

Apêndice



Respostas dos problemas ímpares selecionados

Capítulo 1

5. 29,05 mph
7. (a) 139,33 pés/s (b) 0,431 s (c) 40,91 mph
11. MKS, CGS = 20°C; SI, K = 293,15
13. 45,72 cm
15. (a) 14,6 (b) 56,0 (c) 1.046,1 (d) 0,1 (e) 3,1
17. (a) 14,603 (b) 56,042 (c) 1.046,060 (d) 0,063 (e) 3,142
19. (a) 15×10^3 (b) 5×10^{-3} (c) $2,4 \times 10^6$ (d) 60×10^3 (e) $4,02 \times 10^{-4}$ (f) 2×10^{-10}
21. (a) 100×10^3 (b) 10 (c) 1×10^9 (d) 1×10^{-3} (e) 10 (f) 1×10^{24}
23. (a) 10×10^{-3} (b) 10×10^{-6} (c) 10×10^6 (d) 1×10^{-9} (e) 1×10^{42} (f) 1×10^3
25. (a) 1×10^6 (b) 10×10^{-3} (c) 100×10^{30} (d) 1×10^{-63}
27. (a) 1×10^{-6} (b) 1×10^{-5} (c) 1×10^{-8} (d) 1×10^{11}
29. Científica: (a) $2,05 \times 10^1$ (b) $5,04 \times 10^4$ (c) $6,74 \times 10^{-4}$ (d) $4,60 \times 10^{-2}$
Engenharia: (a) $20,46 \times 10^0$ (b) $50,42 \times 10^3$ (c) $674,00 \times 10^{-6}$ (d) $46,00 \times 10^{-3}$
31. (a) $0,06 \times 10^6$ (b) 400×10^{-6} (c) $0,005 \times 10^9$ (d) 1.200×10^{-9}
33. (a) 90 s (b) 72 s (c) $50 \times 10^3 \mu\text{s}$ (d) 160 mm (e) 120 ns (f) 4.629,63 dias
35. (a) 2,54 m (b) 1,22 m

- (c) 26,7 N (d) 0,13 lb
(e) 4.921,26 pés (f) 3,22 m
37. 26,82 m/s
39. 3.600 quartos
41. 345,6 m
43. 44,82 min/milha
45. (a) $4,74 \times 10^{-3}$ Btus (b) $7,1 \times 10^{-4}$ m³ (c) $1,21 \times 10^5$ s (d) 2.113,38 pintas
47. 14,4
49. 0,93
51. 3,24
53. $1,20 \times 10^{12}$

Capítulo 2

3. (a) 1,11 μN (b) 0,31 N (c) 1138,34 kN
5. $F_2 = r_1^2 F_1 / r_2^2$
7. (a) 72 mN (b) $Q_1 = 20 \mu\text{C}$, $Q_2 = 40 \mu\text{C}$
9. 0,48 J
11. 8 C
13. 4,29 mA
15. 192 C
17. 3 s
19. $2,25 \times 10^{18}$ elétrons
21. 22,43 mA
23. 6,67 V
25. 3,34 A
27. 60,0 Ah
29. $W(60 \text{ Ah}) : W(40 \text{ Ah}) = 1,5 : 1$; $I(60 \text{ Ah}) : I(40 \text{ Ah}) = 3.600 \text{ A} : 2.400 \text{ A} = 1,5 : 1$
31. 13,89%
33. 129,6 kJ
37. (a) 38,1 kV (b) 342,9 kV

Capítulo 3

1. (a) 500 mils (b) 20 mils (c) 250 mils (d) 393,7 mils (e) 120 mils (f) 39,37 mils
3. (a) 0,04 pol. (b) 0,029 pol. (c) 0,2 pol. (d) 0,025 pol. (e) 0,0025 pol. (f) 0,55 pol.

5. (a) 544 CM (b) 0,023 pol.
7. (a) 942,73 CM (b) maior (c) menor
9. (a) 293,82 pés (b) 1,47 lb (c) $-40^\circ\text{F} \rightarrow +221^\circ\text{F}$
11. (a) 21,71 $\mu\Omega$ (b) 35,59 $\mu\Omega$
13. 942,28 m Ω
15. (a) sim (b) $A(\#0) : A(\#12) = 16,16 : 1$, $I(\#0) : I(\#12) = 7,5 : 1$
17. (a) #2 (b) #0
19. 2,57 Ω
21. 3,69 Ω
23. (a) 27,85°C (b) $-210,65^\circ\text{C}$
25. (a) 0,00393 (b) 83,61°C
27. 1,75°
29. 100,30 Ω
31. 6,5 k Ω
35. (a) azul, cinza, preto, prata (b) laranja, laranja, prata, prata (c) vermelho, vermelho, laranja, prata (d) verde, azul, verde, prata
37. sim, 423 Ω a 517 Ω
39. (a) 0,62 k Ω (b) 33 k Ω (c) 390 Ω (d) 1,2 M Ω
41. (a) 629,72 mS (b) 384,11 mS
43. 500 S
49. (a) 21,71 $\mu\Omega$ (b) 35,59 $\mu\Omega$
51. 0,15 pol.
59. (a) 10 fc = 3 k Ω , 100 fc = 0,4 k Ω (b) negativo (c) não (d) $-321,43 \Omega/\text{fc}$

Capítulo 4

1. 1,23 V
3. 16 k Ω
5. 72 mV
7. 54,55 Ω
9. 28,57 Ω
11. 1,2 k Ω
13. (a) 12,63 Ω (b) $8,21 \times 10^6$ J
21. 16 s
23. 2,86 s

25. 207,36 mW
 27. 129,10 mA, 15,49 V
 29. 120 V
 31. 9,61 V
 33. 32 Ω, 120 V
 35. 70,71 mA, 1,42 kV
 37. (a) 86,4 J
 (b) energia dobra, potência não muda
 39. 59,80 kWh
 41. (a) 120 kW (b) 576,92 A
 (c) 216 kWh
 43. (a) \$ 2,39/dia (b) 16 ¢/hora
 (c) 1,45 kWh (d) ≅ 24 (e) não
 45. \$ 25,29
 47. (a) 12 kW
 (b) 10.130 W < 12 kW (sim)
 (c) 20,26 kWh
 49. 52,29 ¢
 51. 84,77%
 53. (a) 238 W (b) 17,36%
 55. (a) 1.657,78 W (b) 15,07 A
 (c) 19,38 A
 57. 88%
 59. 80%
 61. $\eta_1 = 40\%$, $\eta_2 = 80\%$

Capítulo 5

1. (a) E e R_1
 (b) R_1 e R_2
 (c) E_1 , E_2 e R_1
 (d) E_1 e R_1 ; E_2 , R_3 , e R_4
 (e) R_3 , R_4 , e R_5 ; E e R_1
 (f) R_2 e R_3
 3. (a) 7,7 kΩ (b) 17,5 kΩ
 5. (a) 99 Ω (b) 7,52 kΩ
 7. (a) 1,2 kΩ (b) 0 Ω
 (c) ∞ Ω
 9. (a) máximo: R_3 ; mínimo: R_1
 (b) R_3 , $R_T = 90$ kΩ, $I_s = 0,5$ mA
 (c) $V_1 = 0,6$ V, $V_2 = 3,4$ V, $V_3 = 41$ V
 11. (a) 4 A (b) 36 V (c) 3 Ω
 (d) $V_{4,7\Omega} = 18,8$ V, $V_{1,3\Omega} = 5,2$ V,
 $V_{3\Omega} = 12$ V
 13. (a) $R_T = 6$ kΩ, $I = 20$ mA,
 $V_{R_1} = 60$ V, $V_{R_2} = 20$ V,
 $V_{R_3} = 40$ V
 (b) $P_{R_1} = 1,2$ W, $P_{R_2} = 0,4$ W,
 $P_{R_3} = 0,8$ W (c) 2,4 W
 (d) 2,4 W (e) igual
 (f) R_1 (g) dissipado
 (h) $R_1 : 2$ W;
 $R_2 : \frac{1}{2}$ W; $R_3 = 1$ W
 15. $I = 2,828$ A, $E = 90,5$ V, $R_1 = 2$ Ω,
 $R_2 = 29$ Ω
 17. 6 Ω
 19. (a) $I(\text{horário}) = 1,17$ A
 (b) $I(\text{anti-horário}) = 173,91$ mA
 21. (a) $V = 2$ V (b) $V = 42$ V
 (c) $V_1 = 8$ V, $V_2 = -4$ V
 23. (a) $V_1 = 4$ V, $V_2 = 10$ V
 (b) $V_1 = 14$ V, $V_2 = 18$ V
 25. $R_2 = 100$ Ω, $R_3 = 200$ Ω
 27. (a) 20 V (b) 20 V
 (c) 0,36 V
 29. $V_2 = 4$ V, $V_4 = 6$ V, $I = 2$ mA, $E = 24$ V
 31. (a) 80 Ω em série com a lâmpada
 (b) Resistor de $\frac{1}{4}$ W
 33. $V_{R_1} = 12$ V, $V_{R_2} = 42$ V, $V_{R_3} = 6$ V
 35. (a) $V_a = 17$ V, $V_b = 21$ V, $V_{ab} = -4$ V
 (b) $V_a = 14$ V, $V_b = 30$ V, $V_{ab} = -16$ V
 (c) $V_a = 13$ V, $V_b = -8$ V, $V_{ab} = 21$ V
 37. (a) $V_a = 20$ V, $V_b = 26$ V,
 $V_c = 35$ V, $V_d = -12$ V,
 $V_e = 0$ V (b) $V_{ab} = -6$ V,
 $V_{dc} = -47$ V, $V_{cb} = 9$ V
 (c) $V_{ac} = -15$ V, $V_{db} = -38$ V
 39. $R_1 = 2$ kΩ, $R_2 = 2,25$ kΩ,
 $R_3 = 0,75$ kΩ, $R_4 = 1,25$ kΩ
 41. $V_0 = 0$ V, $V_4 = 15$ V, $V_7 = 4$ V,
 $V_{10} = 12$ V, $V_{23} = 12$ V,
 $V_{30} = -8$ V, $V_{67} = 0$ V,
 $V_{56} = -1$ V, $I = 3$ A ↑
 43. (a) 2 Ω (b) 7,14%
 45. (a) 1,2 mA (b) 1,17 mA
 (c) não

Capítulo 6

1. (a) R_2 e R_3 (b) E e R_3
 (c) R_2 e R_3 (d) R_2 e R_3
 (e) E , R_1 , R_2 , R_3 e R_4 (f) E ,
 R_1 , R_2 , R_3 (g) E_2 , R_2 , e R_3
 3. (a) 12 Ω (b) 0,652 kΩ
 (c) 10,81 Ω (d) 3 kΩ
 (e) 2,62 Ω (f) 0,99 Ω
 5. (a) 8 Ω (b) 18 kΩ
 (c) 6,8 kΩ (d) 2,4 kΩ
 7. (a) 1,18 Ω (b) ∞ Ω
 (c) 2 Ω
 9. (a) 6 Ω (b) 36 V
 (c) $I_s = 6$ A, $I_1 = 4,5$ A,
 $I_2 = 1,5$ A
 11. (a) $I_1 = 2,4$ mA, $I_2 = 20$ mA,
 $I_3 = 3,53$ mA (b) 925,93 Ω
 (c) 25,92 mA (d) 25,93 mA
 13. (a) 9 Ω (b) 27 V
 15. $E = 36$ V, $R_1 = 24$ Ω, $I_3 = 9$ A
 17. (a) 4 Ω (b) 12 Ω
 (c) 10 A
 19. (a) 761,79 Ω, $I_1 = 60$ mA,
 $I_2 = 12,77$ mA, $I_3 = 6$ mA
 (b) $P_1 = 3,6$ W, $P_2 = 0,766$ W,
 $P_3 = 0,36$ W (c) 4,73 W
 (d) 4,73 W (e) R_1 — o menor
 21. 1,56 kW
 23. (a) 14,67 A (b) 256 W
 (c) 14,67 A
 25. (a) $I = 8$ A (b) $I_1 = 6$ mA,
 $I_2 = 15$ mA, $I_3 = 5$ mA
 27. $R_1 = 3$ kΩ, $R_3 = 6$ kΩ,
 $R_T = 1,33$ kΩ, $E = 12$ V
 29. (a) $I_1 = 64$ mA, $I_2 = 20$ mA,
 $I_3 = 16$ mA, $R = 3,2$ kΩ

