EL3210 Circuitos Elétricos   Prof: L. Romano

Livro: Análise de circuitos em engenharia (capa marrom)

J. David Irwin (4ª edição)

Conceitos básicos

1.1. Sistema de Unidades

SI - Sistema Internacional de unidade

Comprimento, metro [m]

Tempo, segundo [s]

Corrente Elétrica, Ampère [A]

Prefixos

Múltiplos:

T, Tera, 10^{12}

G, Giga, 10^{9}

M, Mega, 10^{6}

k, Quilo, 10^{3}

Sub-múltiplos:

m, mili, 10^{-3}

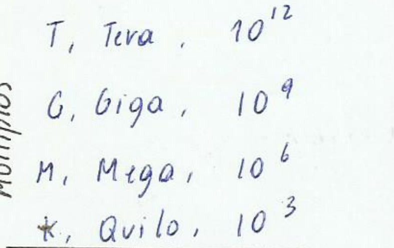
μ, micro, 10^{-6}

n, nano, 10^{-9}

p, pico, 10^{-12}

Quantidades básicas

Carga elétrica, Coulomb [C]



$$\frac{1\,[C]}{1\,[s]} = 1\,[A]$$

$$\boxed{i(t) = \frac{dq}{dt}}$$

tensão elétrica, Volt, [V].

Potência elétrica, watt [W]

$P = U \cdot I$

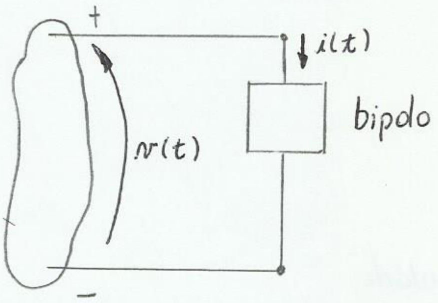
Energia elétrica [J] : Ws

$W = P \cdot t$

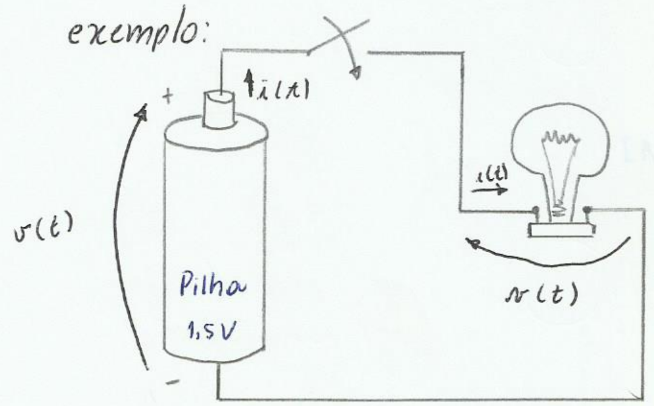
12-08-2011 EL3210 2ª aula

Capítulo Potência em bipolos

Seja um circuito onde está ligado um bipolo.



exemplo:



(convenção

Gerador: $v(t)$ e $i(t)$ tem o mesmo sentido

$$p(t) = v(t) \cdot i(t) \quad \text{onde } p<0$$

Receptor: $v(t)$ e $i(t)$ tem sentidos opostos

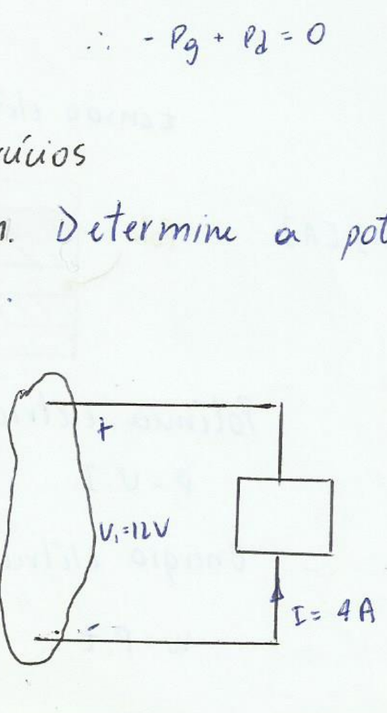
$$p(t) = v(t) \cdot i(t) \quad \text{onde } p>0$$

$$\therefore -P_g + P_d = 0 \qquad \text{Balanço energético}$$

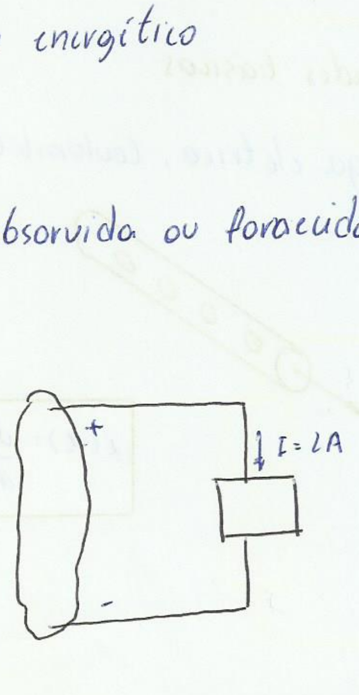
Exercícios

E.1.1. Determine a potência absorvida ou fornecida pelos componentes.

a)

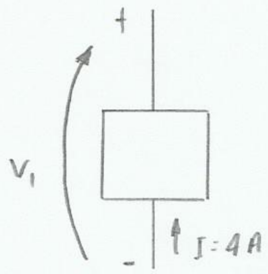


b)



Solução

a)

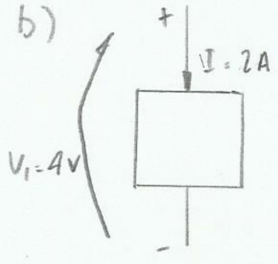


Gerador

$P = V_1 I = 12 \times 4 = 48W$

$P = -48W$

b)

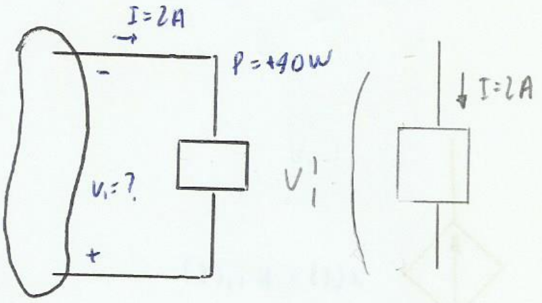


$P = V_1 I = 4 \cdot 2 = 8W$

$\therefore$ é um receptor, $P = 8W$

E1.2 Determine as váriaveis desconhecidas

a)



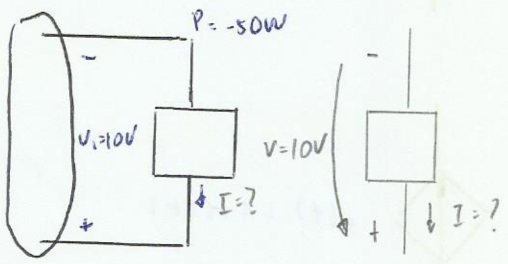
$P = V_1' \cdot I$

$\therefore V_1' = \frac{P}{I} = \frac{40}{2} = 20V$

(Receptor)

$V_1 = -V_1' = -20V$

b)

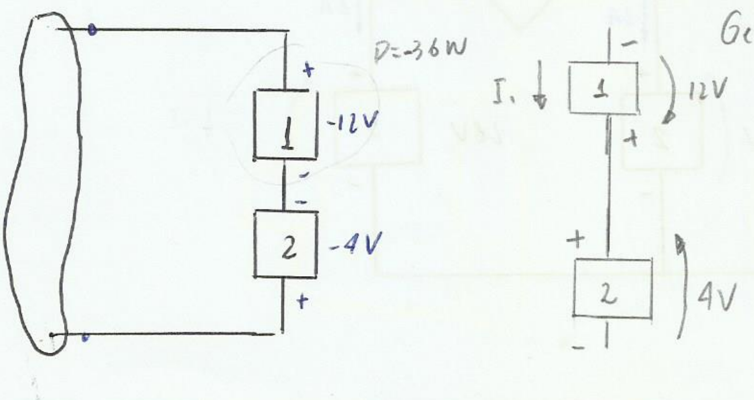


Gerador ($P<0$)

$I = \frac{P}{V} = \frac{50}{10} = 5A$

1.12 pag 15

Dois bipolos estão conectados em série onde, o bipolo 1 fornece ao circuito 36 W, O bipolo fornece ou consome potência? Quanto?



Gerador

$I_1 = \frac{P}{V} = \frac{36}{12} = 3A$

Receptor

$P = V \cdot I = 4 \cdot 3 = 12W$

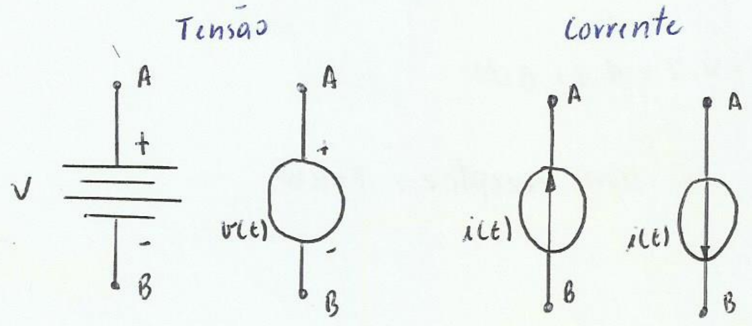
2

Sugestão: (HOMEWOR)

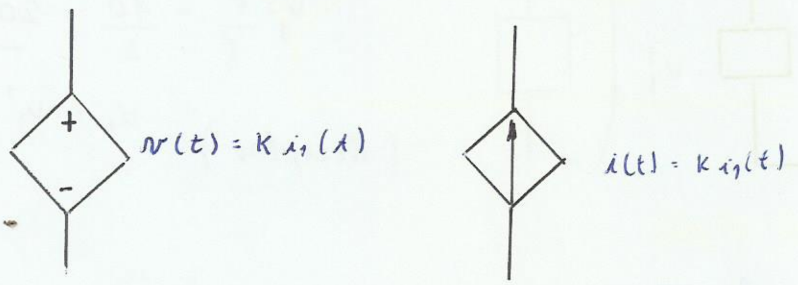
1.8 a 1.11 p:14

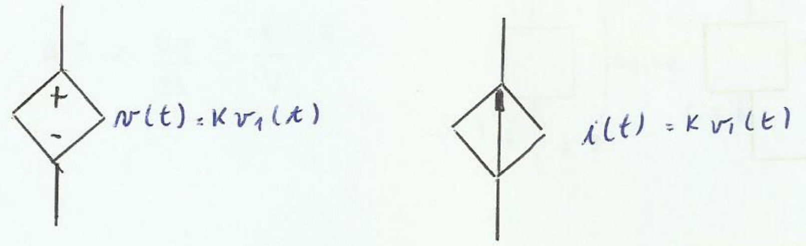
1.3 Componentes de circuitos

- **Fontes Independentes (c.c.)**

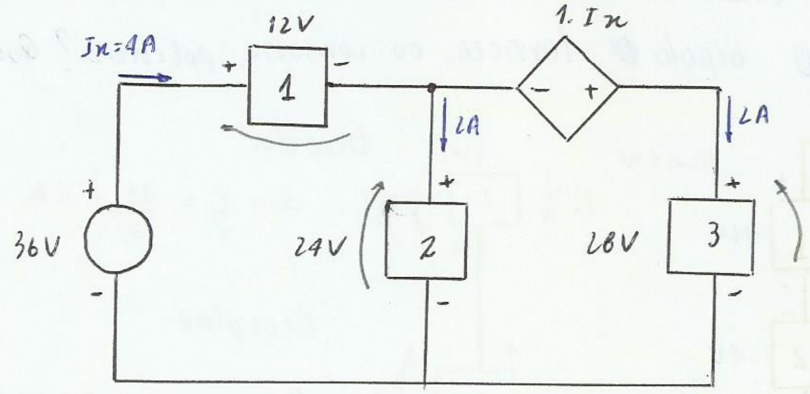


Fontes dependentes
ou vinculadas.





Exemplo 1.7: Dado o circuito verifique o balanço energético.

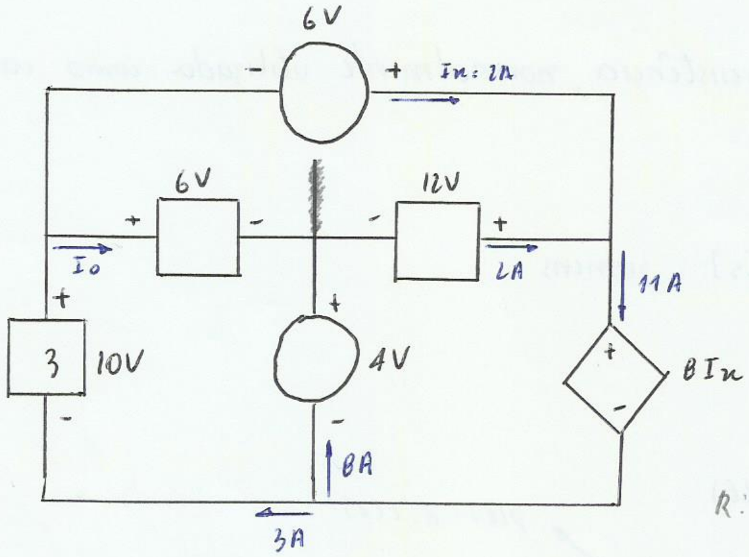


gerada	recebida
$36 \cdot 4 = 144W$	$12 \cdot 4 = 48W$
$1 \cdot I(x) = 4(2) \cdot 8W$	$24 \cdot 2 = 48W$
	$28 \cdot 2 = 56W$
$152W$	$152W$
$P_g = -152W$	$P_{rec} = 152W$

Balanço energético

$-152 + 152 = 0$

1.19 Calcule I_o aplicando balanço energético



Sugestão (HOMEWORK)

1.8 a 1.11 pag 14

1.13 a 1.18 pag 15/16

e 1.20 pag 17

R: $I_o = 1A$

19/08/2014 EL3210 3ª aula

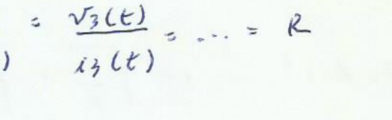
Capítulo 2

Circuitos resistivos

São constituídos de fontes (tensão ou corrente) e resistores

2.1. Lei de Ohm

No resistor existe uma proporcionalidade entre a tensão aplicada e a corrente



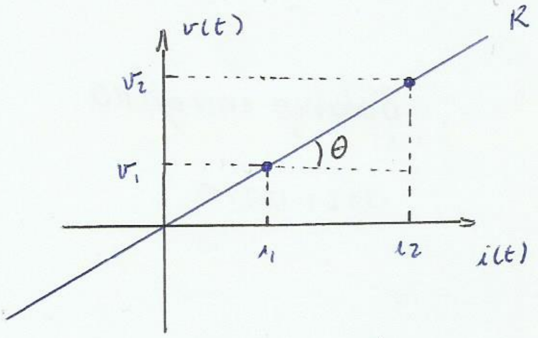
R: cte

$$\frac{v_1(t)}{i_1(t)} = \frac{v_2(t)}{i_2(t)} = \frac{v_3(t)}{i_3(t)} = \dots = R$$

$\boxed{v(t) = R \cdot i(t)}$ Lei de Ohm

unidade, Ohm [Ω]

gráfico de variação $v(t), i(t)$



$$tg\alpha = \frac{v_2 - v_1}{i_2 - i_1}$$

$$tg\alpha = R$$

2.1.1. Condutância G

É o inverso da resistência, normalmente utilizada como característica física de condutores.

$$\boxed{G = \frac{1}{R}} \quad [S] : \text{siemens}$$

Potência elétrica

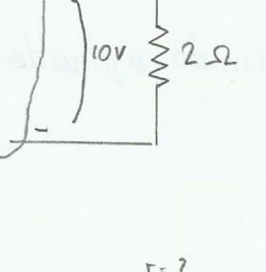
$$p(t) = v(t) . i(t)$$

devido a lei de Ohm → $p(t) = R . i(t)^2$; $p(t) = \frac{v(t)^2}{R}$

Exemplo 2.3 pg 20/21

Determine em cada circuito a grandeza desconhecida

a)

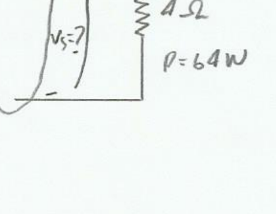


Calcule I e P

$$I = \frac{V}{R} = \frac{10}{2} \therefore \underline{I = 5\,A}$$

$$P = V . I = 5 . 10 \therefore \underline{P = 50\,W}$$

b)

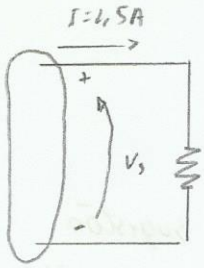


Calcule Vs e I

$$P = R\, i^2 \therefore i = \sqrt{\frac{P}{R}} = \sqrt{\frac{64}{4}} \therefore i = 4\,A$$

$$V = R . I = 4 . 4 \therefore V = 16\,V$$

c)

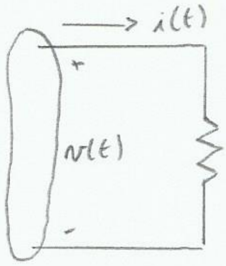


Calcular V, P

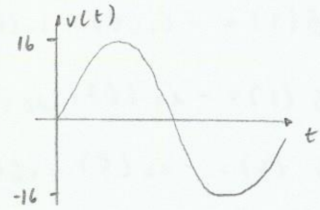
$V = 2,5 \cdot \dfrac{1}{0,25} \quad \therefore V = 10\,V$

$P = 10 \cdot 2,5 = 25\,W$

d)



$v(t) = 16 \operatorname{sen} 377t \quad [V]$



$i(t) = \dfrac{v(t)}{R} \Rightarrow i(t) = \dfrac{16 \operatorname{sen} 377t}{4}$

$\therefore i(t) = 4 \operatorname{sen} 377t \quad [A]$

$p(t) = v(t)\, i(t)$

$= 16 \operatorname{sen} 377t \cdot 4 \operatorname{sen} 377t$

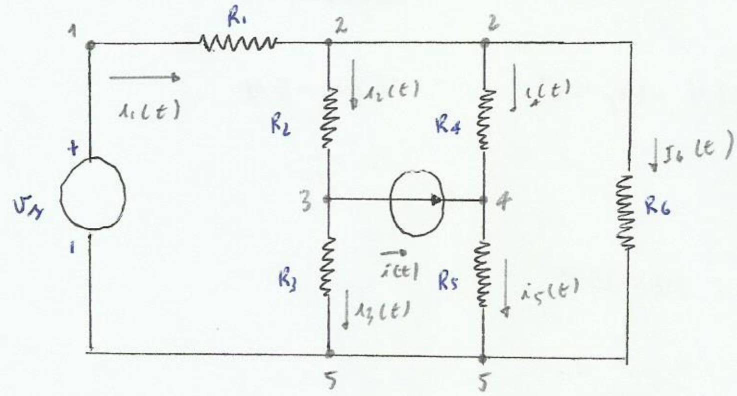
$\therefore p(t) = 64 (\operatorname{sen} 377t)^2 \quad [W]$

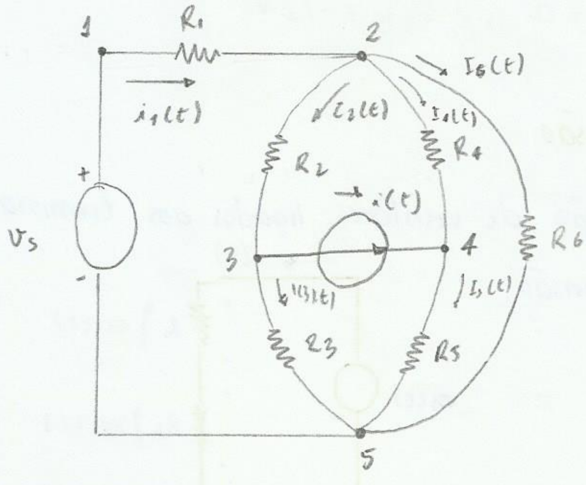
Sugestão E21 e E22
pg 21/22

2.2 Leis de kirchoff

Quando o circuito contiver várias conexões de bipolos (nós) e formar pequenos circuitos (laços ou malhas) pode aplicar as leis de kirchoff.

Ex:





Lei dos nós

A soma algébrica das correntes em um nó é zero.

Convenção

Corrente entra no nó (+) ela é negativa

Corrente sai do nó (−) ela é positiva

sugestão

E.23 ELA pg25

$nó(1) = -i_1(t) + i_1(t) = 0$

$nó(2) = -i_1(t) + i_2(t) + i_4(t) + i_6(t) = 0$

$nó(3) = -i_2(t) + i(t) + i(3) = 0$

$nó(4) = -i(t) - i_4(t) + i_5(t) = 0$

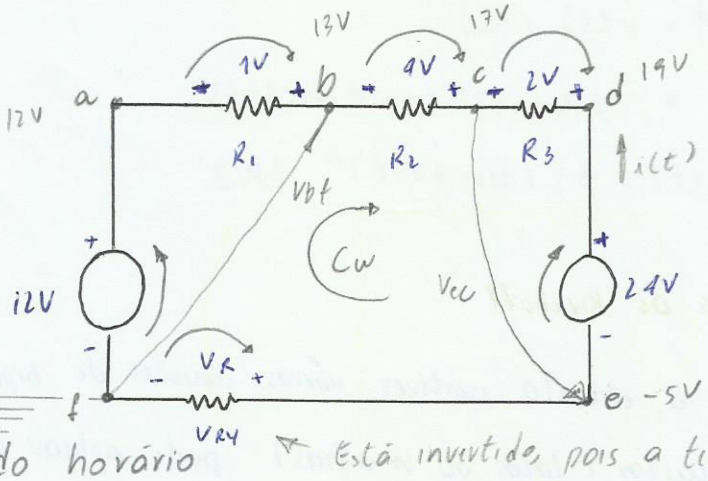
$nó(5) = -i_3(t) - i_5(t) - i_6(t) + i(t) = 0$

ZERO

Lei das malhas

E.26 pg29

Calcule V_{R4}, V_{bf}, V_{ec}



- Aplicamos o sentido horário (CW) — Está invertido, pois a tensão deu negativa

$12 + 1 + 4 + 2 - 24 - V_{R4} = 0 \quad \therefore \quad V_{R4} = -5\,V$

- $V_{bf} = ?$

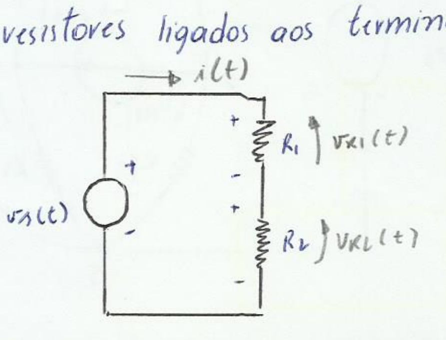
$12 + 1 - V_f = 0 \quad \therefore V_f = 13\,V$

- $V_{ec} = ?$

$2 - 24 - V_{ec} = 0 \quad \therefore V_{ec} = -12\,V$

2.3 Divisor de tensão

Através da utilização de resistores ligados aos terminais da fonte pode obter parte da sua tensão.



$$i(t) = \frac{v_{R1}(t)}{R_1} = \frac{v_{R2}(t)}{R_2} = \frac{v(t)}{R_1 + R_2}$$

I II III

(I) e (II)

$$\frac{v_{R_1}(t)}{R_1} = \frac{v(t)}{R_1+R_2} \Rightarrow \boxed{v_{(R_1)}(t) = \frac{R_1}{R_1+R_2} \cdot v(t)}$$

Exercício E 2.5

(II) = (III) $\Rightarrow$ $\boxed{v_{R_2}(t) = \frac{R_2}{R_1+R_2} \cdot v(t)}$

Ex: dado $R_1 = 2\Omega$; $R_2 = 3\Omega$ e $v(t) = 12V$

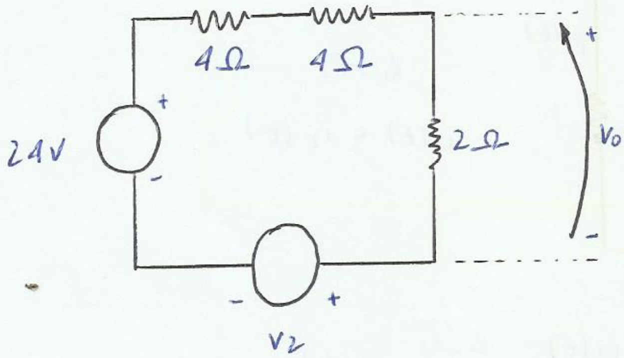
teremos: $v_{R_1}(t) = 4{,}8V$

$v_{R_2}(t) = 7{,}2V$ +

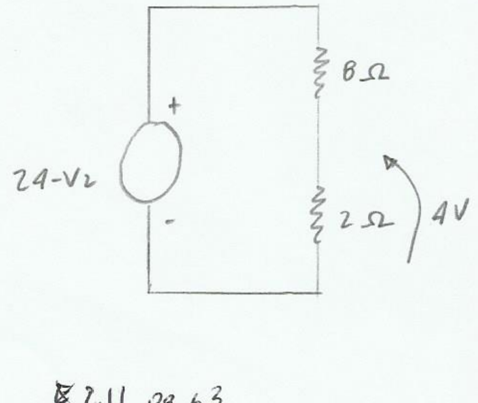
$\overline{\quad 12{,}0 \quad}$

E 2.10 pg 37

Sabe-se que $v_o = 4V$. Determine por divisor de tensão o valor de v_2



Solução



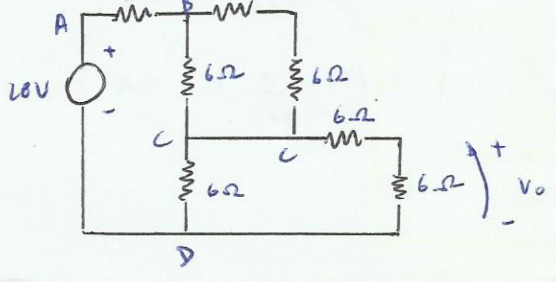
$$v_{R_2}(t) = \frac{R_2}{R_1+R_2} \cdot v(t)$$

$$4 = \frac{2}{2+8} \cdot (24 - v_2)$$

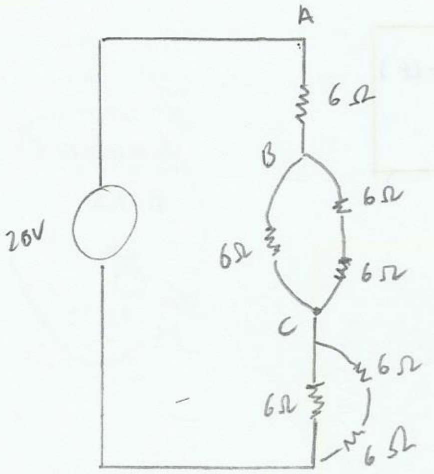
$$\therefore \underline{v_2 = 4V}$$

E 2.11 pg 63

Aplique divisor de tensão e ~~aplique~~ calcule v_o



E: 2.7
2.8
2.9 } pg 36/37



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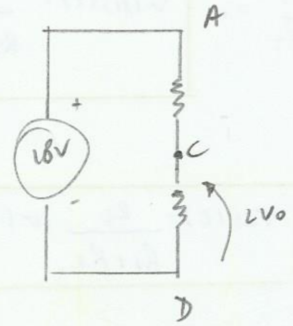
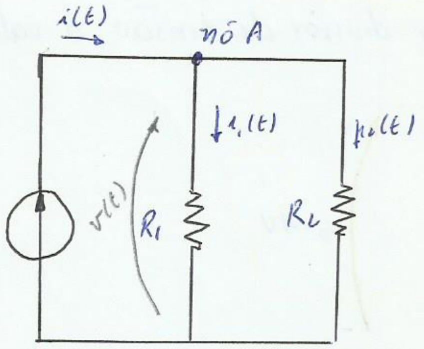


$$2V_0 = \frac{4}{10+1} \cdot 20 \qquad \therefore V_0 = 4V$$

Divisor de corrente

Seja o seguinte circuito



$R_1 > R_2$

$i_1(t) < i_2(t)$

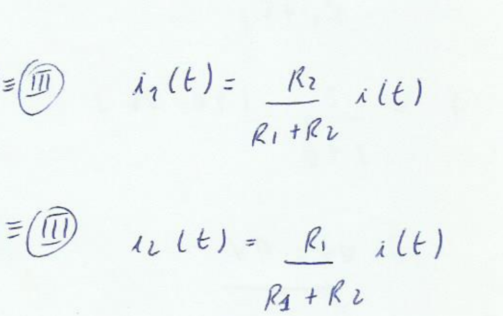
$$v(t) = R_1 i_1(t) = R_2 i_2(t) = \frac{R_1 \cdot R_2}{R_1 + R_2} \cdot i(t)$$

I   II   III

I ≡ III $\quad i_1(t) = \frac{R_2}{R_1 + R_2}\, i(t)$

II ≡ III $\quad i_2(t) = \frac{R_1}{R_1 + R_2}\, i(t)$

Exemplo

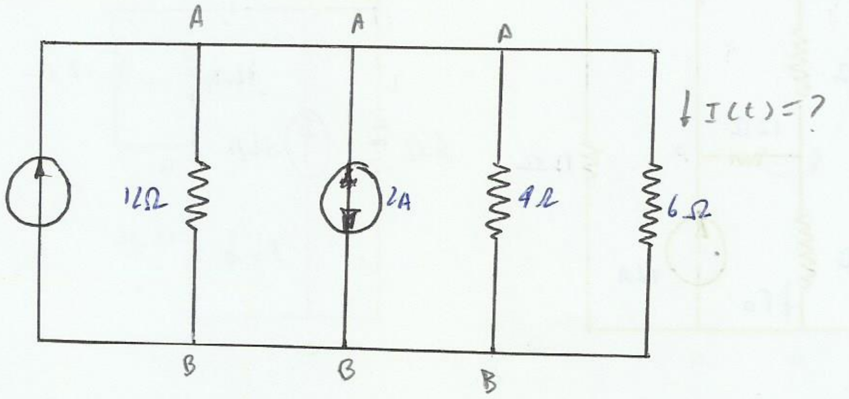


$$\begin{cases} i_1(t) = \frac{2}{8+2} \cdot 5 = \underline{1\,A} \\ i_2(t) = \frac{8}{8+2} \cdot 5 = \underline{4\,A} \end{cases}$$

E2.11 Dado o circuito, determine:

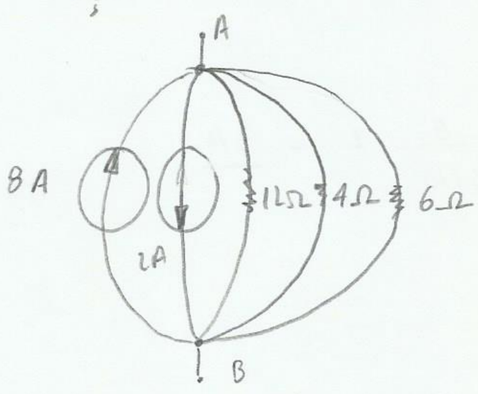
a) A intensidade de corrente em 6Ω

b) A potência dissipada em 6Ω



Solução

a)



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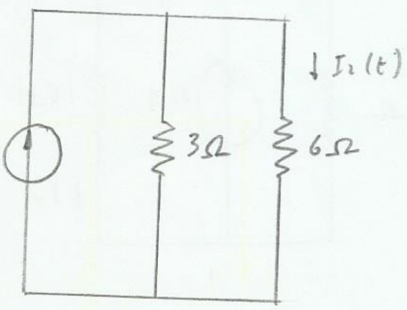


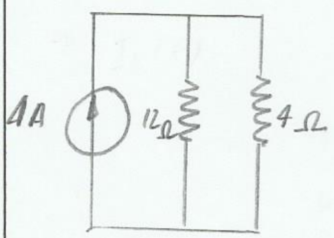
$$I_2(t) = \frac{3}{3+6} \cdot 6 = \underline{2\ A}$$

b) $P = R \cdot I^2(t)$

$P = 6 \cdot 2^2 = \underline{24\ W}$

c) Qual a itensidade de corrente em 12Ω e 4Ω

$$I_1(t) = \frac{6}{3+6} \cdot 6 = 4\ A$$

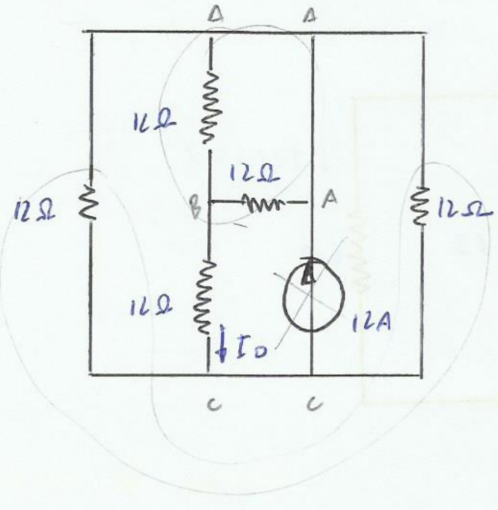


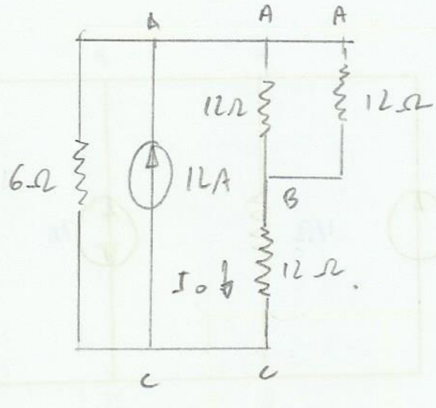
$$I_1(t) = \frac{4}{12+4} \cdot 4 = \underline{1\ A}$$

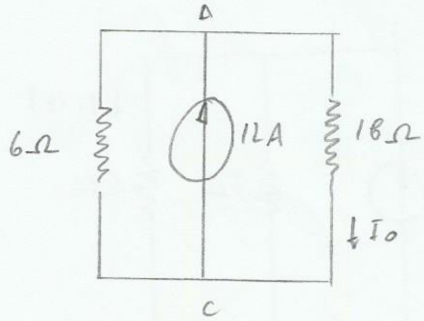
$$I_2(t) = \frac{12}{12+4} \cdot 4 = \underline{3\ A}$$

2.30 pag 68

Aplique divisor de corrente e calcule I_o:

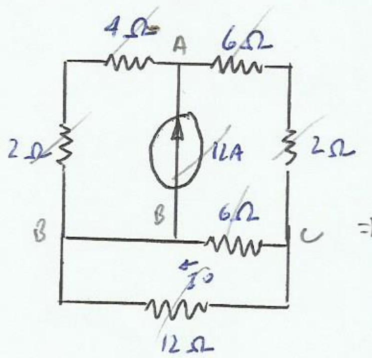






$$I_o(t) = \frac{6}{6+18} \cdot 12 = \underline{3A}$$

2.23 pg 66 Idem ao 30



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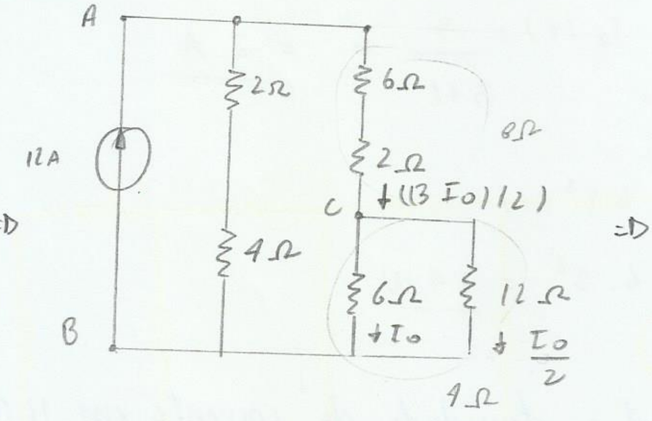

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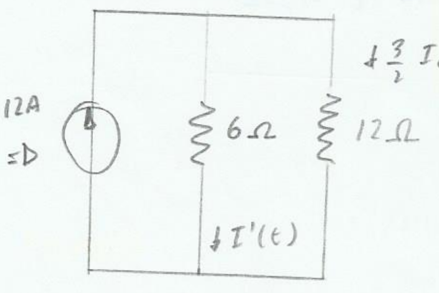
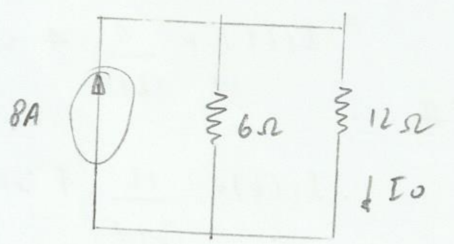


$$I'(t) = \frac{12}{6+12} \cdot 12 = 8\ A$$



$$\frac{3}{2} I_o = \frac{6}{12+6} \cdot 12$$

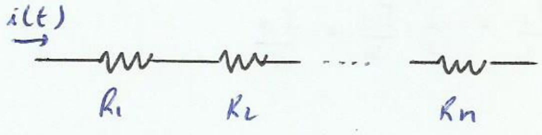
$\therefore I_o = \frac{8}{3}$ A

Versão do professor

$$I_o = \frac{6}{6+12} \cdot 8 = \frac{48}{18} = \frac{24}{9} = \frac{8}{3}\ A$$

Combinação de resistores

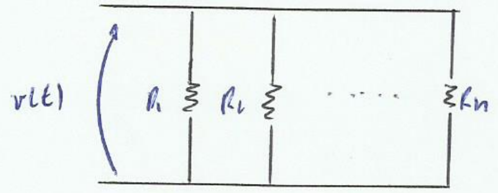
Série



$i(t)$ é a mesma

$$R_T = \sum_{i=1}^{n} R_i$$

Paralelo



$v(t)$ é a mesma

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_n}$$

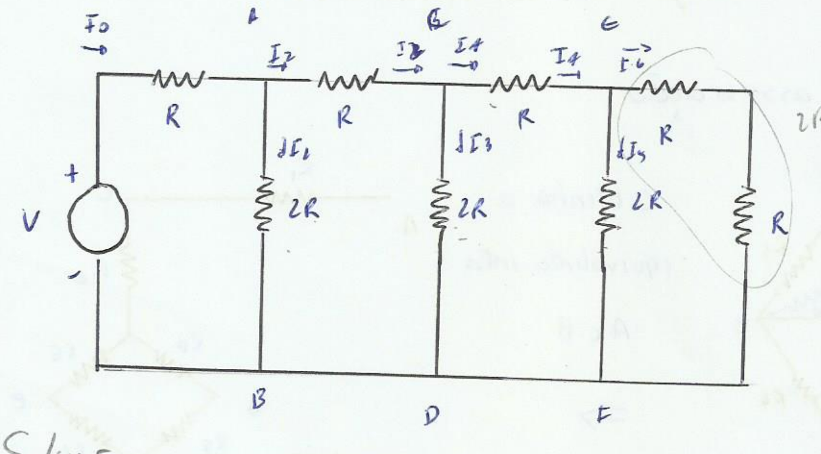
Caso particular (2 resistores em paralelo)

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_T} = \frac{R_2 + R_1}{R_1 \cdot R_2}$$

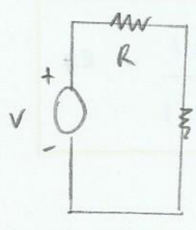
$$\underline{\underline{R_T = \frac{R_2 \cdot R_1}{R_2 + R_1}}}$$

