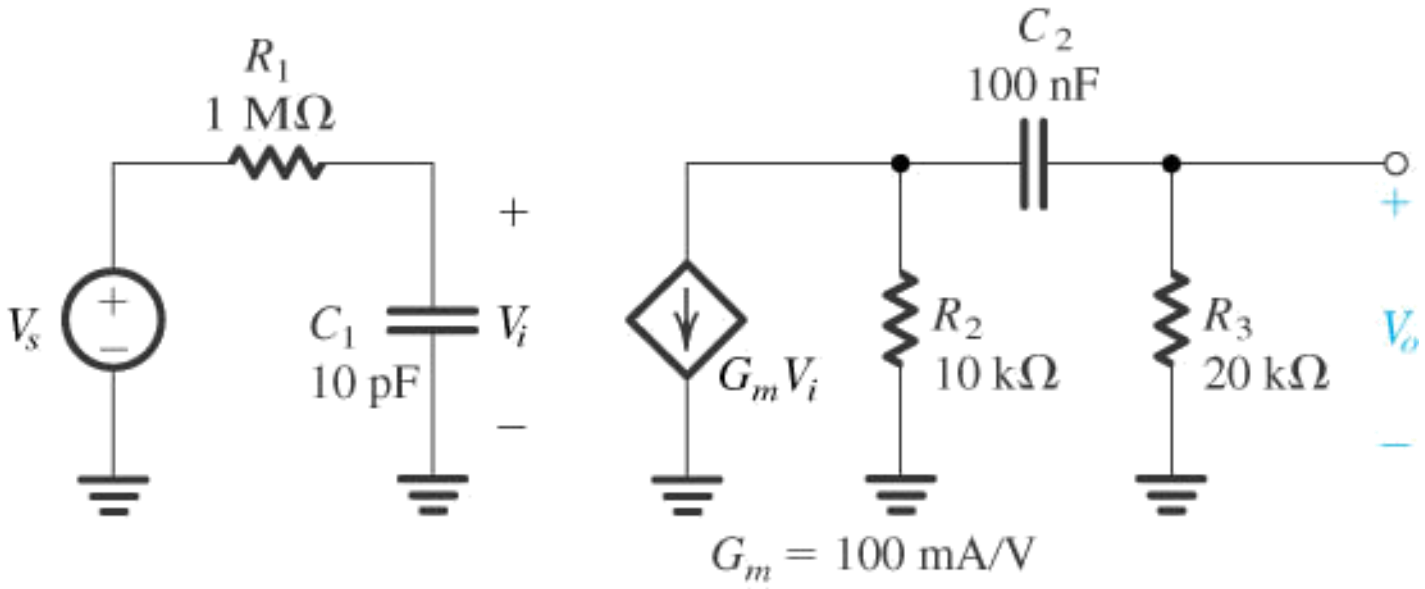


Figure P1.77

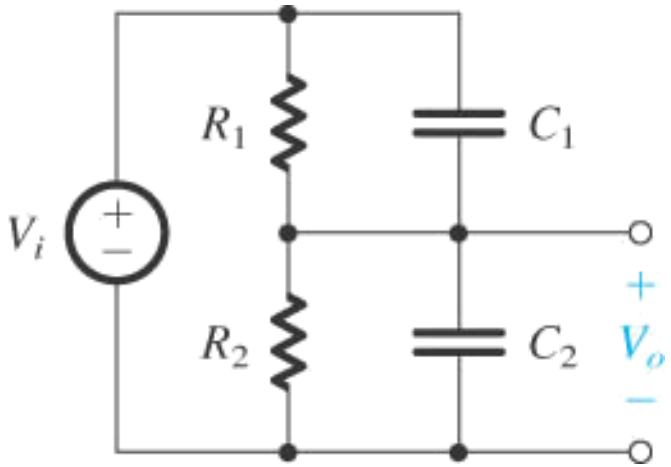


Figure P1.79