- (b) $E = 30$ V, $I_1 = 1$ A,
 $I_3 = 0,5$ A, $R_2 = R_3 = 60$ Ω,
 $P_{R_2} = 15$ W
 31. (a) $I_1 = 3$ A, $I_2 = 4$ A
 (b) $I_T = 8,5$ A, $I_1 = 6$ A
 33. (a) 9 A (b) 0,9 A
 (c) 9 mA
 (d) 90 μA (e) muito pouco
 (f) 9,1 A (g) 0,91 A
 (h) 9,1 mA (i) 91 μA
 35. (a) 6 kΩ (b) $I_1 = 24$ mA, I_2
 $= 8$ mA
 37. (a) $I_1 = I_2 = 3$ A, $I_L = 6$ A
 (b) 36 W (c) 72 W
 (d) 6 A
 39. $I = 3$ A, $R = 2$ Ω
 41. (a) 6,13 V (b) 9 V (c) 9 V
 43. (a) 16,48 V (b) 16,47 V
 (c) 16,32 V (d): (a) 13,33 V,
 (b) 13,25 V, (c) 11,43 V
 45. 6 kΩ não conectado

Capítulo 7

1. (a) R_1 , R_2 e E em série; R_3 , R_4 e R_5
 em paralelo
 (b) E e R_1 em série; R_2 , R_3 e R_4 em
 paralelo
 (c) E e R_1 em série; R_2 , R_3 e R_4 em
 paralelo
 (d) E_1 e R_1 em série; E_2 e R_4 em pa-
 ralelo
 (e) E e R_1 em série; R_2 e R_3 em
 paralelo
 (f) E , R_1 , R_4 e R_6 em paralelo; R_2 e
 R_5 em paralelo
 3. 3,6 kΩ
 5. 12 kΩ
 7. (a) 4 Ω (b) $I_s = 9$ A, $I_1 = 6$ A,
 $I_2 = 3$ A (c) 6 V
 9. (a) $V_a = 36$ V, $V_b = 60$ V,
 $V_c = 20$ V (b) $I_1 = 24$ mA,
 $I_2 = 35,5$ mA
 11. 22,5 Ω
 (a) $I = 14$ A, $I_1 = 6$ A, $I_2 = 8$ A,
 $I_3 = 0,8$ A
 15. (a) $I_s = 5$ A, $I_1 = 1$ A, $I_3 = 4$ A,
 $I_4 = 0,5$ A
 (b) $V_a = 17$ V, $V_{bc} = 10$ V
 17. (a) $I_E = 2$ mA, $I_C = 2$ mA
 (b) $I_B = 24$ μA
 (c) $V_B = 2,7$ V, $V_C = 3,6$ V
 (d) $V_{CE} = 1,6$ V, $V_{BC} = -0,9$ V
 19. (a) 1,88 Ω (b) $V_1 = V_4 = 32$ V
 (c) 8 A (d) $I_s = 17$ A,
 $R_T = 1,88$ Ω
 21. (a) 14 V (b) 9 A
 (c) $V_a = -6$ V, $V_b = -20$ V
 23. 30 Ω
 25. (a) não (b) 6 kΩ aberto
 27. (a) 5,53 Ω (b) 7,23 A
 (c) 0,281 W
 29. (a) 12 A (b) 0,5 A
 (c) 0,5 A (d) 6 A

31. $R_1 = 0,5 \text{ k}\Omega$, $R_2 = 2 \text{ k}\Omega$,
 $R_3 = 4 \text{ k}\Omega$, $R_4 = 1 \text{ k}\Omega$,
 $R_5 = 0,6 \text{ k}\Omega$, $P_{R_1} = 1 \text{ W}$,
 $P_{R_2} = 2 \text{ W}$, $P_{R_3} = \frac{1}{2} \text{ W}$,
 $P_{R_4} = 2 \text{ W}$, $P_{R_5} = 1 \text{ W}$
33. (a) sim (b) $R_1 = 750 \Omega$,
 $R_2 = 250 \Omega$ (c) $R_1 = 745 \Omega$,
 $R_2 = 255 \Omega$
35. (a) 1 mA (b) $R_{\text{shunt}} = 5 \text{ m}\Omega$
37. (a) $R_s = 300 \text{ k}\Omega$
 (b) $20.000 \Omega/\text{V}$
39. $0,05 \mu\text{A}$

Capítulo 8

1. (a) $I_1 = 4,8 \text{ A}$, $I_2 = 1,2 \text{ A}$
 (b) $9,6 \text{ V}$
3. $31,6 \text{ V}$
5. $V_3 = 1,6 \text{ V}$, $I_2 = 0,1 \text{ A}$
7. (a) $I_s = 4,68 \text{ A}$, $R_p = 4,7 \Omega$
 (b) $I_s = 4,09 \text{ mA}$, $R_p = 2,2 \text{ k}\Omega$
9. (a) $18,18 \text{ A}$ (b) sim, $18,18 \text{ A}$
11. (a) $I_T = 4,2 \text{ A}$ (b) $16,8 \text{ V}$
13. (a) $V_{ab} = -7 \text{ V}$ (b) $1,17 \text{ A} \uparrow$
15. (a) $I_1(\text{horário}) = -\frac{1}{7} \text{ A}$,
 $I_2(\text{anti-horário}) = \frac{5}{7} \text{ A}$, $I_3(\text{abaixo}) = \frac{4}{7} \text{ A}$
 (b) $4,57 \text{ V}$
17. $I_1(\text{horário}) = 1,45 \text{ mA}$,
 $I_2(\text{anti-horário}) = 8,51 \text{ mA}$,
 $I_3(\text{abaixo}) = 9,96 \text{ mA}$
19. (d) $63,69 \text{ mA}$
21. (a) $I_{E_1}(\text{anti-horário}) = 3,06 \text{ A}$,
 $I_{E_2}(\text{acima}) = 3,25 \text{ A}$
 (b) $P_{E_2} = 39 \text{ W}$, $P_{R_3} = 0,43 \text{ W}$
23. (a) $I_1(\text{horário}) = 2,03 \text{ mA}$,
 $I_2(\text{esquerda}) = 1,23 \text{ mA}$,
 $I_3 = I_4(\text{horário}) = 1,23 \text{ mA}$
 (b) $5,12 \text{ V}$
25. (b) $I_1(\text{horário}) = 1,21 \text{ mA}$,
 $I_2(\text{horário}) = -0,48 \text{ mA}$,
 $I_3(\text{horário}) = -0,62 \text{ mA}$
 (c) $I_{E_1}(\text{abaixo}) = 1,69 \text{ mA}$,
 $I_{E_2}(\text{acima}) = 0,62 \text{ mA}$
27. (b) $I_1(\text{horário}) = 0,03 \text{ mA}$,
 $I_2(\text{horário}) = -0,88 \text{ mA}$,
 $I_3(\text{horário}) = -0,97 \text{ mA}$,
 $I_4(\text{horário}) = -0,64 \text{ mA}$
 (c) $5,46 \text{ mW}$
29. (a) $I_B = 63,02 \mu\text{A}$,
 $I_C = 4,42 \text{ mA}$, $I_E = 4,48 \text{ mA}$
 (b) $V_B = 2,98 \text{ V}$, $V_E = 2,28 \text{ V}$,
 $V_C = 10,28 \text{ V}$ (c) $70,14$
31. $I_{4\Omega} = 5,53 \text{ A}$, $I_{6\Omega} = 2,47 \text{ A}$,
 $I_{8\Omega} = 0,53 \text{ A}$, $I_{1\Omega} = 8,53 \text{ A}$
33. (b) $3,25 \text{ A}$
35. (b) $I_1(\text{horário}) = 3,31 \text{ A}$,
 $I_2(\text{horário}) = -63,69 \text{ mA}$,
 $I_3(\text{horário}) = 0,789 \text{ A}$ (c) $3,37 \text{ A}$
37. (b) $-6,44 \text{ V}$
39. (b) $I_1(\text{horário}) = 2,37 \text{ A}$,
 $I_2(\text{horário}) = -0,20 \text{ A}$,
 $I_3(\text{horário}) = 1,25 \text{ A}$
 (c) $V_a = 4,48 \text{ V}$, $V_b = 10 \text{ V}$ (d) $-5,52 \text{ V}$

41. (b) $V_1 = -29,29 \text{ V}$,
 $V_2 = -33,34 \text{ V}$ (c) $1,67 \text{ A}$
43. (b) $V_1 = -2,56 \text{ V}$, $V_2 = 4,03 \text{ V}$
 (c) $V_{R_1 \pm} = 2,56 \text{ V}$, $V_{R_2} = V_{R_5 \pm} = 4,03 \text{ V}$,
 $V_{R_4} = V_{R_3(-+)} = 6,59 \text{ V}$
45. (b) $V_1 = 7,24 \text{ V}$, $V_2 = -2,45 \text{ V}$,
 $V_3 = 1,41 \text{ V}$
 (c) $V_{5\Omega(-+)} = 3,86 \text{ V}$
47. (b) $V_1 = -5,31 \text{ V}$, $V_2 = 0,62 \text{ V}$,
 $V_3 = 3,75 \text{ V}$ (c) 69 mA
49. $V_1 = 10,08 \text{ V}$, $V_2 = 6,94 \text{ V}$,
 $V_3 = -17,06 \text{ V}$
51. (a) $V_1 = -10,29 \text{ V}$, $V_2 = -11,43 \text{ V}$
 (b) $V_{3A \pm} = 10,29 \text{ V}$,
 $V_{3A \pm} = 11,43 \text{ V}$
53. (a) $V_1 = -6,64 \text{ V}$, $V_2 = 1,29 \text{ V}$,
 $V_3 = 10,66 \text{ V}$ (b) $1,34 \text{ A}$
55. (a) $V_1 = -6,92 \text{ V}$, $V_2 = 12 \text{ V}$,
 $V_3 = 2,3 \text{ V}$ (b) $3,46 \text{ A}$
57. (b) 20 mA (c) não
 (d) não
59. (b) 0 A (c) sim
 (d) sim
61. $3,33 \text{ mA}$
63. $1,76 \text{ mA}$
65. $133,33 \text{ mA}$
67. $0,83 \text{ mA}$
69. $4,2 \Omega$