2.2.4 Dado o circuito obtenha V_{AB}, V_{CD}, e V_{EF} em função de V



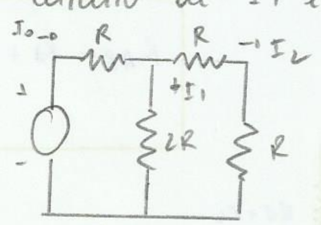
Solução

Cálculo de I_0



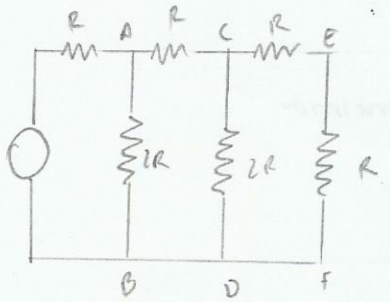
$$I_0 = \frac{V}{2R}$$

Cálculo de I_1 e I_2



$$I_1 = I_2 = \frac{I_0}{2}$$

Cálculo I_3 e I_4



$$I_3 = I_4 = \frac{I_2}{2} = \frac{1}{2}\,\frac{I_0}{2} = \frac{I_0}{4}$$

$$I_5 = I_6 = \frac{I_0}{4} : 2 = \frac{I_0}{8}$$

$$V_{AB} = 2R \cdot \frac{I_0}{2} = R \cdot I_0 = R \cdot \frac{V}{2R} = \frac{V}{2}$$

$$V_{CD} = 2R \cdot \frac{I_0}{4} = \frac{R \cdot I_0}{2} = \left(R \cdot \frac{V}{2R}\right) : 2 = \frac{V}{4}$$

$$V_{EF} = R \cdot \frac{I_0}{8} = \left(R \cdot \frac{V}{2R}\right) : 8 = \frac{V}{16}$$

Sugestões

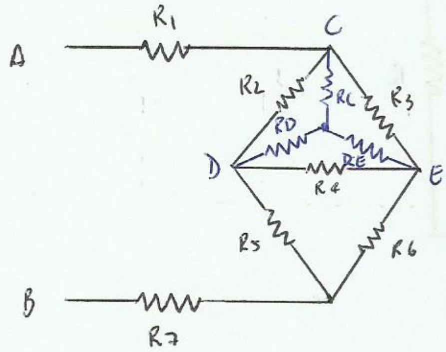
E 2.12 e E 2.13 pg 44

E 2.14 e 2.15 pg 46/47

E 2.16 e E 2.17 pg 52/53

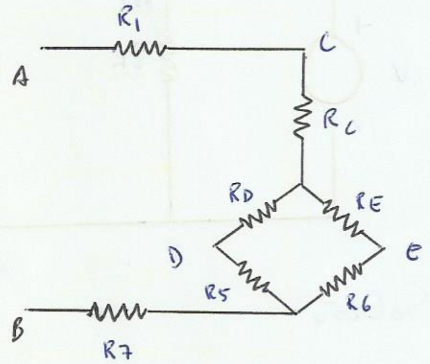
2.7. Transformação triângulo (Δ) em estrela (Y)

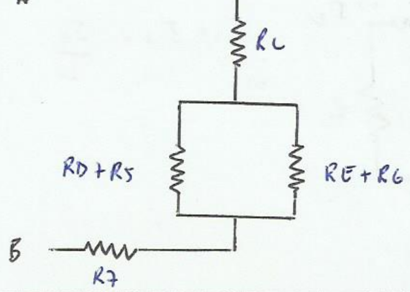
Seja a seguinte associação



Obtenho o equivalente entre A e B

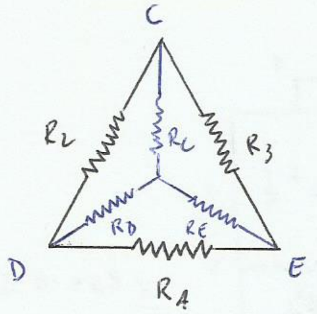
$\Rightarrow$





$$\boxed{R_{AB} = R_1 + R_C + \frac{(R_D + R_5) \cdot (R_E + R_6)}{(R_D + R_5) + (R_E + R_6)} + R_7}$$

Fórmulas de transformação

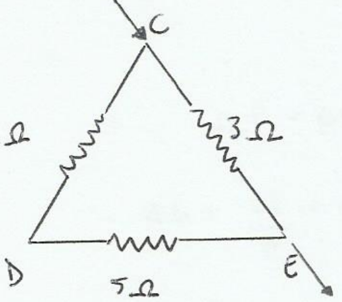


$$R_C = \frac{R_2 . R_3}{R_2 + R_3 + R_4}$$

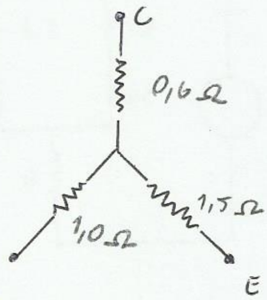
$$R_D = \frac{R_2 . R_4}{R_2 + R_3 + R_4}$$

$$R_E = \frac{R_3 . R_4}{R_2 + R_3 + R_4}$$

Exemplo



$\Rightarrow$



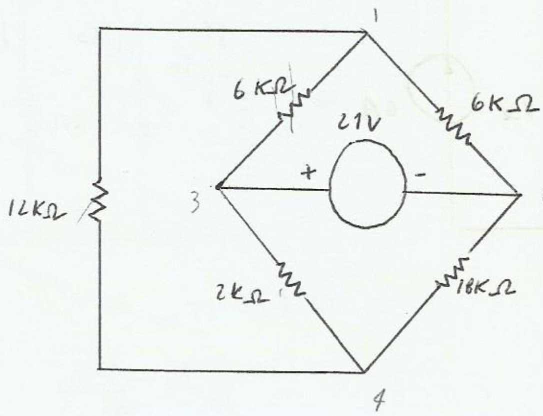
Dedução literal, esta na pagina 53 e 54.

$$RCE_{\Delta} = \frac{3.7}{3+7} = 2,1\ \Omega \qquad RCE_{Y} = 0,6 + 1,5 = 2,1\ \Omega$$

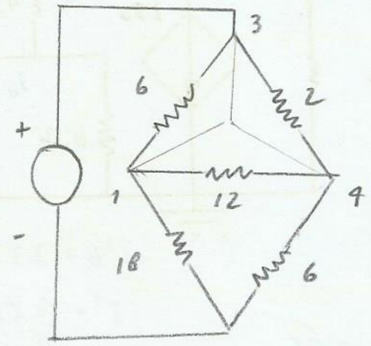
$$RED_{\Delta} = \frac{5.5}{5+5} = 2,5\ \Omega \qquad RED_{Y} = 1,0 + 1,5 = 2,5\ \Omega$$

2.58 pg 74

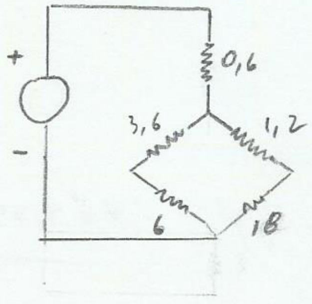
Encontre o valor da potência dissipada pelo circuito



$\Rightarrow$



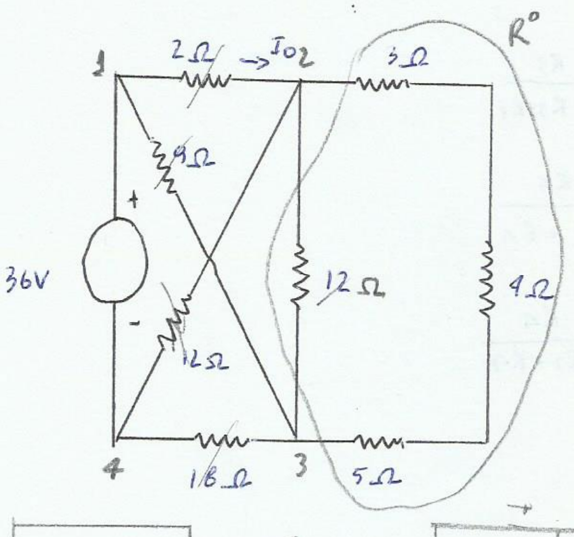
$\Rightarrow$

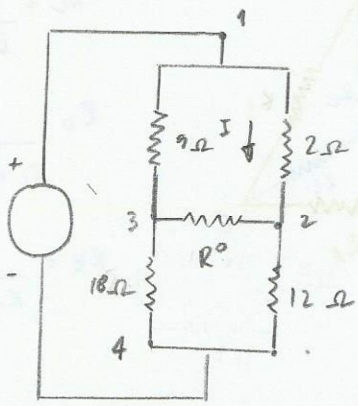


$$R_{eq} = 0,6 + \frac{(3,6+6)(1,2+18)}{3,6+6+1,2+18} = 7$$

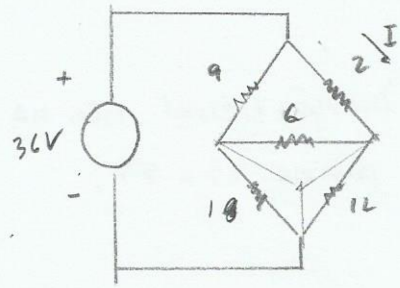
$$P = V.I = V.\frac{V}{R} \therefore P = \frac{V^2}{R} = \frac{21^2}{7} \therefore P = 63.10^{-3}\ W$$

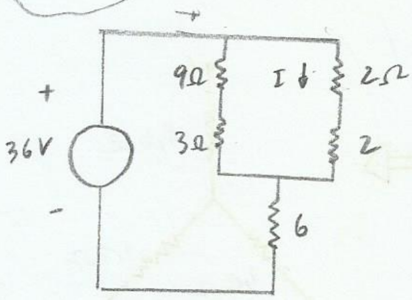
2.59 Calcule I_o





; $R_o = 16\,\Omega$





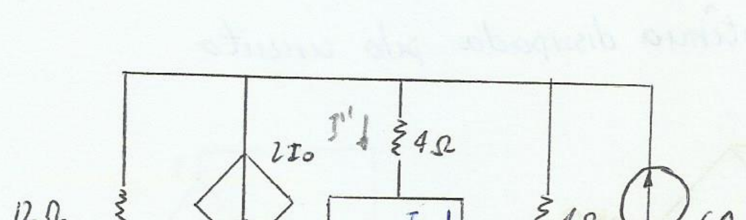
$R_{eq} = 9\,\Omega$

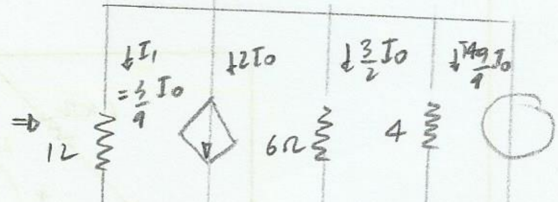
$I_T = \frac{36}{9} = 4\,A$

$\therefore \quad I = \frac{12}{12+4} \cdot 4 \quad \therefore \quad \underline{I = 3\,A}$

2.8. Circuitos com fontes dependentes

2.7. Dado o circuito calcule a potência dissipada em 12Ω





$I'6 = 3I_o$

$I' = \frac{3}{6} I_o = \frac{1}{2} I_o$

$I'' = \frac{1}{2} I_o + I_o = \frac{3}{2} I_o$

$12 I_1 = 9 I_o$

$I_1 = \frac{9}{12} I_o = \frac{3}{4} I_o$

$I_4 \cdot 4 = 9 I_o$

$I_4 = \frac{9}{4} I_o$

Lei dos nós

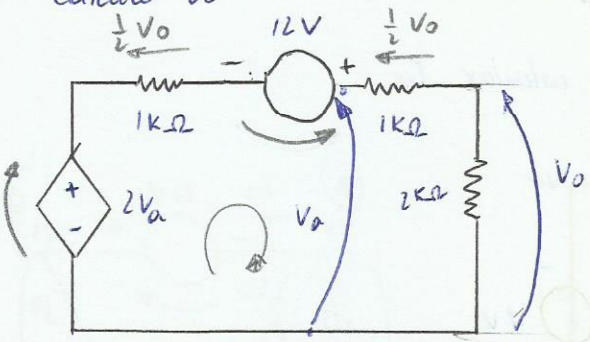
$\frac{3}{4} I_o + 2I_o + \frac{3}{2} I_o + \frac{9}{4} I_o = 6$

$\frac{13}{2} I_o = 6 \quad \therefore \quad I_o = \frac{12}{13} = 0{,}923\,A$

$P = V \cdot I$

$= R \cdot I^2 = 12 \cdot \left(\frac{3}{4} \cdot \frac{12}{13}\right)^2 \quad \therefore \quad \underline{P = 5{,}75\,W}$

2.68 Calcule V_o



$$2V_a - \frac{1}{2}V_o - \frac{1}{2}V_o - V_o + 12 = 0$$

$$V_a - \frac{1}{2}V_o - V_o = 0$$

$$2V_a - 2V_o = -12$$

$$V_a = \frac{3}{2}V_o$$

$$V_a - V_o = -6$$

$$\begin{cases} V_a - V_o = -6 \\ V_a = \frac{3}{2}V_o \end{cases} \qquad \frac{3}{2}V_o - V_o = -6 \quad \therefore \underline{V_o = -12V}$$

Sugestões

E 2.18 pg 55/56

E 2.19 } pg 58/59
E 2.20

2.67 pg 76 resp 6 Ω

2.69 pg 77 resp +2V

Matéria de Prova

Cap. I, II, III (até análise nodal)

3 e 4 (exercícios conceituais)

Análise nodal

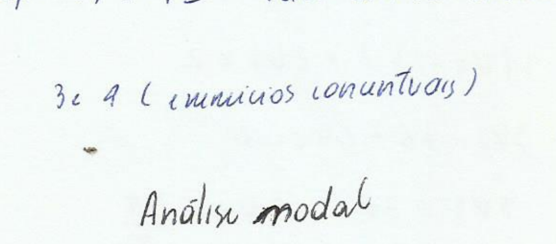
Para a resolução de circuitos

1º) Escrevemos as equações nodais (lei dos nós) necessários

2º) Nominamos a ddp nos terminais de cada bipolo

3º) transformamos para lei de ohm.

Determine V_1 e V_2 aplicando análise nodal



Solução

Nó A: $-4 + I_1 + I_2 = 0$

$$I_1 + I_2 = 4$$

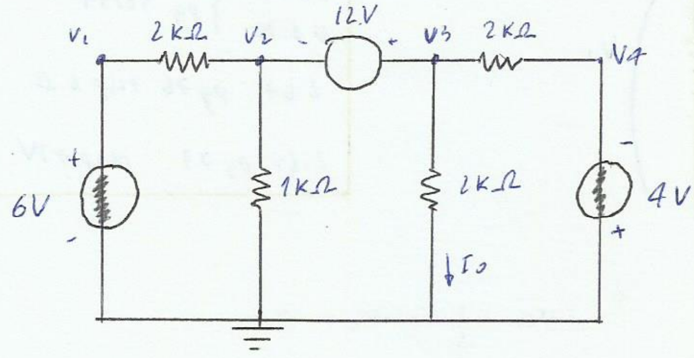
$$\frac{V_1 - 0}{2} + \frac{V_1 - 0}{2} = 4$$

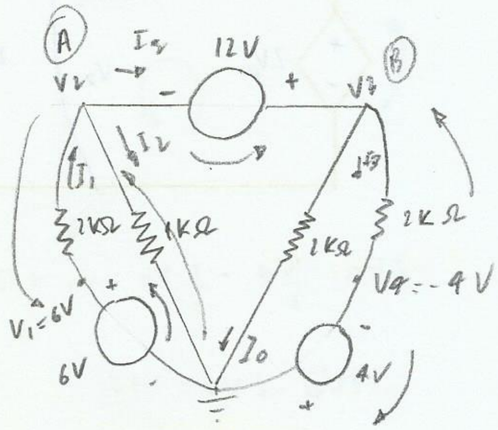
$$V_1 = 4V$$

$$V_2 = \frac{1}{2}V_1 = 2V$$

Exercício com fonte de tensão

Utilize análise ~~a~~nodal para calcular I_o





Lei dos nós

nó A: $-I_1 + I_2 + I_g = 0$

nó B: $-I_g + I_o + I_3 = 0$ $+$ $\Rightarrow$ $-I_1 + I_2 + I_o + I_3 = 0$

Lei de Ohm

$$-\left[\frac{6-V_2}{2K}\right] + \frac{V_2-0}{1K} + \frac{V_3-(-4)}{2K} + \frac{V_3-0}{2K} = 0$$

$$-6 + V_2 + 2V_2 + V_3 + 4 + V_3 = 0$$

$$3V_2 + 2V_3 = 2$$

onde $V_3 - 12 = V_2$

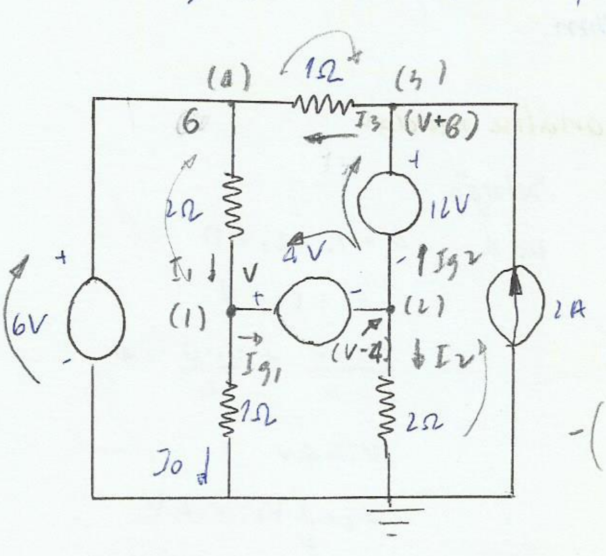
$$3(V_3 - 12) + 2V_3 = 2$$

$$3V_3 - 36 + 2V_3 = 2$$

$$5V_3 = 38 \quad \therefore V_3 = \frac{38}{5}$$

$$\frac{V_3 + 4}{2K} = I_o \quad \therefore \quad I_o = \left(\frac{38}{5} + 4\right) \cdot 2.10^3 \quad \therefore \quad I_o = \; ?$$

3.27 Utilize a análise nodal para determinar I_o na rede



nó (1) = $-I_1 + I_o + \cancel{I_{g1}} = 0$

nó (2) = $-\cancel{I_{g1}} + I_2 + \cancel{I_{g2}} = 0$ $+$

nó (3) = $I_3 - \cancel{I_{g2}} - 2 = 0$

$$-I_1 + I_o + I_2 + I_3 = 2$$

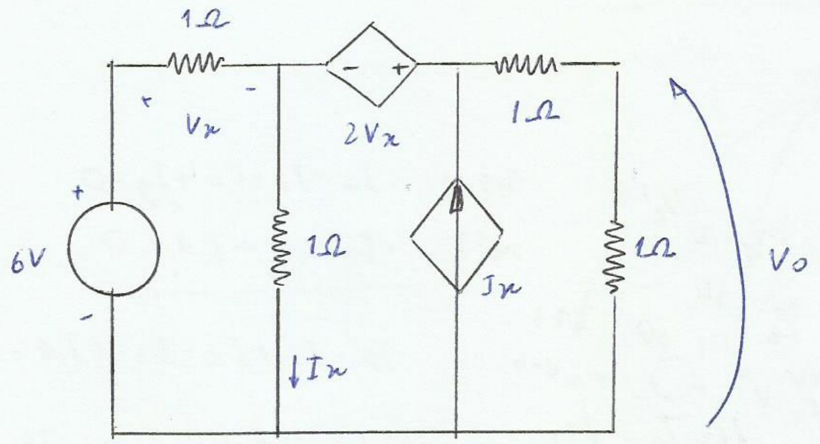
$$-\left(\frac{6-V}{2}\right) + \frac{V-0}{1} + \frac{V-4}{2} + \frac{(V+8)-6}{1} = 2$$

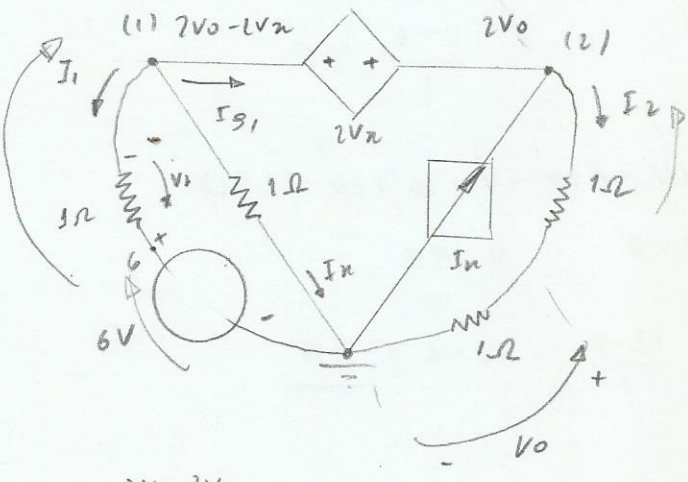
$-6 + V + 2V + V - 4 + 2V + 4 = 4$

$6V = 10 \therefore V = \frac{10}{6} = \frac{5}{3}$

$I_o = \frac{V}{1} \therefore I_o = \frac{5}{3}\,A$

3.36 pg. 134 Determine v_o por análise nodal





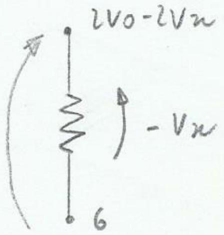
nó (1): $I_1 + I_{g_1} + I_x = 0$

nó (2): $-I_{g_1} - I_x + I_2 = 0$ +

$I_1 + I_2 = 0$

$\frac{2v_o - 2v_x - 6}{1} + \frac{2v_o - 0}{2} = 0$

$3V_o - 2V_x = 6$



$-V_x = 2V_o - 2V_x - 6$

$V_x = 2V_o - 6$

$\hookrightarrow 3V_o - 2(2V_o - 6) = 6$

$3V_o - 4V_o + 12 = 6$

$-V_o = -6 \therefore V_o = 6\,V$

Sugestões

3.30 pg. 133 (R: 3 A) (Adotar 1 sentido para I_o)

3.31 "

3.29 "

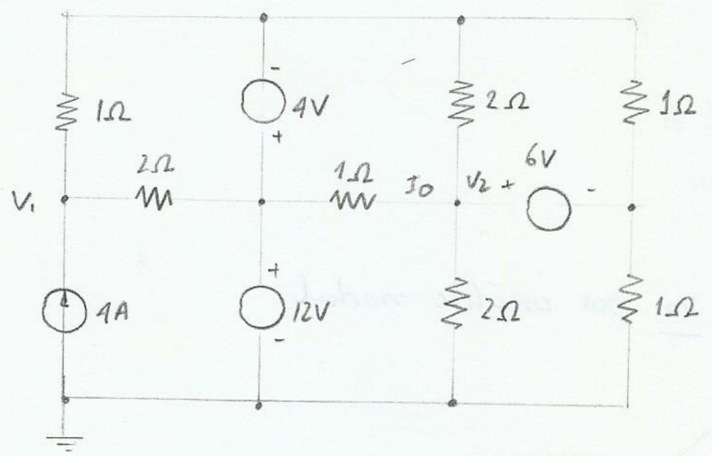
3.33 pg 134

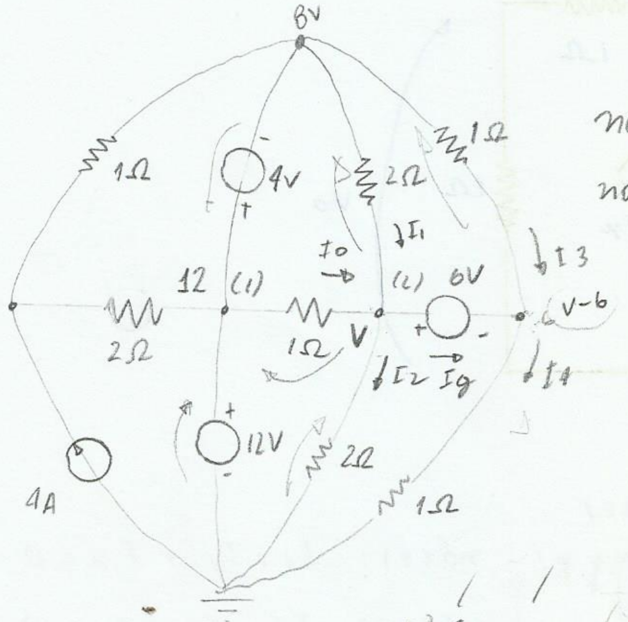
Exercício 3.30

Estrela triângulo

↳ Estudar

triângulo -> estrela





nó 2: $-I_o - I_1 + I_2 + \cancel{I_g} = 0$

nó 3: $\cancel{-I_g} - I_3 + I_4 = 0$

$$-I_o - I_1 + I_2 - I_3 + I_4 = 0$$

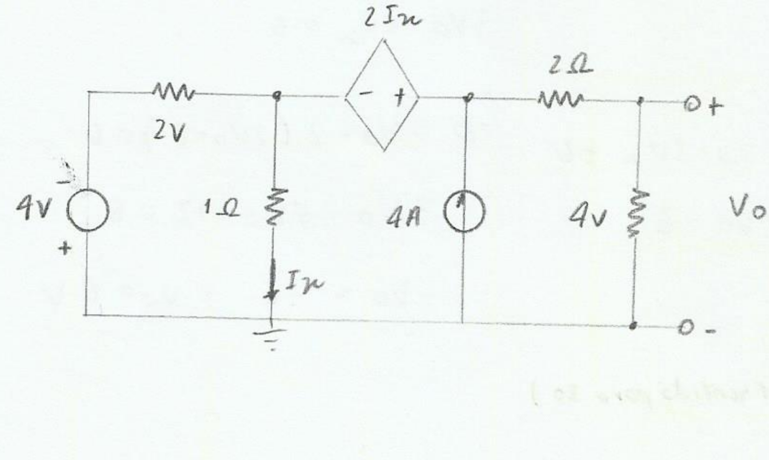
$$-\left(\frac{12-V}{1}\right) - \left(\frac{8-V}{2}\right) + \frac{V}{2} - \left(\frac{8-(V-6)}{1}\right) + \frac{V-6}{1} = 0$$

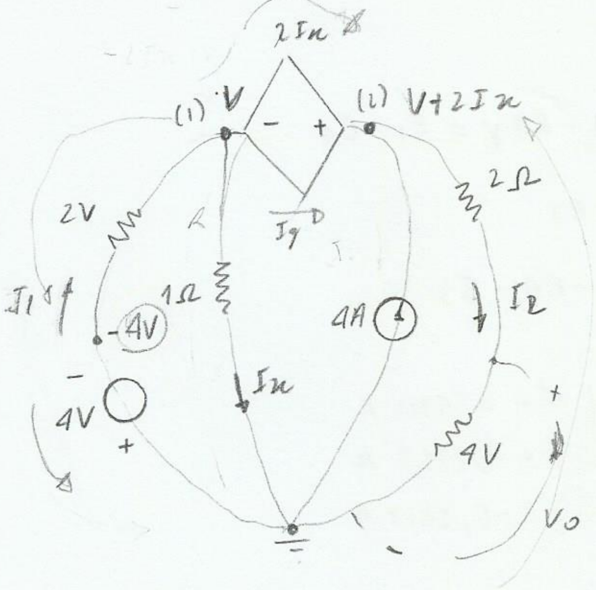
$$-24 + 2V - 8 + V + V - 16 + 2V - 12 = 0$$

$$6V - 64 = 0 \quad \therefore V = 9V$$

$$I_o = \frac{12-V}{1} = 12 - 6 = \underline{3A}$$

Exercício 3.31





$(1) \Rightarrow -I_1 + I_g + I_x = 0$

$(2) \Rightarrow -I_g - 4 + I_2 = 0 \quad +$

$-I_1 + I_x + I_2 = 4$

$$-\left[\frac{-4-V}{2}\right] + \left[\frac{V-0}{1}\right] + \left[\frac{V+2I_x-0}{6}\right] = 4$$

$12 + 3V + 6V + V + 2I_x = 24$

$10V + 2I_x = 12 \quad ; \quad I_x = \frac{V}{1}$

$12V = 12$

$V = \underline{1V} \quad \therefore \quad I_x = 1A$

$V_0 = \frac{4}{4+2} \cdot (V + 2I_x)$

$= \frac{4}{6}(1+2)$

$\therefore V_0 = \underline{2V}$

Capítulo 3

Análise de laço

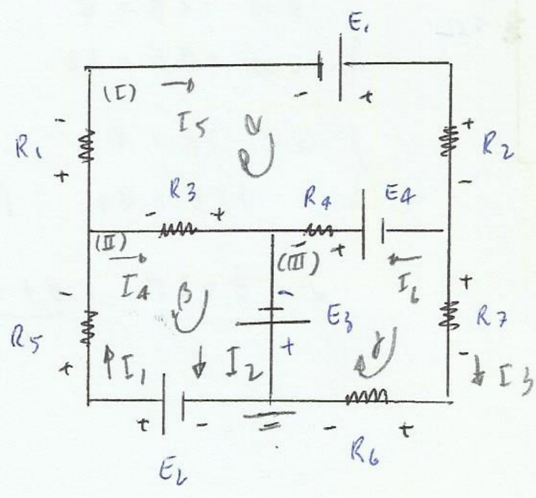
Adotamos uma corrente fictícia para cada laço,

$(\alpha, \beta, \gamma, \ldots)$

uma vez obtido o seu valor partimos as respostas do circuito

Ex pg 44

Circuito de três malhas



Dados: $R_1 = 2\Omega$

$R_2 = R_4 = R_7 = 1\Omega$

$R_3 = 3\Omega$

$R_5 = 4\Omega$

$R_6 = 2\Omega$

$E_1 = 12V$

$E_2 = 6V$

$E_3 = 18V$

$E_4 = 24V$

equações de laço

(I) $(R_2+R_3+R_4+R_1)\alpha - R_3\beta - R_4\gamma = E_1 + E_4$

(II) $(R_3+R_5)\beta - R_3\alpha = E_2 + E_3$

(III) $(R_4 + R_6 + R_7)\gamma - R_4\alpha = -E_4 - E_3$

$$\begin{cases} 7\alpha - 3\beta - \gamma = 36 \\ -3\alpha + 7\beta = 24 \\ -\alpha + 4\gamma = -42 \end{cases} \quad \text{Resp Livro} \quad \begin{cases} \alpha = 6,5490 \text{ A} \\ \beta = 6,2353 \text{ A} \\ \gamma = -8,8627 \text{ A} \end{cases}$$

$I_1 = \beta = 6,2353$ A

$I_2 = \beta - \gamma = 15,098$ A

$I_3 = \gamma = -8,8627$ A

$I_4 = \beta - \alpha = -0,3137$ A

$I_5 = \alpha = 6,5490$ A

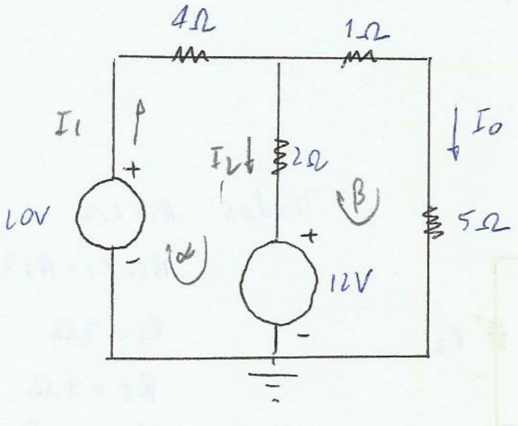
$I_6 = \alpha - \gamma = 15,4117$ A

3.10 (Modificado) pg 135

Dado o circuito aplique análise e calcule

a) I_o?

b) Potência dissipada em 5Ω



$$\begin{cases} (4+2)\alpha - 2\beta = 20 - 12 \\ (2+1+5)\beta - 2\alpha = 12 \end{cases}$$

$$\begin{cases} 6\alpha - 2\beta = 8 \\ -2\alpha + 8\beta = 12 \end{cases}$$

$$\begin{cases} 6\alpha - 3\beta = 8 \\ 22\beta = 44 \end{cases} \quad \therefore \beta = 2$$

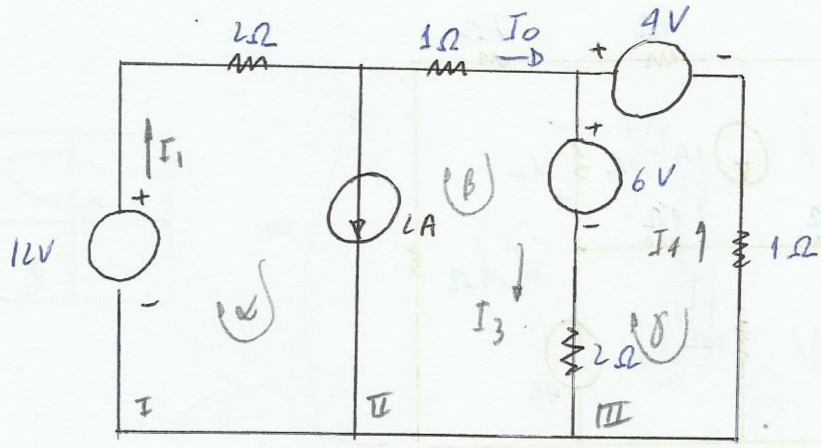
$$\alpha = \frac{8 + 2\beta}{6} = \frac{8+4}{6} = 2$$

$\therefore I_o = \beta = \underline{2 \text{ A}}$

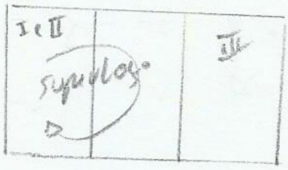
$P = V \cdot I = R \cdot I^2 = 5 \cdot 2^2$

$\therefore P = \underline{20 W}$

3.42) Aplique a análise do laço e calcule I_o



Solução



$$\begin{cases} 2\alpha + 3\beta - 2\gamma = 12 - 6 \\ 3\gamma - 2\beta = 6 - 4 \end{cases}$$

$$\begin{cases} 2\alpha + 3\beta - 2\gamma = 6 \\ -2\beta + 3\gamma = 2 \end{cases}$$

onde $\alpha - \beta = 2$

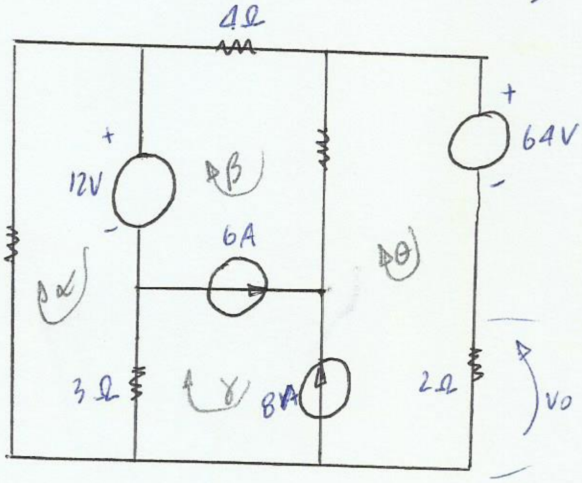
$\alpha = 2 + \beta$

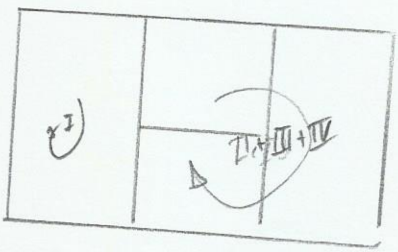
$\gamma = \dfrac{2+2\beta}{3}$ $\qquad 2(2+\beta) + 3\beta - \dfrac{2}{3}(2+2\beta) = 6$

$4 + 2\beta + 3\beta - \dfrac{4}{3} - \dfrac{4}{3}\beta = 6$

$\dfrac{11}{3}\beta = \dfrac{10}{3}$ $\qquad \beta = \dfrac{10}{11}$ $\qquad \therefore I_o = \dfrac{10}{11}$ A

3.58) Determine V_o por análise de laço





$$\begin{cases} 9\alpha - 3\gamma = -12 \\ 4\beta + 2\theta + 3\gamma - 3\alpha = 12 - 64 \end{cases}$$

onde $\gamma - \beta = 6 \quad \beta = \gamma - 6$

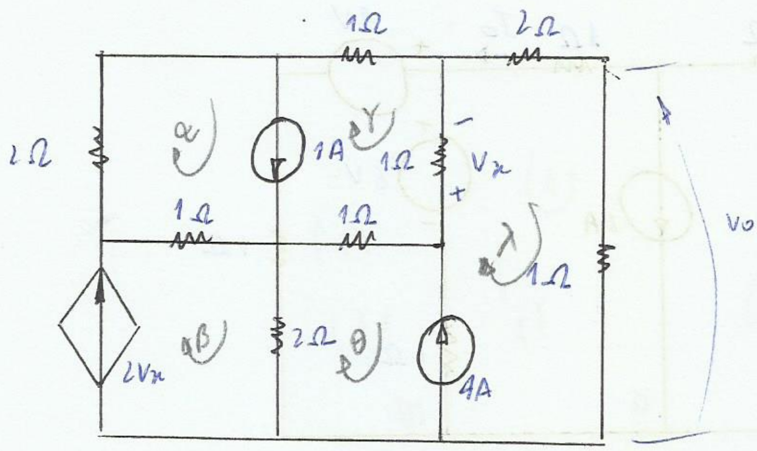
$\theta - \gamma = 8 \quad \theta = 8 + \gamma$

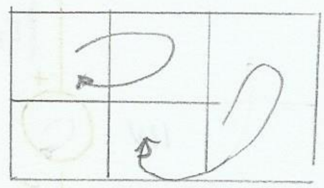
$$\begin{cases} 9\alpha - 3\gamma = -12 \\ 4\gamma - 24 + 16 + 2\gamma + 3\gamma - 3\alpha = -52 \end{cases} \sim \begin{cases} 9\alpha - 3\gamma = -12 \\ -3\alpha + 9\gamma = -44 \end{cases}$$

$\therefore \theta = 2A$

$V_o = 2\theta = 4V$

3.64) pg 142





$$\begin{cases} 3\alpha + 3\gamma - \beta - \theta - \lambda = 0 \\ 3\theta + 4\lambda - 2\beta - 2\gamma = 0 \end{cases}$$

; Onde $\beta = 2Vx \Rightarrow Vx = 1(\lambda - \gamma)$

$\alpha - \gamma = 1$

$\lambda - \theta = 4$

$\lambda = 3{,}43A$

$Vo = 1 \cdot \lambda = 3{,}43V$

Sugestões

3.43 pg136 resp.) 7A

3.55 pg 139 resp) $\frac{3}{2}$ V

3.61 pg 141 resp) $\frac{40}{11}$ V

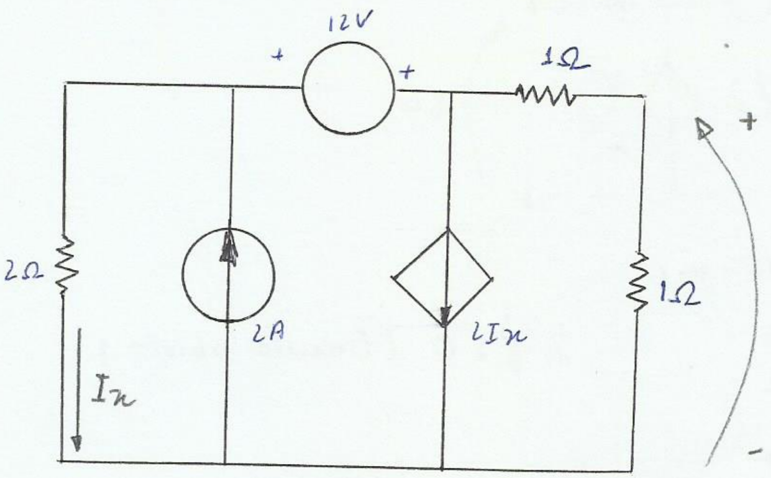
3.65 pg 142 resp) $\frac{36}{11}$ V

Capitulo 5 Teorema thevenan / Norton (continuação)

- Circuito com fonte dependente

5.46 pag 220

Aplique o teorema de thevenan e calcule vo

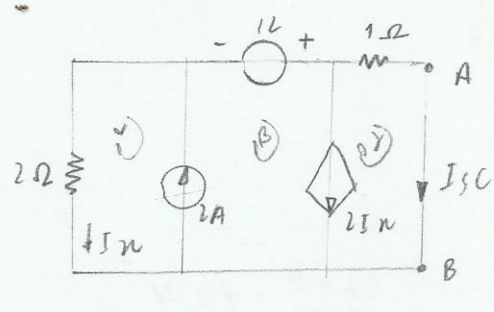


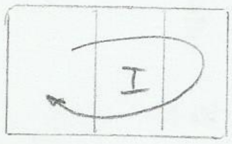
Solução

Fonte dependente => Metodo Indireto

I_{sc}: ?

$$\boxed{R_{th} = \frac{V_{oc}}{I_{sc}}}$$





equação de I: $2\alpha + \gamma = 12$

$\beta - \alpha = 2 \Rightarrow \beta - (-Ix) = 2 \Rightarrow \beta + Ix = 2$

$\beta - \gamma = 2Ix$

$\beta = 2Ix + \gamma = 2 - Ix$

$3Ix = 2 - \gamma$

$\gamma = 2 - 3Ix$

$2\alpha + \gamma = 12$

$-2Ix + 2 - 3Ix = 12$

$-5Ix = 10$

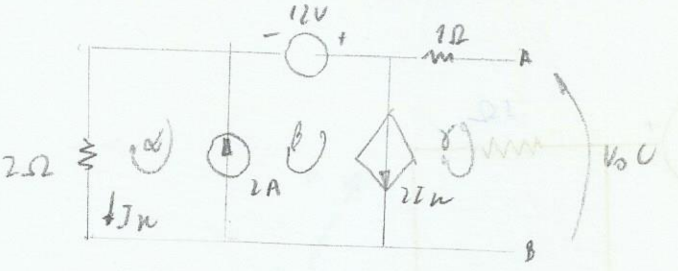
$\underline{Ix = -2A}$

$2\alpha+\gamma=12$; $\alpha=-I_x=2$

$\gamma=12-2\alpha$

$=12-2.2$ ∴ $\gamma=8$ ∴ $I_{sc}=8A$

V_{OC}:



$2\alpha+\cancel{\gamma}^{\to 0}=12-V_{OC}$

$\alpha=-I_x$

$\beta-\alpha=2$

$\beta-\cancel{\gamma}^{\to 0}=2I_x$

; $\gamma=0$ (circuito aberto)

$\alpha=-I_x$

$\beta-\alpha=2$

$2I_x-(-I_x)=2$

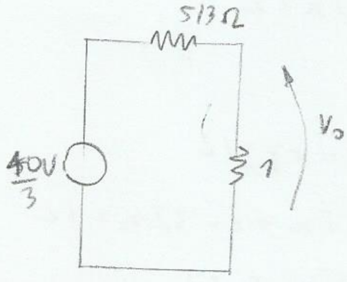
$3I_x=2$ -> $I_x=\frac{2}{3}$

$\alpha=-\frac{2}{3}$

$2\alpha=12-V_{OC}$

$V_{OC}=12-2\alpha=12+2.\frac{2}{3}=\frac{36+4}{3}=\frac{40}{3}$ V

$R_{th}=\frac{V_{OC}}{I_{sc}}=\frac{40}{3}:8=\frac{5}{3}\ \Omega$

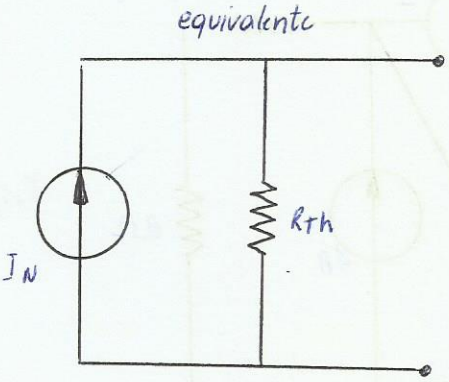


$V_0=\frac{1}{1+\frac{5}{3}}\cdot\frac{40}{3}$

$V_0=\frac{\cancel{3}}{8}\cdot\frac{40}{\cancel{3}}$

$V_0=\underline{5V}$

Teorema de Norton

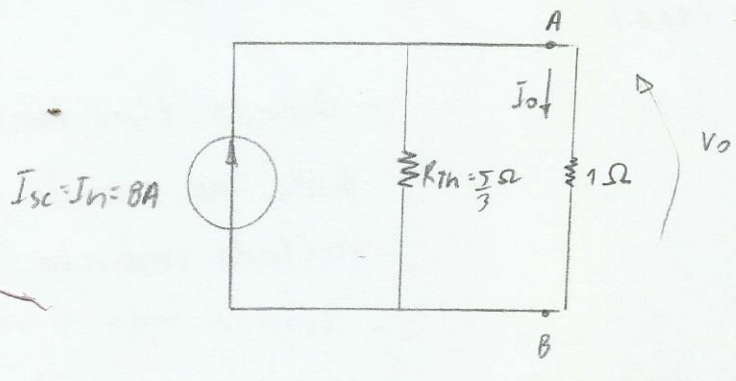


exercício anterior (5.46) e resolvemos por Norton

Como há ponto dependente $\begin{cases} I_{sc} = 8A \\ V_{oc} = \frac{40}{3} V \end{cases}$

$$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{40}{3} \div 8 = \frac{5}{3} \Omega$$

equivalente de Norton

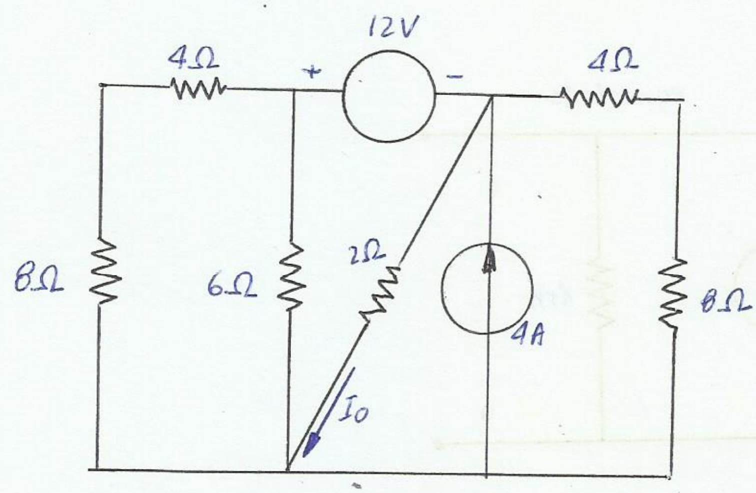


$$I_o = \left(\frac{5}{3} : \left(\frac{5}{3} + 1 \right) \right) \times 8$$

$$\left(\frac{5}{3} : \frac{8}{3} \right) \cdot 8 = \frac{5}{8} \cdot 8 = 5 \text{ A}$$

$$V_o = 5 \cdot 1 = \underline{5V}$$

5.50 Determine I_o aplicando Norton

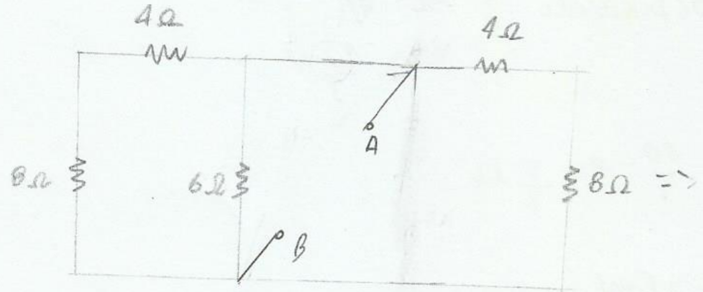


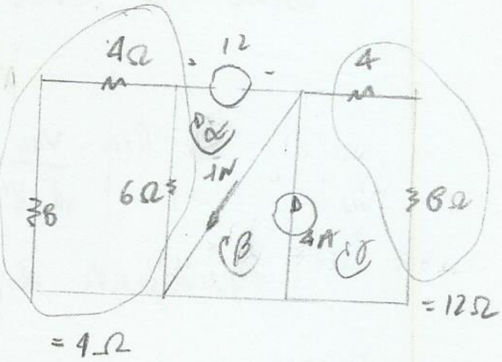
Resp: $R_{th} = 3\Omega$

$I_n = 1A$

$I_o = \frac{3}{5}A$

Solução





$R_{th} = (4+8) \,//\, 6 \,//\, (4+8)$

$R_{th} = 3\,\Omega$

- Quando tiver fonte dependente no circuito usar método indireto
- Quando não tiver, abre as correntes e fecha as tensões em curto

→ equações:

$4\alpha + 12\gamma = -12 \sim \alpha + 3\gamma = -3$

$4\alpha = -12$

$\alpha = -3$

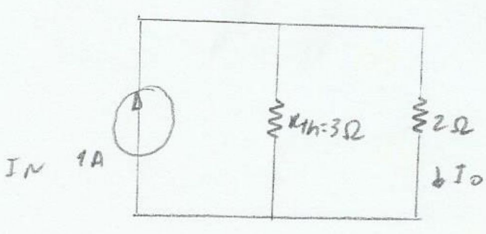
$\gamma - \beta = 4$

$I_N = \alpha - \beta$

→ $\gamma = \frac{-3-\alpha}{3} = \frac{-3-(-3)}{3} = 0$

$\beta = \gamma - 4 = 0 - 4 = -4$

$I_N = -3 - (-4) = 1\,A$



$I_o = \frac{3}{3+2} \cdot 1 = \frac{3}{5}\,A$

Suplentes

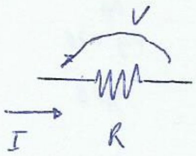
✓ 5.36 pg. 218 $R_{th} = 4\,\Omega$ $V_{th} = 16V$ $V_o = 8V$

5.45 pg 220 $V_{OG} = 24V$ $V_o = 6V$ $I_N = 12A$

✓ 5.53 pg 221 Resp: $R_{th} = \frac{12}{5}\,\Omega$ $I_N = 6A$ $I_o = 1A$

✓ 5.52 pg 221 $R_{th} = \frac{18}{5}\,\Omega$ $I_o = 3A$ $I_N = 8A$

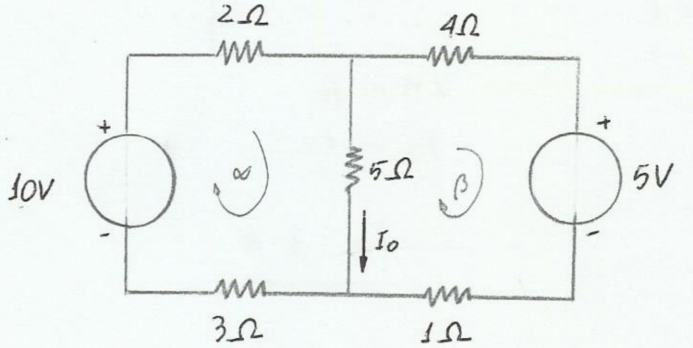
Linearidade



$\frac{V}{I} = \frac{2V}{2I} = \frac{mV}{mI} = R$

existe uma variação linear quando R é constante.

Ex:



$\begin{cases} 10\alpha - 5\beta = 10 \\ 10\beta - 5\alpha = -5 \end{cases} \sim \begin{cases} 10\alpha - 5\beta = 10 \\ -10\alpha + 20\beta = -10 \end{cases}$ $\quad 15\beta = 0 \quad \therefore \quad \alpha = 1$, $\beta = 0$

$I_o = \alpha - \beta = 1 - 0 \quad \therefore \quad I_o = 1\,A$

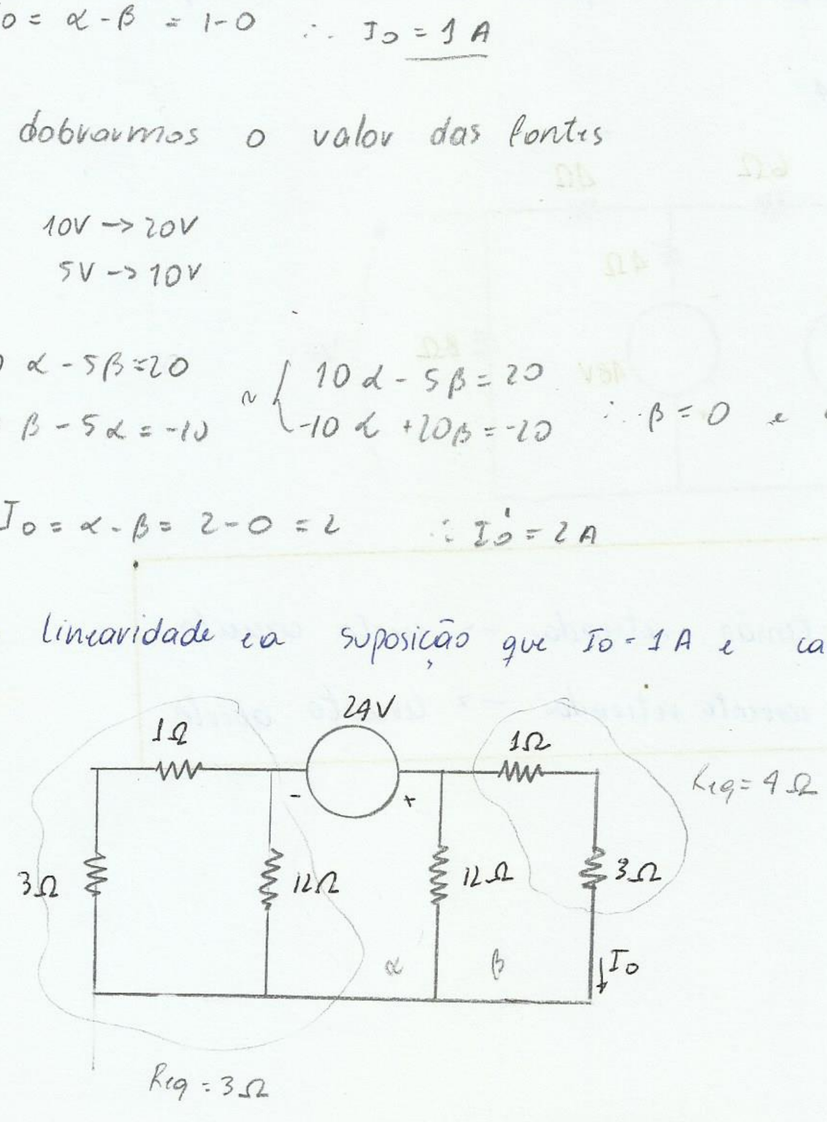
Se dobrarmos o valor das fontes

$10V \to 20V$
$5V \to 10V$

$\begin{cases} 10\alpha - 5\beta = 20 \\ 10\beta - 5\alpha = -10 \end{cases} \sim \begin{cases} 10\alpha - 5\beta = 20 \\ -10\alpha + 20\beta = -20 \end{cases}$ $\quad \therefore \beta = 0 \;\text{e}\; \alpha = 2$

$I_o = \alpha - \beta = 2 - 0 = 2 \qquad \therefore I_o' = 2\,A$

E. 5.3 Use a linearidade e a suposição que $I_o = 1\,A$ e calcule o verdadeiro valor de I_o



Solução

$12I = 4I_0$

$I = \frac{4I_0}{12} = \frac{I_0}{3}$

$I_T = \frac{I_0}{3} + I_0 = \frac{4I_0}{3}$

$R_{eq} = 3 + (12 \parallel 4) = 6$

Admitindo $I_0 = 1$

$I_T = \frac{4}{3}$

$V' = \frac{4}{3} \cdot 6 = 8V$

$24 - 8$

$I_0 - 1$

$\therefore \underline{I_0 = 3\ A}$

Sugestões

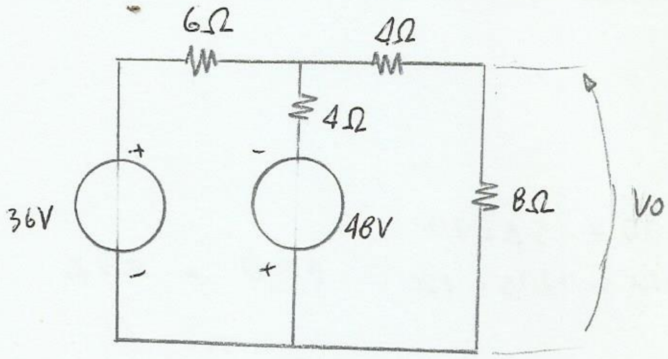
Linearidade:

Ex	Pg
E 5.1	Pg 176
5.2	178
5.4	210

Superposição de efeitos

Qualquer valor de tensão ou correntes nos resistores do circuitos, pode ser obtido parcialmente a partir de cada fonte que o compõe.

Ex: E5.4 pg 184

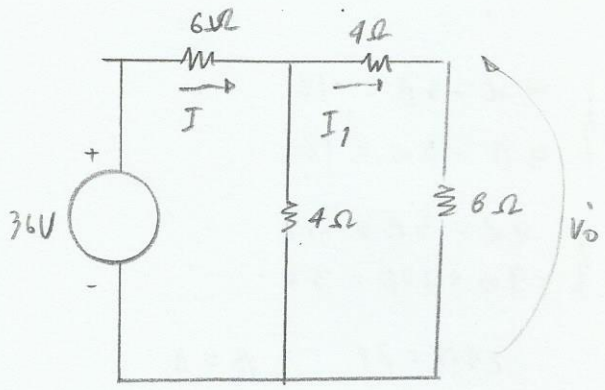


Método:

A fonte de tensão retirada -> curto circuito

A fonte de corrente retirada -> circuito aberto

Influência de 36V



$R_{eq} = 6 + 4 // (4+8)$

$= 6 + 3 = 9\ \Omega$

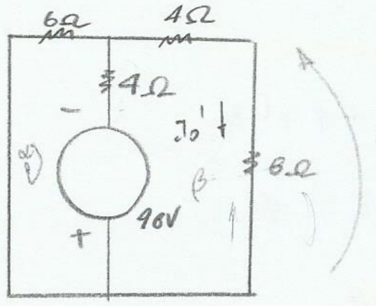
$I = \frac{36}{9} = 4\,A$

$I_1 = \frac{4}{4+12} \cdot 4 = 1\,A$

$V_o = 8 \cdot 1$

$\underline{V_o' = 8\,V}$

Influência de 48V



$R_{eq} = 4 + 6 // 12 = 8$

$I_T = \frac{48}{8} = 6\,A$

$V_o'' = 8 \cdot 2 = 16\,V$

$I_o' = \frac{6}{18} \cdot 6 = 2\,A$

ou

$\begin{cases} 10\alpha - 4\beta = 48 \\ 16\beta - 4\alpha = -48 \end{cases} \sim \begin{cases} 40\alpha - 16\beta = 192 \\ -4\alpha + 16\beta = -48 \end{cases}$ $36\alpha = 144$

$\alpha = 4$

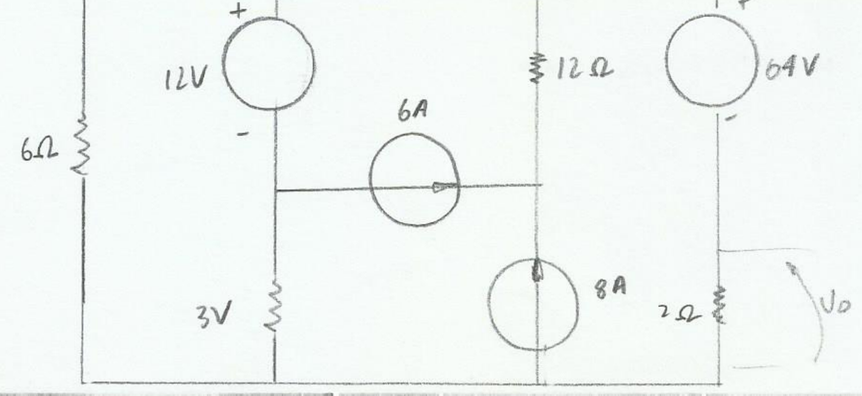
$\beta = \frac{10 \cdot 4 - 48}{4} = -2$ $V'' = 8 \cdot -2 = -16V$

$V_o = V_o' + V_o''$

$= 8 + (-16) = -8V \quad \therefore \quad \underline{V_o = -8V}$

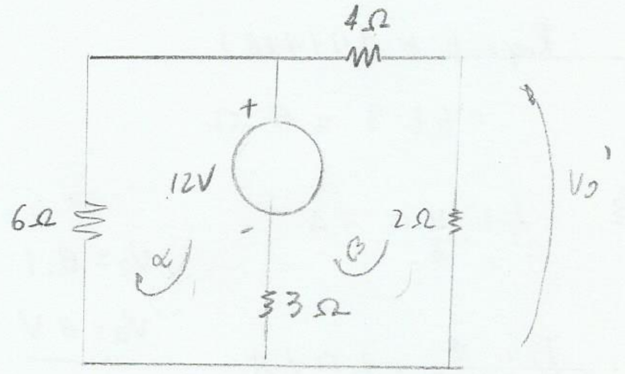
5.14 p.g. 213

Aplique superposição de efeitos e calcule V_o



R: $V_o = 4V$

Influência de 12V



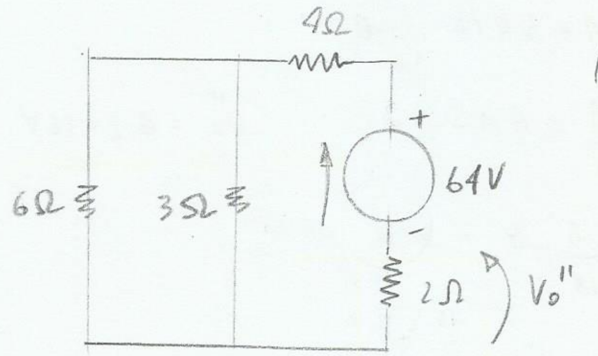
$$\begin{cases} 9\alpha - 3\beta = -12 \\ 9\beta - 3\alpha = 12 \end{cases}$$

$$\begin{cases} 9\alpha - 3\beta = -12 \\ -9\alpha + 27\beta = 36 \end{cases}$$

$24\beta = 24 \quad \therefore \beta = 1$

$V_o' = 1 \cdot 2 = 2V$

Influência de 64V



$R_{eq} = (6 \| 3) + 4 + 2$

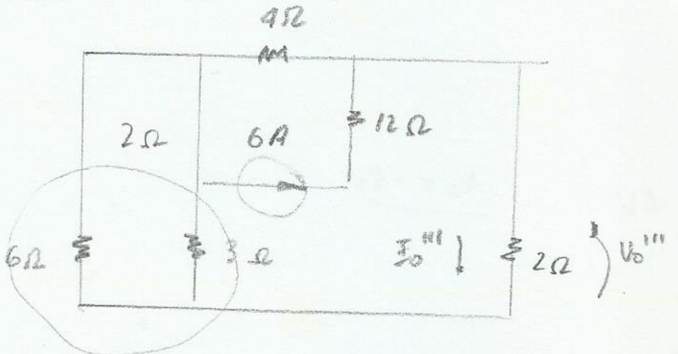
$= 2 + 4 + 2 = 8$

$I_T = \frac{64}{8} = 8A$

$V_o'' = 8 \cdot 2 = -16V$

Temos que calcular com as fontes de corrente

6A



6V

8A

$V = 12$

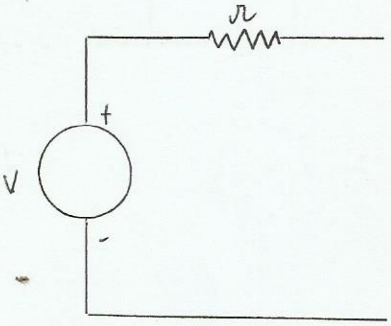
$V = V_1 + V_1 + V_1 + V_3 + V_r = 4V$

Matéria de prova $\quad$ 3.54 ⇒ 6V

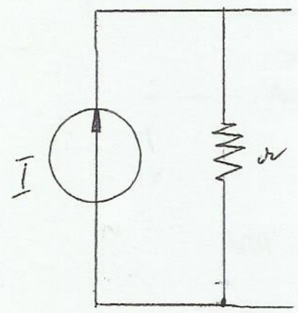
- Capítulo 3
  - Análise de laços
- Capítulo 5
  - Linearidade
  - Superposição de Efeitos
  - Transformação de fontes
  - Teorema de thevenan e Norton
  - Transferência Max de Potência

Transformação de fontes

As fontes independentes chamadas de fontes reais são representadas com a sua resistência.



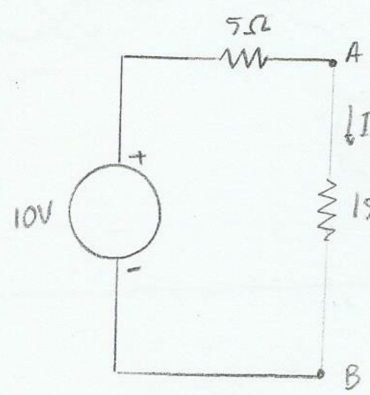
ou



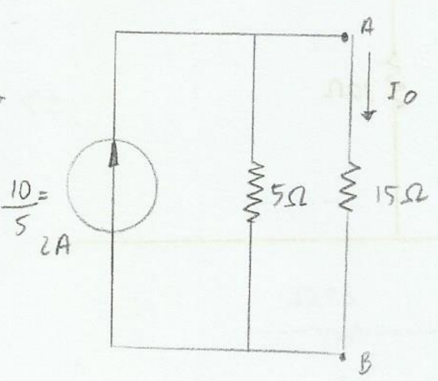
Fonte real de Tensão

Fonte real de corrente

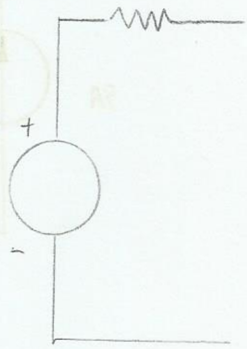
Conversão



⇨



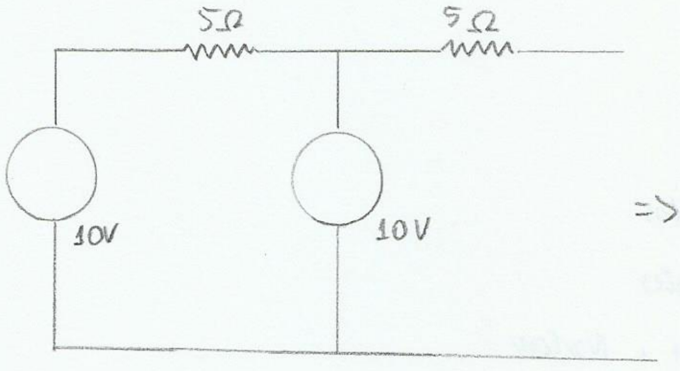
⇨

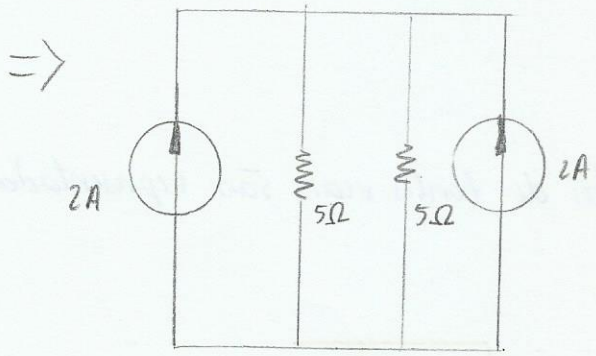


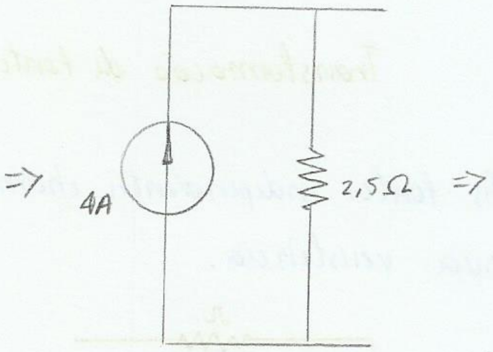
$$I_o = \frac{10}{5+15} = 0{,}5\,A$$

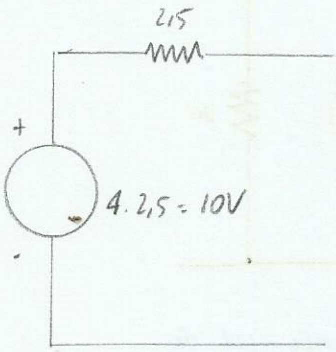
$$I_o = \frac{5}{15+5} \cdot 2 = 0{,}5\,A$$

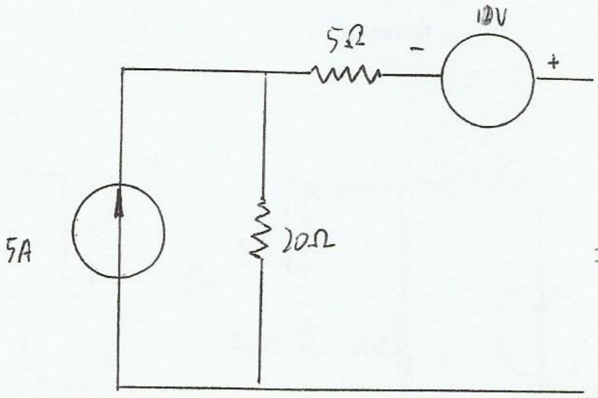
Vantagens da transformação

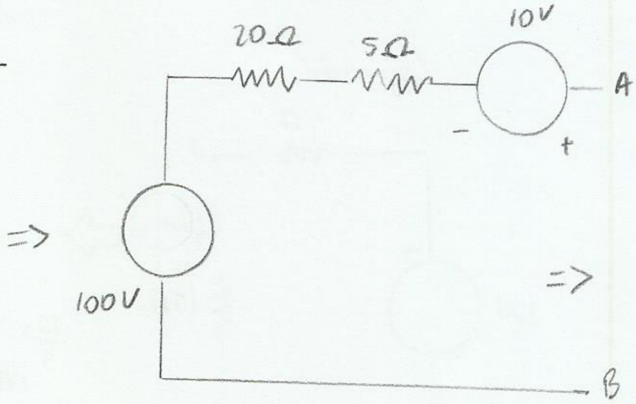


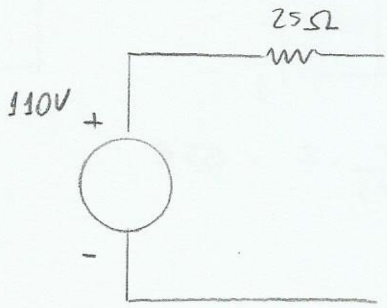




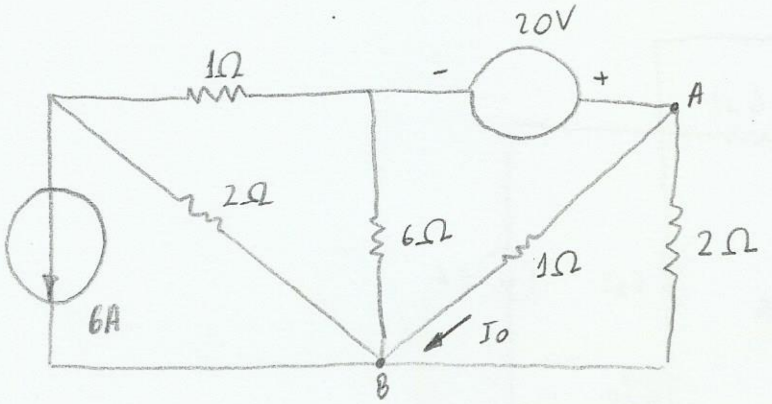


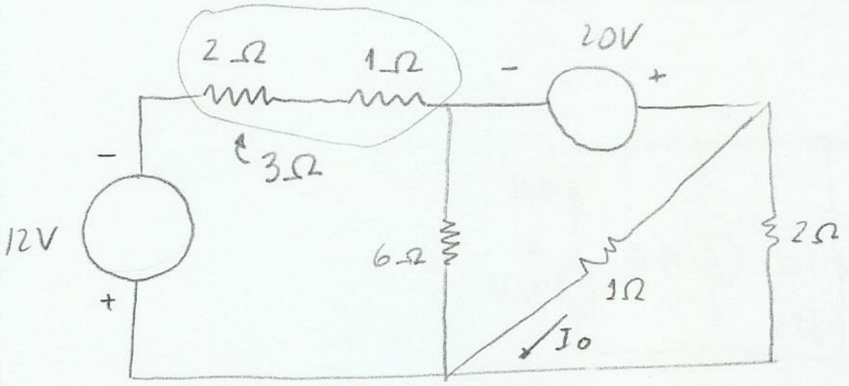




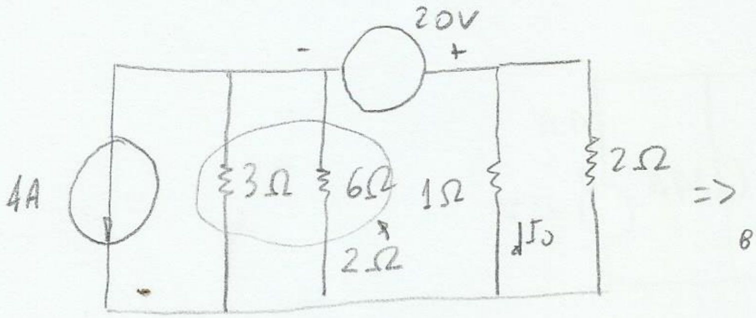


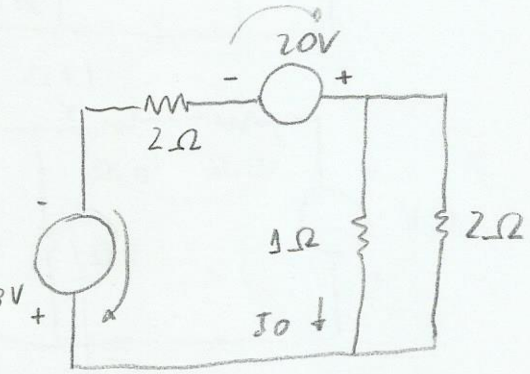
5.18 - (p. 214)

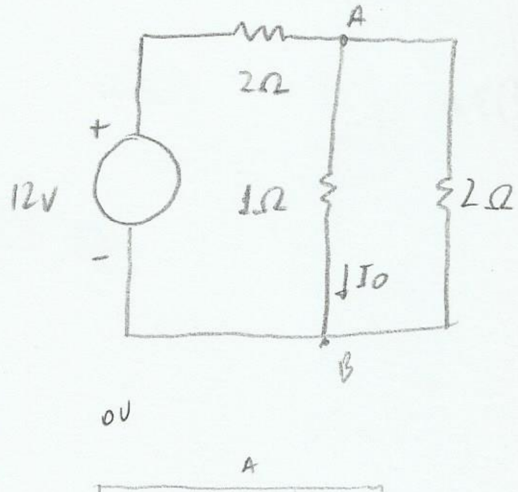




Para uma fonte de tensão vir fonte de corrente, ela tem que ter uma resistência em série



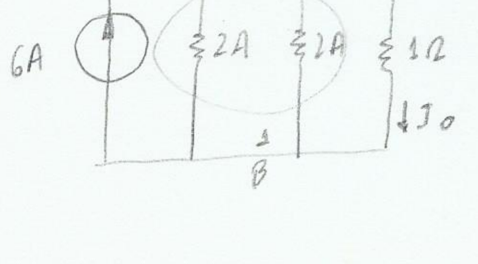




$$V_{AB} = \frac{2}{3} \div \left(\frac{2}{3} + 2\right) \cdot 12 = 3$$

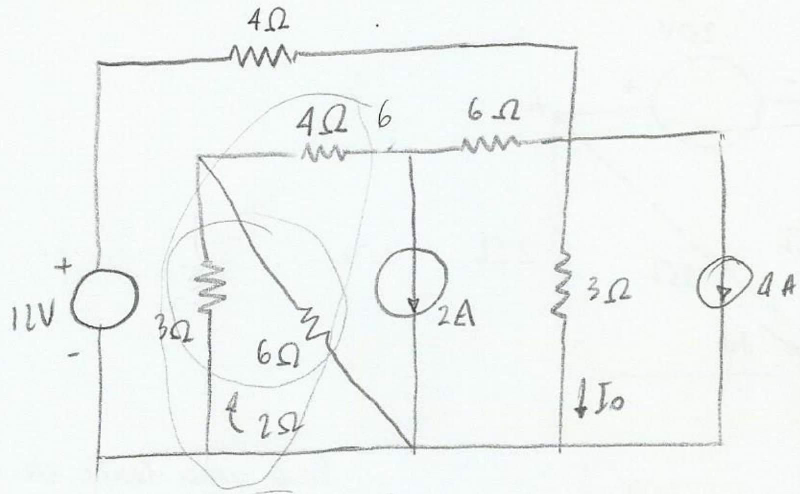
$$I_o = \frac{3}{1} = \underline{3A}$$

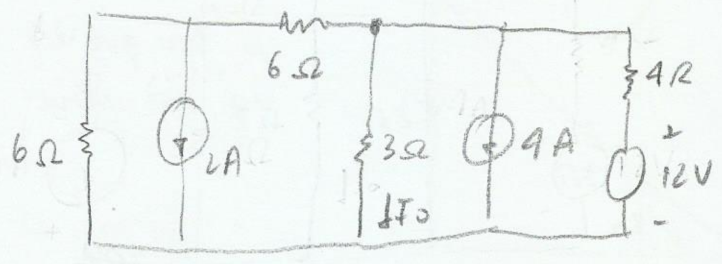
ou

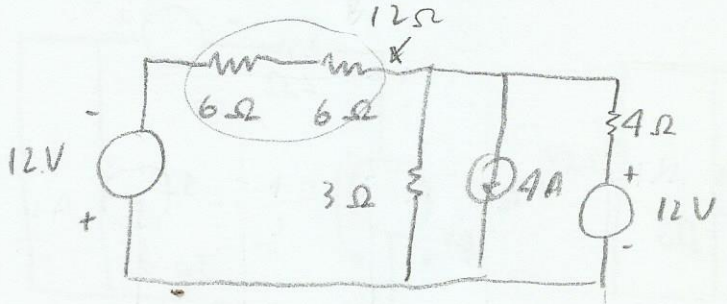


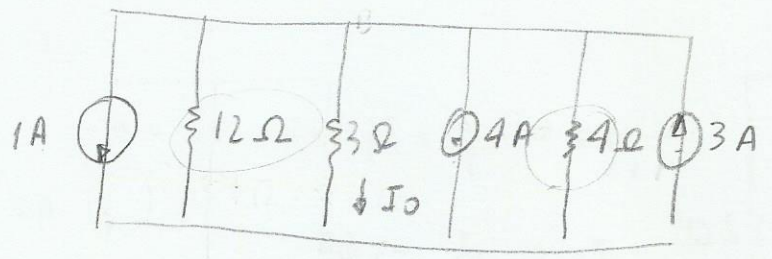
$$I_o = \frac{1}{1+1} \cdot 6 = \underline{3A}$$

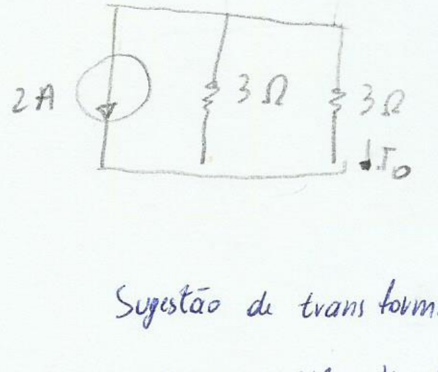
5.23 Aplique transformação de fonte para determinar I_o











$I_o = -1A$.