Capítulo 9

1. (a) $0,1 \text{ A} \uparrow$ (b) igual (c) igual
3. $1,25 \text{ A} \downarrow$
5. $52,12 \text{ V}$
7. $10,66 \text{ V}$
9. (a) $R_{Th} = 4,1 \text{ k}\Omega$, $E_{Th} = 96 \text{ V}$
 (b) $2 \text{ k}\Omega$; $0,495 \text{ W}$,
 $100 \text{ k}\Omega$; 85 mW
11. $R_{Th} = 2,18 \Omega$, $E_{Th} = 9,81 \text{ V}$
13. $R_{Th} = 2 \Omega$, $E_{Th} = 60 \text{ V}$
15. (a) $R_{Th} = 10 \Omega$, $E_{Th} = 2 \text{ V}$
 (b) 20Ω : $66,67 \text{ mA}$, 50Ω : $33,33 \text{ mA}$, 100Ω : $18,18 \text{ mA}$
17. $R_{Th} = 4,04 \text{ k}\Omega$, $E_{Th} = 9,74 \text{ V}$
19. (a) $R_{Th} = 12,5 \text{ k}\Omega$, $E_{Th} = 20 \text{ V}$
 (b) $R_{Th} = 2,72 \text{ k}\Omega$, $E_{Th} = 60 \text{ mV}$
 (c) $R_{Th} = 2,2 \text{ k}\Omega$, $E_{Th} = 16 \text{ V}$
21. (a) $R_N = 6 \Omega$, $I_N = 1 \text{ A}$
 (b) $E_{Th} = 6 \text{ V}$, $R_{Th} = 6 \Omega$
23. $R_N = 2,18 \Omega$, $I_N = 4,5 \text{ A}$
25. $R_N = 2 \Omega$, $I_N = 30 \text{ A}$
27. $R_N = 4,04 \text{ k}\Omega$, $I_N = 2,41 \text{ mA}$
29. (a) $R_N = 3 \Omega$, $I_N = 5 \text{ A}$
 (b) $V_{100\Omega \pm} = 55,34 \text{ V}$
31. (a) $2,18 \Omega$ (b) $11,06 \text{ W}$
33. (a) $4,04 \text{ k}\Omega$ (b) $5,87 \text{ mW}$
35. 0Ω
37. 500Ω , $P_{\text{máx}} = 1,44 \text{ W}$
39. $I_L = 39,3 \mu\text{A}$, $V_L = 220 \text{ mV}$
41. $I_L = 2,25 \text{ A}$, $V_L = 6,08 \text{ V}$
47. (a) $0,36 \text{ mA}$ (b) $0,36 \text{ mA}$
 (c) sim

Capítulo 10

1. (a) $36 \times 10^3 \text{ N/C}$
 (b) $36 \times 10^9 \text{ N/C}$
3. $50 \mu\text{F}$
5. (a) $16,69 \text{ V/m}$ (b) $1,97 \text{ kV/m}$
 (c) $100 : 1$
7. $348,43 \text{ pF}$
9. $2,66 \mu\text{m}$
11. (a) $24,78 \text{ nF}$ (b) 10^6 V/m
 (c) $4,96 \mu\text{C}$
13. $25,6 \text{ kV}$
15. $0,35 \mu\text{F}$
17. $470 \mu\text{F}$, $465,3 \mu\text{F}$ – $474,7 \mu\text{F}$
19. (a) $0,56 \text{ s}$
 (b) $v_C = 20 \text{ V}(1 - e^{-t/0,56 \text{ s}})$
 (c) $1\tau = 12,64 \text{ V}$, $3\tau = 19 \text{ V}$,
 $5\tau = 19,87 \text{ V}$
 (d) $i_C = 0,2 \text{ mA} e^{-t/0,56 \text{ s}}$,
 $v_R = 20 \text{ V} e^{-t/0,56 \text{ s}}$
21. (a) $5,5 \text{ ms}$
 (b) $v_C = 100 \text{ V}(1 - e^{-t/5,5 \text{ ms}})$
 (c) $1\tau = 63,21 \text{ V}$, $3\tau = 95,02 \text{ V}$,
 $5\tau = 99,33 \text{ V}$
 (d) $i_C = 18,18 \text{ mA} e^{-t/5,5 \text{ ms}}$,
 $v_{R_2} = 60 \text{ V} e^{-t/5,5 \text{ ms}}$
23. (a) $100 \mu\text{s}$ (b) $4,72 \text{ V}$
 (c) $11,99 \text{ V}$
25. (a) $263,2 \text{ ms}$
 (b) $v_C = 22 \text{ V}(1 - e^{-t/263,2 \text{ ms}})$,
 $i_C = 4,68 \text{ mA} e^{-t/263,2 \text{ ms}}$
 (c) $21,51 \text{ V}$, $0,105 \text{ mA}$
 (d) $v_C = 21,51 \text{ V} e^{-t/263,2 \text{ ms}}$,
 $i_C = 4,58 \text{ mA} e^{-t/263,2 \text{ ms}}$
27. (a) $v_C = 60 \text{ V}(1 - e^{-t/4,84 \mu\text{s}})$,
 $i_C = 272,73 \mu\text{A} e^{-t/4,84 \mu\text{s}}$
 (b) $v_C = 59,6 \text{ V} e^{-t/15,18 \mu\text{s}}$,
 $i_C = -86,96 \mu\text{A} e^{-t/15,18 \mu\text{s}}$
29. (a) $v_C = 40 \text{ V} - 34 \text{ V} e^{-t/22,1 \text{ ms}}$
 (b) $i_C = 7,23 \text{ mA} e^{-t/22,1 \text{ ms}}$
31. $v_C = -20 \text{ V} + 10 \text{ V} e^{-t/2,71 \mu\text{s}}$,
 $i_C = -12,2 \text{ mA} e^{-t/2,71 \mu\text{s}}$
33. (a) $55,99 \text{ mV}$ (b) $139,99 \text{ mV}$
 (c) $2,5 \text{ ms}$ (d) $8,54 \text{ ms}$
35. $R = 54,60 \text{ k}\Omega$
37. (a) $22,07 \text{ V}$ (b) $0,81 \mu\text{A}$
 (c) $3,58 \text{ s}$
39. (a) $v_C = -27,2 \text{ V} + 37,2 \text{ V} e^{-t/18,26 \text{ ms}}$,
 $i_C = -4,48 \text{ mA} e^{-t/18,26 \text{ ms}}$
41. (a) $v_C = 3,27 \text{ V}(1 - e^{-t/53,80 \text{ ms}})$,
 $i_C = 1,22 \text{ mA} e^{-t/53,80 \text{ ms}}$
43. (a) $19,63 \text{ V}$ (b) $2,32 \text{ s}$
 (c) $1,15 \text{ s}$
45. $10 \mu\text{s}$ – $20 \mu\text{s}$: $-1,18 \text{ A}$; $20 \mu\text{s}$ – $30 \mu\text{s}$: $+7,05 \text{ A}$; $30 \mu\text{s}$ – $40 \mu\text{s}$: $-7,05 \text{ A}$; $40 \mu\text{s}$ – $50 \mu\text{s}$: 0 A ; $50 \mu\text{s}$ – $55 \mu\text{s}$: $-4,7 \text{ A}$; $55 \mu\text{s}$ – $60 \mu\text{s}$: $+4,7 \text{ A}$; $60 \mu\text{s}$ – $70 \mu\text{s}$: 0 A ; $70 \mu\text{s}$ – $80 \mu\text{s}$: $+4,7 \text{ A}$; $80 \mu\text{s}$ – $100 \mu\text{s}$: $-1,175 \text{ A}$
47. $6,67 \mu\text{F}$
49. $V_1 = 10 \text{ V}$, $Q_1 = 60 \mu\text{C}$;
 $V_2 = 6,67 \text{ V}$, $Q_2 = 40 \mu\text{C}$;
 $V_3 = 3,33 \text{ V}$, $Q_3 = 40 \mu\text{C}$

51. $V_1 = 13,45 \text{ V}$, $Q_1 = 2,96 \text{ mC}$;
 $V_2 = 6,55 \text{ V}$, $Q_2 = 2,16 \text{ mC}$;
 $V_3 = 6,55 \text{ V}$, $Q_3 = 0,786 \text{ mC}$
53. 8640 pJ
55. $W_{200 \mu\text{F}} = 9,70 \text{ mJ}$,
 $W_{100 \mu\text{F}} = 1,75 \text{ mJ}$

Capítulo 11

- (a) 0,04 Wb/m² (b) 0,04 T
(c) 88 Ae (d) $0,4 \times 10^3$ gauss
- (a) 20,06 mH (b) taxa de aumento = μ_r
- (a) 42,3 mH (b) 1,57 mH
(c) 75,2 mH (d) 1,76 H
- 6,0 V
- 14 voltas
- (a) 15 μs
(b) $i_L = 1 \text{ mA} (1 - e^{-t/15} \mu\text{s})$
(c) $v_L = 20 \text{ V} e^{-t/15} \mu\text{s}$
 $v_R = 20 \text{ V} (1 - e^{-t/15} \mu\text{s})$
(d) i_L : $1\tau = 0,632 \text{ mA}$, $3\tau = 0,951 \text{ mA}$, $5\tau = 0,993 \text{ mA}$; v_L : $1\tau = 7,36 \text{ V}$, $3\tau = 0,98 \text{ V}$, $5 = 140 \text{ mV}$
- $R = 1,2 \text{ k}\Omega$, $L = 3,6 \text{ mH}$
- (a) $i_L = 9,23 \text{ mA} - 17,23 \text{ mA} e^{-t/30,77} \mu\text{s}$, $v_L = 67,2 \text{ V} e^{-t/30,77} \mu\text{s}$
- (a) $i_L = 2 \text{ mA} + 4 \text{ mA} e^{-t/19,23} \mu\text{s}$,
 $v_L = 41,6 \text{ V} e^{-t/19,23} \mu\text{s}$
- (a) $i_L = 6 \text{ mA} (1 - e^{-t/0,5} \mu\text{s})$,
 $v_L = 12 \text{ V} e^{-t/0,5} \mu\text{s}$
(b) $i_L = 5,19 \text{ mA} e^{-t/83,3} \mu\text{s}$,
 $v_L = 62,28 \text{ V} e^{-t/83,3} \text{ ms}$
- (a) $i_L = 1,3 \text{ mA} (1 - e^{-t/7,56} \mu\text{s})$,
 $v_L = 8,09 \text{ V} e^{-t/7,56} \mu\text{s}$
(b) 0,822 mA, 2,98 V
- (a) $i_L = -4,54 \text{ mA} (1 - e^{-t/6,67} \mu\text{s})$,
 $v_L = -6,81 \text{ V} e^{-t/6,67} \mu\text{s}$
(b) $i_L = -3,53 \text{ mA}$, $v_L = 1,52 \text{ V}$
(c) $i_L = -3,53 \text{ mA} e^{-t/2,13} \mu\text{s}$,
 $v_L = +16,59 \text{ V} e^{-t/2,13} \mu\text{s}$
- (a) $i_L = 0,68 \text{ mA} + 1,32 \text{ mA} e^{-t/0,49} \text{ ms}$,
 $v_L = -5,43 \text{ V} e^{-t/0,49} \text{ ms}$
- (a) 0,92 μs (b) 16,2 V
(c) 0,81 V
- (a) 4,88 mA (b) 99,33 mA
(c) 13,86 ms
- (a) 13,33 V (b) 7,98 μA
(c) 4,12 μs (d) 0,244 V
- 0 ms–2 ms: 37,5 mV; 2 ms–6 ms: –37,5 mV; 6 ms–9 ms: +25 mV; 9 ms–13 ms: 0 V; 13 ms–14 ms: +25 mV; 14 ms–17 ms: 0 V; 17 ms–19 ms: –12,5 mV
- 10,75 mH
- 6,8 mH, 5,7 k Ω ,
9,1 k $\Omega \parallel 2,45 \text{ mH}$
- 25 mH, 2,2 k Ω , 18 μF
- (a) $i_L = 3,56 \text{ mA} (1 - e^{-t/8,31} \mu\text{s})$,
 $v_L = 4,29 \text{ V} e^{-t/8,31} \mu\text{s}$
- $I_1 = 7 \text{ A}$, $I_2 = 2 \text{ A}$
- $V_1 = 12 \text{ V}$, $I_1 = 3 \text{ A}$, $V_2 = -8 \text{ V}$, $I_2 = 0 \text{ A}$