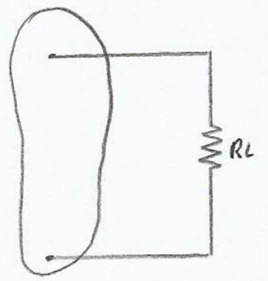
Sugestão de transformadas:

5.20 pg 214 $V_o = \frac{10}{7} V$

5.22 " $I_o = 2A$

Transferência Máxima de Potência

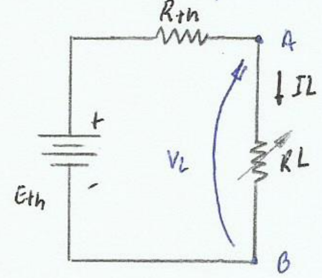
Seja um circuito qualquer



Qual o valor de R_1 para que receba a máxima potência transferida pelo circuito?

$\boxed{R_L = ? \Rightarrow R_L \text{ seja máxima}}$

O circuito pode ser representado por um equivalente de thevenin



$$I_L = \frac{E_{th}}{R_{th} + R_L}$$

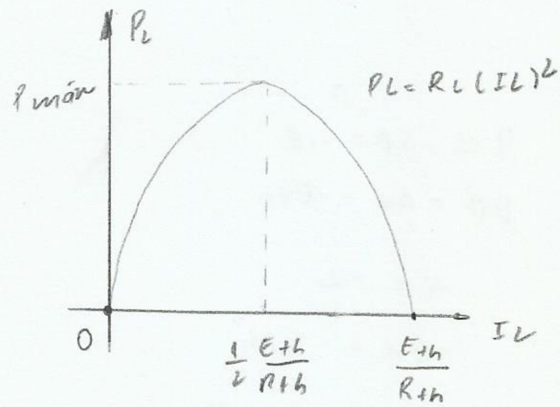
$$P_L = R_L \cdot (I_L)^2$$

R_L é variável

a) $R_L >> R_{th} \to \infty$ logo $I_L \to 0$ e $P_L = 0$

b) $R_L \cong 0$ logo $I_L = \frac{E_{th}}{R_{th}}$ e $P_L = 0$

gráfico de $P_L \times I_L$



A potência máxima (P_{max}) acontece quando:

$$I_L = \frac{E_{th}}{2R_{th}} = \frac{E_{th}}{R_{th} + R_{th}} \; R_L$$

Conclusão: R_L recebe a máxima potência transferida do circuito quando

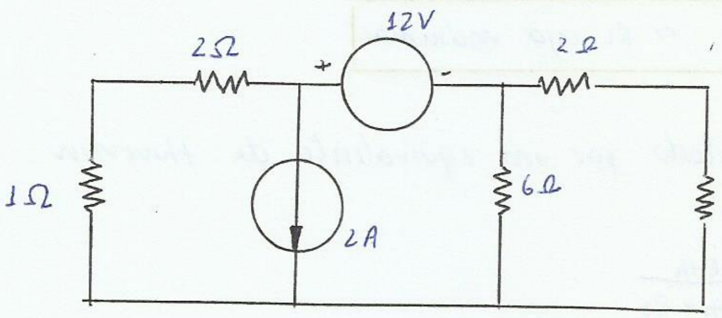
$$\boxed{R_L = R_{th}}$$

Exercício 4

Dado o circuito. Pede-se (5.59 pg 222)

a) o valor de R_L para que ele receba a máxima potência transferida pelo circuito.

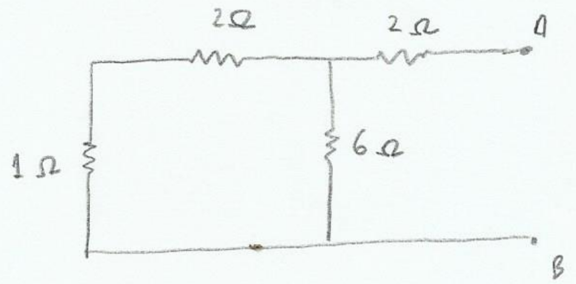
b) O valor dessa potência transferida



Solução:

(a)

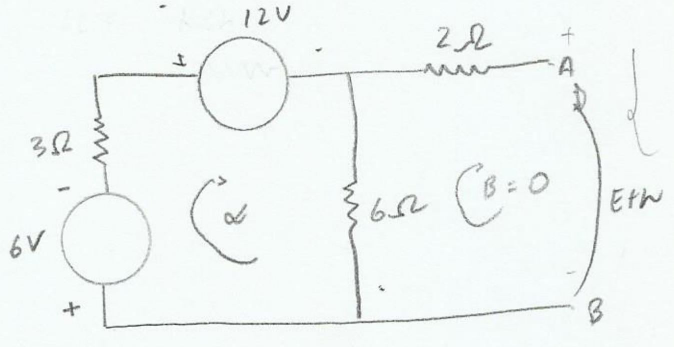
$R_{th} = ?$



$R_{th} = 4\,\Omega$

$R_L = R_{th} = 4\,\Omega$

(b) $E_{th} = ?$



$9\alpha - \cancel{6\beta} = -18$

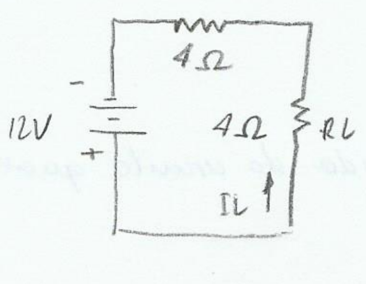
$\cancel{8\beta} - 6\alpha = -E_{th}$

$\alpha = -2$

$-6\alpha = -E_{th}$

$\therefore E_{th} = -12\,V$

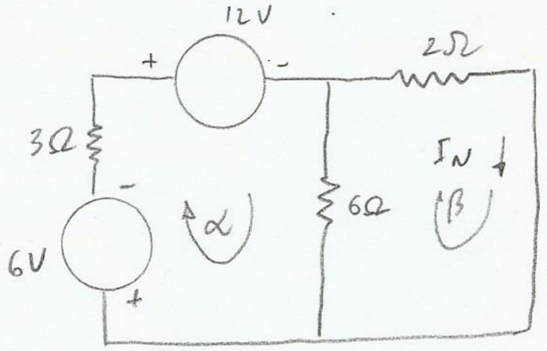
equivalente de thevenin



$P = R_L \cdot (I_L)^2 = 4 \cdot \left(\frac{12}{8}\right)^2$

$\therefore P = 9\,W$

Solução por Norton



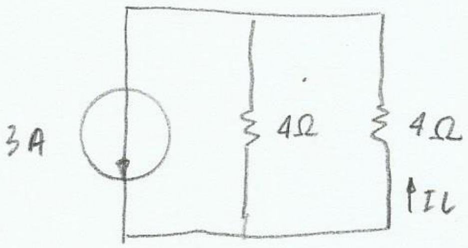
$$\begin{cases} 9\alpha - 6\beta = -18 \\ 8\beta - 6\alpha = 0 \end{cases}$$

$$\begin{cases} 9\alpha - 6\beta = -18 \\ -6\alpha + 8\beta = 0 \end{cases} \sim \begin{cases} 18\alpha - 12\beta = -36 \\ -18\alpha + 24\beta = 0 \end{cases}$$

$$12\beta = -36$$

$\therefore \beta = -3$

$\therefore I_N = \beta = -3A$



$\therefore I_L = 1{,}5 \quad \therefore P_L = 9W$

Sugestão:

E. 5.19
E. 5.20 pg 204

Circuitos elétricos

Técnicas de Análises Nodal de laço

Análise de laço

Exercícios

3.40 P no $R=5\Omega = ?$

$$\begin{cases} 6\alpha - 2\beta = 20-12 \\ 8\beta - 2\alpha = 12 \end{cases} \sim \begin{cases} 6\alpha - 2\beta = 8 \\ -2\alpha + 8\beta = 12 \end{cases} \sim \begin{cases} 6\alpha - 2\beta = 8 \\ 22\beta = 44 \end{cases}$$

$\therefore \beta = 2 \quad \alpha = 2$

$I = 2 \quad \therefore \quad P = V.I = R.I^2 = 5.2^2 \quad \therefore \quad \underline{P = 20W}$

3.42 Determine $I_o: ?$

$$\begin{cases} 2\alpha + 3\beta - 2\gamma = 12-6 \\ 3\gamma - 2\beta = 6-4 \end{cases} \sim \begin{cases} 2\alpha + 3\beta - 2\gamma = 6 \; \text{(I)} \\ -2\beta + 3\gamma = 2 \end{cases} \quad \begin{aligned} \alpha - \beta &= 2 \\ \alpha &= 2+\beta \end{aligned}$$

(I) $2(2+\beta) + 3\beta - 2\gamma = 6$

$4 + 2\beta + 3\beta - 2\gamma = 6$

$5\beta - 2\gamma = 2$

$$\begin{cases} 5\beta - 2\gamma = 2 \; (\times 3) \\ -2\beta + 3\gamma = 2 \; (\times 2) \end{cases} \sim \begin{cases} 5\beta - 2\gamma = 2 \\ 11\beta = 10 \end{cases}$$

$\therefore \beta = \frac{10}{11} \quad \therefore \quad I_o = \frac{10}{11} A$

3.50) Determine V_o

$$\begin{cases} 9\alpha - 3\gamma = -12 \\ 4\beta + 2\theta + 3\gamma - 3\alpha = 12-64 \end{cases} \quad \begin{cases} \gamma - \beta = 6 \\ \theta - \gamma = 8 \end{cases} \quad \begin{aligned} \beta &= \gamma - 6 \\ \theta &= 8 + \gamma \end{aligned}$$

$4(\gamma - 6) + 2(8+\gamma) + 3\gamma - 3\alpha = -52$

$4\gamma - 24 + 16 + 2\gamma + 3\gamma - 3\alpha = -52$

$9\gamma - 3\alpha = -44$

$$\begin{cases} 9\alpha - 3\gamma = -12 \\ -3\alpha + 9\gamma = -44 \end{cases} \sim \begin{cases} 9\alpha - 3\gamma = -12 \\ 24\gamma = -144 \end{cases}$$

$\therefore \gamma = -6$

$\theta = 8 + \gamma = 8 + (-6) \quad \therefore \theta = 2 \qquad \underline{V_o = 4V}$

3.64 Determine Vo

$$\begin{cases} 3\alpha + 3\gamma - \beta - \theta - \lambda = 0 \\ 3\theta + 4\lambda - 2\gamma - 2\beta = 0 \end{cases} \quad ; \quad \begin{cases} \alpha - \gamma = 1 \rightarrow \alpha = 1 + \gamma \\ \beta = 2V_x = 2.1.(\lambda - \gamma) = 2\lambda - 2\gamma \\ \lambda - \theta = 4 \quad \theta = \lambda - 4 \end{cases}$$

$$3(1+\gamma) + 3\gamma - 2(\lambda - \gamma) - (\lambda - 4) - \lambda = 0$$

$$3 + 3\gamma + 3\gamma - 2\lambda + 2\gamma - \lambda + 4 - \lambda = 0$$

$$8\gamma - 4\lambda = -7$$

$$\begin{cases} 8\gamma - 4\lambda = -7 \\ 2\gamma + 3\lambda = 12 \end{cases} \sim$$

$$3(\lambda - 4) + 4\lambda - 2\gamma - 2(2(\lambda - \gamma)) = 0$$

$$3\lambda - 12 + \cancel{4\lambda} - 2\gamma - \cancel{4\lambda} + 4\gamma = 0$$

$$3\lambda + 2\gamma = 12$$

$$\begin{cases} 8\gamma - 4\lambda = -7 \\ -16\lambda = -55 \end{cases}$$

$$\lambda = \frac{55}{16}$$

$$Vo = 1.\frac{55}{16} = \underline{3{,}4375\ V}$$

3.43 Determine Io

$$2\beta + 3\gamma = 12 \quad ; \quad \beta - \gamma = 4 \quad \alpha - \beta = 2 \quad \therefore \gamma = \alpha - 2 - 4$$

$$\gamma = \beta - 4 \quad \beta = \alpha - 2 \quad \gamma = \alpha - 6 \ \text{ e } \ \beta = \alpha - 2$$

$$2(\alpha - 2) + 3(\alpha - 6) = 12$$

$$2\alpha - 4 + 3\alpha - 18 = 12$$

$$5\alpha = 34 \quad \therefore \alpha = \frac{34}{5} = 6{,}8 \qquad \therefore \underline{Io = 6{,}8\ A}$$

3.55 Determinar Vo:

$$3\alpha + \beta - \theta + \gamma = 24 \quad ; \quad \beta - \alpha = 4 \quad \therefore \beta = 4 + \alpha \quad ; \ \theta = -2 \ \text{ e } \ \gamma = -4$$

$$3\alpha + 4 + \alpha - (-2) - (-4) = 24$$

$$4\alpha = 14 \quad \therefore \alpha = \frac{14}{4} = \frac{7}{2}$$

$$Io = \alpha - \theta$$

$$= \frac{7}{2} - (-2) = \underline{\frac{11}{2}}\ A$$

3.61-) Determine Vo

$2\alpha + 4\beta = 12$ $\cdot$ $\beta - \alpha = 2V\alpha = 2.(2.\alpha)$

$\alpha + 2\beta = 6$ $\beta - \alpha = 4\alpha$ $\alpha = \frac{1}{5}\beta$

$\cancel{3\gamma} - 3\beta = Vo$

$2.\frac{1}{5}\beta + 4\beta = 12$ $22\beta = 60$

$\beta = \frac{60}{22} = \frac{30}{11}$ $Vo = \frac{3.30}{11} = \frac{90}{11}V$

$2\beta + 20\beta = 60$

Exercícios faltantes

3.41 Determinar Vo

$\begin{cases} 2\alpha - \beta = 4 \\ 2\gamma - \beta = -4 \end{cases}$; $\beta = 2$ $\gamma = \frac{-4+2}{2} = -1$ $Vo = -1.1 = \underline{-1V}$

3.44 Determinar Io

$5\alpha - 2\beta - 2\gamma = 0$; $\beta = 2$ e $\gamma = -4$; $\gamma - \beta = Io$

$\gamma - \beta = Io$

$Io = -4 - 2 = -6$ $\therefore$ $\underline{Io = -6A}$

3.45 Determinar Io

$3\gamma - \beta = 12$; $\beta = -2$; $\alpha = 4$; $Io = \beta - \gamma$

$\gamma = \frac{12+\beta}{3} = \frac{12-2}{3} = \frac{10}{3}$ $Io = \beta - \gamma$

$= -2 - \frac{10}{3} = \frac{-16}{3}$ $\therefore$ $Io = \frac{-16}{3}A$

3.46 Determine Vo

$2\alpha + 3\beta = 12$; $\beta - \alpha = 2$ $\alpha = \beta - 2$

$2(\beta - 2) + 3\beta = 12$

$2\beta - 4 + 3\beta = 12$

$5\beta = 16$ $\therefore$ $\beta = \frac{16}{5}$ $Vo = \frac{16}{5}.2 = \frac{32}{5}V$ $\therefore$ $\underline{Vo = \frac{32}{5}V}$

3.47 Determinar Vo

$\begin{cases} 12\alpha - 6\beta = 12 \\ 12\gamma - 6\beta = -12 \end{cases} \sim \begin{cases} 2\alpha - \beta = 2 \\ 2\gamma - \beta = -2 \end{cases}$; $\beta = 6$; $Io = \beta - \gamma$

$\gamma = \frac{-2+6}{2} = \frac{4}{2} = 2$ $Io = 6 - 2$ $\therefore$ $Io = 4$

$Vo = \underline{24V}$

3.48 Determinar Vo

$$\begin{cases} 8I_1 - 2I_2 - 4I_3 = 0 \\ 5I_3 - 4I_1 - I_2 = 12 \end{cases} \qquad I_2 = 4 \; ; \; I_0 = I_2 - I_3$$

$$\begin{cases} 8I_1 - 4I_3 = 8 \\ -4I_1 + 5I_3 = 16 \end{cases} \sim \begin{cases} 8I_1 - 4I_3 = 8 \\ 6I_3 = 40 \end{cases} \quad \therefore \quad I_3 = \frac{40}{6} = \frac{20}{3}$$

$$I_0 = 4 - \frac{20}{3} = \frac{-8}{3} \quad \therefore \quad V_0 = \underline{\frac{-8}{3}\,V}$$

3.49 Determinar Vo

$$\begin{cases} 18\beta - 6\alpha - 6\gamma = 0 \\ 6\alpha - 6\beta - 6\gamma = 12 \end{cases} \sim \begin{cases} 3\beta - \alpha - \gamma = 0 \\ \alpha - \beta - \gamma = 2 \end{cases} \; ; \quad \begin{aligned} \gamma - \alpha &= 6 \\ \gamma &= 6 + \alpha \end{aligned}$$

$$3\beta - \alpha - 6 + \alpha = 0$$

$$3\beta = 6 \quad \therefore \beta = 2 \qquad V_0 = 6.2 \quad \therefore \underline{V_0 = -12V}$$

3.50 Determinar a potência disipada no resistor de 2Ω

$$\begin{cases} 3\alpha - \gamma - 2\theta = 6 \\ 3\beta - \gamma - \theta = 0 \end{cases} \; ; \; \gamma = 2 \quad \theta = -2 \qquad I = \theta - \alpha$$

$$3\alpha - 2 + 4 = 6$$

$$\alpha = \frac{4}{3} \qquad I = -2 - \frac{4}{3} = \frac{-6-4}{3} = \frac{-10}{3}$$

$$P = V.I = RI^2 = 2.\left(\frac{-10}{3}\right)^2 = \frac{2.100}{9} = \frac{200}{9}\,W$$

3.51 Determinar Io

$$2\beta + 3\alpha - 3\gamma = 12$$

$$\beta - \gamma = I_0 \; ; \; \gamma = -4 \qquad \beta - \alpha = 2$$

$$\beta + 4 = I_0 \qquad \alpha = \beta - 2$$

$$\beta = I_0 - 4 \qquad \alpha = I_0 - 6$$

$$2(I_0 - 4) + 3(I_0 - 6) - 3.(-4) = 12$$

$$2I_0 - 8 + 3I_0 - 18 + \cancel{12} = \cancel{12}$$

$$5I_0 = 26$$

$$I_0 = \frac{26}{5}$$

?

3.52

$3\alpha + 2\theta + 2\gamma - 3\beta = 0$; $\beta = 4$

$\theta - \alpha = 2 \rightarrow \alpha = \theta - 2$

$\gamma - \theta = 2 \qquad \gamma = 2 + \theta$

$I_O = \beta - \gamma = 4 - \gamma$

$3(\theta - 2) + 2\cdot\theta + 2(2+\theta) - 3\cdot 4 = 0$

$3\theta - 6 + 2\theta + 4 + 2\theta - 12 = 0$

$7\theta = 14 \quad \therefore \theta = 2$

$I_O = 4 - \gamma$

$I_O = 4 - (2+\theta)$

$I_O = 4 - (2+2) = \underline{0}$

3.53

$2\alpha + \beta + 2\gamma - \theta - 2\lambda = 12$; $\beta - \alpha = 4$ $\qquad I_O = \gamma - \lambda$

$\gamma - \alpha = 2 \qquad I_O = \gamma + 3$

$\theta = -6$

$\lambda = -3$

$\beta = 4 + \alpha$

$\gamma = 2 + \alpha$

$2\alpha + 4 + \alpha + 2\cdot(2+\alpha) - (-6) - 2\cdot(-3) = 12$

$2\alpha + 4 + \alpha + 4 + 2\alpha + 6 + 6 = 12$

$5\alpha = -8$

$\alpha = -\frac{8}{5}$ $\qquad I_O = \gamma + 3$

$= 2 + \alpha + 3$

$= 2 - \frac{8}{5} + 3$

$\therefore I_O = \frac{17}{5}$ A

3.54

$2\alpha - \beta = -12$; $\beta = 4 \quad \theta - \gamma = 2$

$\gamma + 2\theta - \beta - \cancel{\lambda}^{\to 0} = 12 \qquad \gamma = \theta - 2$

$\cancel{\lambda} - \theta = -V_O \quad \therefore V_O = \theta$

$\theta - 2 + 2\theta - 4 = 12$

$3\theta = 18$

$\theta = 6 \qquad \therefore \underline{V_O = 6V}$

3.56

$$\begin{cases} 3\alpha - \beta - \gamma = 0 \\ \gamma + 2\theta - \alpha - \beta - \cancel{\lambda}^{0} = -6 \\ \cancel{\lambda}^{0} - \theta = -V_0 \end{cases}$$

$; \beta = -2$

$\theta - \gamma = 2 \; ; \gamma = \theta - 2$

$\rightarrow V_0 = \theta$

$\theta - 2 + 2\theta - \alpha - (-2) = -6$

$3\theta - \alpha = -6$

$3\alpha - \beta - \gamma = 0$

$3\alpha - (-2) - (\theta - 2) = 0$

$3\alpha + 2 - \theta + 2 = 0$

$\alpha = \dfrac{\theta - 4}{3}$

$3\theta - \alpha = -6$

$3\theta - \left(\dfrac{\theta - 4}{3}\right) = -6$

$\dfrac{9\theta - \theta + 4}{3} = -6$

$8\theta = -18 - 4$

$\theta = \dfrac{-22}{8} = \dfrac{-11}{4}$

3.57-)

$$\begin{cases} 4\alpha - 2\beta - 2\gamma = 12 \\ 4\gamma - 2\alpha - \theta = 0 \end{cases}$$

$; \beta = 2 \quad \theta = -1 \quad I_0 = \alpha - \gamma$

$$\begin{cases} 4\alpha - 2\gamma = 16 \\ -2\alpha + 4\gamma = -1 \end{cases} \sim \begin{cases} 4\alpha - 2\gamma = 16 \\ 6\gamma = 14 \end{cases}$$

$\gamma = \dfrac{14}{6} = \dfrac{7}{3}$

$\alpha = \dfrac{16 + 2\gamma}{4} = \left(16 + \dfrac{14}{3}\right) \div 4 = \dfrac{48 + 14}{12} = \dfrac{62}{12} = \dfrac{31}{6}$

$I_0 = \dfrac{31}{6} - \dfrac{14}{6} = \dfrac{17}{6}$ A

3.59-)

$$\begin{cases} 2\beta + 3\theta - \alpha - \gamma - \cancel{2\lambda}^{0} = 0 \\ \cancel{2\lambda}^{0} - 2\theta = -V_0 \end{cases}$$

$; \alpha = 4 \quad \gamma = -2 \quad \theta - \beta = 1$

$\beta = \theta - 1$

$2(\theta - 1) + 3\theta - 4 - (-2) = 0$

$2\theta - 2 + 3\theta - 4 + 2 = 0$

$5\theta - 4 = 0$

$\theta = \dfrac{4}{5}$

$V_0 = 2\theta$

$V_0 = \dfrac{8}{5}$ V

3.60

$$\begin{cases} 4\beta - \alpha - 2\gamma - \theta = -4 \\ 2\alpha + 2\gamma + \theta - 4\beta = -8 \end{cases} \quad ; \begin{cases} \gamma - \alpha = 2 \\ \gamma - \theta = 4 \end{cases} \quad ; \ I_0 = \theta$$

$$\alpha = \gamma - 2$$
$$\theta = \gamma - 4$$

$$4\beta - (\gamma - 2) - 2\gamma - (\gamma - 4) = -4$$
$$4\beta - \gamma + 2 - 2\gamma - \gamma + 4 = -4$$
$$4\beta - 4\gamma = -10$$

$$2(\gamma - 2) + 2\gamma + \gamma - 4 - 4\beta = -8$$
$$\underline{2\gamma} - 4 + \underline{2\gamma} + \gamma - 4 - 4\beta = -8$$
$$-4\beta + 5\gamma = 0$$

$$\begin{cases} 4\beta - 4\gamma = -10 \\ -4\beta + 5\gamma = 0 \end{cases}$$

$$\gamma = -10$$

$$I_0 = \theta = \gamma - 4 = -10 - 4$$

$$\therefore \ \underline{I_0 = -14\,A}$$

3.62

$$\begin{cases} 6I_1 - 4I_2 = 12 \\ 10I_2 - 4I_1 - \cancel{6I_0}^{\to 0} = 2Va \end{cases} \quad ; \ Va = 2I_1$$
$$\cancel{6I_0}^{\to 0} - 6I_2 = -V_0$$

$$\begin{cases} 6I_1 - 4I_2 = 12 \\ -4I_1 + 10I_2 = 4I_1 \end{cases} \sim \begin{cases} 6I_1 - 4I_2 = 12 \\ -8I_1 + 10I_2 = 0 \end{cases} \sim \begin{cases} 15I_1 - 10I_2 = 30 \\ -8I_1 + 10I_2 = 0 \end{cases}$$

$$7I_1 = 30$$

$$I_1 = \frac{30}{7} \qquad Va = \frac{2.30}{7} = \frac{60}{7}$$

Capítulo 5: Teorema thevenon

5.46

* Obs.: Quando tiver fonte dependente usar método indireto.

$$R_{th} = \frac{V_{oc}}{I_{sc}}$$

Determinação do Isc

$2\alpha + \gamma = 12$; $\beta - \alpha = 2$, $\alpha = -I_x$ $\therefore$ $\beta = 2 + \alpha = 2 - I_x$

$\beta - \gamma = 2I_x = 2.(-\alpha)$ $\therefore$ $\beta - \gamma = -2\alpha$

$\beta - \gamma = -2\alpha$

$\gamma = \beta + 2\alpha = 2 - I_x + 2(-I_x)$ $\quad \gamma = 2 - 3I_x$

$2.(-I_x) + 2 - 3I_x = 12$

$-2I_x - 3I_x = 12 - 2$

$-5I_x = 10$ $\therefore$ $I_x = -2$ $\quad I_{sc} = \gamma$

$\beta - \gamma = -2\alpha$

$\gamma = \beta + 2\alpha = 2 - I_x + 2.(-I_x)$

$= 2 + 2 + 2.(2)$ $\therefore$ $\underline{I_{sc} = 8A}$

Determinação do Voc

$2\alpha + \cancel{\gamma}^{0} = 12 - V_{oc}$; $\beta - \alpha = 2$

$\beta - \cancel{\gamma}^{0} = 2I_x$; $I_x = -\alpha$

$\beta = 2 + \alpha = 2I_x$

$2 + \alpha = -2\alpha$

$-3\alpha = 2$ $\quad \alpha = -\frac{2}{3}$

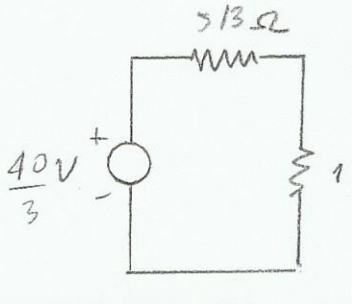
$2\alpha = 12 - V_{oc}$

$V_{oc} = 12 - 2.\left(-\frac{2}{3}\right)$

$= 12 + \frac{4}{3} = \frac{40}{3}$

$R_{th} = \frac{40}{3} \div 8$

$R_{th} = \frac{40}{24} = \frac{20}{12} = \frac{10}{6} = \frac{5}{3}$



$V_o = \frac{1}{\frac{5}{3} + 1} \cdot \frac{40}{3} = \underline{5V}$

Determine Io, assumindo $I_o = 1A$

$$\begin{cases} 15\alpha - 12\beta = 24 \\ 16\beta - 12\alpha = 0 \end{cases} \qquad \beta = I_o$$

$$\begin{cases} 5\alpha - 4\beta = 8 \\ -3\alpha + 4\beta = 0 \end{cases} \qquad \therefore I_t = 4\Omega$$

$2\alpha = 8$

$\alpha = 4$

$4 I_o = 12 I'$ $\qquad I_t = I_o + \frac{I_o}{3} = \frac{4 I_o}{3}$

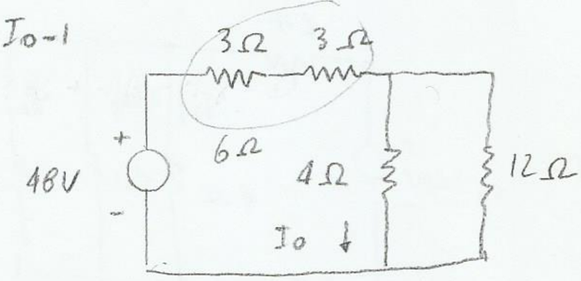
$I' = \frac{I_o}{3}$

$I_T' = \frac{4 \cdot 1}{3} = \frac{4}{3}$

$4 = 4/3$

$I_o = 1$ $\qquad \therefore I_o = 4 \div \frac{4}{3} = \frac{12}{4} = \underline{3A}$

5.1 $I_o - 1$



$4 I_o = 12x$

$x = \frac{I_o}{3}$

$I_T = \frac{I_o}{3} + I_o = \frac{4}{3} I_o$

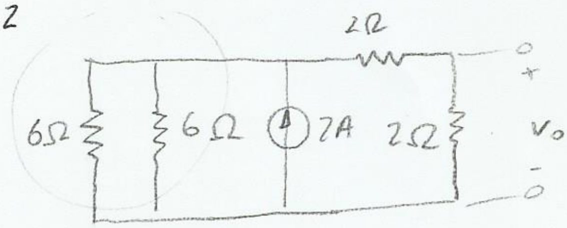
$R_T = 6 + (4 \| 12) = 6 + 3 \qquad \therefore R_T = 9$

$I_T = \frac{48}{9} = \frac{16}{3} \qquad I_T' = \frac{4}{3}$

$\frac{16}{3} = \frac{4}{3} \qquad \therefore I_o = \frac{16}{3} \div \frac{4}{3} = 4 \qquad \therefore \underline{I_o = 4A}$

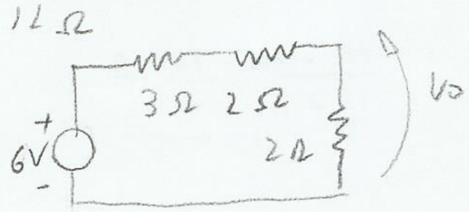
$I_o = 1$

5.2



; $V_o = 1V$

12Ω



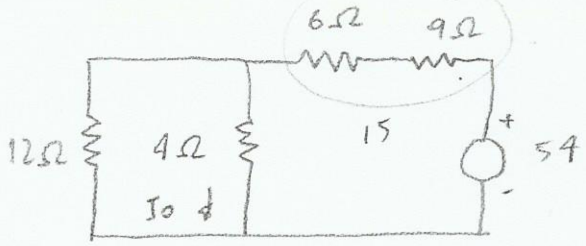
$I_o = \frac{V_o}{2} \qquad I_o' = \frac{1}{2}$

$I_o = \frac{6}{7}$

$\frac{6}{7} = \frac{1}{2} \qquad \therefore V_o = \frac{6}{7} \div \frac{1}{2}$

$V_o = 1$

$V_o = \frac{12}{7} V$



$$I_T = \frac{54}{(12 \| 4) + 15} = \frac{54}{3+15} = 3$$

$\frac{4}{3} = 3$

$1 = I_o$

$12x = 4I_o$

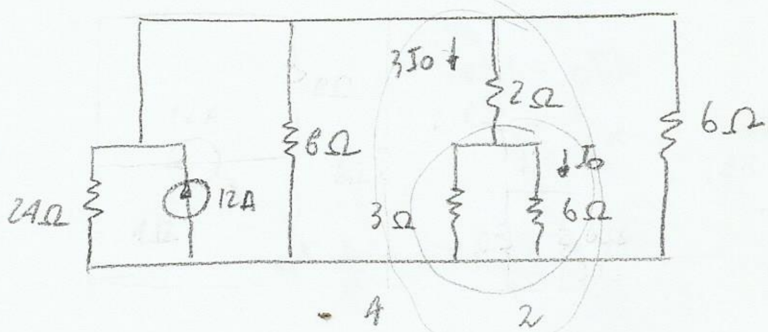
$x = \frac{I_o}{3}$ $\quad I_T = \frac{4I_o}{3}$ $\quad I_T' = \frac{4}{3}$

$\therefore I_o = 3 \div \frac{4}{3} = \frac{9}{4}$ A

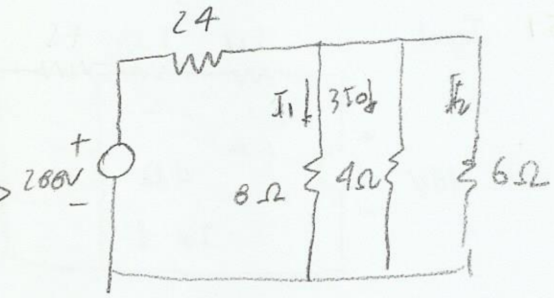
5.4-)

$6I_o = 3x$ $\quad I = 2I_o + I_o = 3I_o$

$x = 2I_o$



=>



$8I_1 = 12I_o$ $\qquad 6I_2 = 12I_o$

$I_1 = \frac{12I_o}{8} = \frac{6I_o}{4} = \frac{3I_o}{2}$ $\qquad I_2 = 2I_o$

$I_T = \frac{3}{2}I_o + 2I_o + 3I_o = \frac{13}{2}I_o$ $\qquad I_T' = \frac{13}{2}$

$R_T = 24 + (8 \| 4 \| 6) = \frac{336}{13}$

$I_T = 288 \div \frac{336}{13} = \frac{78}{7}$

$\frac{78}{7} = \frac{13}{2}$

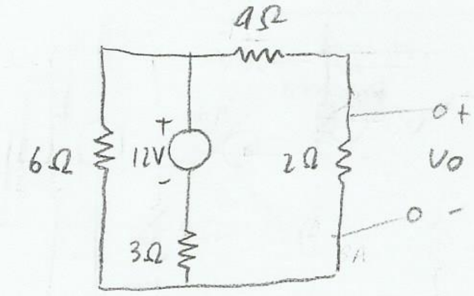
$I_o = 1$

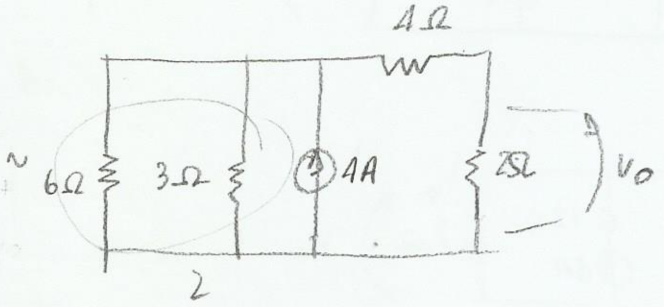
$\therefore I_o = \frac{78}{7} \div \frac{13}{2} = \frac{78 \cdot 2}{13 \cdot 7} = \frac{12}{7}$ A

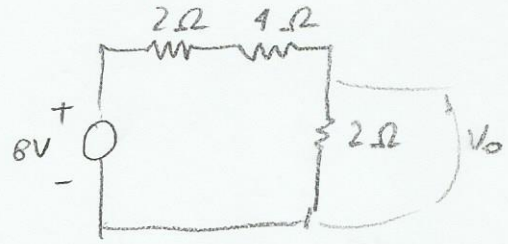
Superposição de efeitos

5.14)

Influência de 12V

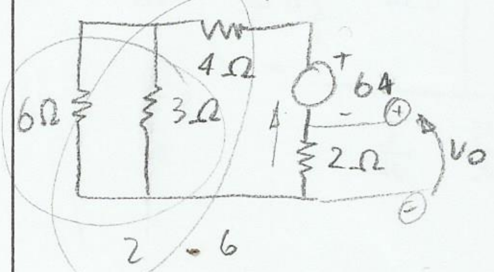






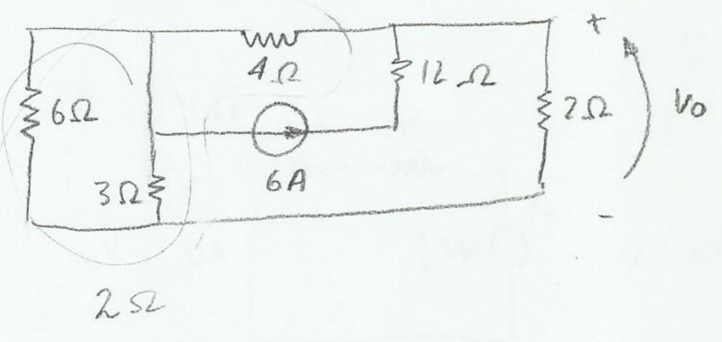
$$V_o' = \frac{2}{8} \cdot 8 = 2V$$

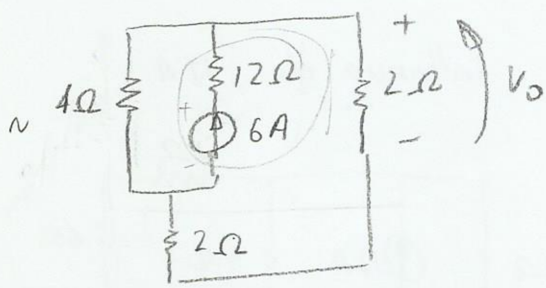
Influência de 64V

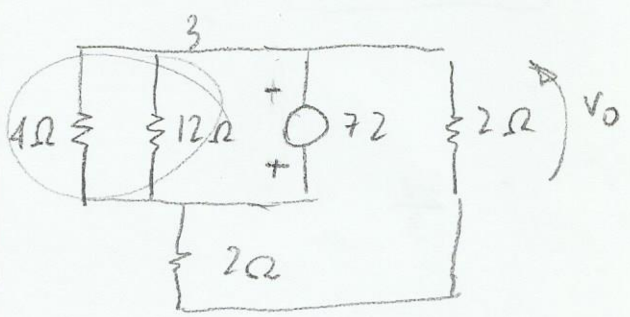


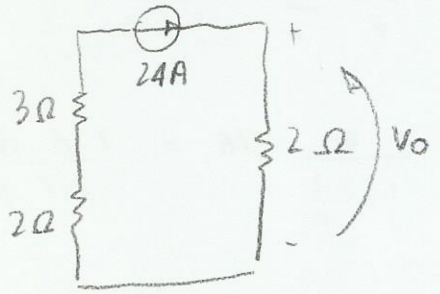
$$V_o'' = \frac{2}{8} \cdot 64 = \underline{16V}$$

Influência de 6A



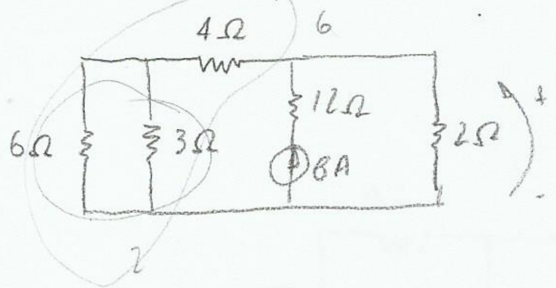






$\therefore V_o''' = 48V$

Influência de 8A



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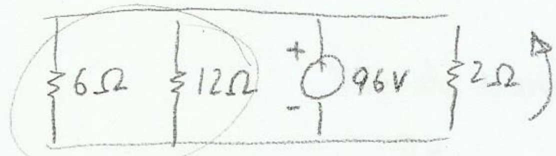
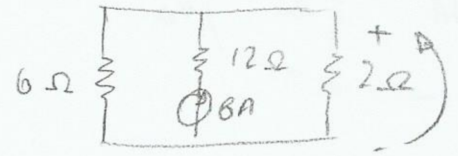


4

$V_o^{IV} = 96$

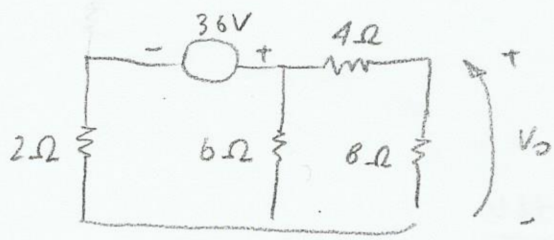


$V_o : 96$

?

5.5

Influência de 36V



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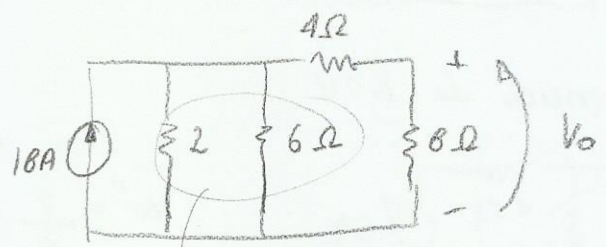
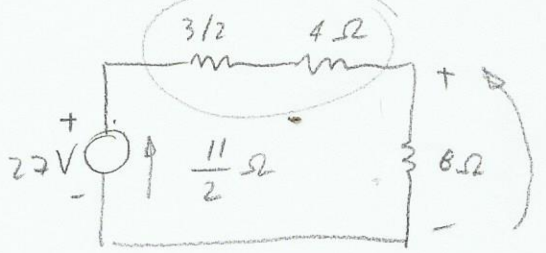
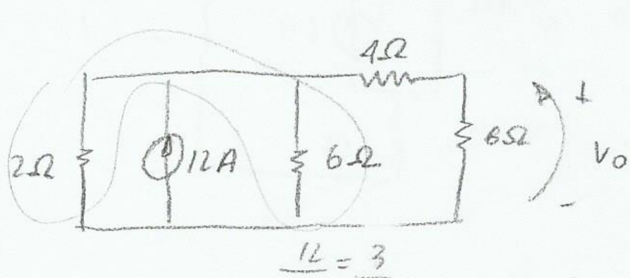


$\frac{12}{8} = \frac{3}{2}$



$$V_o' = \frac{8}{\frac{11}{2}+6} \cdot 27 = \frac{8 \cdot 2 \cdot \cancel{27}}{\cancel{27}} = 16V$$

Influência de 12A



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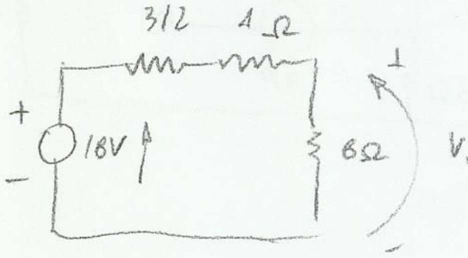


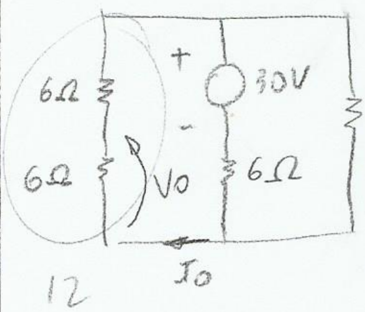
$\frac{12}{8} = \frac{3}{2}$

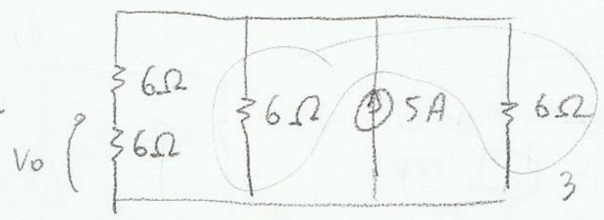
$$V_o'' = \frac{8}{12+\frac{3}{2}} \cdot 18 = \frac{2 \cdot 8 \cdot \cancel{18}^{2}}{\cancel{27}_{\cancel{9}}\ 3} = \frac{32}{3}$$

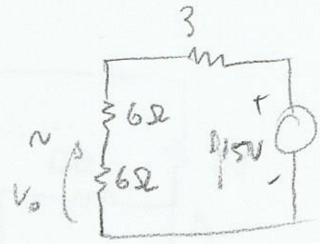
$$V = \frac{32}{3} + 16 = \frac{32+48}{3} = \frac{80}{3} V$$

5.6

Influência de 30V

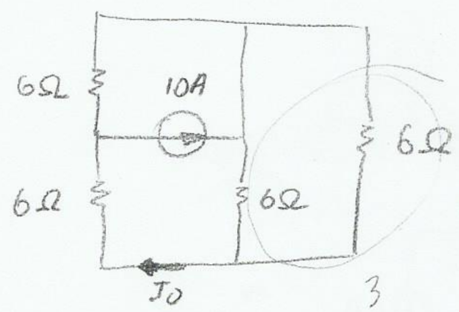


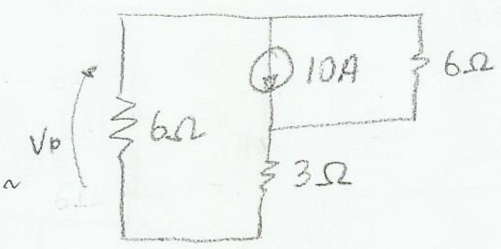


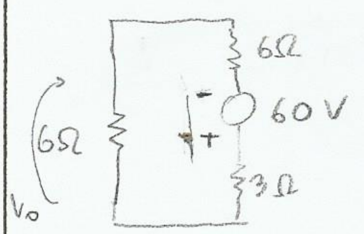


$$V_o' = \frac{6}{15}\,15 = 6V$$

Influência de 10A







$$V_o'' = \frac{6}{15} \cdot 60 = -24$$

$V = 6 - 24 = 18$ ∴ $\underline{I = 3A}$

$$\begin{cases} 18\alpha - 6\beta = -30 \\ 12\beta - 6\alpha = 30 \end{cases} \sim \begin{cases} 3\alpha - \beta = -10 \\ -3\alpha + 6\beta = 15 \end{cases} \qquad \alpha = \frac{-10+\beta}{3} = \frac{-10+1}{3} = -3$$

$5\beta = 5$ ∴ $\beta = 1$

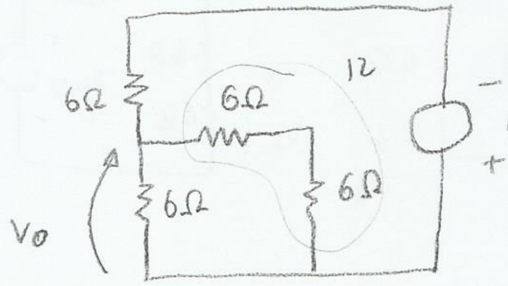
$V_o' = 6V$

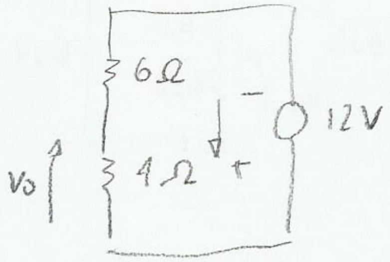
$V_o'' = -24V$ ∴ $I = 3A$

$V = -18V$

5.7-)

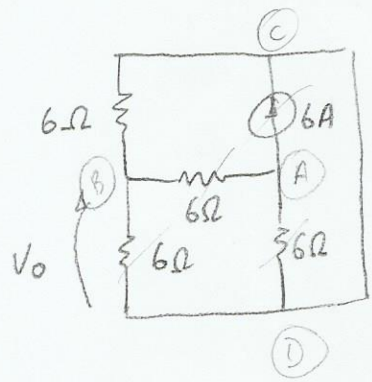
Influência de 12V

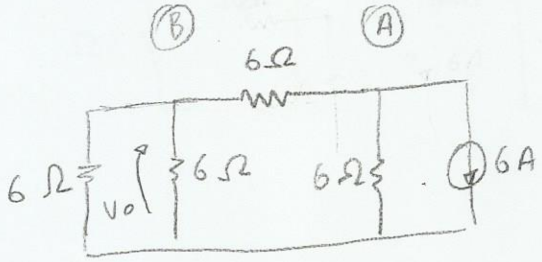




$$V_o' = \frac{-4}{4+6} \cdot 12 = \frac{-24}{5}$$

Influência de 6A





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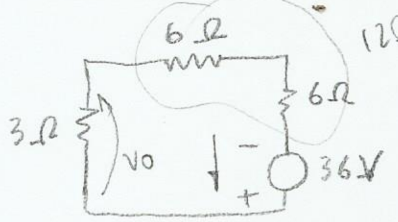
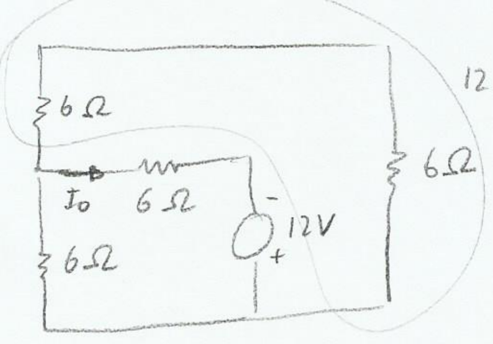


$$V_o'' = \frac{3}{15} \cdot 36 = \frac{-36}{5}$$

$$V = \frac{-36}{5} - \frac{24}{5} = \frac{-60}{5} = \underline{-12\,V}$$

5.8-)

Influência de 12V



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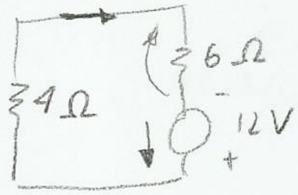
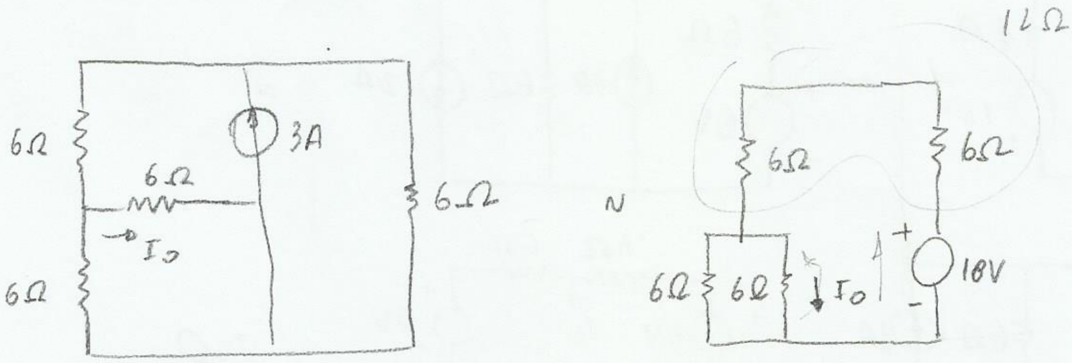


$$V_o' = \frac{6}{10} \cdot 12 = \frac{72}{10} = \frac{36}{5}$$

Jnfluência de 3A

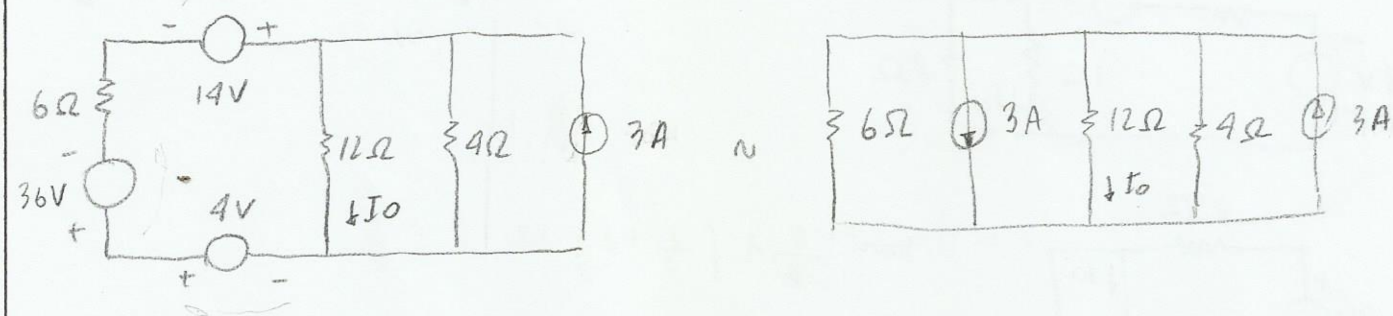


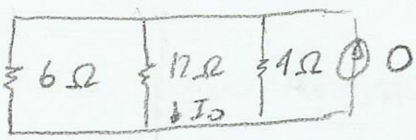
$$I_T = \frac{18}{12+3} = \frac{18}{15} = \frac{6}{5} = 2I_o \quad \therefore \quad I_o = \frac{3}{5}$$

$$V_o'' = \frac{3}{5} \cdot 6 = \frac{18}{5}$$

$$V = \frac{18}{5} + \frac{36}{5} = \frac{54}{5} \quad \therefore \quad I_o = \frac{54}{5} \div 6 = \frac{54}{30} = \frac{27}{15} = \underline{\frac{9}{5}\,A}$$

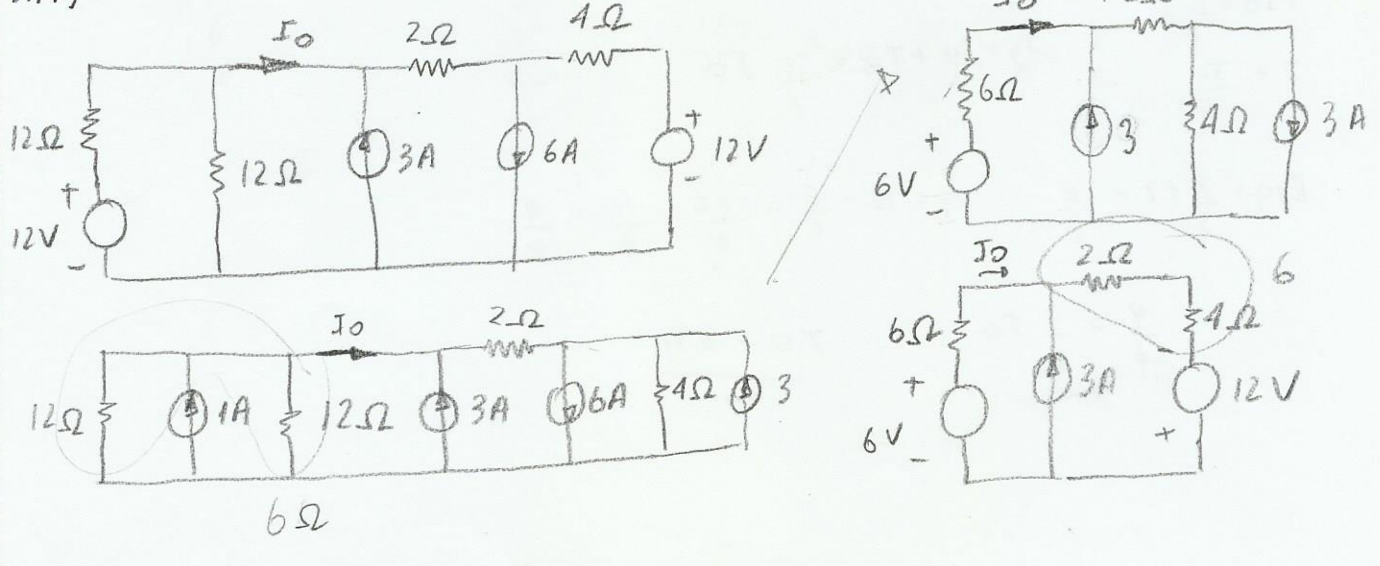
5.16)

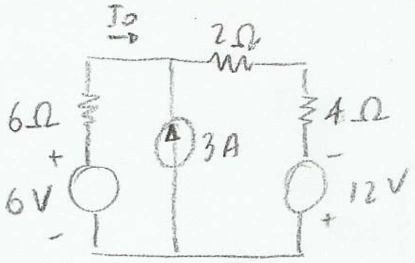




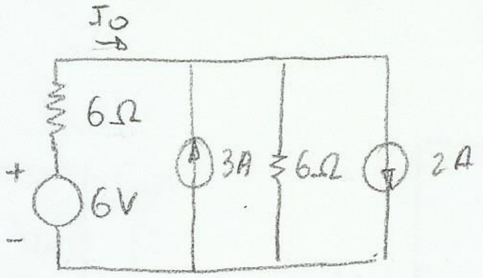
$\therefore I_o = 0$

5.17)

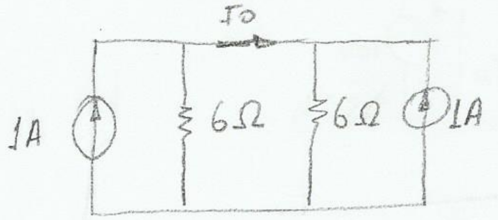


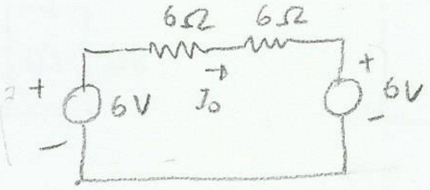


$\sim$



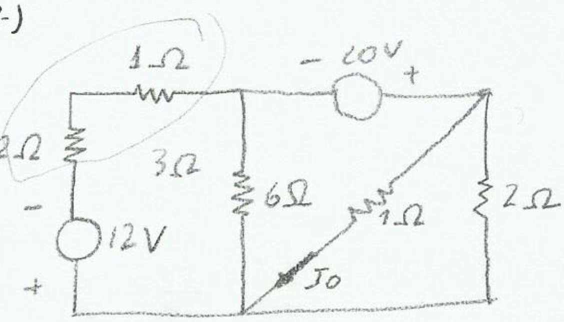
$\sim$



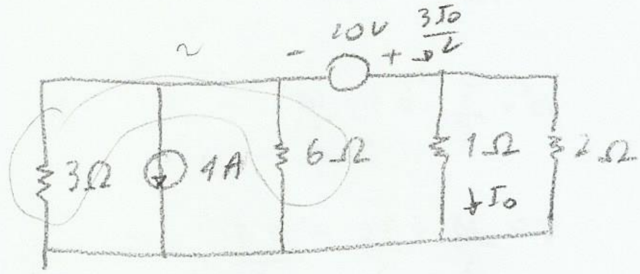


$\therefore I_o = 0$

5.18-)

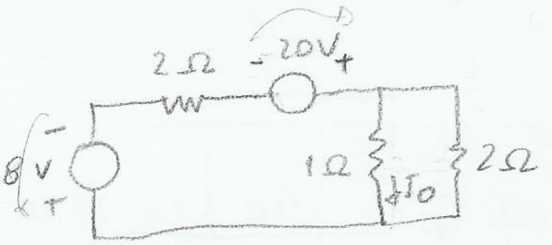


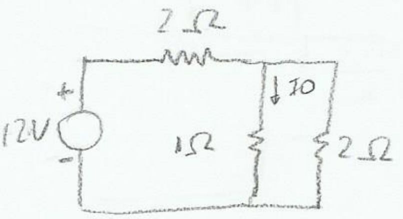
$\sim$



$I_o = 2I$

$I = \frac{I_o}{2} \quad \therefore \quad I_o + \frac{I_o}{2} = \frac{3 I_o}{2}$





$V_o = \frac{2}{3} \div \left(\frac{2}{3} + 2 \right) \cdot 12$

$= \frac{2}{3} \div \frac{8}{3} \cdot 12$

$= \frac{1}{4} \cdot 12 = 3 \quad \therefore \quad \underline{I_o = 3A}$

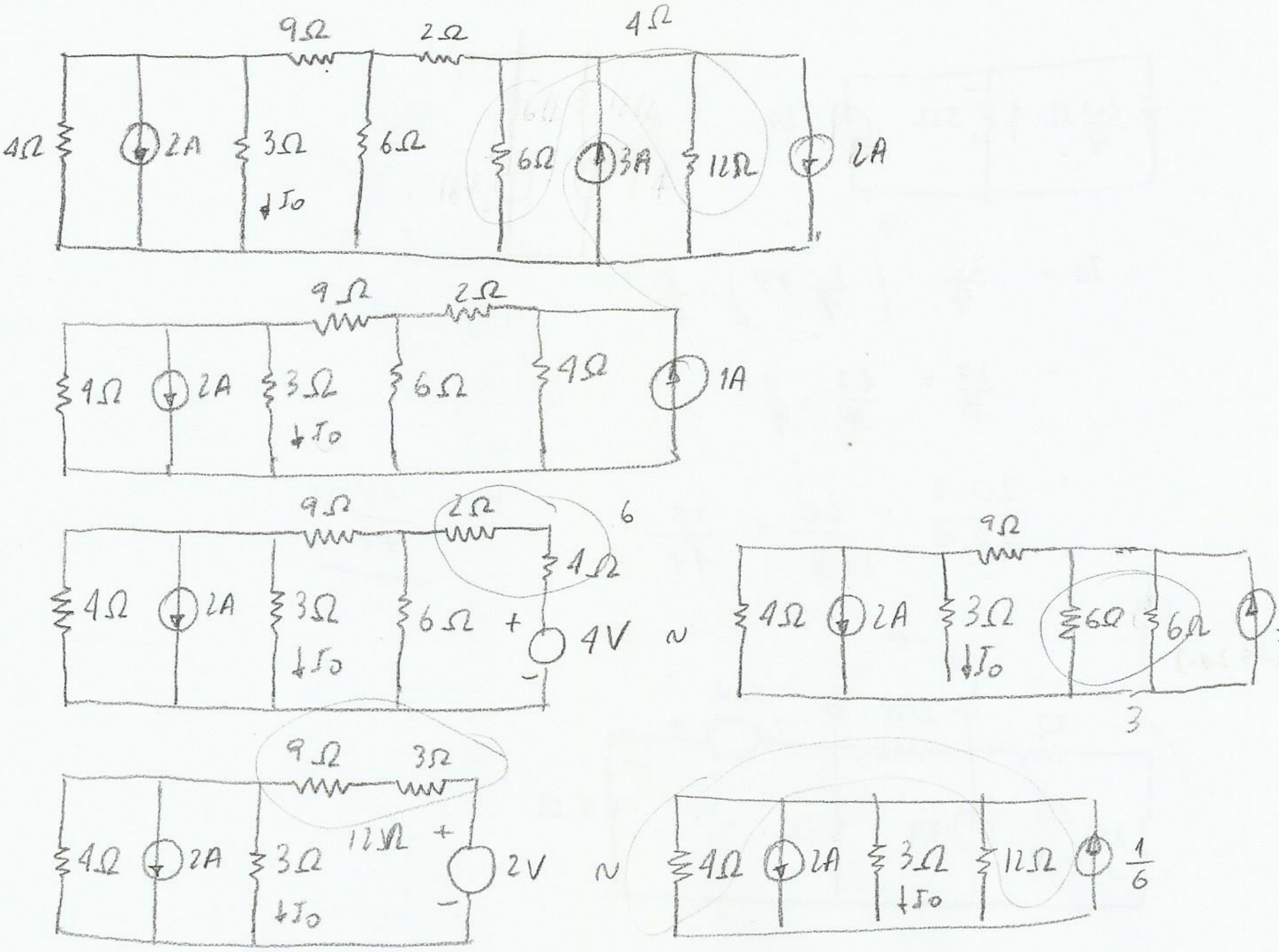
$1 I_o = 2I$

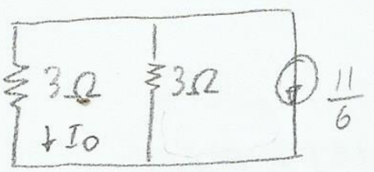
$I = \frac{I_o}{2} \quad \therefore \quad I_g = \frac{I_o}{2} + I_o = \frac{3}{2} I_o$

$R_{eq} = \frac{2}{3} + 2 = \frac{8}{3} \qquad I_T = 12 \div \frac{8}{3} = \frac{36}{8} = \frac{18}{4} = \frac{9}{2}$

$\frac{9}{\cancel{2}} = \frac{3}{\cancel{2}} I_o \quad \therefore \quad \underline{I_o = 3A}$

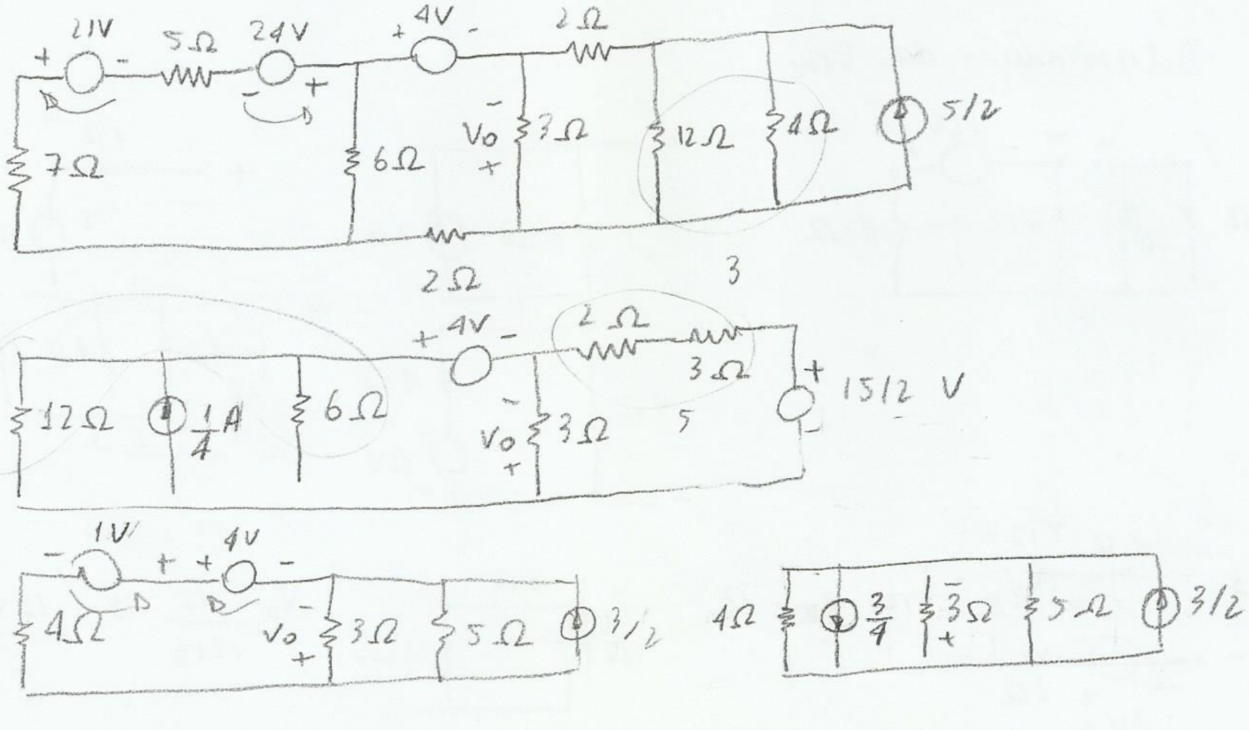
5.19-)

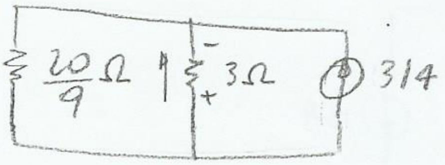




$\therefore\ I_o = \frac{11}{6} \div 2 = -\frac{11}{12}$ A

5.20-)



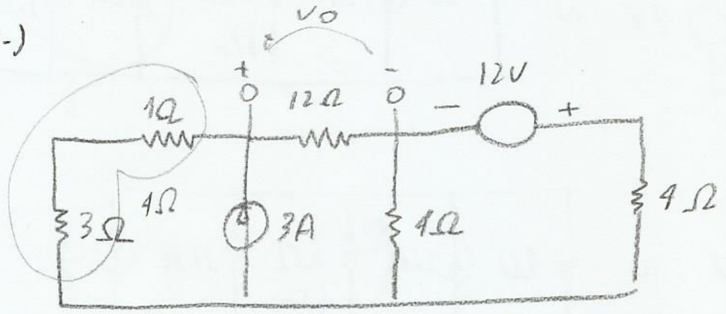


$$I_o = \frac{20}{9} \div \left(\frac{20}{9}+3\right)\cdot\frac{3}{4}$$

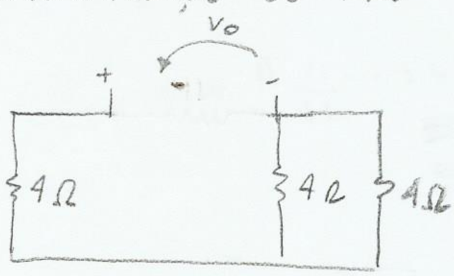
$$= \frac{20}{\cancel{9}} \div \frac{47}{\cancel{9}}\cdot\frac{3}{4}$$

$$= \frac{20\cdot 3}{47\cdot 4} = \frac{60}{188} = \frac{15}{47} \qquad \therefore V_o = \underline{\frac{45}{47}\,V}$$

5.24-)

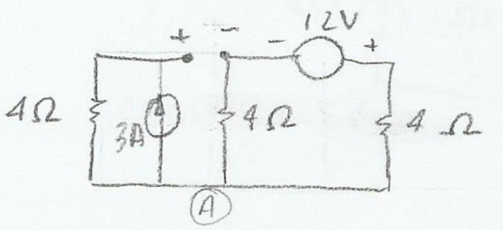


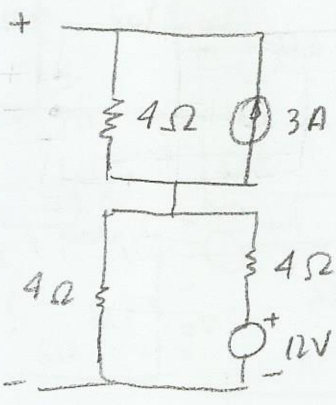
Determinação do R_{th}



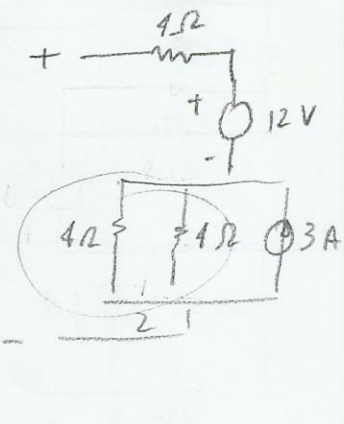
$R_{eq} = 4 + (4 \parallel 4) = 6\,\Omega$

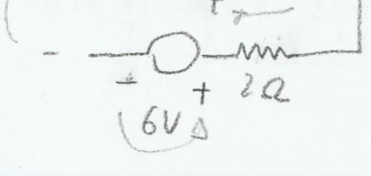
Determinação do E_{th}





$\sim$



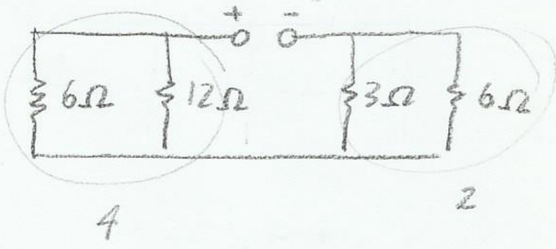


$E_{th} = 18$

$V_o = \frac{12}{12+6}\cdot 18 = \underline{12\,V}$

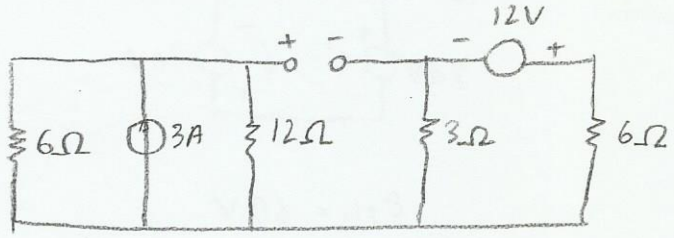
5.25

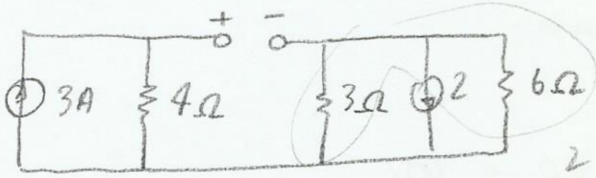
Para determinar R_{th}

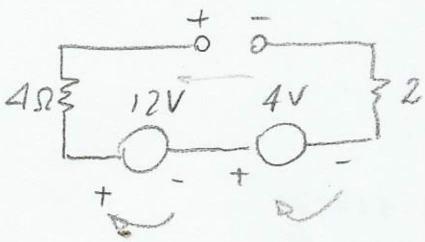


$\therefore R_{th} = 6\ \Omega$

Para determinar E_{th}

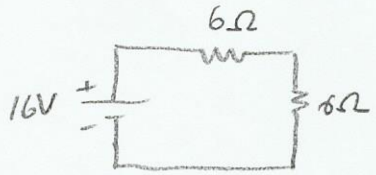






$\therefore E_{th} = 16V$

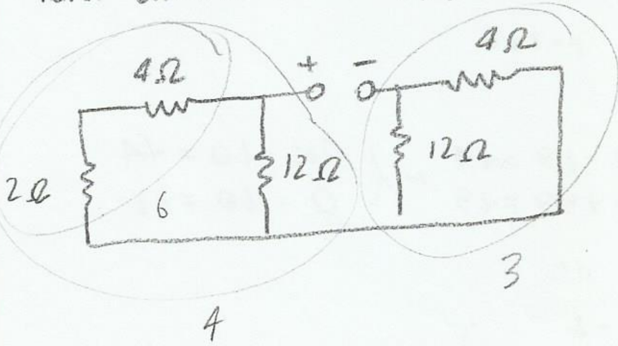
Gerador equivalente de thevenin



$\therefore \underline{V_o = 8V}$

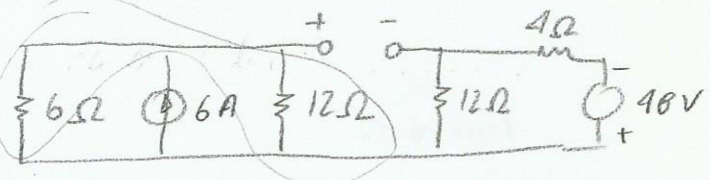
5.26

Para determinar R_{th}

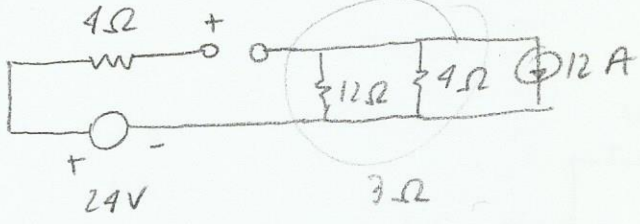


$\therefore \underline{R_{th} = 7\ \Omega}$

Para determinar E_{th}.