Capítulo 12

- Φ : CGS: 5×10^4 maxwells; inglês: 5×10^4 linhas
 B : CGS: 8 gauss; inglês: 51,62 linhas/pol.²
- (a) 0,04 T
- $952,4 \times 10^3 \text{ Ae/Wb}$
- 2.624,67 Ae/m
- 2,13 A
- (a) 60 t (b) $13,34 \times 10^{-4} \text{ Wb/Am}$
- 2,70 A
- 1,35 N
- (a) 2,02 A (b) 2 N
- 6,12 mWb
- (a) $B = 1,5 \text{ T} (1 - e^{-H/700 \text{ Ae/m}})$
(b) 900 At/m: gráfico = 1,1 T, Eq. = 1,09 T; 1.800 Ae/m: gráfico = 1,38 T, Eq. = 1,39 T; 2.700 Ae/m: gráfico = 1,47 T, Eq. = 1,47 T
Resultados excelentes
(c) $H = -700 \log_e(1 - \frac{8}{1,5T})$
(d) 1 T: gráfico = 750 Ae/m, Eq. = 769,03 Ae/m; 1,4 T: gráfico = 1.920 Ae/m, Eq. = 1895,64 Ae/m
(e) 40,1 mA vs. 44 mA no Exemplo 12.1

Capítulo 13

- (a) 10 V (b) 15 ms: –10 V, 20 ms: 0 V
(c) 20 V (d) $T = 20 \text{ ms}$
- (a) 40 mV (b) 1,5 ms: –40 mV; 5,1 ms: –40 mV
(c) 80 mV (d) 2 ms
(e) 3,5
- (a) 1 Hz (b) 16 Hz
(c) 25 Hz (d) 40 kHz
- 0,3 ms
- (a) 125 mV (b) 32 μs
(c) 31,25 kHz
- (a) 60° (b) 216°
(c) 18°
(d) 108°
- (a) 628,32 rad/s
(b) $1,57 \times 10^3 \text{ rad/s}$
(c) $12,56 \times 10^3 \text{ rad/s}$
(d) $25,13 \times 10^3 \text{ rad/s}$
- 2,78 ms
- (a) 20, 60 Hz (b) 12.120 Hz
(c) 10^6 , 1591,55 Hz (d) 8, 1,6 kHz
- 0,48 A
- 11,54°, 168,46°
- (a) $v = 6 \times 10^{-3} \text{ sen}(2\pi \cdot 2.000t + 30^\circ)$
(b) $i = 20 \times 10^{-3} \text{ sen}(2\pi \cdot 60t - 60^\circ)$
- $v = 12 \times 10^{-3} \text{ sen}(2\pi \cdot 2.000t + 135^\circ)$
- v adiantada 90° em relação a i
- em fase
- 13,95 μs
- $\frac{1}{12} \text{ ms}$
- 1 V

- 2,33 V
- (a) 0 V (b) 0 V
(c) o mesmo
- (a) 0,4 ms (b) 2,5 kHz
(c) –25 mV
- (a) 84,85 V (b) 4,24 mA
(c) 5,66 μA
- 1,43 V
- $G = 0 \text{ V}$, $V_{\text{rms}} = 8 \text{ V}$
- (a) $y = 2x \Rightarrow y^2 = 4x^2$
(b) 360 (c) 5,48 (d) 3,67
(e) rms $\cong 1,5$ média

Capítulo 14

-
- (a) 3.770 cos 377t
(b) 120 cos(200t + 20°)
(c) 4.440,63 cos(157t – 20°)
(d) 200 cos t
- (a) $v = 700 \text{ sen } 1.000t$
(b) $v = 14,8 \text{ sen}(400t - 120^\circ)$
- (a) 22 mH (b) 1,2 H
- (a) $v = 100 \text{ sen}(\omega t + 90^\circ)$
(b) $v = 0,8 \text{ sen}(\omega t + 150^\circ)$
(c) $v = 120 \text{ sen}(\omega t - 120^\circ)$
- (a) $i = 24 \text{ sen}(\omega t - 90^\circ)$
(b) $i = 0,6 \text{ sen}(\omega t - 70^\circ)$
- (a) $\infty \Omega$ (b) 530,79 Ω
(c) 15,92 Ω (d) 62,83 Ω
- (a) 4,08 kHz (b) 34 Hz
(c) 408,09 kHz (d) 20,40 Hz
- (a) $i = 6 \times 10^{-3} \text{ sen}(200t + 90^\circ)$
(b) $i = 22,64 \times 10^{-6} \text{ sen}(377t + 90^\circ)$
- (a) $v = 1.190,48 \text{ sen}(300t - 90^\circ)$
(b) $v = 37,81 \text{ sen}(377t - 120^\circ)$
- (a) $X_C = 400 \Omega$
(b) $X_L = 40 \Omega$, $L = 254,78 \text{ mH}$
(c) $R = 5\Omega$
-
- 318,47 mH
- 5.070 pF
- 192 W em cada caso
- $i = 40 \text{ sen}(\omega t - 50^\circ)$
- (a) $i = 4,27 \text{ sen}(1.000t - 30^\circ)$
(b) 30 mH (c) 0 W
- (a) $i_1 = 2,4 \text{ sen}(10^4t + 150^\circ)$,
 $i_2 = 12 \text{ sen}(10^4t + 150^\circ)$
(b) $i_3 = 14,40 \text{ sen}(10^4t + 150^\circ)$
- (a) 5,0 $\angle 36,87^\circ$ (b) 2,83 $\angle 45^\circ$
(c) 12,65 $\angle 7,57^\circ$
(d) 1.001,25 $\angle 2,86^\circ$
(e) 4.123,11 $\angle 104,04^\circ$
(f) 0,894 $\angle 116,57^\circ$
- (a) $4,6 + j 3,86$
(b) $-6,0 + j 10,39$ (c) $-j 2.000$
(d) $-0,006 - j 0,0022$
(e) 47,97 + $j 1,68$
(f) $4,7 \times 10^{-4} - j 1,71 \times 10^{-4}$
- (a) 11,8 + $j 7,0$
(b) 151,90 + $j 49,90$
(c) $4,72 \times 10^{-6} + j 71$
- (a) 7,03 + $j 9,93$
(b) 95,7 + $j 22,77$
(c) 28,07 $\angle -115,91^\circ$

45. (a) $8,00 \angle 20^\circ$
 (b) $49,68 \angle -64,0^\circ$
 (c) $40 \times 10^{-3} \angle 40^\circ$
47. (a) $4 \angle 0^\circ$ (b) $5,93 \angle -134,47^\circ$
 (c) $9,30 \angle -43,99^\circ$
49. (a) $5,06 \angle 88,44^\circ$
 (b) $426 \angle 109,81^\circ$
51. (a) $x = 3, y = 6$ ou $x = 6, y = 3$
 (b) $\theta = 30^\circ$
53. (a) $14,14 \angle -180^\circ$
 (b) $4,24 \times 10^{-6} \angle 90^\circ$
 (c) $2,55 \times 10^{-6} \angle 70^\circ$
55. $v_a = 63,25 \text{ sen}(377t + 63,43^\circ)$
 57. $v_a = 108,92 \text{ sen}(377t - 0,33^\circ)$

Capítulo 15

1. (a) $6,8 \Omega \angle 0^\circ = 6,8 \Omega$
 (b) $452,4 \Omega \angle 90^\circ = +j 452,4 \Omega$
 (c) $1,48 \Omega \angle 90^\circ + j 1,48 \Omega$
 (d) $1 \text{ k}\Omega \angle -90^\circ = -j 1 \text{ k}\Omega$
 (e) $33,86 \Omega \angle -90^\circ = -j 33,86 \Omega$
 (f) $220 \Omega \angle 0^\circ = 220 \Omega$
3. (a) $v = 88 \times 10^{-3} \text{ sen } 1.000t$
 (b) $v = 22,62 \text{ sen}(2\pi 200t + 150^\circ)$
 (c) $v = 270,96 \text{ sen}(157t - 50^\circ)$
5. (a) $3 \Omega - j 1 \Omega = 3,16 \Omega \angle -18,43^\circ$
 (b) $1 \text{ k}\Omega + j 4 \text{ k}\Omega = 4,12 \text{ k}\Omega \angle 75,96^\circ$
 (c) $470 \Omega - j 40 \Omega = 471,7 \Omega \angle -4,86^\circ$
7. (a) $10 \Omega \angle 36,87^\circ$ (b) —
 (c) $I = 10 \text{ A} \angle -36,87^\circ$,
 $V_R = 80 \text{ V} \angle -36,87^\circ$,
 $V_L = 60 \text{ V} \angle 53,13^\circ$ (d) —
 (e) — (f) 800 W
 (g) $0,8$ atrasado
 (h) $v_R = 113,12 \text{ sen}(\omega t - 36,87^\circ)$,
 $v_L = 84,84 \text{ sen}(\omega t + 53,13^\circ)$,
 $i = 14,14 \text{ sen}(\omega t - 36,87^\circ)$
9. (a) $5,66 \Omega \angle -45^\circ$ (b) —
 (c) $L = 16 \text{ mH}$, $C = 265 \mu\text{F}$
 (d) $I = 8,83 \text{ A} \angle 45^\circ$,
 $V_R = 35,32 \text{ V} \angle 45^\circ$,
 $V_L = 52,98 \text{ V} \angle 135^\circ$,
 $V_C = 88,30 \text{ V} \angle -45^\circ$ (e) —
 (f) — (g) $311,8 \text{ W}$
 (h) $0,707$ adiantado
 (i) $i = 12,49 \text{ sen}(377t + 4,5^\circ)$,
 $e = 70,7 \text{ sen } 377t$,
 $v_R = 49,94 \text{ sen}(377t + 45^\circ)$,
 $v_L = 74,91 \text{ sen}(377t + 135^\circ)$,
 $v_C = 124,86 \text{ sen}(377t - 45^\circ)$
11. $6,8 \Omega$
 13. (a) $292,4 \mu\text{A}$ (b) 100 pF
 15. (a) $V_1 = 14,14 \text{ V} \angle -155^\circ$,
 $V_2 = 28,29 \text{ V} \angle 25^\circ$
 (b) $V_1 = 112,92 \text{ V}$,
 $V_2 = 58,66 \text{ V} \angle -139,94^\circ$
17. $3,2 \Omega + j 2,4 \Omega$
 19. —
 21. —
 23. (a) $Y_T = 0,147 \text{ S} \angle 0^\circ = 0,147 \text{ S}$