4



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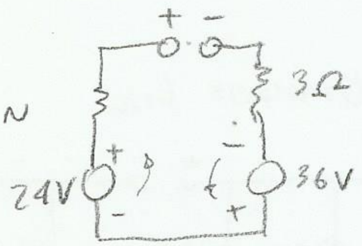
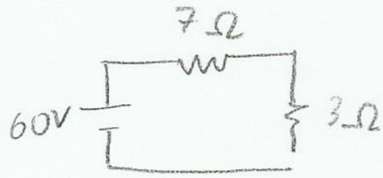


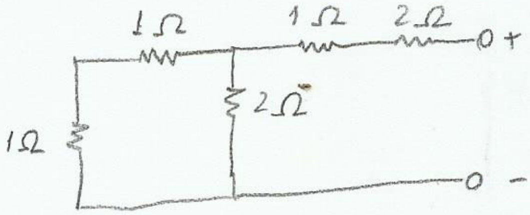
$\therefore E_{th} = 60V$

Gerador equivalente de thevenin



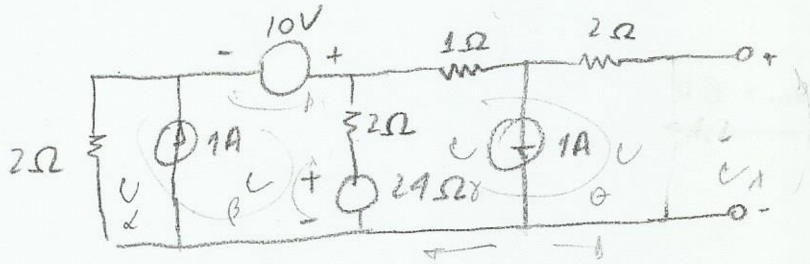
$V_0 = \frac{3}{3+7} \, 60 = \underline{18V}$

5.30



$R_{th} = (1+1) \| 2 + 1 + 2$

$\therefore R_{th} = 4\Omega$



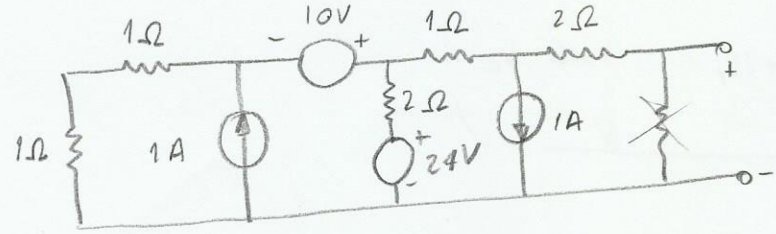
$\begin{cases} 2\alpha + 2\beta - 2\gamma = -14 \\ 3\gamma + 6\theta - 2\beta = 24 \end{cases}$; $\beta - \alpha = 1$ $\quad \beta = 1 + \alpha$

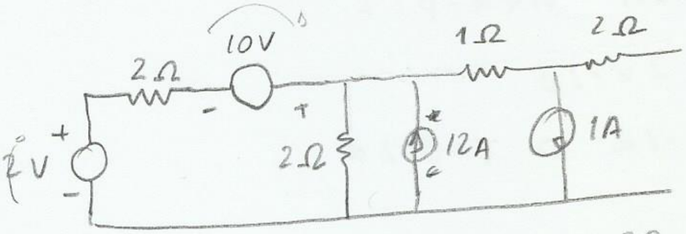
$\gamma - \theta = 1$ $\quad \gamma = 1 + \theta$

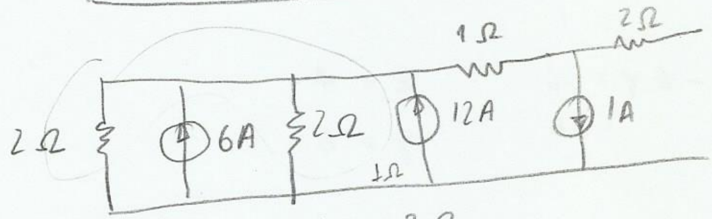
$\begin{cases} 2\alpha + \cancel{2} + 2\alpha - \cancel{2} - 2\theta = -14 \\ 3 + 3\theta + 6\theta - 2 - 2\alpha = 24 \end{cases} \sim \begin{cases} 4\alpha - 2\theta = -14 \\ -2\alpha + 9\theta = 23 \end{cases} \sim \begin{cases} 4\alpha - 2\theta = -14 \\ 0 + 16\theta = 32 \end{cases}$

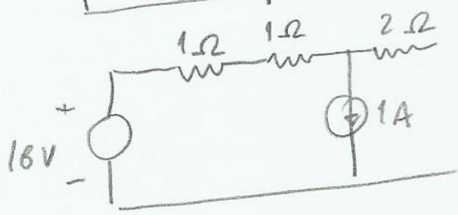
$\therefore \theta = 2 \quad \gamma = 1 + 2 = 3 \quad \therefore I_{th} = 1 - 3 = -2$

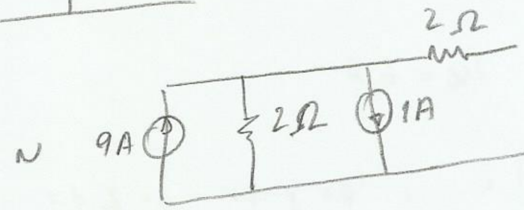
Outra forma

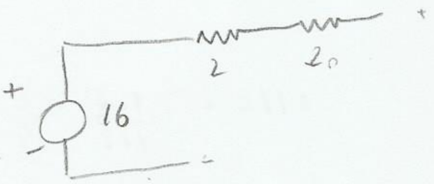






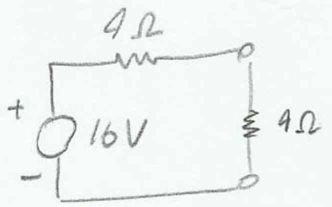






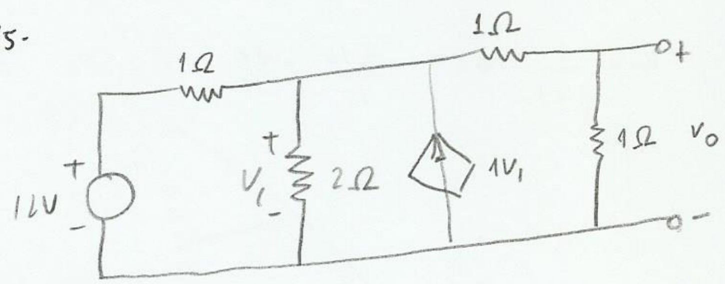
$\therefore V_{th} = 16V$

Gerador equivalente de thevenan

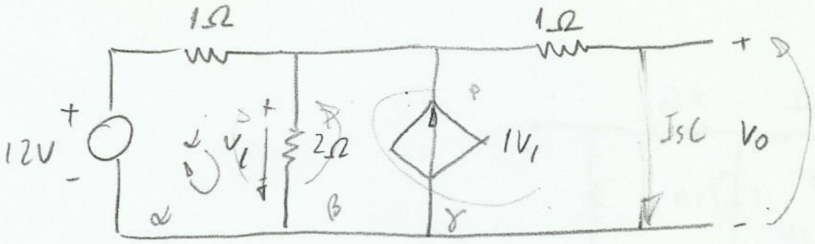


$\therefore \underline{V_o = 8V}$

5.45-



Utilizar método indireto



$$\begin{cases} 3\alpha - 2\beta = 12 \\ 2\beta + \gamma - 2\alpha = 0 \end{cases}$$

$\gamma - \beta = 1V_1 \quad V_1 = (\alpha - \beta).2$

$\gamma - \beta = 2\alpha - 2\beta$

$\beta = \gamma - 2\alpha \rightarrow \gamma = \beta + 2\alpha$

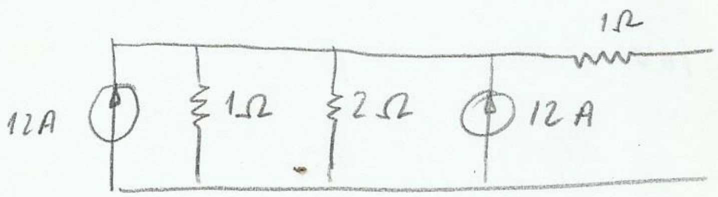
$$\begin{cases} 3\alpha - 2\gamma + 4\alpha = 12 \\ 2\gamma - 4\alpha + \gamma - 2\alpha = 0 \end{cases}$$

$$\begin{cases} 7\alpha - 2\gamma = 12 \\ -6\alpha + 3\gamma = 0 \end{cases} \sim \begin{cases} 21\alpha - 6\gamma = 36 \\ 9\alpha = 36 \end{cases} \quad \therefore \alpha = 4, \ \gamma = 6$$

$I_{SC} = 6\ A$

$V_1 = (\alpha - \beta)\, 2 \quad ; \quad \beta = \gamma - 2\alpha = 6 - 2.4 = -2$

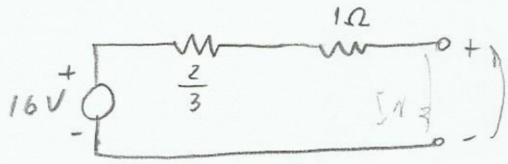
$= (4 - (-2)).2 = 12$



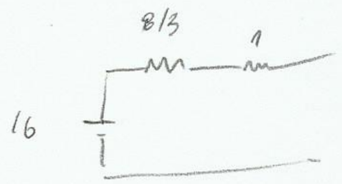
$\sim$

$1 // 2 = \frac{1.2}{1+2} = \frac{2}{3}$

$24.\frac{2}{3} = \frac{48}{3} = 16$



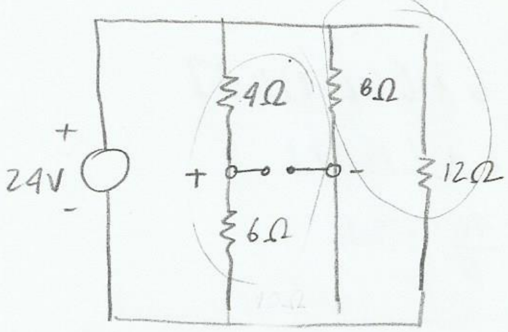
$\therefore V_{OC} = 16$



$R_{th} = \frac{16}{6} = \frac{8}{3}$

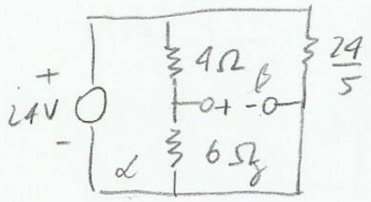
$V_0 = \frac{1}{\frac{8}{3}+1} 16 = \frac{3.16}{11} = \frac{48}{11}$

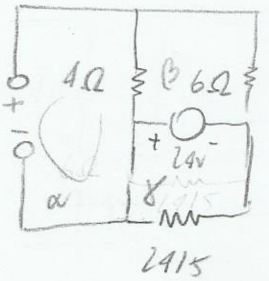
5.53



$$8 \| 12 = \frac{8 \cdot 12}{8+12} = \frac{96}{20} = \frac{48}{10} = \frac{24}{5}$$

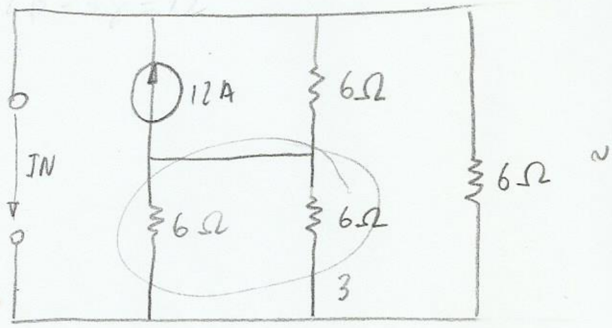
$\sim$



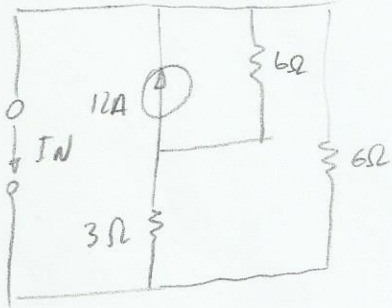


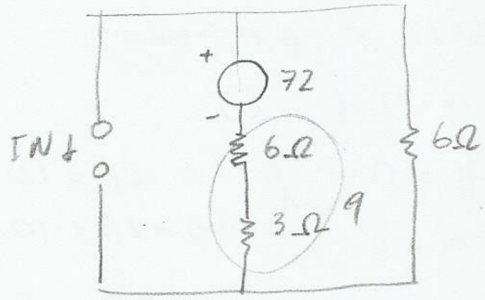
$$10\alpha - 4\beta - 6\gamma = 24$$
$$\frac{44}{5}\beta - 4\alpha = V_{OC}$$
$$6\gamma - 6\alpha = -V_{OC}$$

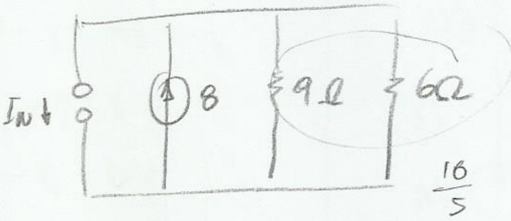
5.52



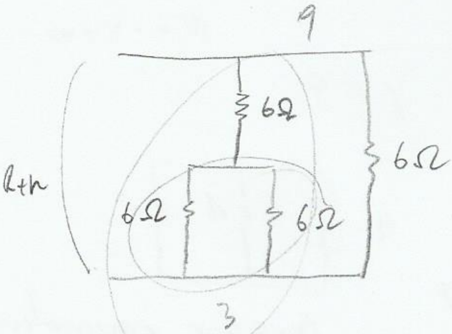
$\sim$



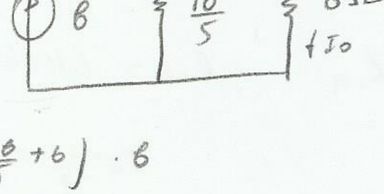




$\therefore\ I_N = 8$



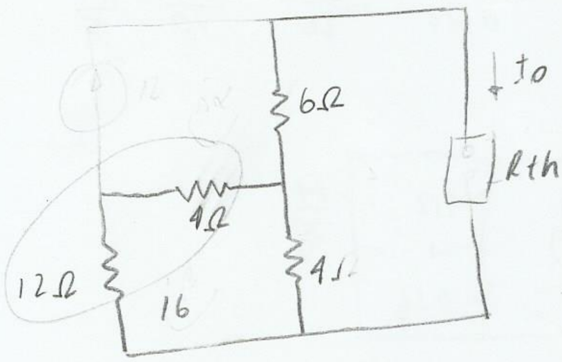
$$R_{th} = [(6 \| 6) + 6] \| 6 = \frac{18}{5}$$



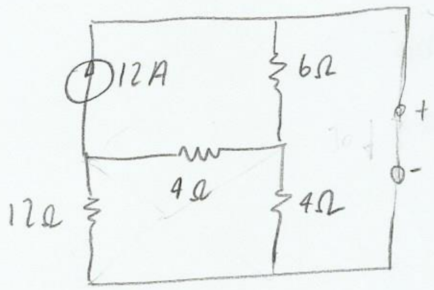
$$I_o = \frac{18}{5} \div \left(\frac{18}{5} + 6\right) \cdot 8$$
$$= \frac{18}{\cancel{5}} \cdot \frac{\cancel{5}}{48} \cdot 8 = \frac{18}{6} = 3$$

$\therefore\ I_o = 3A$

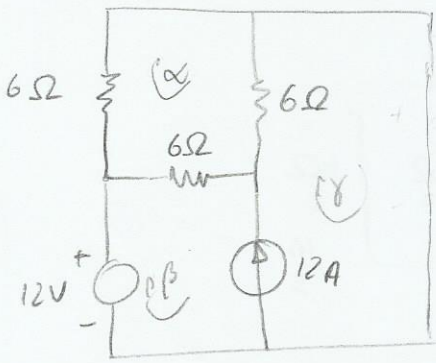
5.18



$$R_{th} = 6 + [(12+4)\|4] = 6 + (16\|4) = \frac{46}{5} = 9{,}2$$



5.29



$$\begin{cases} 16\alpha - 6\beta - 6\gamma = 0 \sim 3\alpha - \beta - \gamma \\ 6\beta + 6\gamma - 12\alpha = 12 \sim \beta + \gamma - 2\alpha = 2 \\ \gamma - \beta = 12 \quad \gamma = 12 + \beta \end{cases}$$

$$\begin{cases} 3\alpha - \beta - 12 - \beta = 0 \\ \beta + 12 + \beta - 2\alpha = 2 \end{cases} \sim \begin{cases} 3\alpha - 2\beta = 12 \\ -2\alpha + 2\beta = -10 \end{cases}$$

$$-\alpha + \beta = -5$$

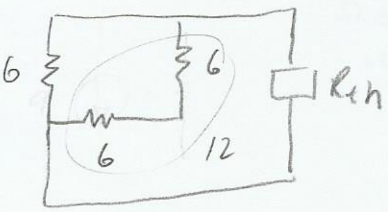
$$\beta = -5 + \alpha$$

$$\begin{cases} 3\alpha - 2\beta = 12 \\ \alpha = 2 \end{cases}$$

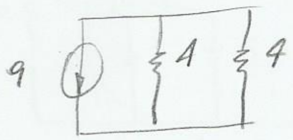
$$\gamma = 12 + \beta$$

$$\gamma = 12 - 5 + \alpha = 12 - 5 + 2 \quad \therefore \gamma = 9$$

$I_N = 9$



$$\therefore R_{th} = 6\|(6+6) = 4$$

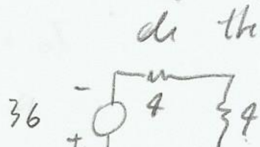


Gerador equivalente de thevenin

$$I_o = \frac{18}{4} = \frac{9}{2}$$

$$I_o + 12 = \frac{9}{2}$$

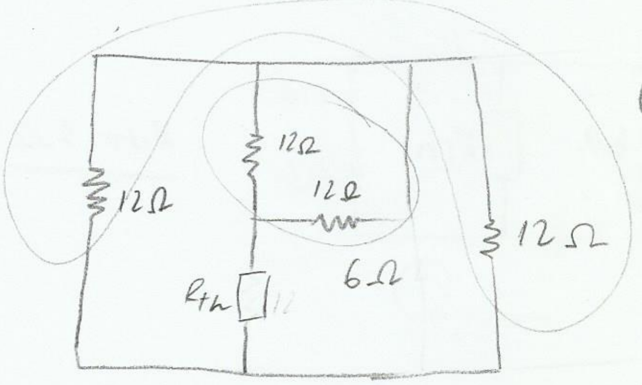
$$\therefore I_o = -7{,}5\text{ A}$$

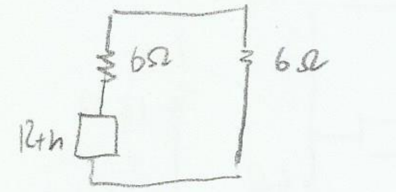


$\therefore V = 18$

5.32

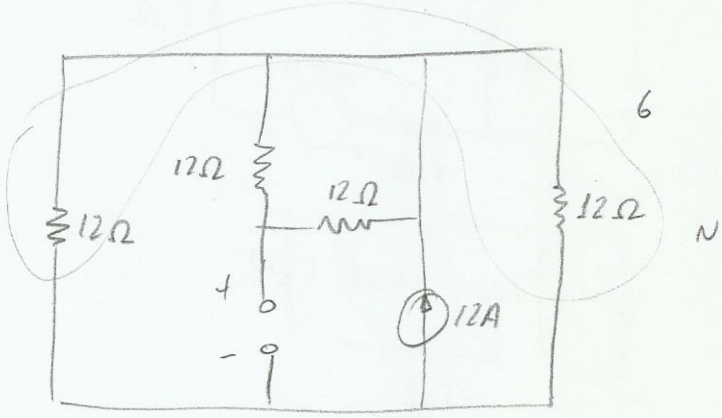
Determinação do R_{th}

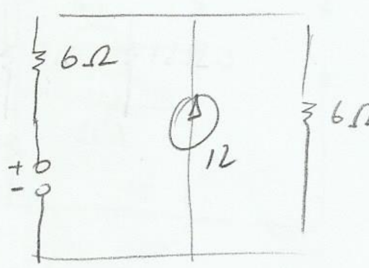


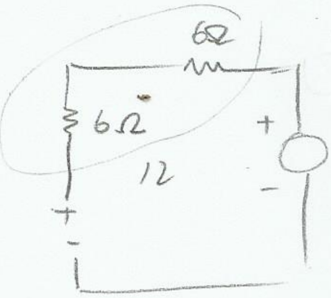


$\therefore R_{th} = 12\ \Omega$

Para determinar E_{th}

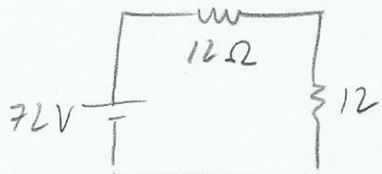






$\therefore E_{th} = 72$

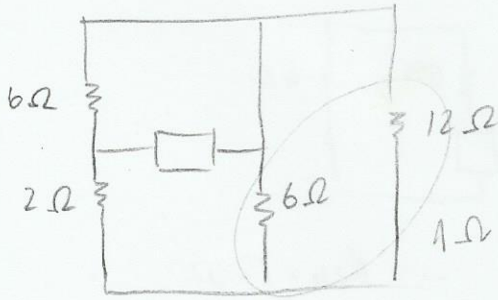
Gerador equivalente de thevenan

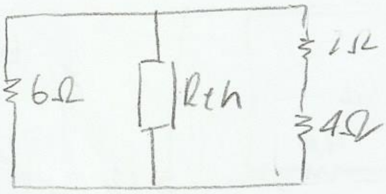


$\therefore V_o = 36 \quad \therefore I_o = \frac{36}{12} = \underline{3A}$

5.33

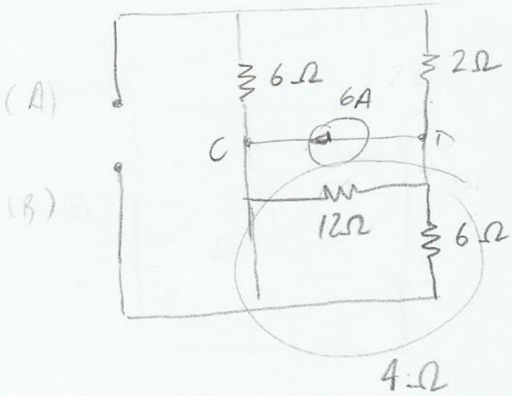
Determinação R_{th}

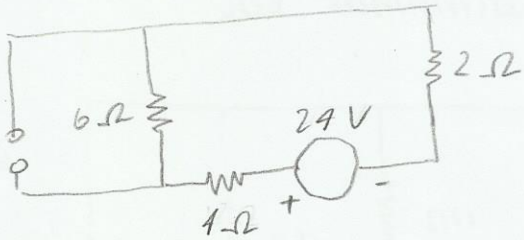


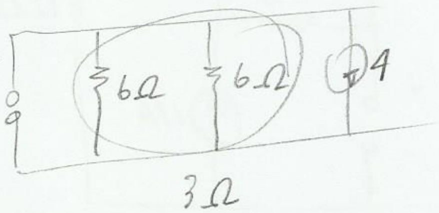


$\therefore R_{th} = 3\,\Omega$

Determinação do E_{th}

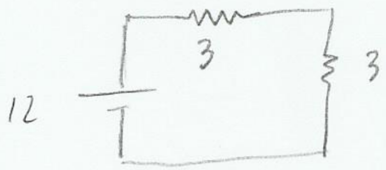






Gerador equivalente de thevenin

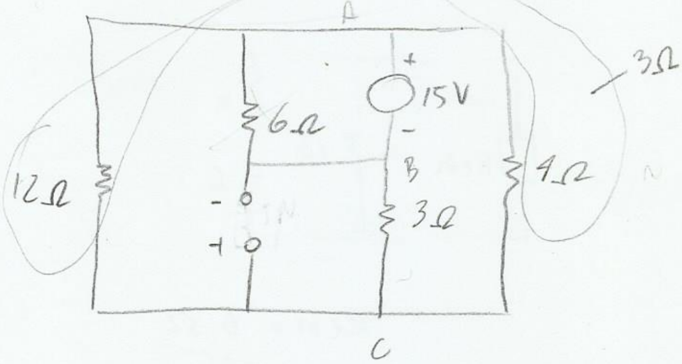
$\therefore E_{th} = 12$

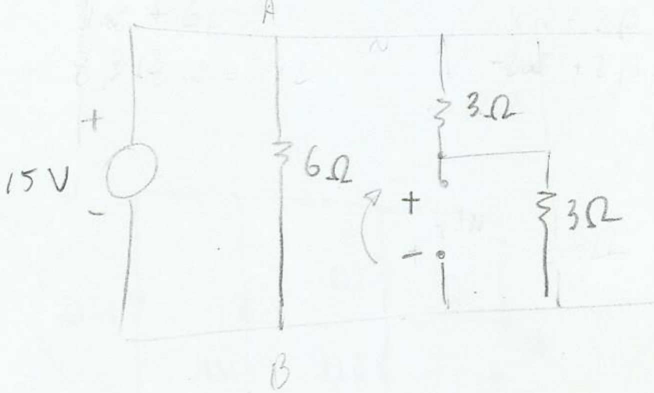


$\therefore V_o = 6$ e $I_o = 2A$

5.34

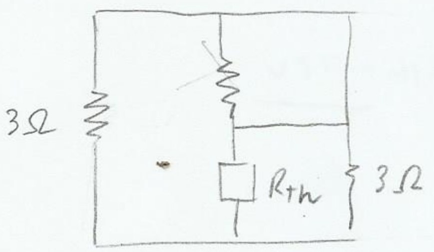
Determinação do Eth





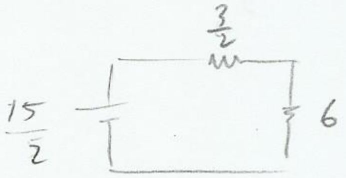
$V = \frac{15}{2} = 7{,}5\,V$

Determinação do Rth



$\therefore R_{th} = \frac{3}{2}$

Gerador equivalente de thevinan



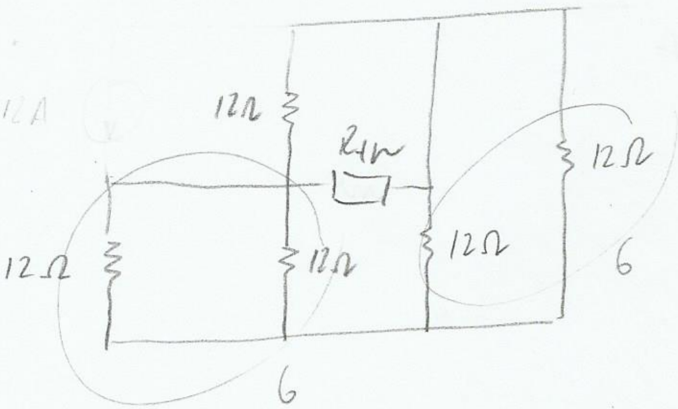
$$V = \frac{6}{6+\frac{3}{2}} \cdot \frac{15}{2}$$

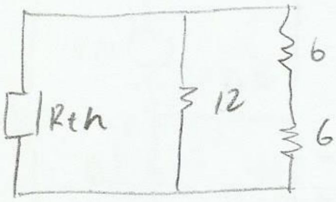
$$= \frac{6 \cdot 2}{\cancel{15}} \cdot \frac{\cancel{15}}{2} = 6$$

$$I = \frac{6}{6} = 1\,A$$

5.35

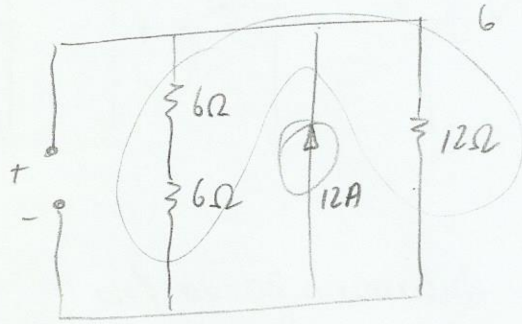
Determinação do R_{th}





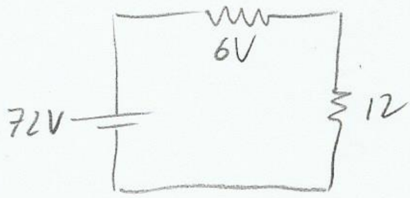
$\therefore$ $R_{th} = \underline{6\ \Omega}$

Determinação do E_{th}



$\therefore$ $E_{th} = \underline{72\ V}$

Gerador equivalente de thevenon

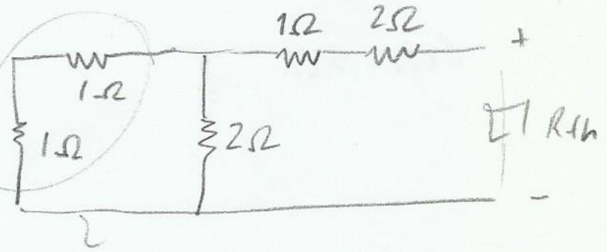


$$V = \frac{12}{12+6} \cdot 72 = \frac{12 \cdot 72}{18} = \frac{2 \cdot 72}{3} = 48$$

$$I_o = \frac{48}{12} = \underline{4\ A}$$

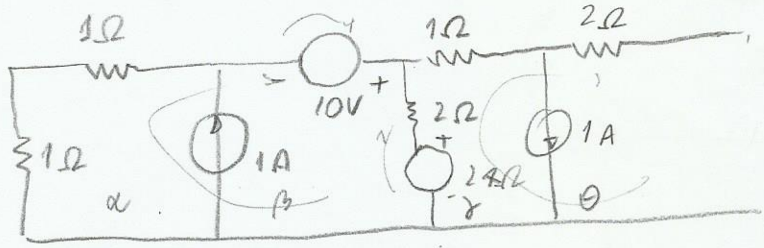
5.30-)

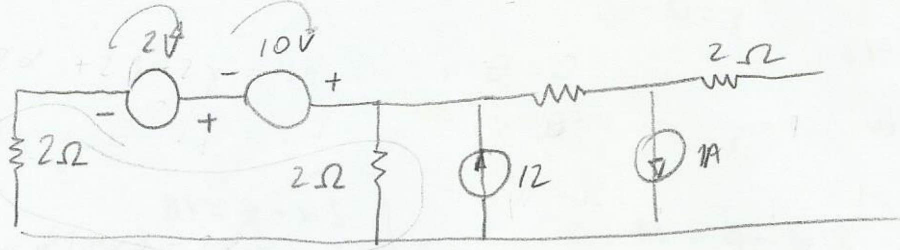
Determinação do Rth

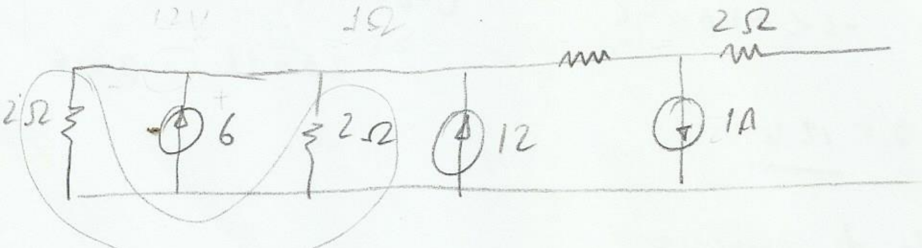


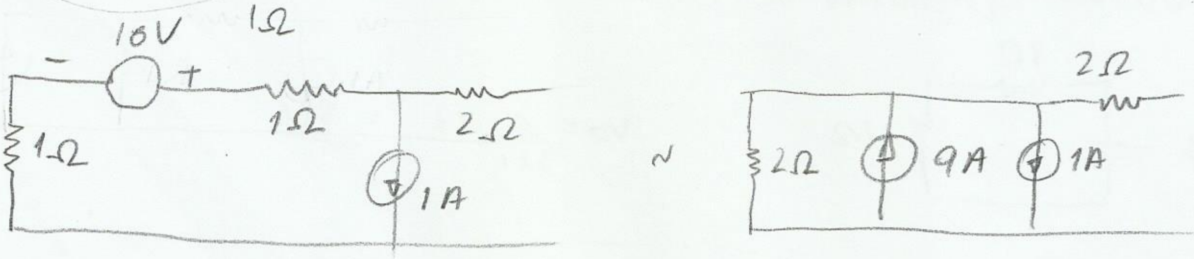
∴ Rth = 4Ω

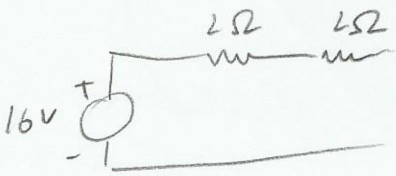
Determinação do Eth





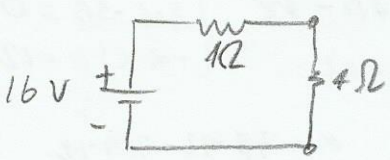






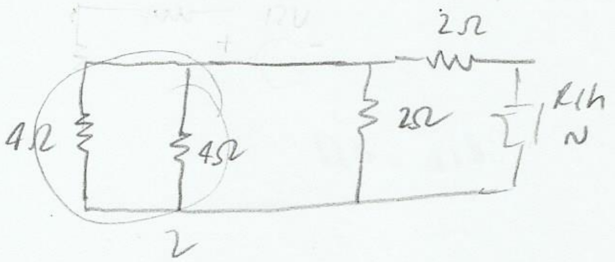
∴ Eth = 16V

Gerador equivalente de thevenon



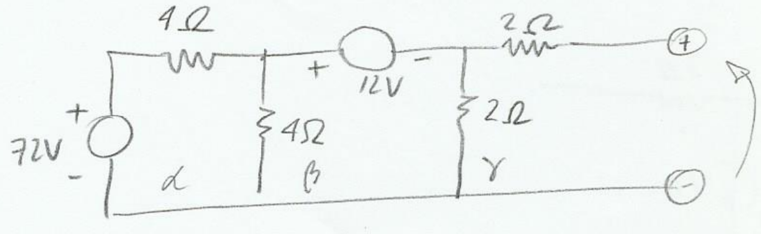
∴ Vo = 8V

5.37 Determinação do Rth



∴ $R_{th} = 3\Omega$

Determinação do Eth



$$\begin{cases} 8\alpha - 4\beta = 72 \\ 6\beta - 4\alpha - \cancel{2\gamma} = -12 \\ \cancel{4\gamma} - 2\beta = -E_{th} \end{cases} \qquad \gamma = 0$$

$8\alpha - 4\beta = 72 \sim 2\alpha - \beta = 18$

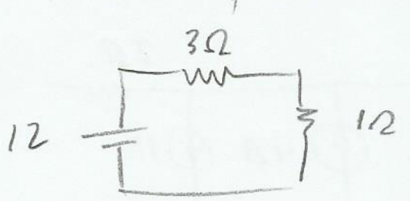
$6\beta - 4\alpha = -12 \sim -2\alpha + 3\beta = -6$

$$\sim \begin{cases} 2\alpha - \beta = 18 \\ -2\alpha + 3\beta = -6 \end{cases}$$

$2\beta = 12 \quad \therefore \beta = 6$

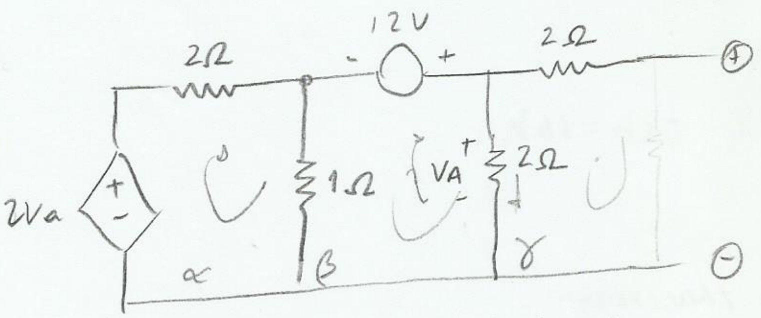
$E_{th} = -2.\beta = 2.6 = \underline{12\,V}$

Gerador equivalente de thévenin



$V_o = \frac{1}{3+1} . 12 = \underline{3V}$

5.38-)



$$\begin{cases} 3\alpha - \beta = 2Va \\ 3\beta - \alpha - \cancel{2\gamma} = 12 \\ \cancel{4\gamma} - 2\beta = -Vo \end{cases}$$

$Va = 2(\beta - \gamma)$

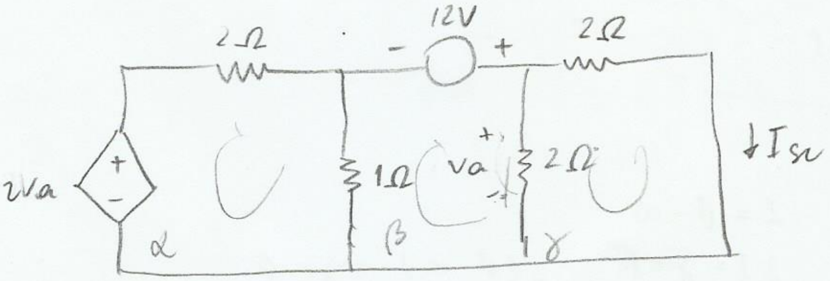
$$\begin{cases} 3\alpha - \beta = 4\beta - \cancel{4\gamma}^{\to 0} \\ 3\beta - \alpha = 12 \end{cases} \sim \begin{cases} 3\alpha - 5\beta = 0 \\ -\alpha + 3\beta = 12 \end{cases}$$

$$\begin{cases} 3\alpha - 5\beta = 0 \\ 4\beta = 36 \end{cases}$$

$\beta = 9 \quad \alpha = 3\beta - 12 = \overset{27}{3.9} - 12$

$\therefore \alpha = 15$

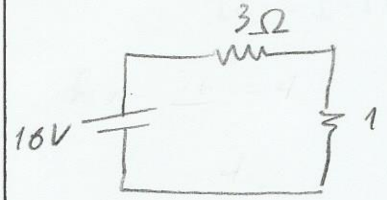
$V_o = 29$
$= 16$



$$\begin{cases} 3\alpha - \beta = 2V_a & ; \; V_a = 2(\beta - \gamma) \\ 3\beta - \alpha - 2\gamma = 12 \\ 4\gamma - 2\beta = 0 \end{cases}$$

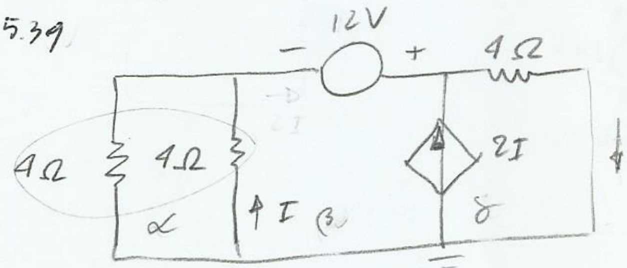
$$\begin{cases} 3\alpha - \beta = 4\beta - 4\gamma \\ -\alpha + 3\beta - 2\gamma = 12 \\ -2\beta + 4\gamma = 0 \end{cases} \sim \begin{cases} 3\alpha - 5\beta + 4\gamma = 0 \\ 4\beta - 2\gamma = 36 \\ 6\gamma = 36 \end{cases} \therefore \gamma = 6$$

$I_{sc} = 6$ A $\qquad R_{th} = \frac{18}{6} = 3$



$\therefore \; V_o = \frac{1}{3+1} \, 18 = \frac{18}{4} = \frac{9}{2}$ V

5.39



$$\begin{cases} 8\alpha - 4\beta = 0 \\ 4\beta + 4\gamma - 4\alpha = 12 \end{cases} \qquad \gamma - \beta = 2I \; ; \; I = \beta - \alpha$$

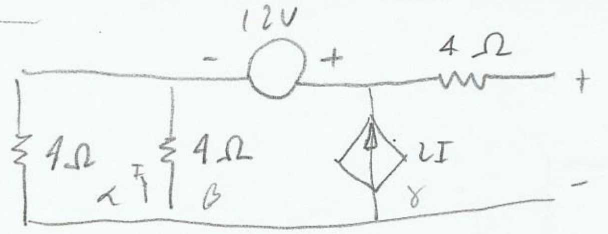
$$\gamma - \beta = 2\beta - 2\alpha$$

$$\begin{cases} 8\alpha - 4\beta = 0 \\ 4\beta + 12\beta - 8\alpha - 4\alpha = 12 \end{cases} \qquad \gamma = 3\beta - 2\alpha$$

$$\begin{cases} 8\alpha - 4\beta = 0 \\ -12\alpha + 16\beta = 12 \end{cases} \sim \begin{cases} 8\alpha - 4\beta = 0 \\ 20\alpha = 12 \end{cases} \quad \therefore \alpha = \frac{12}{20} = \frac{6}{10} = \frac{3}{5}$$

$8\alpha - 4\beta = 2\alpha - \beta = 0 \quad \beta = 2 \cdot \alpha = \frac{6}{5}$

$\gamma = 3 \cdot \frac{6}{5} - 2 \cdot \frac{3}{5} = \frac{18}{5} - \frac{6}{5} = \frac{12}{5}$



$$\begin{cases} 8\alpha - 4\beta = 0 \\ 4\beta + 4\gamma - 4\alpha = 12 - E \end{cases}$$

$$4\beta + 12\beta - 8\alpha - 4\alpha = 12 - E$$

$I = \beta - \alpha$

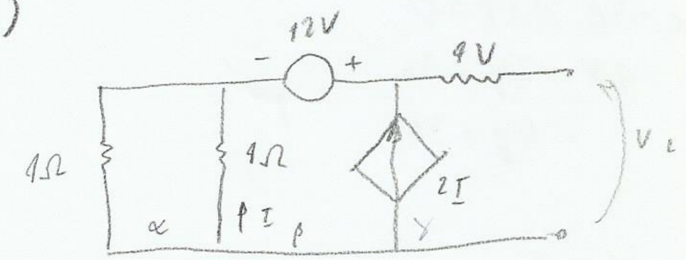
$2I = \gamma - \beta$

$2(\beta - \alpha) = \gamma - \beta$

$2\beta - 2\alpha = \gamma - \beta$

$\gamma = 3\beta - 2\alpha$

5.39)



$8\alpha - 4\beta = 0$

$4\beta + \cancel{4\gamma}^{=0} - 4\alpha = 12 - V_L$

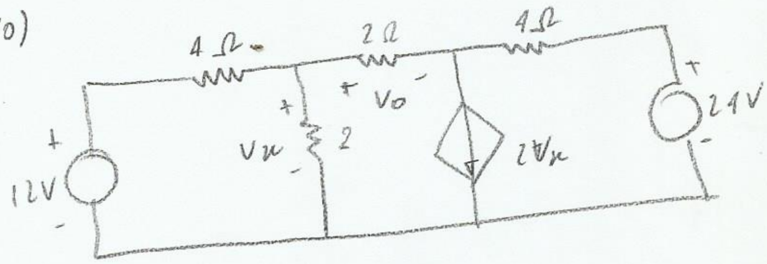
$\beta - \alpha = I$

$\cancel{\gamma}^{=0} - \beta = 2I$

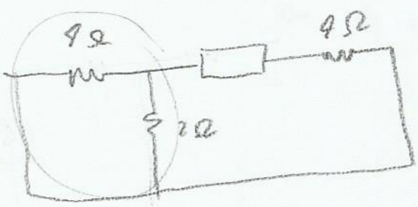
$\alpha = \beta - I = -2I - I = -3I$

$\beta = -2I$

5.40)

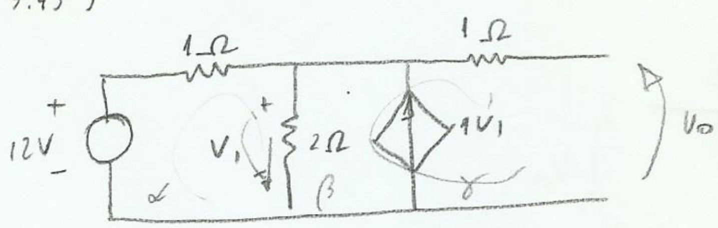


Determinação do Rl



$\frac{4 \cdot 2}{6} = \frac{8}{6} = \frac{4}{3}$ $\quad R = \frac{4}{3} + 4 = \frac{16}{3}$

5.45.)



$3\alpha - 2\beta = 12$

$2\beta + 1\cancel{\gamma}^{\to 0} - 2\alpha = -V_{oc}$

$3\alpha - 4\alpha = 12$

$-\alpha = 12 \quad \alpha = -12$

$\cancel{\gamma}^{\to 0} - \beta = 1V_1 \quad ; V_1 = 2(\alpha - \beta)$

$\beta = -2(\alpha - \beta)$

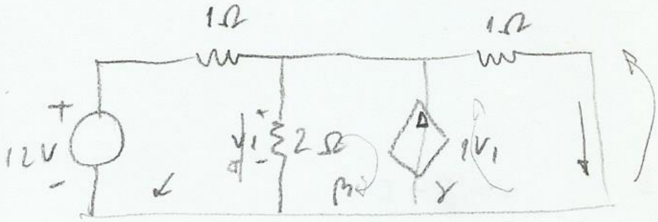
$\beta = -2\alpha + 2\beta \qquad -\beta = -2\alpha$

$\beta = 2\alpha$

$V_{oc} = -(2\beta - 2\alpha)$

$= -(4\alpha - 2\alpha) = -(-12 \cdot 4 - 2 \cdot (-12)) \quad \therefore V_{oc} = \underline{24V}$

$-48 + 24 = -24$



$\begin{cases} 3\alpha - 2\beta = 12 \\ 2\beta + \gamma - 2\alpha = 0 \end{cases}$

$\gamma - \beta = 1V_1 = 2(\alpha - \beta)$

$\gamma - \beta = 2\alpha - 2\beta$

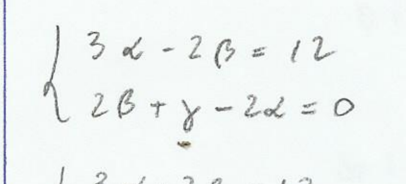
$\gamma = 2\alpha - \beta$

$\begin{cases} 3\alpha - 2\beta = 12 \\ -\cancel{2\alpha} + 2\beta + \cancel{2\alpha} - \beta = 0 \end{cases}$

$\begin{cases} 3\alpha - 2\beta = 12 \\ \beta = 0 \end{cases} \Rightarrow 3\alpha = 12 \quad \therefore \alpha = 4$

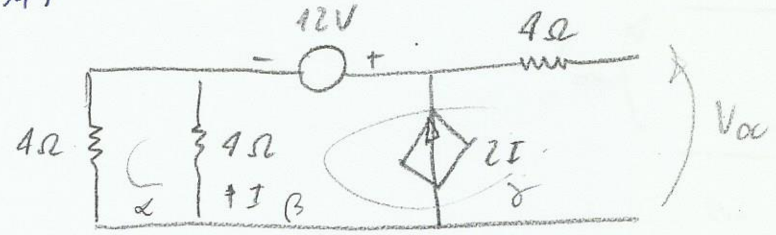
$\gamma = 2\alpha - \beta \quad \therefore \gamma = 8 = I_{sc}$

$R_{th} = \frac{24}{8} = \frac{12}{4} = 3$



$\therefore V_o = \frac{1}{1+3} \cdot 24 = \frac{24}{4} = \underline{6V}$

5.39-)



$$\begin{cases} 8\alpha - 4\beta = 0 \\ 4\beta + \cancel{4\gamma} - 4\alpha = 12 - V_{oc} \end{cases}$$

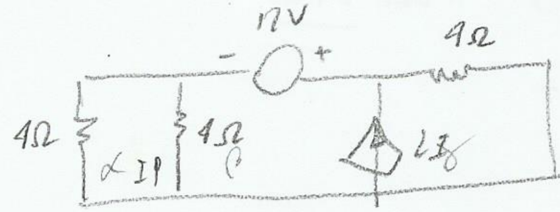
$\cancel{\gamma} - \beta = 2I$ $\qquad \beta - \alpha = I$

$\beta = -2I$ $\qquad \alpha = \beta - I$

$\alpha = -3I$

$-12I + 8I = 0 \quad \therefore I = 0, \quad \beta = 0, \quad \alpha = 0$

$V_{oc} = 12$



$$\begin{cases} 8\alpha - 4\beta = 0 \\ 4\beta + 4\gamma - 4\alpha = 12 \end{cases}$$

$\beta - \alpha = I \qquad \alpha = \beta - I$

$\gamma - \beta = 2I \qquad \gamma = 2I + \beta$

$2\alpha = \beta$

$\gamma = 2I + \beta$

$4\beta + 12\beta - 8\alpha - 4\alpha = 12 \quad \gamma = 2\beta - 2\alpha + \beta = 3\beta - 2\alpha$

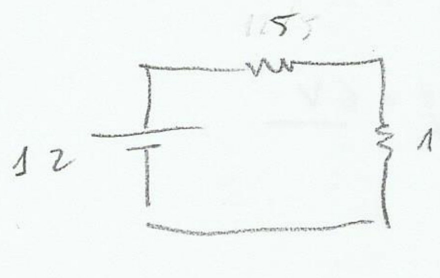
$16\beta - 6\beta = 12$

$10\beta = 12 \quad \beta = \frac{12}{10} = \frac{6}{5} \quad \alpha = \frac{6}{10} = \frac{3}{5}$

$\gamma = 2(\beta - \alpha) + \beta$

$\gamma = 3\beta - 2\alpha = \frac{3 \cdot 6}{5} - \frac{6}{5} = \frac{18-6}{5} = \frac{12}{5}$

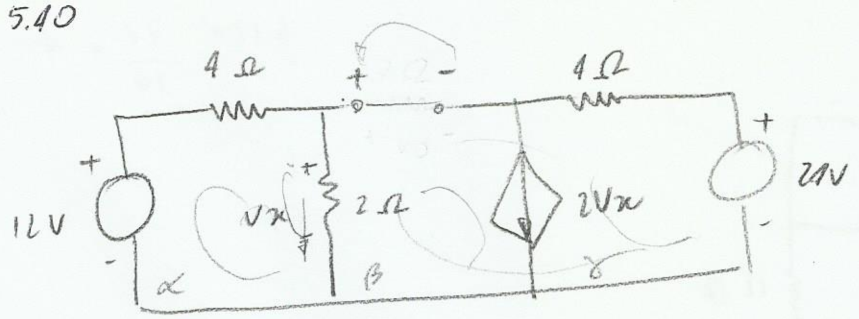
$R_{th} = 12 : \frac{12}{5} = 5$



$V_0 = \frac{1}{1+5} \cdot 12 = 2$

$\underline{I = 2A}$

5.10



$$\begin{cases} 6\alpha - 2\beta = 12 \\ 2\beta + 4\gamma - 2\alpha = -24 \end{cases}$$

$\beta - \gamma = 2V_x$

$\beta - \gamma = 2(2.(\alpha - \beta))$

$\beta - \gamma = 4\alpha - 4\beta$

$\gamma = 5\beta - 4\alpha$

$$\begin{cases} 3\alpha - \beta = 12 \\ 2\beta + 20\beta - 16\alpha - 2\alpha = -24 \end{cases}$$

$$\begin{cases} 3\alpha - \beta = 6 \\ 22\beta - 18\alpha = -24 \end{cases} \sim \begin{cases} 18\alpha - 6\beta = 36 \\ -18\alpha + 22\beta = -24 \end{cases}$$

$16\beta = 12$

$\beta = \frac{12}{16} = \frac{6}{8} = \frac{3}{4}$

$I_{sc} = \frac{3}{4}$

Determinar Voc

$$\begin{cases} 6\alpha - \cancel{2\beta}^{0} = 12 \\ \cancel{2\beta} + 4\gamma - 2\alpha = -V_{oc} - 24 \end{cases}$$

$\beta - \gamma = 2V_x$

$\cancel{\beta}^{0} - \gamma = 4(\alpha - \beta)$

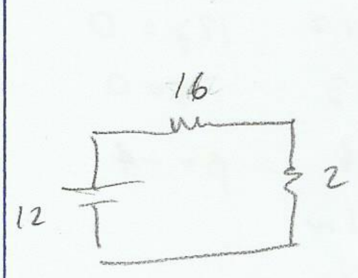
$\gamma = -4\alpha$

$\alpha = 2$

$-16\alpha - 2\alpha = -V - 24$

$V = -24 + 18.2 \quad \therefore \quad \underline{V = 12\,V}$

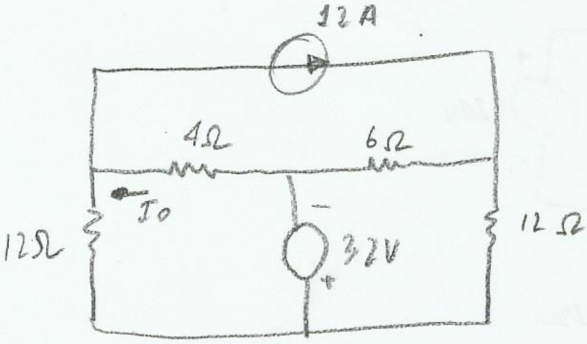
$R_{th} = \frac{12}{3} \div \frac{3}{4} = \frac{12.4}{3} = 4.4 = 16$



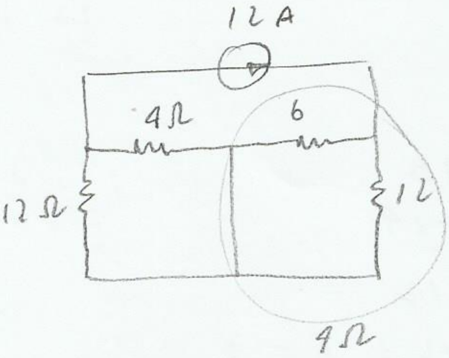
$V = \frac{2}{2+16} \cdot 12 = \frac{24}{18} = \frac{12}{9} = \underline{\frac{4}{3}\,V}$

5.9

$6 \cdot 12 = \frac{72}{16} = 4$



Influência de 12A



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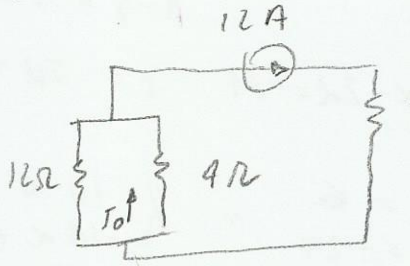
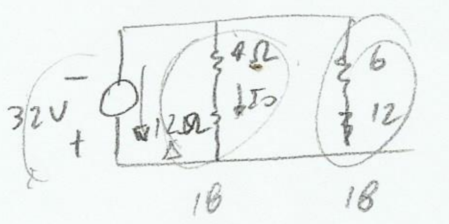


$I_0 = \frac{12}{12+4} \cdot 12 = \frac{12 \cdot 12}{16} = \frac{12 \cdot 6}{8} = \frac{12 \cdot 3}{4}$

$I_0' = 3 \cdot 3 = 9$

Influencia de 32V

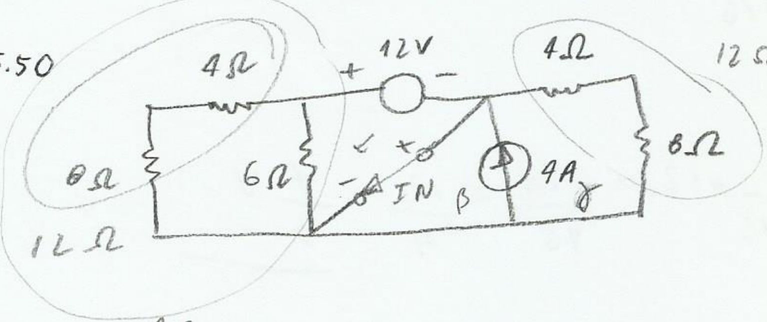


$\therefore I_T = \frac{32}{8} = 4$

$I_0' = 2$

$\therefore I = 9 - 2 = \underline{7\,A}$

5.50



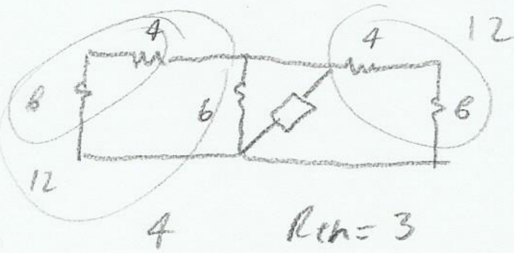
$4\alpha = -12 \qquad 12\gamma = 0$

$\alpha = -3 \qquad \gamma = 0$

$\cancel{\gamma}^{0} - \beta = 4 \quad \therefore \beta = -4$

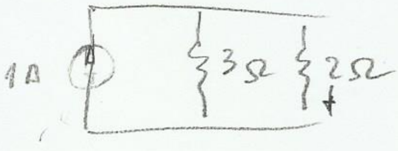
$\alpha - \beta = I_N$

4Ω



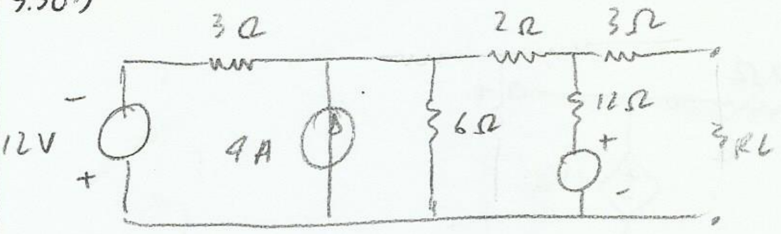
$I_N = -3 - (-4) = 1\,A$

4 $\qquad R_{th} = 3$

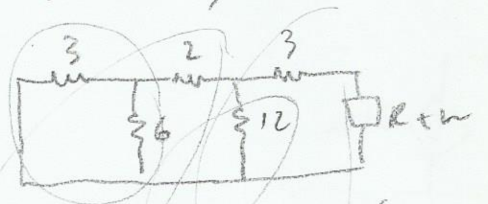


$I_0 = \frac{3}{2+3} \cdot 1 = \frac{3}{5}\,A$

5.58.)



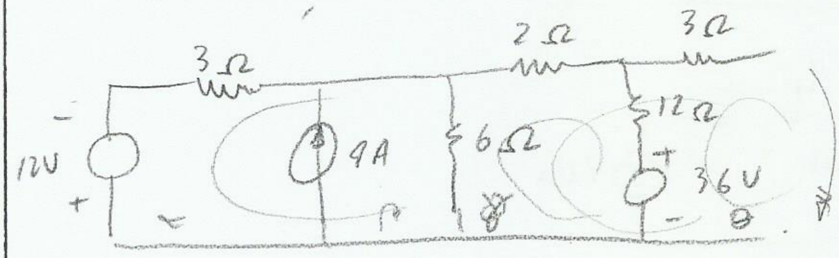
Determinação do Rth



$\frac{18}{9} = 2$ 4   3   6

$\therefore \underline{Rth = 6\,\Omega}$

Determinação do Eth



$$\begin{cases} 3\alpha + 6\beta - 6\gamma = -12 \\ 8\gamma - 6\beta - 12\cancel{\theta} = -36 \\ 15\cancel{\theta} - 12\gamma = V + 36 \end{cases}$$

$\beta - \alpha = 4$

$\beta = 4 + \alpha$

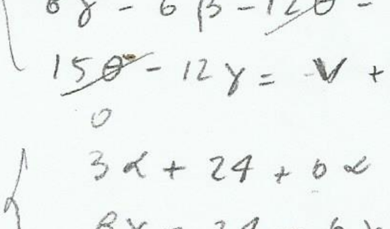
$$\begin{cases} 3\alpha + 24 + 6\alpha - 6\gamma = -12 \\ 8\gamma - 24 - 6\gamma = -36 \end{cases} \sim \begin{cases} 9\alpha - 6\gamma = 12 \\ 2\gamma = -12 \\ \gamma = -6 \end{cases}$$

$9\alpha - 6\gamma = 12$

$3\alpha - 2\gamma = 4 \qquad \alpha = \frac{4 + 2.(-6)}{3} = \frac{4 - 12}{3} = -3$

$V = -12.(-6) - 36$

$= 72 - 36 = 36$

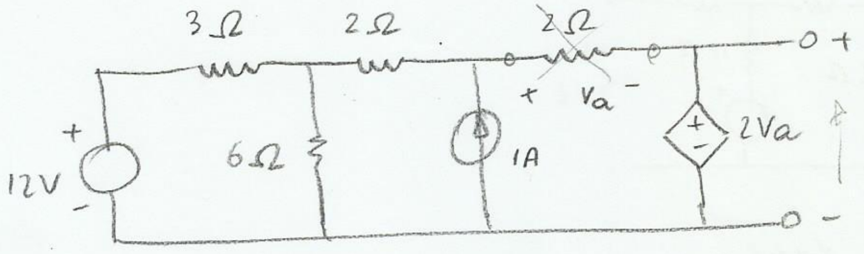


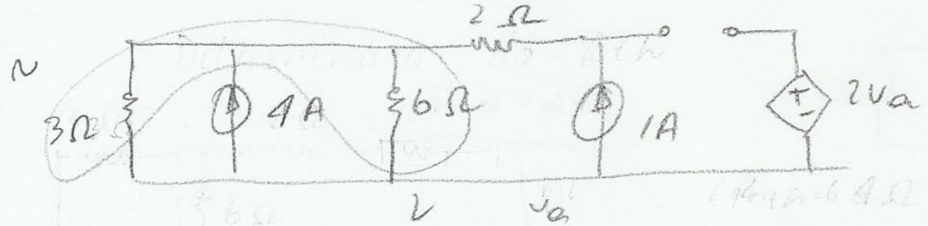
$\therefore \; P = V.I$

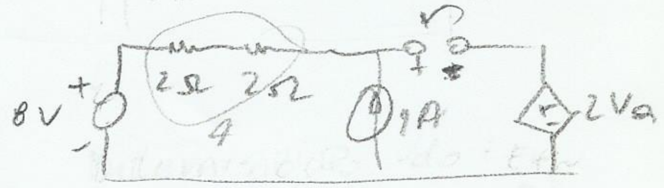
$= V.\frac{V}{R} = \frac{V^2}{R} = \frac{36^2}{6} = \frac{36.36}{6} = 36.6$

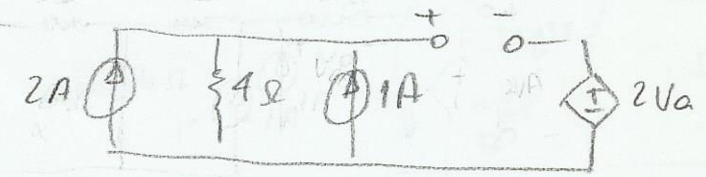
$\therefore \underline{P = 216W}$

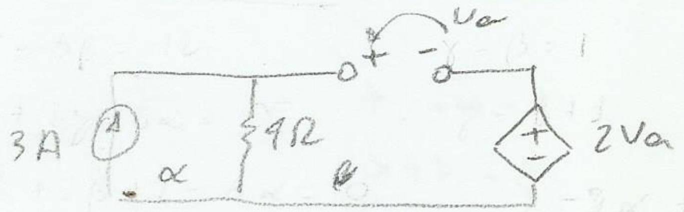
5.41







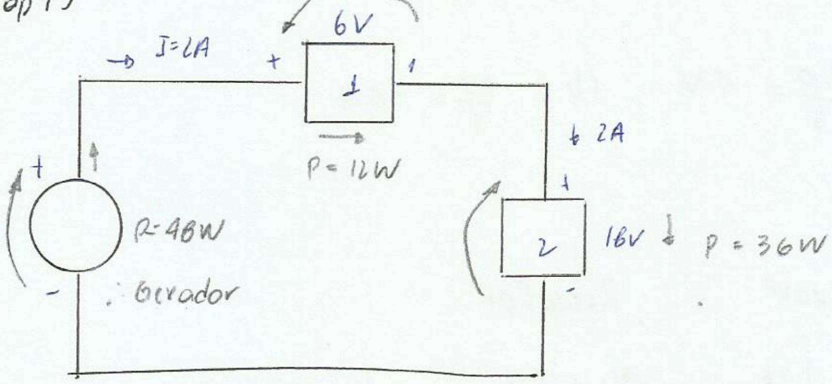




$4\beta - 4\alpha = -V_a - 2V_a \quad ; \quad \alpha = 3$

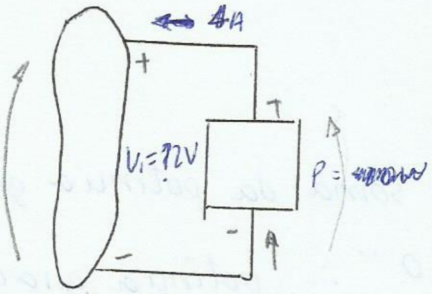
Fontes dependentes e independentes

Exemplo 1.5 (cap 1)

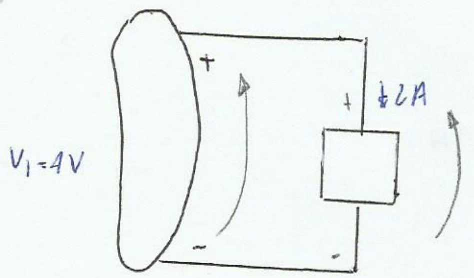


Exercício 1.1

Determine a quan. de potência absorvida ou fornecida pelos componentes



∴ Gerador P = 12.4 = -48W



∴ Receptor P = 2.4 = 8W

Conclusão:

- Gerador, a v(t) e i(t) possuem o mesmo sentido

  $p(t) = v(t) \cdot i(t)$; $p(t) < 0$

- Receptor, a v(t) e i(t) possuem sentidos opostos

  $p(t) = v(t) \cdot i(t)$; $p(t) > 0$

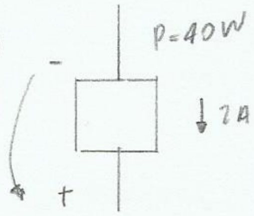
Determinar as váriaveis faltantes:

Ex. 1.4

(a). $V = \frac{P}{I} = \frac{20}{5} = 4V$ (b) $\frac{40}{5} = -8A$

E.1.2

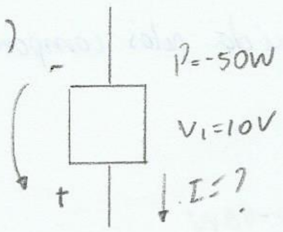
(a)



∴ Receptor

$V_1 = -\frac{40}{2}$ ∴ $\underline{V_1 = -20V}$

(b)

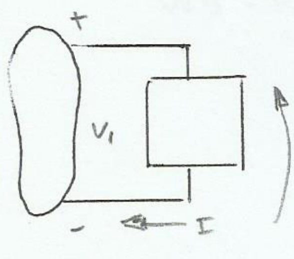


∴ Gerador

$I = \frac{P}{V} = \frac{-50}{10} = -5A$

*Obs.: Balanço energético, significa que a soma da potencia gerada + potência recebida é igual a "0" ∴ potência gerada igual a potencia recebida

1.8



(a) $V_1 = 10$ e $I = 3A$

∴ Receptor

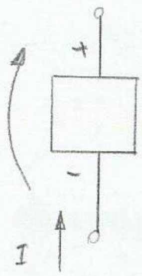
$P = 10.3 = 30W$

(b) $V_1 = 4$ e $I = -4A$

Gerador

$P = 4 \cdot -4 = -16W$

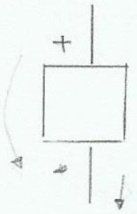
1.9



Gerador

$V_1 = -12V$ $P = V \cdot I$

$P = -48W$ $I = \frac{48}{12} = 4A$

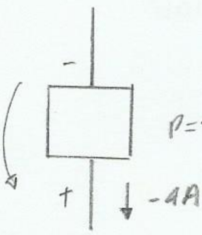


Receptor

$P = 36W$

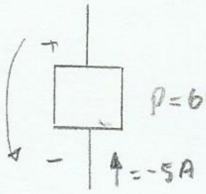
$V_1 = -6V$ $I = 6A$

1.10



Gerador

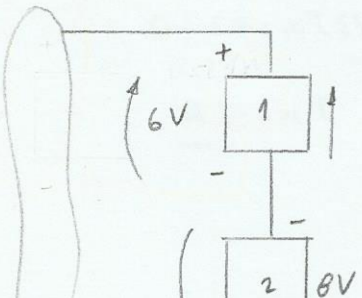
$P = -40W$ $V = \frac{-40}{-(-4)} = 10V$



Receptor

$P = 60W$ $V = \frac{60}{-(5)} = 12V$

1.11.

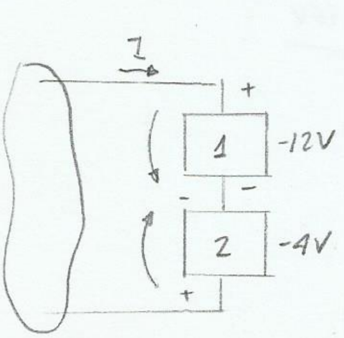


$P_1 = -24W$

$I_1 = 4A$

$\therefore$ $P_2 = 32W$ (Receptor)

1.12



$P_1 = -36W$ (Gerador) P_2 (receptor, "consome")

$I = \frac{-36}{-12} = 3A$

$P = -4 \cdot 3 = -12W$

1.13

Geradores: -144W

Receptores: 30+18+48 = 96W

$G+R=0$

$-144+96+x=0$

$\therefore x = \underline{48\,W}$

$\therefore$ A fonte V_s esta consumindo potência de 48W.

1.14 Potências consumida:

$P_1 = 12W$; $P_2 = 12W$; 36W ; $P_3 = 8W$

Potências fornecida: 12W e fonte dependente de 56V

1.15

Consumidos	Fornecidos
2.6 = 12W	2.24 = 48W
2.12 = 24W	2.18 = 36W
2Vx = 2Vx	
2.16 = 32W	

$\therefore 68 + 2Vx - 84 = 0$

$\therefore Vx = \underline{8\,V}$

1.16

Consumidas

2x12 = 24W

1x12 = 12W

4 Ix (W)

8 Ix (W)

1.12 = 12W

Fornecida

12.6 = 72

$\therefore 48 + 12Ix - 72 = 0$

$\therefore Ix = \underline{2\,A}$

1.17

Gerador

2x6 = 12W

4Vx (W)

Receptor

2.2 = 4W

6.4 = 24W

8.4 = 32W

4.6 = 24W

$84 - 12 - 4Vx = 0$

$\therefore Vx = \underline{18V}$

1.18 Consumidos — fornecida

$12.8 = 96W$ — $8V_x$ (W)

$18.2 = 36W$ — $12.6 = 72W$

$6.6 = 36W$

$4.6 = 24W$

$18.4 = 72W$

$264 - 72 - 8V_x = 0$

$\underline{V_x = 24V}$

1.19 Gerador — Receptor

$3.10 = 30W$ — $6I_0$ (W)

$6.2 = 12W$ — $11.16 = 176W$

$12.9 = 108W$

$8.4 = 32W$

$-182 + 176 + 6I_0 = 0$

$\therefore I_0 = \underline{1A}$

1.20 Gerador — Receptor

$24.6 = 144W$ — $8.6 = 96W$

$8.3 = 24W$ — $10.4 = 40W$

$6I_0$ (W)

$2.16 = 32W$

$1.6 = 6W$

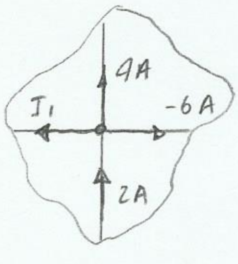
$8.3 = 24W$

$150 + 6I_0 - 168 = 0$

$\therefore I_0 = \underline{3A}$

Capítulo 2 - Circuitos Resistivos

E 2.3



$I + 4 - 6 - 2 = 0$

$I = 4A$

E2.4 nó 1: $3 - 2 - 4 - I_1 = 0$ $\therefore I_1 = -3A$

nós 2: $I_2 + 3 + 1 - 2 = 0$ $\therefore I_2 = -2A$

nó 3: $I_2 - 4 + 4 + 2 = 0$ $\therefore I_2 = -2A$

nó 4: $I_3 - 1 - 4 + 2 = 0$ $\therefore I_3 = 3A$

Resumo:

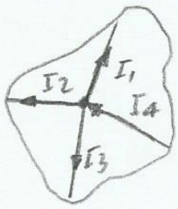
$v(t) = R\,i(t)$ $\qquad G = \frac{1}{R}$

$p(t) = R\,i^2(t) = \frac{v^2(t)}{R}$

Leis de Kirchhoff

"A soma algébrica das correntes entrando em qualquer nó é zero".

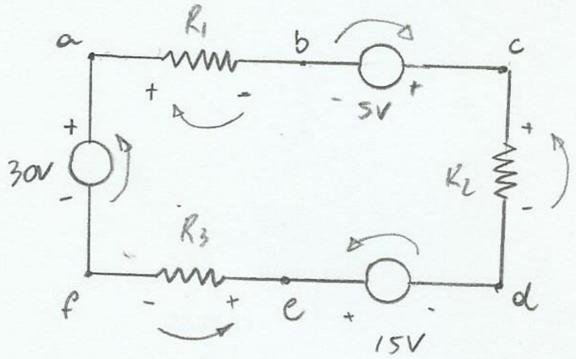
"A soma algébrica das tensões ao longo de qualquer laço é zero".



$I_1 + I_2 + I_3 - I_4 = 0$

Obs.: Quando a corrente sai do nó, ela é positiva, caso contrário é negativa.

Ex:



$-V_{r1} + 5V - V_{r2} + 15 - V_{r3} + 30 = 0$

Admitindo $V_{r1} = 18V$. $V_{r2} = +12V$

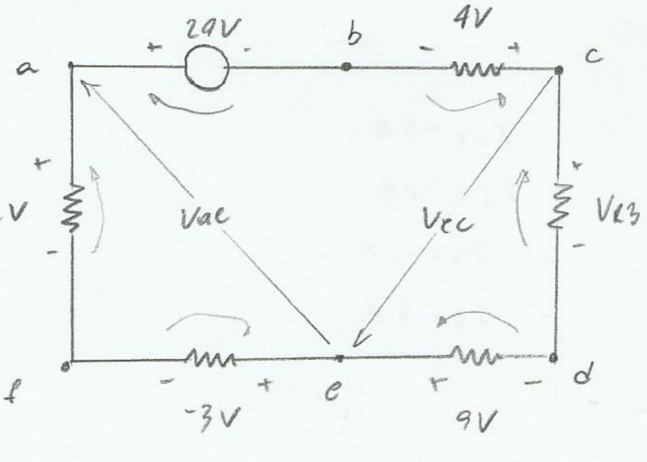
$V_{r3} = 20V$

$V_{r1} + V_{r2} + V_{r3} = 5 + 15 + 30$

$V_{r1} + V_{r2} + V_{r3} = 50$

$18 + 12 + 20 = 50$

Exemplo 2.9



Determine

V_{ae}, V_{ec} e V_{r3}

$-24 + 4V - V_{R3} + 9 + 3 + 2 = 0 \quad \therefore V_{R3} = \underline{-6V}$

$-V_{ae} + 3 + 2 = 0 \quad \therefore \quad V_{ae} = 5V$

$V_{ec} - 9 - 6 = 0 \quad \therefore \quad V_{ec} = \underline{15V}$

E2.5

$-4 - V_{R2} + 6 + 12 = 0 \quad \therefore \quad V_{R2} = \underline{14V}$

$V - 14 + 6 = 0 \quad \therefore \quad V = 8 \qquad V_{bd} = -V$

$V_{bd} = \underline{-8V}$

E2.6 $\quad 12 + 1 + 4 + 2 - 24 - V_{r4} = 0 \quad \therefore \quad V_{r4} = \underline{-5V}$

$V_{bf} - 1 - 12 = 0 \quad \therefore \quad V_{bf} = \underline{13V}$

$V_{ec} + 24 - 2 = 0 \quad \therefore \quad V_{ec} = \underline{-22V}$

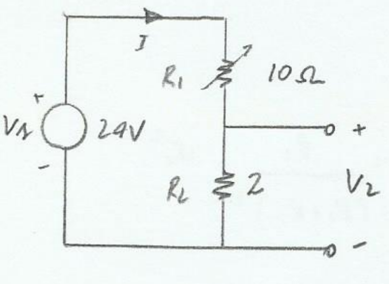
Divisor de tensão

$$v_{R2}(t) = \frac{R_2}{R_1 + R_2} v(t)$$

Divisor de corrente

$$i_2(t) = \frac{R_1}{R_1 + R_2} \cdot i(t)$$

Exemplo.



$$v_s = v_{R1} + v_{R2}$$

$$v_s = R_1 \cdot I + R_2 \cdot I$$

$$v_s = I(R_1 + R_2)$$

$$I = \frac{v_s}{R_1 + R_2}$$

$v_{R1} = R_1 \cdot I$

$v_{R2} = R_2 \cdot I$

$$\frac{v_{R1}}{R_1} = \frac{v_s}{R_1 + R_2} \sim v_{R1} = \frac{R_1}{R_1 + R_2} v_s$$

$$\frac{v_{R2}}{R_2} = \frac{v_s}{R_1 + R_2} \sim v_{R2} = \frac{R_2}{R_1 + R_2} \cdot v_s$$

$$V_2 = \frac{2}{2 + 10} \cdot 24 \quad \therefore \quad V_2 = \underline{4V}$$

Problemas

2.1

nó 1: $16 - I_0 - 3 - 4 - 2 = 0 \therefore I_0 = 7A$

nó 2: $-16 + I_1 + 7 = 0 \therefore I_1 = 9A$

nó 3: $I_2 - 9 + 3 = 0 \therefore I_2 = 6A$

2.2 nó A: $I_1 + 4 - 12 = 0 \therefore I_1 = 12A$

nó D: $I_3 - 4 - 2 = 0 \therefore I_3 = 6A$

nó C: $9 - I_2 - 6 - 12 = 0 \therefore I_2 = -9A$

nó B: $I_4 - 9 + 12 = 0 \therefore I_4 = -3A$

2.3 nó E: $2 - 9 - I_4 = 0 \therefore I_4 = -7A$

nó B: $I_2 + 12 - 7 = 0 \therefore I_2 = -5A$

nó D: $I_3 - 4 - 2 = 0 \therefore I_3 = 6A$

nó C: $9 + 5 - 6 - I_1 = 0 \therefore I_1 = 8A$

2.4

Observação:

$$P_1(t) = v_1(t) \cdot i(x) = \frac{v_1^2(t)}{R}$$

$$P_1(t) = \frac{v_1^2}{R_1} = \frac{R_1}{(R_1+R_2)^2} \cdot v_1^2 \cdot R' \therefore P_1(t) = \frac{R_1}{(R_1+R_2)^2} \cdot v_1^2$$

$$P = \frac{2}{(2+10)^2} \cdot 12^2 \therefore \underline{P = 2W}$$

2.5 $R' = \dfrac{(3+1) \cdot 4}{(3+1+4)} = 2 \qquad V = 12V$

$$P = \frac{1}{(1+3)^2} \cdot 12^2 \therefore P = 9W$$

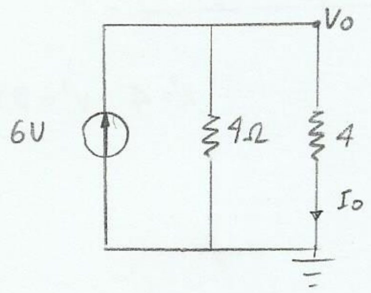
2.6

Usando as somas das tensões, e igualando a "0".