- (b) $Y_T = 5 \text{ mS} \angle -90^\circ = -j 5 \text{ mS}$
 (c) $Y_T = 0,5 \text{ mS} \angle 90^\circ = +j 0,5 \text{ mS}$
25. (a) $54,7 \text{ mS} - j 93,12 \text{ mS}$
 (b) $6,88 \text{ mS} - j 9,08 \text{ mS}$
 (c) $4 \text{ mS} + j 2 \text{ mS}$
27. (a) $111,8 \text{ mS} \angle -26,57^\circ$ (b) —
 (c) $E = 17,89 \text{ V} \angle 26,57^\circ$,
 $I_R = 1,79 \text{ A} \angle 26,57^\circ$,
 $I_L = 0,89 \text{ A} \angle -63,43^\circ$
 (d) —
 (e) — (f) $32,04 \text{ W}$
 (g) $0,894$ atrasado
 (h) $e = 25,30 \text{ sen}(377t + 26,57^\circ)$,
 $i_R = 2,58 + \text{sen}(377t + 26,57^\circ)$,
 $i_L = 1,26 \text{ sen}(377t - 63,43^\circ)$,
 $i_S = 2,83 \text{ sen } 377t$
29. (a) $Y_T = 0,89 \text{ S} \angle -19,81^\circ$,
 $Z_T = 1,12 \Omega \angle 19,81^\circ$ (b) —
 (c) $C = 531 \mu\text{F}$, $L = 5,31 \text{ mH}$
 (d) $E = 2,40 \text{ V} \angle 79,81^\circ$,
 $I_R = 2,00 \text{ A} \angle 79,81^\circ$,
 $I_L = 1,20 \text{ A} \angle -10,19^\circ$,
 $I_C = 0,48 \text{ A} \angle 169,81^\circ$ (f) —
 (g) $4,8 \text{ W}$ (h) $0,941$ atrasado
 (i) $e = 3,39 \text{ sen}(377t + 79,81^\circ)$,
 $i_R = 2,83 \text{ sen}(377t + 79,81^\circ)$,
 $i_L = 1,70 \text{ sen}(377t - 10,19^\circ)$,
 $i_C = 0,68 \text{ sen}(377t + 169,81^\circ)$
31. (a) $I_1 = 18,78 \text{ A} \angle 60,14^\circ$,
 $I_2 = 6,88 \text{ A} \angle -29,86^\circ$
 (b) $I_1 = 6,62 \text{ A} \angle 12,89^\circ$,
 $I_2 = 1,97 \text{ A} \angle 129,46^\circ$
 (c) $I_1 = 2,4 \text{ A} \angle 0^\circ$, $I_2 = 1,6 \text{ A} \angle 0^\circ$
33. —
 35. —
 37. (a) $R_p = 100 \Omega$, $X_p = 50 \Omega$ (C)
 (b) $R_p = 34 \text{ k}\Omega$, $X_p = 8,5 \text{ k}\Omega$ (L)
39. (a) $E = 176,68 \text{ V} \angle 36,44^\circ$,
 $I_R = 0,803 \text{ A} \angle 36,44^\circ$,
 $I_L = 2,813 \text{ A} \angle -53,56^\circ$
 (b) $0,804$ atrasado
 (c) $141,86 \text{ W}$
 (d) — (e) —
 (f) $1,11 \text{ A} \angle 126,43^\circ$
 (g) $142,15 \Omega + j 104,96 \Omega$

Capítulo 16

1. (a) $4 \Omega \angle -22,65^\circ$
 (b) $3,5 \text{ A} \angle 22,65^\circ$
 (c) $3,5 \text{ A} \angle 22,65^\circ$
 (d) $1,94 \text{ A} \angle -33,66^\circ$
 (e) $14 \text{ V} \angle 112,65^\circ$
3. (a) $19,86 \Omega \angle 37,17^\circ$
 (b) $3,02 \text{ A} \angle -37,17^\circ$
 (c) $3,98 \text{ A} \angle 52,83^\circ$
 (d) $47,81 \text{ V} \angle -37,17^\circ$
 (e) $144,42 \text{ W}$
5. (a) $0,25 \text{ A} \angle 36,86^\circ$
 (b) $89,44 \text{ V} \angle -26,57^\circ$ (c) 20 W
7. (a) $1,42 \text{ A} \angle 18,26^\circ$
 (b) $26,57 \text{ V} \angle 4,76^\circ$ (c) $54,07 \text{ W}$
9. (a) $537,51 \Omega \angle 56,07^\circ$

- (b) $93 \text{ mA} \angle -56,07^\circ$
 (c) $I_1 = 106,48 \text{ mA} \angle -56,07^\circ$,
 $I_2 = 13,48 \text{ mA} \angle 123,93^\circ$
 (d) $V_1 = 16,93 \text{ V} \angle 213,93^\circ$,
 $V_{ab} = 41,49 \text{ V} \angle 33,92^\circ$
 (e) $2,595 \text{ W}$ (f) $0,558$ atrasado
11. (a) $1,52 \Omega \angle -38,89^\circ$
 (b) $42,43 \text{ V} \angle 45^\circ$
 (c) $14,14 \text{ A} \angle 45^\circ$
 (d) $39,47 \text{ A} \angle 38,89^\circ$
13. $139,71 \text{ mW}$

Capítulo 17

1. —
 3. $Z = 5,15 \Omega \angle 59,04^\circ$,
 $E = 10,30 \text{ V} \angle 179,04^\circ$
 5. $5,15 \text{ A} \angle -24,5^\circ$
 7. $2,55 \text{ A} \angle 132,72^\circ$
 9. $48,33 \text{ A} \angle -77,57^\circ$
 11. $0,68 \text{ A} \angle -162,9^\circ$
 13. $42,91 \text{ I} \angle 149,31^\circ$
 15. $2,69 \text{ mA} \angle -174,8^\circ$
 17. $V_1 = 14,68 \text{ V} \angle 68,89^\circ$,
 $V_2 = 12,97 \text{ V} \angle 155,88^\circ$
 19. $V_1 = 19,86 \text{ V} \angle 43,8^\circ$,
 $V_2 = 8,94 \text{ V} \angle 106,9^\circ$
 21. $V_1 = 220 \text{ V} \angle 0^\circ$,
 $V_2 = 96,30 \text{ V} \angle -12,32^\circ$,
 $V_3 = 100 \text{ V} \angle 90^\circ$
 23. $V_1 = 5,74 \text{ V} \angle 122,76^\circ$,
 $V_2 = 4,04 \text{ V} \angle 145,03^\circ$,
 $V_3 = 25,94 \text{ V} \angle 78,07^\circ$
 25. $V_1 = 4,37 \text{ V} \angle -128,66^\circ$,
 $V_2 = V_{1\text{k}\Omega} = 2,25 \text{ V} \angle 17,63^\circ$
 27. $V_1 = V_{2\text{k}\Omega} = 10,67 \text{ V} \angle 180^\circ$,
 $V_2 = 6 \text{ V} \angle 180^\circ$
 29. $V_L = -2.451,92 \text{ E}_i$
 31. (a) desequilibrado
 (b) $I_{X_C} = 1,76 \text{ mA} \angle -71,54^\circ$
 (c) $V_{X_C} = 7,03 \text{ V} \angle -18,46^\circ$
33. equilibrado
 35. $R_x = \frac{R_2 R_3}{R_1}$, $L_x = \frac{R_2 L_3}{R_1}$
 37. $7,02 \text{ A} \angle 20,56^\circ$
 39. $36,9 \text{ A} \angle 23,87^\circ$

Capítulo 18

1. $6,09 \text{ A} \angle -32,12^\circ$
 3. $3,40 \text{ A} \angle 135,36^\circ$
 5. $v_c = 12 \text{ V} + 3,75 \text{ sen}(\omega t - 83,66^\circ)$
 7. $178,5 \text{ mA} \angle -26,57^\circ$
 9. $70,61 \text{ mA} \angle -11,31^\circ$
 11. $2,94 \text{ mA} \angle 0^\circ$
 13. $Z_{Th} = 2,4 \Omega \angle 36,87^\circ$,
 $E_{Th} = 80 \text{ V} \angle 36,87^\circ$
 15. $Z_{Th} = 21,31 \Omega \angle 32,2^\circ$,
 $E_{Th} = 2,13 \text{ V} \angle 32,2^\circ$
 17. $Z_{Th} = 5,00 \Omega \angle -38,66^\circ$,
 $E_{Th} = 77,14 \text{ V} \angle 50,41^\circ$
 19. (a) CC: $R_{Th} = 22 \Omega$, $E_{Th} = -5 \text{ V}$;
 CA: $Z_{Th} = 66,04 \Omega \angle 57,36^\circ$,
 $E_{Th} = 6,21 \text{ V} \angle 207,36^\circ$

- (b) $i = -72,46 \text{ mA} + 62,36 \times 10^{-3} \text{ sen}(1.000t + 173,42^\circ)$
21. (a) $Z_{Th} = 4,47 \text{ k}\Omega \angle -26,57^\circ$,
 $E_{Th} = 31,31 \text{ V} \angle -26,57^\circ$
 (b) $6,26 \text{ mA} \angle 63,44^\circ$
23. $Z_{Th} = 4,44 \text{ k}\Omega \angle -0,03^\circ$,
 $E_{Th} = -444,45 \times 10^3 \text{ V} \angle 0,26^\circ$
25. $Z_{Th} = 5,10 \text{ k}\Omega \angle -11,31^\circ$,
 $E_{Th} = -50 \text{ V} \angle 0^\circ$
27. $Z_{Th} = -39,22 \Omega \angle 0^\circ$,
 $E_{Th} = 20 \text{ V} \angle 53^\circ$
29. $Z_{Th} = 607,42 \Omega \angle 0^\circ$,
 $E_{Th} = 1,62 \text{ V} \angle 0^\circ$
31. $Z_N = 21,31 \Omega \angle 32,2^\circ$,
 $I_N = 0,1 \text{ A} \angle 0^\circ$
33. $Z_N = 9,66 \Omega \angle 14,93^\circ$,
 $I_N = 2,15 \text{ A} \angle -42,87^\circ$
35. (a) CC: $R_N = 22 \Omega$,
 $I_N = -227,27 \text{ mA}$;
 CA: $Z_N = 66,04 \Omega \angle 57,36^\circ$,
 $I_N = 94 \text{ mA} \angle 150^\circ$
 (b) $I = -72,46 \text{ mA} + 62,68 \times 10^{-3} \text{ sen}(1.000t + 173,22^\circ)$
37. (a) $Z_N = 4,47 \text{ k}\Omega \angle -26,57^\circ$,
 $I_N = 7 \text{ mA} \angle 0^\circ$
 (b) $6,26 \text{ mA} \angle 63,44^\circ$
39. $Z_N = 4,44 \text{ k}\Omega \angle -0,03^\circ$,
 $I_N = 1001 \angle 0,29^\circ$
41. $Z_N = 25 \text{ k}\Omega \angle 0^\circ$,
 $I_N = 72 \text{ mA} \angle 0^\circ$
43. $Z_N = 6,65 \text{ k}\Omega \angle 0^\circ$,
 $I_N = 0,79 \text{ mA} \angle 0^\circ$
45. $Z_L = 1,51 \Omega - j 0,39 \Omega$,
 $P_{\text{máx}} = 1,61 \text{ W}$
47. $Z_L = 2,48 \Omega + j 5,15 \Omega$,
 $P_{\text{máx}} = 618,33 \text{ W}$
49. $Z_L = 1,38 \text{ k}\Omega - j 5,08 \text{ k}\Omega$,
 $P_{\text{máx}} = 50,04 \text{ mW}$
51. (a) $Z_L = 4 \text{ k}\Omega + j 2 \text{ k}\Omega$
 (b) $61,27 \text{ mW}$
53. (a) $7,31 \text{ nF}$ (b) $2.940,27 \Omega$
 (c) 1 mW
55. (a) $0,83 \text{ mA} \angle 0^\circ$
 (b) $0,83 \text{ mA} \angle 0^\circ$
 (c) o mesmo

Capítulo 19

1. (a) 130 W (b) $Q_T = 0 \text{ VAR}$,
 $S_T = 130 \text{ VA}$ (c) $0,542 \text{ A}$
 (d) $R_1 = 371,6 \Omega$, $R_2 = 668,9 \Omega$
 (e) $I_1 = 0,348 \text{ A}$, $I_2 = 0,193 \text{ A}$
3. (a) $P_T = 400 \text{ W}$, $Q_T = -400 \text{ VAR}$
 (C), $S_T = 565,69 \text{ VA}$,
 $F_p = 0,707$ (adiantado) (b) —
 (c) $5,66 \text{ A} \mu 135^\circ$
5. (a) $P_T = 350 \text{ W}$, $Q_T = -450 \text{ VAR}$ (C),
 $S_T = 570,09 \text{ VA}$
 (b) $0,614$ (adiantado) (c) —
 (d) $11,4 \text{ A} \angle 52,12^\circ$
7. (a) $P_R = 200 \text{ W}$, $P_{L,C} = 0 \text{ W}$
 (b) $Q_R = 0 \text{ VAR}$, $Q_C = 800 \text{ VAR}$ (C),
 $Q_L = 100 \text{ VAR}$ (L)

- (c) $S_R = 200 \text{ VA}$,
 $S_C = 80 \text{ VA}$, $S_L = 100 \text{ VA}$
- (d) $P_T = 200 \text{ W}$, $Q_T = 20 \text{ VAR}$ (L),
 $S_T = 200 \text{ VA}$,
 $F_p = 0,995$ atrasado (e) —
 (f) $10,05 \text{ A} \angle -5,73^\circ$
9. (a) $P_L = 0 \text{ W}$, $P_C = 0 \text{ W}$,
 $P_R = 38,99 \text{ W}$
 (b) $Q_L = 126,74 \text{ VAR}$, $Q_C = 46,92 \text{ VAR}$, $Q_R = 0 \text{ VAR}$
 (c) $S_L = 126,74 \text{ VA}$,
 $S_C = 46,92 \text{ VA}$, $S_R = 38,99 \text{ VA}$
 (d) $P_T = 38,99 \text{ W}$,
 $Q_T = 79,82 \text{ VAR}$ (L), $S_T = 88,83 \text{ VA}$, $F_p = 0,439$ (atrasado)
 (e) — (f) $0,31 \text{ J}$
 (g) $W_L = 0,32 \text{ J}$, $W_C = 0,12 \text{ J}$
11. (a) $Z_T = 2,30 \Omega + j 1,73 \Omega$
 (b) 4.000 W
13. (a) $P_T = 900 \text{ W}$, $Q_T = 0 \text{ VAR}$,
 $S_T = 900 \text{ VA}$, $F_p = 1$
 (b) $9 \text{ A} \angle 0^\circ$ (c) —
 (d) carga 1: $X_C = 20 \Omega$; carga 2: $R = 2,83 \Omega$;
 carga 3: $R = 5,66 \Omega$; $X_L = 4,72 \Omega$
15. (a) $P_T = 1.100 \text{ W}$,
 $Q_T = 2.366,26 \text{ VAR}$ (C),
 $S_T = 2.609,44 \text{ VA}$,
 $F_p = 0,422$ (adiantado)
 (b) $521,89 \text{ V} \angle -65,07^\circ$
 (c) carga 1: $R = 1743,38 \Omega$,
 $X_C = 1307,53 \Omega$; carga 2:
 $R = 43,59 \Omega$, $X_C = 99,88 \Omega$
17. (a) $7,81 \text{ kVA}$ (b) $0,640$ (atrasado)
 (c) $65,08 \text{ A}$ (d) $1.105 \mu\text{F}$
 (e) $41,67 \text{ A}$
19. (a) $128,14 \text{ W}$
 (b) a-b: $42,69 \text{ W}$, b-c: $64,03 \text{ W}$,
 a-c: $106,72 \text{ W}$, a-d: $106,72 \text{ W}$,
 c-d: 0 W , d-e: 0 W , f-e: $21,34 \text{ W}$
21. (a) $R = 5 \Omega$, $L = 132,03 \text{ mH}$
 (b) $R = 10 \Omega$
 (c) $R = 15 \Omega$, $L = 262,39 \text{ mH}$

Capítulo 20

1. (a) $\omega_s = 250 \text{ rad/s}$, $f = 39,79 \text{ Hz}$
 (b) $\omega_s = 3496,50 \text{ rad/s}$,
 $f_s = 556,49 \text{ Hz}$
3. (a) $2 \text{ k}\Omega$ (b) 120 mA
 (c) $V_R = 12 \text{ V}$, $V_L = 240 \text{ V}$,
 $V_C = 240 \text{ V}$ (d) 20
 (e) $L = 63,7 \text{ mH}$, $C = 15.920 \text{ pF}$
 (f) 250 Hz
 (g) $f_1 = 4,88 \text{ kHz}$, $f_2 = 5,13 \text{ kHz}$
5. (a) 400 Hz
 (b) $f_1 = 5,8 \text{ kHz}$, $f_2 = 6,2 \text{ kHz}$
 (c) $X_L = X_C = 45 \Omega$
 (d) 375 mW
7. (a) 10 (b) 20Ω
 (c) $1,5 \text{ mH}$, $3,98 \mu\text{F}$
 (d) $f_1 = 1,9 \text{ kHz}$, $f_2 = 2,1 \text{ kHz}$
9. (a) $R = 10 \Omega$, $L = 13,26 \text{ mH}$,
 $C = 27,07 \mu\text{F}$, $f_1 = 8,34 \text{ kHz}$,
 $f_2 = 8,46 \text{ kHz}$

11. (a) 1 MHz (b) 160 kHz
 (c) $R = 720 \Omega$, $L = 0,716 \text{ mH}$,
 $C = 35,38 \text{ pF}$ (d) $56,23 \Omega$
13. (a) $159,16 \text{ kHz}$ (b) 4 V
 (c) 40 mA (d) 20
15. (a) $1,027 \text{ MHz}$ (b) $114,1 \text{ V}$
 (c) $13,69 \text{ W}$ (d) 669 mW
17. $R = 91 \text{ k}\Omega$ (mais próximo de $93,33 \text{ k}\Omega$),
 $C = 240 \text{ pF}$ (mais próximo de 250 pF)
19. (a) $f_s = 7,12 \text{ kHz}$,
 $f_p = 6,65 \text{ kHz}$, $f_m = 7,01 \text{ kHz}$
 (b) $X_L = 20,88 \Omega$, $X_C = 23,94 \Omega$
 (c) $55,56 \Omega$
 (d) $Q_p = 2,32$, $\text{BW} = 2,87 \text{ kHz}$
 (e) $I_C = 92,73 \text{ mA}$, $I_L = 99,28 \text{ mA}$
 (f) $2,22 \text{ V}$
21. (a) $3558,81 \text{ Hz}$
 (b) $138,2 \text{ V}$
 (c) 691 mW
 (d) $575,86 \text{ Hz}$
23. (a) $98,54 \Omega$ (b) $8,21$
 (c) $8,05 \text{ kHz}$ (d) $4,83 \text{ V}$
 (e) $f_1 = 7,55 \text{ kHz}$, $f_2 = 8,55 \text{ kHz}$
25. $R_s = 2,79 \text{ k}\Omega$, $C = 31.660 \text{ pF}$
27. (a) $251,65 \text{ kHz}$ (b) $4,44 \text{ k}\Omega$
 (c) $14,05$ (d) $17,91 \text{ kHz}$
 (e) $f_s = 251,65 \text{ kHz}$,
 $Z_{Tp} = 49,94 \Omega$, $Q_p = 2,04$,
 $\text{BW} = 95,55 \text{ kHz}$
 (f) $f_s = 251,65 \text{ kHz}$,
 $Z_{Tp} = 13,33 \text{ k}\Omega$,
 $Q_p = 21,08$, $\text{BW} = 11,94 \text{ kHz}$
 (g) Circuito: $L/C = 100 \times 10^3$;
 parte (e): $L/C = 1 \times 10^3$;
 parte (f): $L/C = 400 \times 10^3$
 (h) Como a razão L/C aumentou,
 BW diminuiu e V_p aumentou,

Capítulo 21

1. (a) esquerdo: $1,54 \text{ kHz}$, direito: $5,62 \text{ kHz}$
 (b) inferior: $0,22 \text{ V}$, superior: $0,52 \text{ V}$
3. (a) 1000 (b) 10^{12} (c) $1,59$
 (d) $1,1$ (e) 10^{10}
 (f) $1513,56$
 (g) $10,02$ (h) $1.258.925,41$
5. $1,68$
7. $-0,30$
9. (a) $1,85$
 (b) $18,45 \text{ dB}$
11. $13,01$
13. $38,49$
15. $24,08 \text{ dB}_s$
17. —
19. (a) $f_c = 3617,16 \text{ Hz}$;
 $f = f_c : A_v = 0,707$;
 $f = 0,1f_c : A_v = 0,995$;
 $f = 0,5f_c : A_v = 0,894$;
 $f = 2f_c : A_v = 0,447$;
 $f = 10f_c : A_v = 0,0995$
 (b) $f = f_c : \theta = -45^\circ$;

- $f = 0,1f_c$: $\theta = -5,71^\circ$;
 $f = 0,5f_c$: $\theta = -26,57^\circ$;
 $f = 2f_c$: $\theta = -63,43^\circ$;
 $f = 10f_c$: $\theta = -84,29^\circ$
21. $C = 0,265 \mu\text{F}$
23. (a) $f_c = 3,62 \text{ kHz}$;
 $f = f_c$: $A_v = 0,707$;
 $f = 2f_c$: $A_v = 0,894$;
 $f = 0,5f_c$: $A_v = 0,447$;
 $f = 10f_c$: $A_v = 0,995$;
 $f = \frac{1}{10}f_c$: $A_v = 0,0995$
- (b) $f = f_c$: $\theta = 45^\circ$; $f = 2f_c$:
 $\theta = 26,57^\circ$; $f = 0,5f_c$: $\theta = 63,43^\circ$;
 $f = 10f_c$: $\theta = 5,71^\circ$; $f = \frac{1}{10}f_c$:
 $\theta = 84,29^\circ$
25. $R = 795,77 \Omega$, $R_{\text{padrão}} = 750 \Omega + 47 \Omega = 797 \Omega$
27. (a) seção passa-baixa:
 $f_{c1} = 795,77 \text{ Hz}$; seção passa-alta:
 $f_{c2} = 1,94 \text{ kHz}$;
 $f = f_{c1}$: $V_o = 0,654V_i$;
 $f = f_{c2}$: $V_o = 0,64V_i$;
 Para $f = f_{c1} + \frac{BW}{2} = 1,37 \text{ kHz}$;
 $V_o = 0,706V_i$
- (b) BW definida em $0,5V_i$;
 $f = 500 \text{ Hz}$: $V_o = 0,515V_i$;
 $f = 4 \text{ kHz}$: $V_o = 0,429V_i$; pelo gráfico BW $\cong 2,9 \text{ kHz}$ com $f_{\text{centro}} = 1,93 \text{ kHz}$
29. (a) $f_s = 98,1 \text{ kHz}$
 (b) $Q_s = 16,84$, BW = 5,83 kHz
 (c) $f = f_s$: $A_v = 0,93$;
 $f_1 = 95,19 \text{ kHz}$, $f_2 = 101,02 \text{ kHz}$;
 $f = f_1$: $V_o = 0,64 \text{ V}$; $f = f_2$: $V_b = 0,66 \text{ V}$
 (d) $f = f_s$: $V_{o,\text{máx}} = 0,93 \text{ V}$;
 $f_1 = 95,19 \text{ kHz}$, $V_o = 0,66 \text{ V}$;
 $f_2 = 101,02 \text{ kHz}$: $V_o = 0,66 \text{ V}$
31. (a) $Q_s = 12,5$
 (b) BW = 400 Hz, $f_1 = 4,8 \text{ kHz}$,
 $f_2 = 5,2 \text{ kHz}$
 (c) $f = f_s$, $V_o = 25 \text{ mV}$;
 (d) $f = f_s$: $V_o = 25 \text{ mV}$
33. (a) $f_p = 726,44 \text{ kHz}$ (banda de atenuação);
 $f(\text{banda de passagem}) = 2,01 \text{ MHz}$
35. (a), (b) $f_c = 7,20 \text{ kHz}$
 (c) $f = 0,5f_c$: $A_{v\text{dB}} = -7 \text{ dB}$;
 $f = 2f_c$: $A_{v\text{dB}} = -0,969 \text{ dB}$;
 $f = \frac{1}{10}f_c$: $A_{v\text{dB}} = -20,04 \text{ dB}$;
 $f = 10f_c$: $A_{v\text{dB}} = -0,043 \text{ dB}$
 (d) $f = 0,5f_c$: $A_v = 0,447$; $f = 2f_c$:
 $A_v = 0,894$;
 (e) $f = 0,5f_c$: $\theta = 63,43^\circ$;
 $f = f_c$: $\theta = 45^\circ$; $f = 2f_c$: $\theta = 26,57^\circ$
37. (a), (b) $f_c = 13,26 \text{ kHz}$
 (c) $f = 0,5f_c$: $A_{v\text{dB}} = -0,97 \text{ dB}$;
 $f = 2f_c$: $A_{v\text{dB}} = -6,99 \text{ dB}$;
 $f = \frac{1}{10}f_c$: $A_{v\text{dB}} = -0,04 \text{ dB}$;
 $f = 10f_c$: $A_{v\text{dB}} = -20,04 \text{ dB}$
 (d) $f = 0,5f_c$: $A_v = 0,894$;
 $f = 2f_c$: $A_v = 0,447$
 (e) $f = 0,5f_c$: $\theta = -26,57^\circ$;

- $f = f_c$: $\theta = -45^\circ$;
 $f = 2f_c$: $\theta = -63,43^\circ$
39. (a) $f_1 = 642,01 \text{ Hz}$,
 $f_c = 457,47 \text{ Hz}$, deslocamento vertical = -2,94 dB (b) $f = f_1$: $\theta = 45^\circ$;
 $f = f_c$: $\theta = 54,52^\circ$; $f = f_1/2$:
 $\theta = 63,44^\circ$; $f = \frac{1}{10}f_1$: $\theta = 84,29^\circ$;
 $f = 2f_1$: $\theta = 26,57^\circ$;
 $f = 10f_1$: $\theta = 5,71^\circ$
41. (a) $f_1 = 19,41 \text{ kHz}$, $f_c = 1,92 \text{ kHz}$, deslocamento vertical = -20 dB
 (b) $f = f_c = f_1$: $\theta = -39,29^\circ$;
 $f = 10 \text{ kHz}$: $\theta = -51,88^\circ$
43. (a) $f_1 = 945,66 \text{ Hz}$, $f_c = 7,59 \text{ kHz}$, deslocamento vertical = -18,08 dB
 (b) $f = f_1$: $\theta = 37,89^\circ$;
 $f = f_c$: $\theta = 37,89^\circ$;
 $f = 4 \text{ kHz}$: $\theta = 48,96^\circ$
45. (a) $f_1 = 180 \text{ Hz}$, $f_2 = 18 \text{ kHz}$, BW = 17.820 Hz, $f = 180 \text{ Hz}$;
 $A_{v\text{dB}} = -2,99 \text{ dB} \cong -3 \text{ dB}$,
 $f = 18 \text{ kHz}$: $A_{v\text{dB}} = -3,105 \text{ dB} \cong -3 \text{ dB}$
 (b) $f = f_1$: $\theta = 90^\circ$; $f = 1,8 \text{ kHz}$:
 $\theta = 0,12^\circ \cong 0^\circ$; $f = 18 \text{ kHz}$:
 $\theta = -90^\circ$
47. $A_v = -120 / [(1 - j 50/f)(1 - j 200/f)(1 + j f/36 \text{ kHz})]$
49. $A_v = 1 / (1 + j f/2000)$, $f_c = 2 \text{ kHz}$
51. $A_{v\text{dB}} = 20 \log_{10} \sqrt{1 + (f_1/1000)^2} + 20 \log_{10} \sqrt{1 + (f_2/2000)^2} + 40 \log_{10} 1 / \sqrt{1 + (f_3/3000)^2}$;
 $f = 1 \text{ kHz}$: $A_{v\text{dB}} = 3,06 \text{ dB}$,
 $f = 2 \text{ kHz}$: $A_{v\text{dB}} = 6,81 \text{ dB}$,
 $f = 3 \text{ kHz}$: $A_{v\text{dB}} = 9,1 \text{ dB}$
 0 dB inclinação para assíntota em 13,06 dB para $f \gg f_3$
53. (a) woofer, 400 Hz: $A_v = 0,673$;
 tweeter, 5 kHz: $A_v = 0,678$
 (b) woofer, 3 kHz: $A_v = 0,015$;
 tweeter, 3 kHz: $A_v = 0,337$
 (c) midrange, 3 kHz: $A_v = 0,998$

Capítulo 22

1. (a) 50 mH
 (b) $e_p = 1,6 \text{ V}$, $e_s = 5,12 \text{ V}$
 (c) $e_p = 15 \text{ V}$, $e_s = 12 \text{ V}$
3. (a) 355,56 mH
 (b) $e_p = 24 \text{ V}$, $e_s = 0,6 \text{ V}$
 (c) $e_p = 15 \text{ V}$, $e_s = 12 \text{ V}$
5. (a) 5 V (b) 625,59 μWb
7. 120 Hz
9. 30 Ω
11. 12.000 espiras
13. (a) 3 (b) 2,78 W
15. (a) 364,55 $\Omega \angle 86,86^\circ$
 (b) 329,17 mA $\angle -86,86^\circ$
 (c) $V_{Re} = 6,58 \text{ V} \angle -86,86^\circ$,
 $V_{Xe} = 14,48 \text{ V} \angle 3,14^\circ$,
 $V_{XL} = 105,33 \text{ V} \angle 3,14^\circ$
17. —
19. 3,2 H

21. $I_1(Z_{R1} + Z_{L1}) + I_2(Z_m) = E_1$;
 $I_1(Z_m) + I_2(Z_{L2} + Z_{R2}) = 0$
23. (a) 20 (b) 83,33 A
 (c) 4,17 A
 (d) $I_s = 4,17 \text{ A}$, $I_p = 83,33 \text{ A}$
25. (a) $V_L = 25 \text{ V} \angle 0^\circ$
 (b) $I_L = 5 \text{ A} \angle 0^\circ$
 (c) $Z_L = 80 \Omega \angle 0^\circ$
 (d) $Z_{1/2} = 20 \Omega \angle 0^\circ$
27. (a) $E_Z = 40 \text{ V} \angle 0^\circ$,
 $I_2 = 3,33 \text{ A} \angle 60^\circ$,
 $E_3 = 30 \text{ V} \angle 60^\circ$, $I_3 = 3 \text{ A} \angle 60^\circ$
 (b) $R_1 = 64,52 \Omega$
29. $[Z_1 + Z_{L1}]I_1 - Z_{M12}I_2 - Z_{M13}I_3 = E_1$;
 $Z_{M12}I_1 - [Z_2 + Z_3 + Z_{L2}]I_2 + Z_2I_3 = 0$;
 $Z_{M13}I_1 + Z_2I_2 + [Z_2 + Z_4 + Z_{L3}]I_3 = 0$

Capítulo 23

1. (a) 120,1 V (b) 120,1 V
 (c) 12,01 A (d) 12,01 A
3. (a) 120,1 V (b) 120,1 V
 (c) 16,98 A (d) 16,98 A
5. (a) $\theta_2 = -120^\circ$, $\theta_3 = +120^\circ$
 (b) $V_{an} = 120 \text{ V} \angle 0^\circ$, $V_{bn} = 120 \text{ V} \angle -120^\circ$, $V_{cn} = 120 \text{ V} \angle 120^\circ$
 (c) $I_{an} = 8 \text{ A} \angle -53,13^\circ$,
 $I_{bn} = 8 \text{ A} \angle -173,13^\circ$,
 $I_{cn} = 8 \text{ A} \angle 66,87^\circ$ (e) 8 A
 (f) 207,85 V
7. $V_\phi = 127,0 \text{ V}$, $I_\phi = 8,98 \text{ A}$,
 $I_L = 8,98 \text{ A}$
9. (a) $E_{AN} = 12,7 \text{ kV} \angle -30^\circ$,
 $E_{BN} = 12,7 \text{ kV} \angle -150^\circ$,
 $E_{CN} = 12,7 \text{ kV} \angle 90^\circ$
 (b-c) $I_{an} = I_{Aa} = 11,29 \text{ A} \angle -97,54^\circ$, $I_{bn} = I_{Bb} = 11,29 \text{ A} \angle -217,54^\circ$, $I_{cn} = 11,29 \text{ A} \angle 22,46^\circ$
 (d) $V_{an} = 12,16 \text{ kV} \angle -29,34^\circ$,
 $V_{bn} = 12,16 \text{ kV} \angle -149,34^\circ$,
 $V_{cn} = 12,16 \text{ kV} \angle -90,66^\circ$
11. (a) 120,1 V (b) 208 V
 (c) 13,36 A (d) 23,15 A
13. (a) $\theta_2 = -120^\circ$, $\theta_3 = +120^\circ$
 (b) $V_{ab} = 208 \text{ V} \angle 0^\circ$,
 $V_{bc} = 208 \text{ V} \angle -120^\circ$,
 $V_{ca} = 208 \text{ V} \angle 120^\circ$
 (d) $I_{ab} = 9,46 \text{ A} \angle 0^\circ$,
 $I_{bc} = 9,46 \text{ A} \angle -120^\circ$,
 $I_{ca} = 9,46 \text{ A} \angle 120^\circ$
 (e) 16,38 A (f) 120,1 V
15. (a) $\theta_2 = -120^\circ$, $\theta_3 = +120^\circ$
 (b) $V_{ab} = 208 \text{ V} \angle 0^\circ$,
 $V_{bc} = 208 \text{ V} \angle -120^\circ$,
 $V_{ca} = 208 \text{ V} \angle 120^\circ$
 (d) $I_{ab} = 86,67 \text{ A} \angle -36,87^\circ$,
 $I_{bc} = 16,67 \text{ A} \angle -156,87^\circ$,
 $I_{ca} = 86,67 \text{ A} \angle 83,13^\circ$
 (e) 150,11 A (f) 120,1 V
17. (a) $I_{ab} = 15,33 \text{ A} \angle -73,30^\circ$,

- $I_{bc} = 15,33 \text{ A} \angle -193,30^\circ$
 $I_{ca} = 15,33 \text{ A} \angle 46,7^\circ$
(b) $I_{Aa} = 26,55 \text{ A} \angle -103,30^\circ$,
 $I_{Bb} = 26,55 \text{ A} \angle 136,70^\circ$,
 $I_{Cc} = 26,55 \text{ A} \angle 16,70^\circ$
(c) $E_{AB} = 17,01 \text{ kV} \angle -0,59^\circ$,
 $E_{BC} = 17,01 \text{ kV} \angle -120,59^\circ$,
 $E_{CA} = 17,01 \text{ kV} \angle 119,41^\circ$
19. **(a)** 208 V **(b)** 120,09 V
(c) 7,08 A **(d)** 7,08 A
21. $V_\phi = 69,28 \text{ V}$, $I_\phi = 2,89 \text{ A}$,
 $I_L = 2,89 \text{ A}$
23. $V_\phi = 69,28 \text{ V}$, $I_\phi = 5,77 \text{ A}$,
 $I_L = 5,77 \text{ A}$
25. **(a)** 440 V **(b)** 440 V
(c) 29,33 A **(d)** 50,8 A
27. **(a)** $\theta_2 = -120^\circ$, $\theta_3 = +120^\circ$
(b) $V_{ab} = 100 \text{ V} \angle 0^\circ$,
 $V_{bc} = 100 \text{ V} \angle -120^\circ$,
 $V_{ca} = 100 \text{ V} \angle 120^\circ$ **(d)** $I_{ab} = 5 \text{ A} \angle 0^\circ$, $I_{bc} = 5 \text{ A} \angle -120^\circ$,
 $I_{ca} = 5 \text{ A} \angle 120^\circ$ **(e)** 8,66 A
29. **(a)** $\theta_2 = -120^\circ$, $\theta_3 = +120^\circ$
(b) $V_{ab} = 100 \text{ V} \angle 0^\circ$,
 $V_{bc} = 100 \text{ V} \angle -120^\circ$,
 $V_{ca} = 100 \text{ V} \angle 120^\circ$ **(d)** $I_{ab} = 7,07 \text{ A} \angle 45^\circ$, $I_{bc} = 7,07 \text{ A} \angle -75^\circ$,
 $I_{ca} = 7,07 \text{ A} \angle 165^\circ$ **(e)** 12,25 A
31. $P_T = 2160 \text{ W}$, $Q_T = 0 \text{ VAR}$, $S_T = 2160 \text{ VA}$, $F_p = 1$
33. $P_T = 7210,67 \text{ W}$, $Q_T = 7210,67 \text{ VAR}$ (C),
 $S_T = 10.197,42 \text{ VA}$,
 $F_p = 0,707$ (adiantado)
35. $P_T = 7,26 \text{ kW}$, $Q_T = 7,26 \text{ kVAR}$ (L),
 $S_T = 10,27 \text{ kVA}$,
 $F_p = 0,707$ (atrasado)
37. $P_T = 287,93 \text{ W}$,
 $Q_T = 575,86 \text{ VAR}$ (L),
 $S_T = 643,83 \text{ VA}$,
 $F_p = 0,447$ (atrasado)
39. $P_T = 900 \text{ W}$, $Q_T = 1200 \text{ VAR}$ (L),
 $S_T = 1500 \text{ VA}$, $F_p = 0,6$ (atrasado)
41. $12,98 \Omega - j 7,31 \Omega$
43. **(a)** 9.237,6 V **(b)** 80 A
(c) 1276,8 kW **(d)** 0,576 atrasado
(e) $I_{Aa} = 80 \text{ A} \angle -54,83^\circ$
(f) $V_{an} = 7773,45 \text{ V} \angle -4,87^\circ$
(g) $62,52 \Omega + j 74,38 \Omega$
(h) Sistema: 0,576 atrasado; Carga: 0,643 atrasado **(i)** 93,98%
45. **(b)** $P_T = 5899,64 \text{ W}$,
 $P_{medador} = 1966,55 \text{ W}$
49. **(a)** 120,09 V **(b)** $I_{an} = 8,49 \text{ A}$,

- $I_{bn} = 7,08 \text{ A}$, $I_{cn} = 42,47 \text{ A}$
(c) $P_T = 4,93 \text{ kW}$, $Q_T = 4,93 \text{ kVAR}$ (L), $S_T = 6,97 \text{ kVA}$,
 $F_p = 0,707$ (atrasado)
(d) $I_{an} = 8,49 \text{ A} \angle -75^\circ$,
 $I_{bn} = 7,08 \text{ A} \angle -195^\circ$,
 $I_{cn} = 42,47 \text{ A} \angle 45^\circ$
(e) $35,09 \text{ A} \angle -43,00^\circ$

Capítulo 24

1. **(a)** positivo **(b)** 2 V
(c) 0,2 ms **(d)** 6 V **(e)** 6,5%
(f) 625 Hz **(g)** 12,5%
3. **(a)** positivo **(b)** 10 mV
(c) 3,2 ms **(d)** 20 mV
(e) 6,9%
5. $V_2 = 13,58 \text{ mV}$
7. **(a)** 120 μs **(b)** 8,33 kHz
(c) máximo: 440 mV; mínimo: 80 mV
9. $\text{prf} = 125 \text{ kHz}$
Ciclo de trabalho = 62,5%
11. **(a)** 8 μs **(b)** 2 μs
(c) 125 kHz
(d) 0 V **(e)** 3,46 mV
13. 18,88 mV
15. 117 mV
17. $v_C = 4 \text{ V} (1 - e^{-t/20 \text{ ms}})$
19. $i_C = -8 \text{ mA} e^{-t}$
21. $i_C = 4 \text{ mA} e^{-t/0,2 \text{ ms}}$
23. $0 \rightarrow \frac{t}{2}: v_C = 20 \text{ V}$,
 $\frac{t}{2} \rightarrow T: v_C = 20 \text{ V} e^{-t/0,2 \text{ ms}}$
 $T \rightarrow \frac{3}{2}T: v_C = 20 \text{ V} (1 - e^{-t/0,2 \text{ ms}})$
 $\frac{3}{2}T \rightarrow 2T: v_C = 20 \text{ V} e^{-t/0,2 \text{ ms}}$
25. $V_{\text{osc}} = 10 \text{ V} \angle 0^\circ$, $\theta_{z_s} = \theta_{z_p} = -59,5^\circ$

Capítulo 25

1. **(I)**: **(a)** não **(b)** não **(c)** sim
(d) não **(e)** sim
(II): **(a)** sim **(b)** sim **(c)** sim
(d) sim **(e)** não
(III): **(a)** sim **(b)** sim **(c)** não
(d) sim **(e)** sim
(IV): **(a)** não **(b)** não **(c)** sim
(d) sim **(e)** sim
7. **(a)** 19,04 V **(b)** 4,53 A
9. 71,87 W
(a) $2 + 2,08 \text{ sen}(400t - 33,69^\circ) + 0,5 \text{ sen}(800t - 53,13^\circ)$
(b) 2,51 A **(c)** $24 + 24,96 \text{ sen}(400t - 33,69^\circ) + 6 \text{ sen}(800t - 53,13^\circ)$ **(d)** 30,09 V

- (e)** $16,64 \text{ sen}(400t + 56,31^\circ) + 8 \text{ sen}(800t + 36,87^\circ)$ **(f)** 13,06 V
(g) 75,48 W
13. **(a)** $1,2 \text{ sen}(400t + 53,13^\circ)$
(b) 0,85 A **(c)** 18 sen
 $(400t + 53,13^\circ)$ **(d)** 12,73 V
(e) $18 + 23,98 \text{ sen}(400t - 36,87^\circ)$
(f) 24,73 V **(g)** 10,79 W
15. $2,26 \times 10^{-3} \text{ sen}(377t + 93,66^\circ) + 1,92 \times 10^{-3} \text{ sen}(754t + 1,64^\circ)$
17. $30 + 30,27 \text{ sen}(20t + 7,59^\circ) + 0,5 \text{ sen}(40t - 30^\circ)$

Capítulo 26

1. $Z_i = 986,84 \Omega$
3. **(a)** $I_{i1} = 10 \mu\text{A}$
(b) $Z_{i2} = 4,5 \text{ k}\Omega$
(c) $E_{i3} = 6,9 \text{ V}$
5. $Z_o = 44,59 \text{ k}\Omega$
7. $Z_o = 10 \text{ k}\Omega$
9. **(a)** $A_v = -392,98$
(b) $A_{vT} = -320,21$
11. **(a)** $A_{vNL} = -2398,8$
(b) $E_i = 50 \text{ mV}$
(c) $Z_i = 1 \text{ k}\Omega$
13. **(a)** $A_G = 6,067 \times 10^4$
(b) $A_{GT} = 4,94 \times 10^4$
15. **(a)** $A_{vT} = 1500$
(b) $A_{iT} = 187,5$
(c) $A_{i1} = 15$, $A_{i2} = 12,5$
(d) $A_{iT} = 187,5$
17. **(a)** $z_{11} = (Z_1 Z_2 + Z_1 Z_3) / (Z_1 + Z_2 + Z_3)$, $z_{12} = Z_1 Z_3 / (Z_1 + Z_2 + Z_3)$, $z_{21} = z_{12}$, $z_{22} = (Z_1 Z_3 + Z_2 Z_3) / (Z_1 + Z_2 + Z_3)$
19. **(a)** $y_{11} = (Y_1 Y_2 + Y_1 Y_3) / (Y_1 + Y_2 + Y_3)$, $y_{12} = -Y_1 Y_2 / (Y_1 + Y_2 + Y_3)$, $y_{21} = y_{12}$, $y_{22} = (Y_1 Y_2 + Y_2 Y_3) / (Y_1 + Y_2 + Y_3)$
21. $h_{11} = Z_1 Z_2 / (Z_1 + Z_2)$,
 $h_{21} = -Z_1 / (Z_1 + Z_2)$,
 $h_{12} = Z_1 / (Z_1 + Z_2)$,
 $h_{22} = (Z_1 + Z_2 + Z_3) / (Z_1 Z_3 + Z_2 Z_3)$
23. $h_{11} = (Y_1 + Y_2 + Y_3) / (Y_1 Y_2 + Y_1 Y_3)$, $h_{21} = -Y_2 / (Y_2 + Y_3)$,
 $h_{12} = Y_2 / (Y_2 + Y_3)$, $h_{22} = Y_2 Y_3 / (Y_2 + Y_3)$
25. **(a)** 47,62 **(b)** -99
27. $Z_i = 9.219,5 \Omega \angle -139,4^\circ$,
 $Z_o = 29,07 \text{ k}\Omega \angle -86,05^\circ$
29. $h_{11} = 2,5 \text{ k}\Omega$, $h_{12} = 0,5$,
 $h_{21} = -0,75$, $h_{22} = 0,25 \text{ mS}$