$12 - 6I_1 + 12 = 0 \therefore$

$I_1 = 4A$

2.7



$V_o = 6V$

$I_T = \frac{6}{2} = 3\ A$

$I_o = \frac{4}{8} \cdot 3 = 1{,}5\ A$

2.8

$R_1 = \left(\frac{1}{7 \cdot 5}\right) \div \left(\frac{1}{7} + \frac{1}{5}\right) = 0{,}0833$

$R_2 = \frac{1}{12} + \frac{1}{4} + \frac{1}{6} = 0{,}5$

$R_3 = \frac{0{,}5 \cdot 0{,}5}{1} = 0{,}25$

$R = \frac{1}{12} + \frac{1}{6} + \frac{1}{4} \quad \therefore \quad R = 0{,}5\ \Omega$

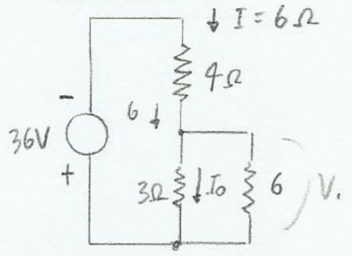
$\therefore \quad G = 2\Omega$

2.9 $12{,}5\,\Omega$

2.10

$R_{eq} = 6\,\Omega$

$I_T = 6\,A$



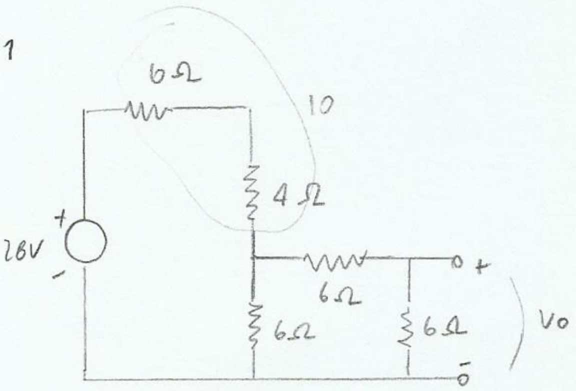
$3I_o = 6I'$

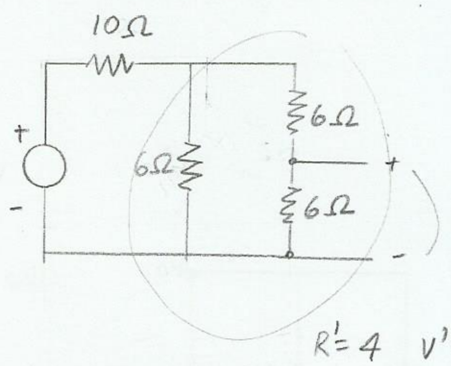
$I' = \frac{3I_o}{6} = \frac{I_o}{2}$

$I = \frac{I_o}{2} + I_o = \frac{3I_o}{2}$

$I_o = \frac{2I}{3} = \frac{2.6}{3} = 4A$

2.11





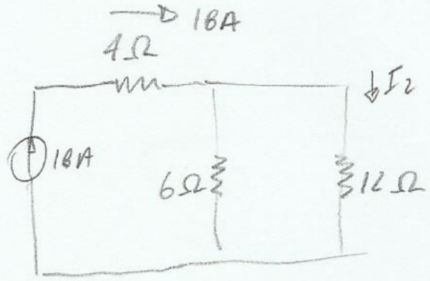
$R' = 4 \quad V' = 8V$

$V' = \frac{4}{14} . 28 = 8V$

$V = \frac{6}{12} . 8 = \underline{4V}$

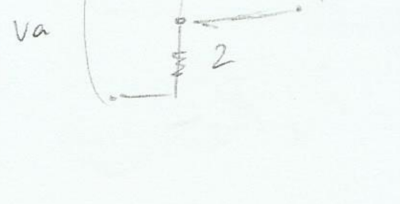
2.12

$V_a = 18.4 = \underline{72\,V}$



$I_2 = \frac{6}{6+12} . 18 \quad \therefore I_2 = 6A \quad \therefore I_1 = 12A$

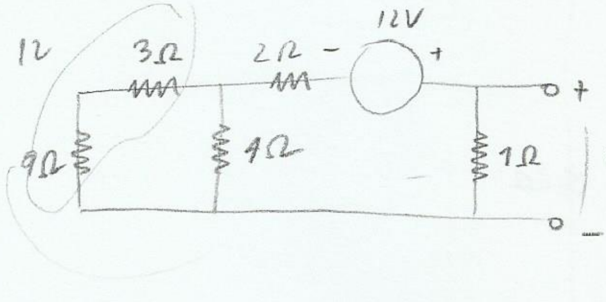
$V_2 = \underline{72V} = V_a$

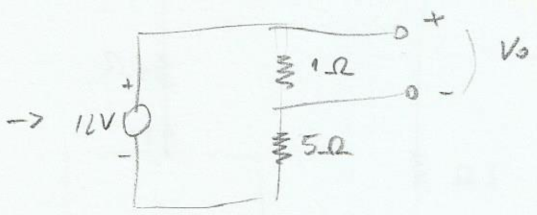


$\therefore \quad V_b = \frac{10}{10+2} . 72 \quad \therefore V_b = \underline{60.V}$

$2.12 - 60 - V_c = 0 \quad \therefore \quad V_c = \underline{-36V}$

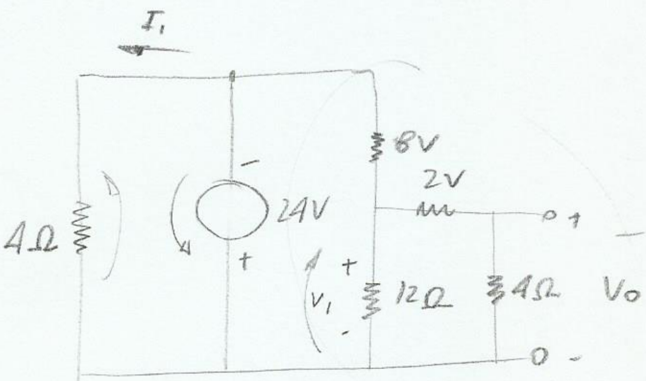
2.13-) Determine Vo





$$V_o = \frac{1}{5+1} \cdot 12 = \underline{2V}$$

2.14-) Determine I_1 e V_o

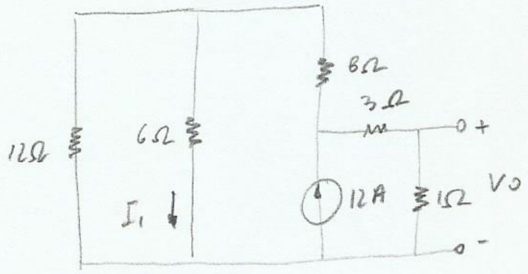


$$I_1 = \frac{24}{4} = \underline{6A}$$

$$V_1 = \frac{4}{4+8} \cdot 24 \quad \therefore V_1 = 8V$$

$$V_o = \frac{4}{2+4} \cdot 8 \quad \therefore V_o = \underline{\frac{16}{3} V}$$

215



Determine I_1 e V_o

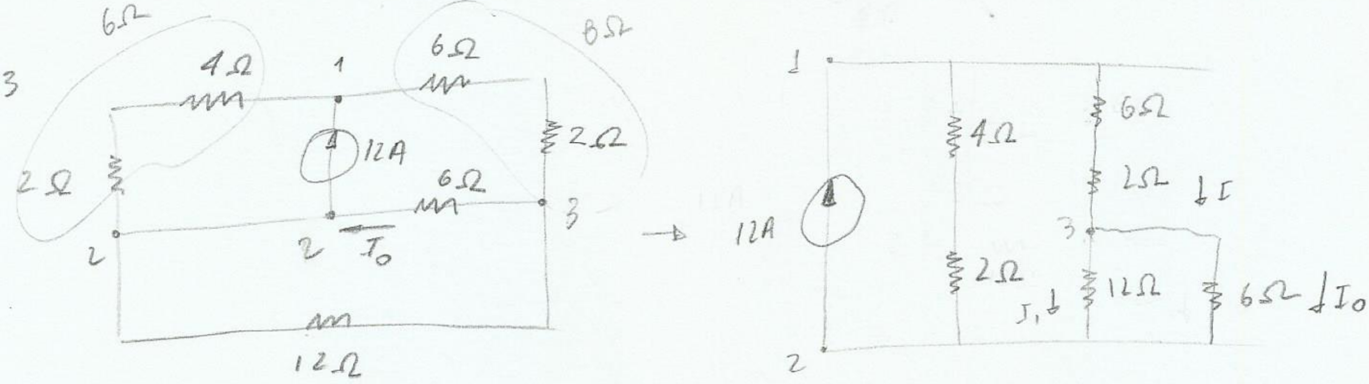
$$V = 12 \cdot 12 = 144V$$

$$I_1 = \frac{144}{6} \quad \therefore I_1 = \underline{24A}$$

$$V' = 12 \cdot 4 = 48V$$

$$V_o = \frac{1}{3+1} \cdot 48 \quad \therefore V_o = \underline{12V}$$

2.23



$R_{eq} = 4 \quad V_{12} = 48V$

$$I_0 = \frac{16}{6} = \frac{8}{3}\ A$$

$$V_{32} = \frac{4}{12} \cdot 48 = 16V$$

ou

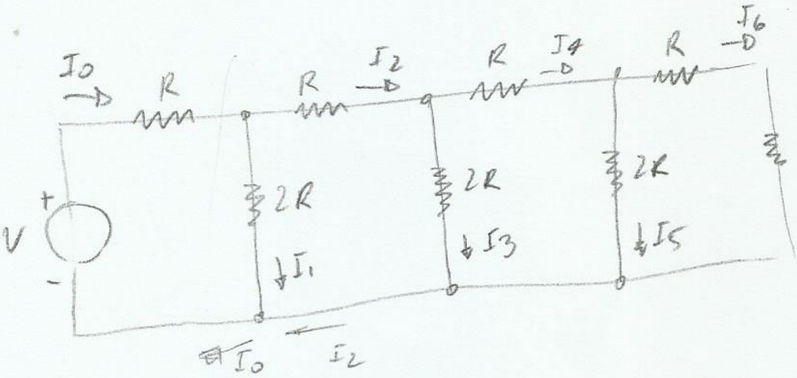
$$12 I_1 = 6 I_0$$

$$I_1 = \frac{6 I_0}{12} = \frac{I_0}{2}$$

$$\therefore\ I = \frac{I_0}{2} + I_0 = \frac{3 I_0}{2}$$

$$I = \frac{48}{12} = 4 \quad \therefore\ I_0 = \frac{2.4}{3} = \frac{8}{3}\ A$$

2.24



$R_{eq} = 2R$

$$I_0 = \frac{V}{2R}$$

$$I_1 = \frac{2R}{2R + 2R} \cdot I_0 = \frac{2R I_0}{4R} \quad \therefore\ I_1 = \frac{I_0}{2}\ A$$

$$I_2 + I_1 = I_0$$

$$I_2 = I_0 - \frac{I_0}{2} = \frac{I_0}{2}\ A$$

$I_3 = \frac{2\cancel{R}}{4\cancel{R}} \cdot \frac{I_0}{\cancel{2}} = \frac{I_0}{4}$

$I_5 = \frac{2R}{4R} \cdot \frac{I_0}{4} = \frac{I_0}{8}\ A$

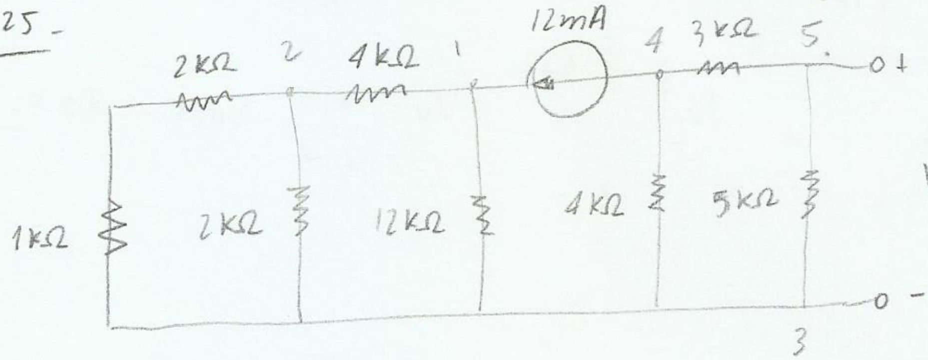
$I_4 = I_2 - I_3$

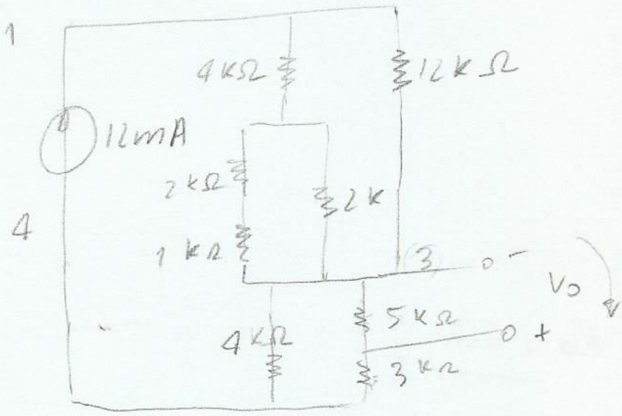
$= \frac{I_0}{2} - \frac{I_0}{4} \quad \therefore \quad I_4 = \frac{I_0}{4}$

$I_6 = I_4 - I_5$

$= \frac{I_0}{4} - \frac{I_0}{8} \quad \therefore \quad I_6 = \frac{I_0}{8}\ A$

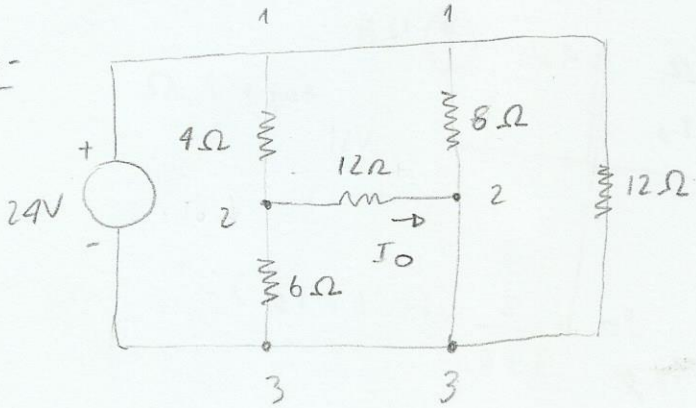
2.25 -

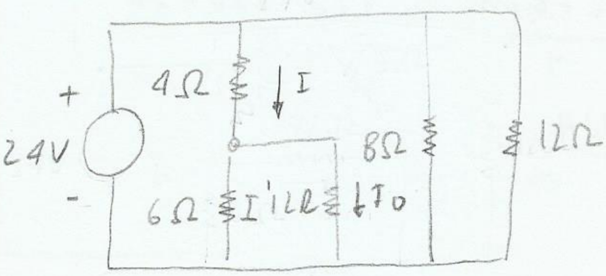




$V = 75{,}53\ V$

2.26 -





$6I' = 12I_0$

$I' = 2I_0$

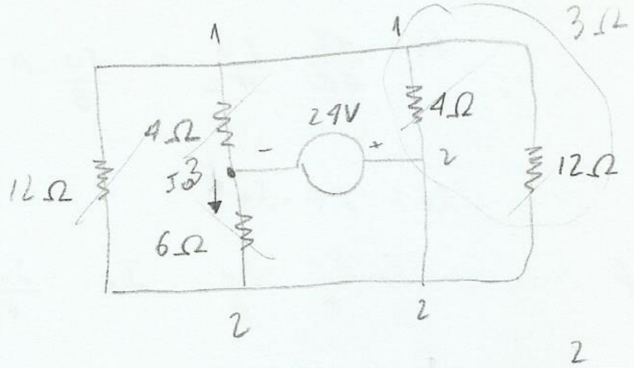
$I = 3I_0$

$I = \frac{4{,}8}{8+4{,}8} \cdot \frac{24}{3}$

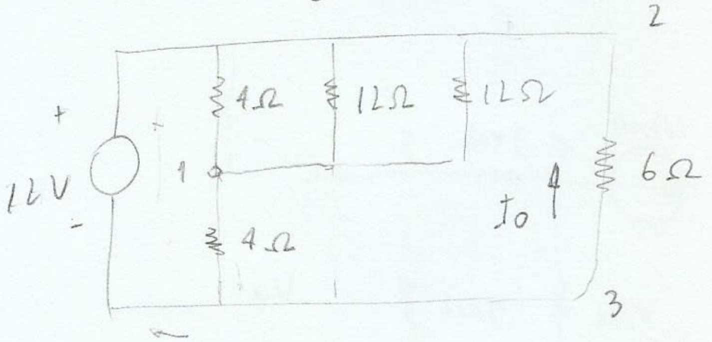
$\therefore I = 3$

$I_0 = \underline{1\ A}$

2.27



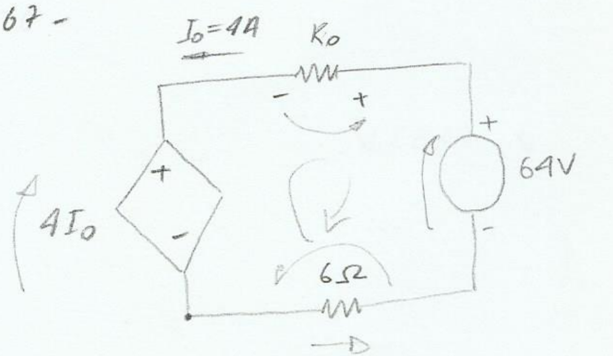
Determine Io



$I_T = 3{,}875$ A

$Io = \frac{6{,}4}{12{,}4} \cdot 3{,}875 \therefore Io = \underline{2A}$

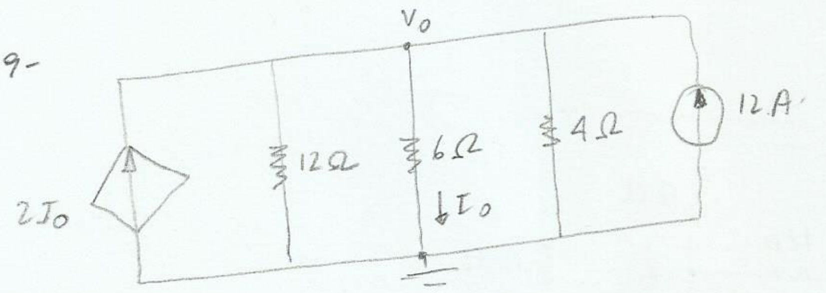
2.67-



Calcular Ro:

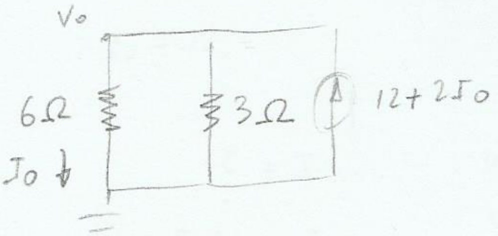
$4.4 + 4Ro - 64 + 4.6 = 0 \therefore Ro = \underline{6\Omega}$

2.69-



Calcule Vo:

$Req = 2\ \Omega$



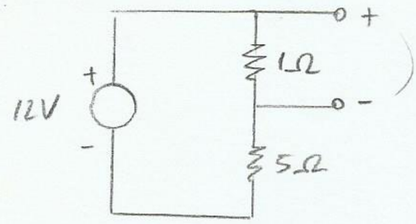
$Io = \frac{3}{3+6} \cdot (12 + 2Io)$

$Io = \frac{36 + 6Io}{9} \rightarrow 9Io - 6Io = 36$

$\therefore Io = \underline{12A}$

$Vo = 12.6 \quad \therefore Vo = \underline{72V}$

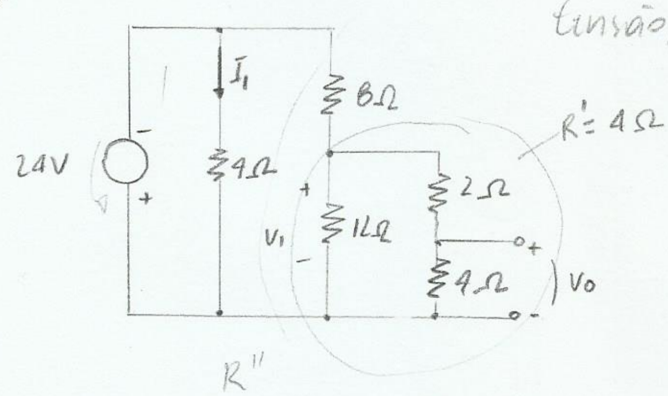
2.13



$V = \frac{1}{6} \cdot 12 = \underline{2V}$

2.14

Como determinar o sinal da minha tensão, quando eu uso um divisor.



$V' = \frac{4}{12} \cdot 24$

$V' = 8V$

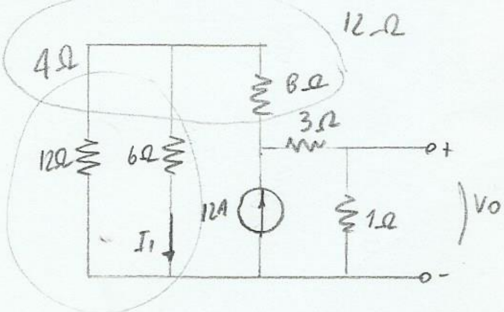
$Vo = \frac{4}{6} \cdot 8 = \underline{\frac{16}{3} V}$

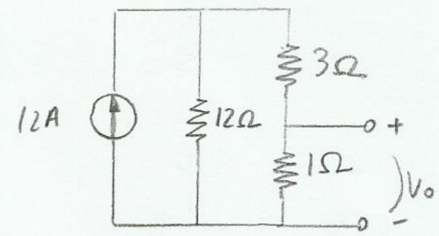
$R_T = 3$

$I_T = 8A$

$I_1 = \frac{12}{16} \cdot 8 = \underline{6A}$

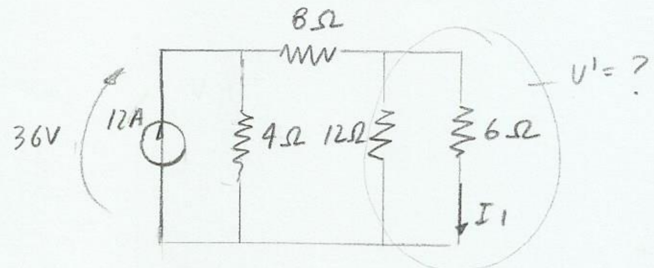
2.15





$R_T = 3 \Omega$

$V_T = 36 \Omega$

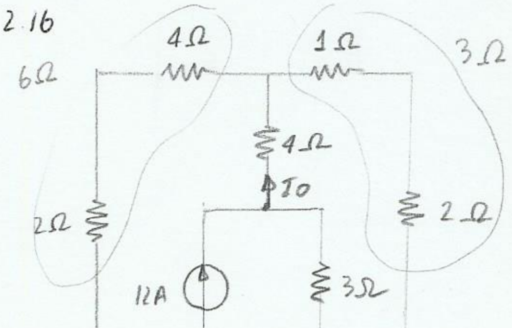


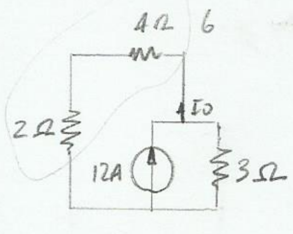
$Vo = \frac{1}{4} \cdot 36 = 9 \Omega$

$V' = \frac{4}{12} \cdot 36 = 12$

$I_1 = \frac{12}{6} = \underline{2A}$

2.16





$I_1 = \frac{R_2}{R_1 + R_2} \cdot I_T$

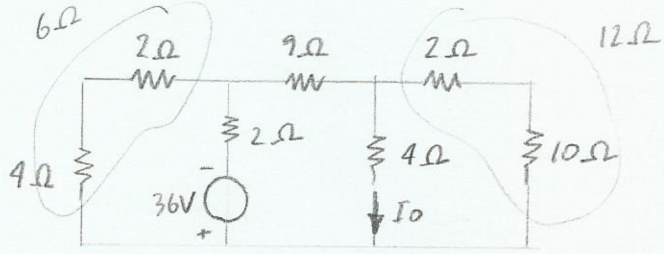
$12 = \frac{3}{3} \cdot Io$

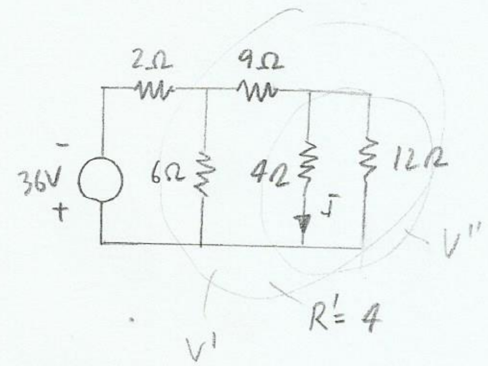
?

2.17

$R = [(10+2) \parallel (2+(6\parallel 3))] + 8 \quad \therefore \quad R_T = 11 \quad \therefore V = 66V$

2.18



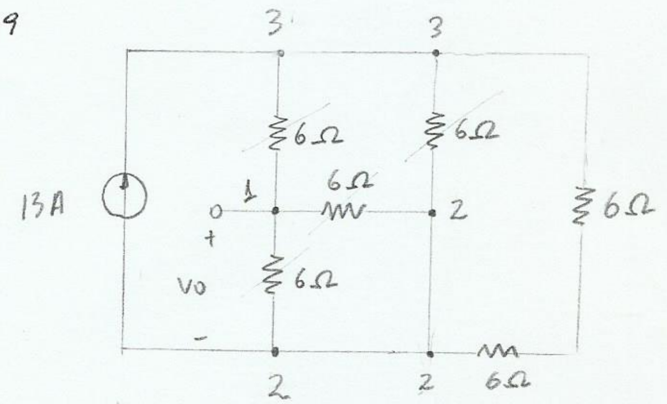


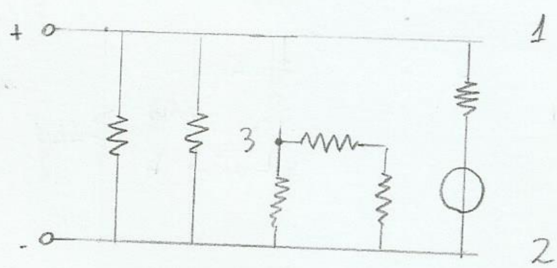
$V' = \frac{4}{6} \cdot 36 = 24$

$I_o = \frac{6}{4} = \underline{1{,}5A}$

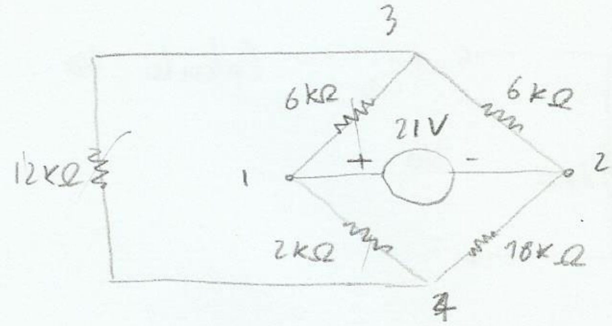
$V'' = \frac{3}{12} \cdot 24 = 6V$

2.19

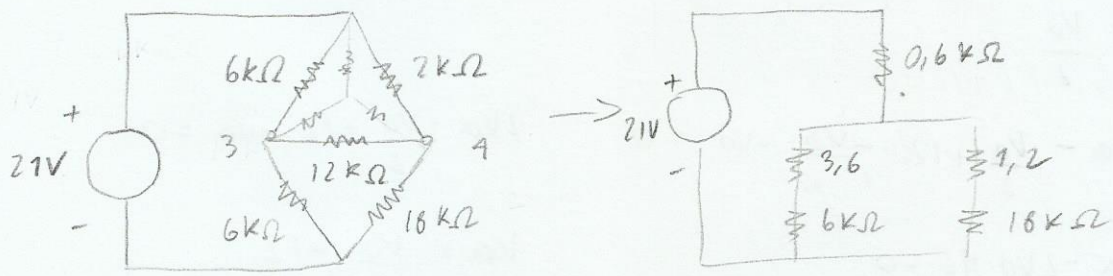




2.58



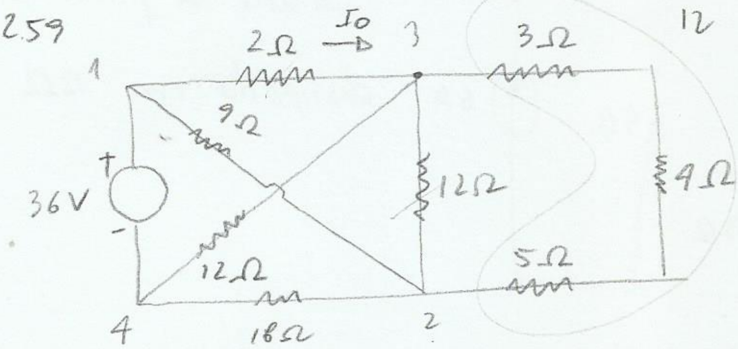
Encontre a potência dissipada no circuito total.



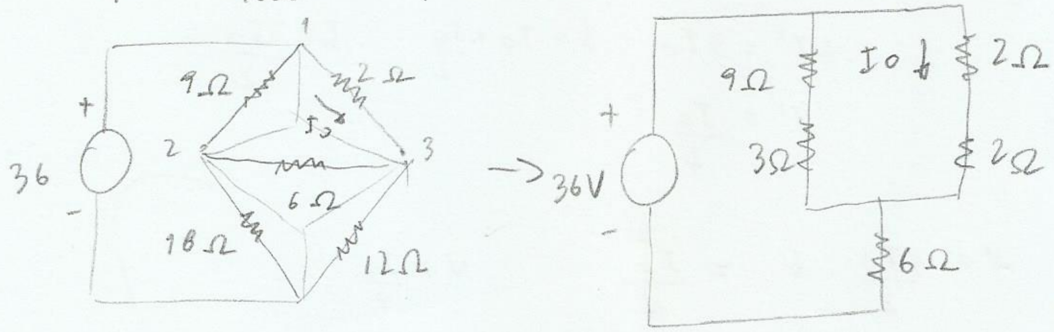
$R_{eq} = 7$

$$P = VI = V \cdot \frac{V}{R} = \frac{V^2}{R} = \frac{21^2}{7} \quad \therefore P = \underline{63\,mW}$$

2.59



Calcule I_o.



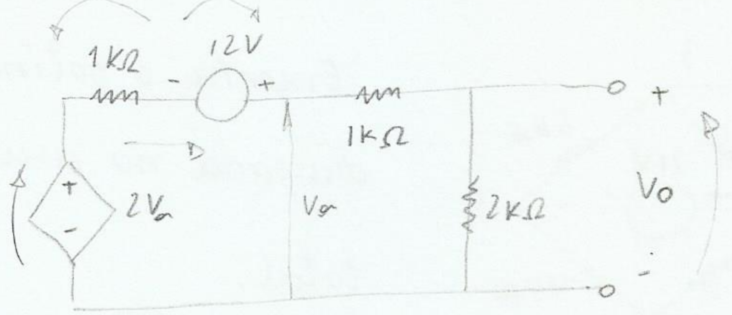
$R_{eq} = 9$

$$I_o = \frac{12}{12+4} \cdot 4$$

$$I_T = \frac{36}{9} = 4A$$

$$\therefore I_o = \underline{3A}$$

2.68 -



Calcule Vo

$I = \frac{V_o}{2}$

$2V_a - \frac{V_o}{2} + 12 - \frac{V_o}{2} - V_o = 0$

$2V_a - 2V_o + 12 = 0$

$V_a - V_o + 6 = 0$

$V_a = V_o - 6$

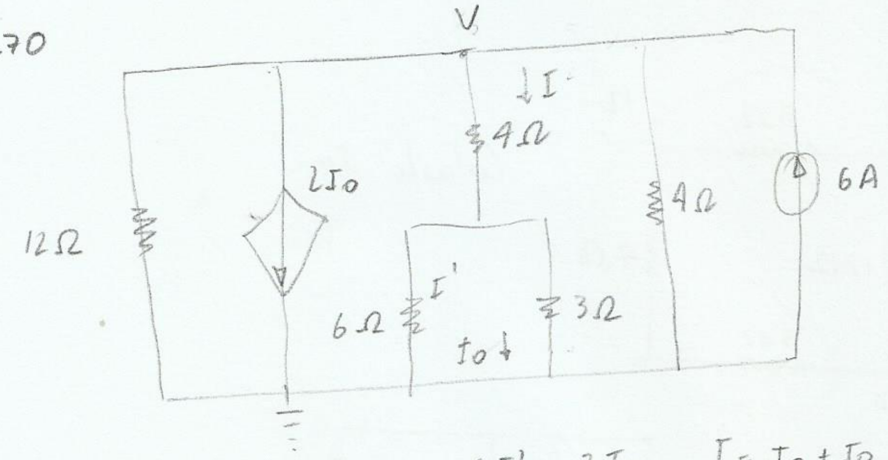
$2V_a - \frac{V_o}{2} + 12 - V_a = 0$

$V_a = \frac{V_o}{2} - 12$

$V_o - 6 = \frac{V_o}{2} - 12$

$\frac{V_o}{2} = -6 \quad \therefore \; \underline{V_o = -12V}$

2.70



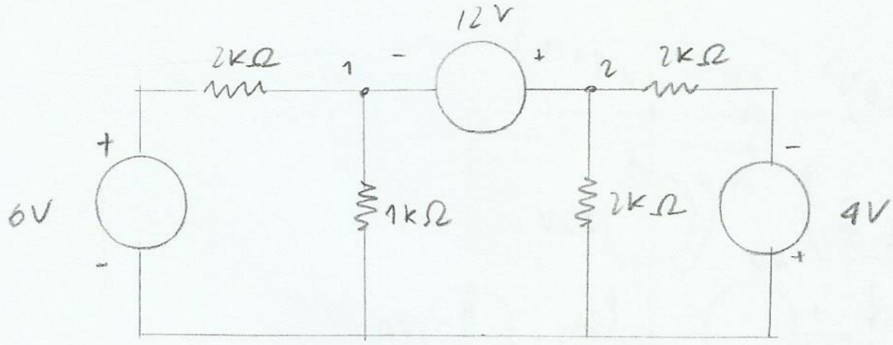
Calcule a potencia dissipada em 12Ω

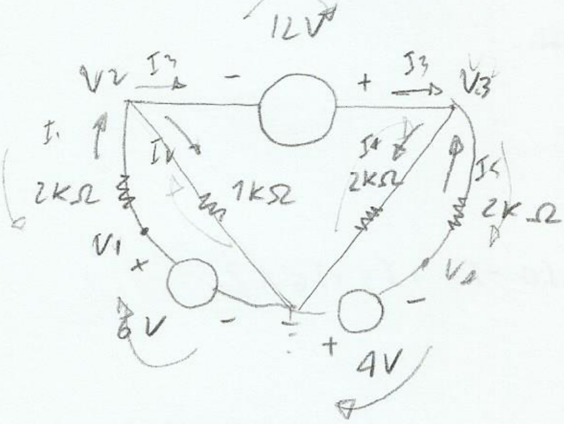
$6I' = 3I_o \qquad I = I_o + \frac{I_o}{2} \quad \therefore I = \frac{3I_o}{2}$

$I' = \frac{I_o}{2}$

$R_{eq} = 2\Omega$

$V = \frac{I}{6} \qquad V = \frac{3I_o}{2} : 6 = \frac{I_o}{4} \qquad \therefore V = \frac{I_o}{4}$





nó 1 : $I_3 + I_2 - I_1 = 0$

nó 2 : $I_4 - I_3 - I_5 = 0$

$-I_1 + I_2 + I_4 - I_5 = 0$

$$-\left[\frac{6 - V_2}{2}\right] + \frac{V_2 - 0}{1} + \frac{V_3 - 0}{2} - \left[\frac{V_3 - 4}{2}\right] = 0$$

$-6 + V_2 + 2V_2 + \cancel{V_3} - \cancel{V_3} - V_3 + 4 = 0$

$3V_2 - V_3 = 2$

$V_2 + 12 + \frac{V_3}{2} = 0 \Rightarrow 2V_2 + 24 + V_3 = 0$

$$\begin{cases} 3V_2 - V_3 = 2 \\ 2V_2 + V_3 = -24 \end{cases}$$

$5V_2 = -22$

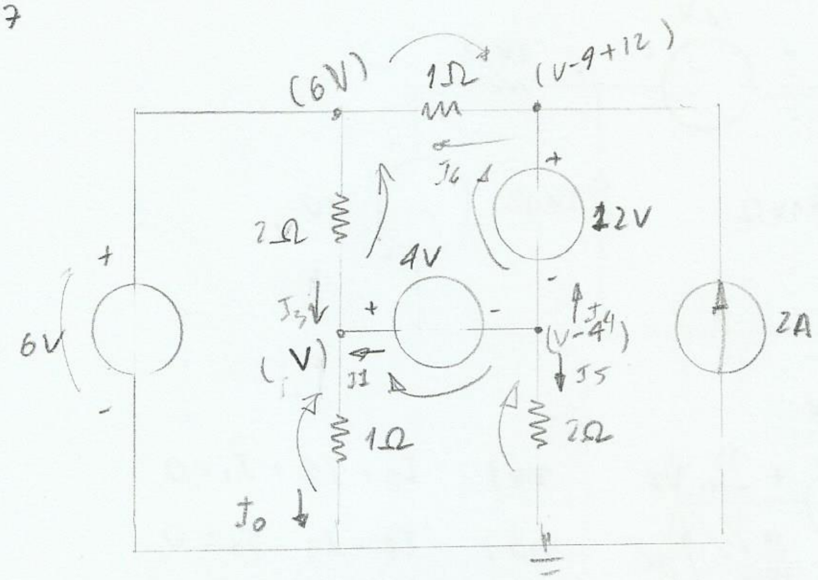
$V_2 = -\frac{22}{5}$

$V_3 = 3V_2 - 2$

$V_3 = 3 \cdot \left(-\frac{22}{5}\right) - 2$

$\therefore V_3 = 15{,}02$

3.27



nó 1: $I_0 - \cancel{I_1} - I_3 = 0$

nó 2: $\cancel{I_1} + \cancel{I_4} + I_5 = 0$ +

nó 3: $-\cancel{I_4} + I_6 - 2 = 0$

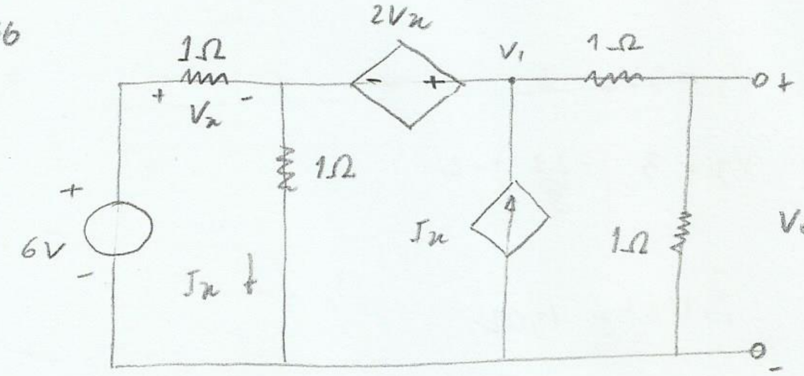
$$I_0 - I_3 + I_5 + I_6 = 2$$

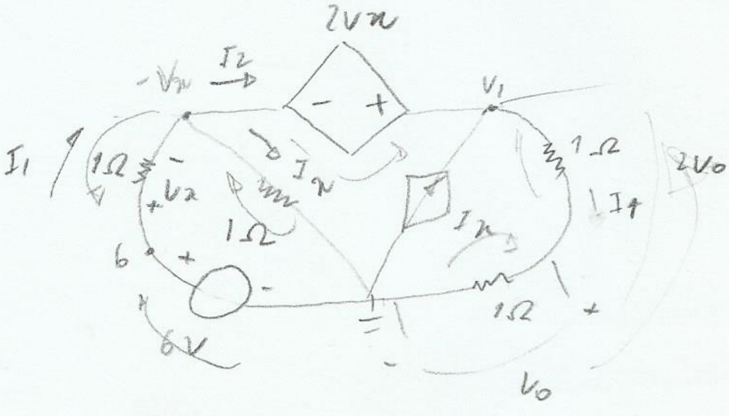
$$\frac{V-0}{1} - \left(\frac{6-V}{2}\right) + \frac{V-4}{2} + \frac{V+8-6}{1} = 2$$

$$2V - 6 + V + V - 4 + 2V - 4 = 4$$

$$6V = 10 \quad \therefore V = \frac{5}{3}$$

3.36





nó 1: $-I_1 + I_2 + I_x = 0$

nó 2: $-\cancel{I_2} - I_x + I_4 = 0$

$-I_1 + I_4 = 0$

$I_1 = I_4$

$$\frac{6-(2V_0-2V_x)}{1} = \frac{2V_0-0}{2}$$

$6-2V_0+2V_x = V_0$ $\qquad V_x = 6-(2V_0-2V_x)=0$

$6-3V_0+2V_x=0$ $\qquad V_x = 6-2V_0+2V_x$

$-3V_0+2V_x=-6$ $\qquad -V_x = 6-2V_0$

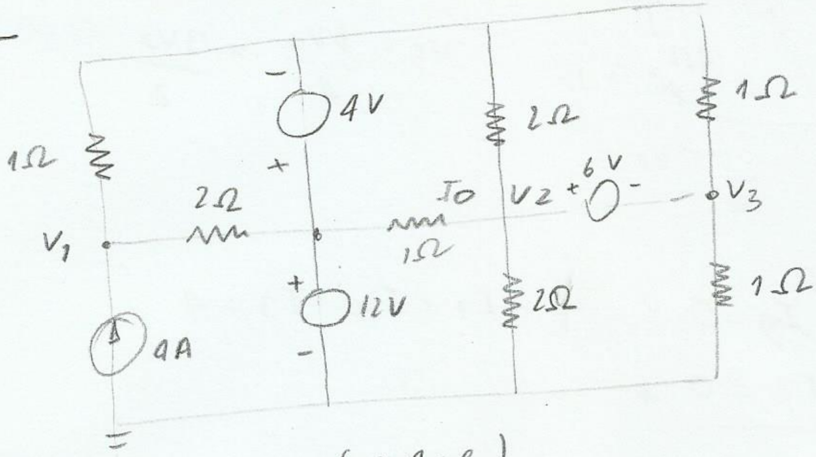
$\qquad V_x = 2V_0-6$

$-3V_0+2(V_0-6)=-6$

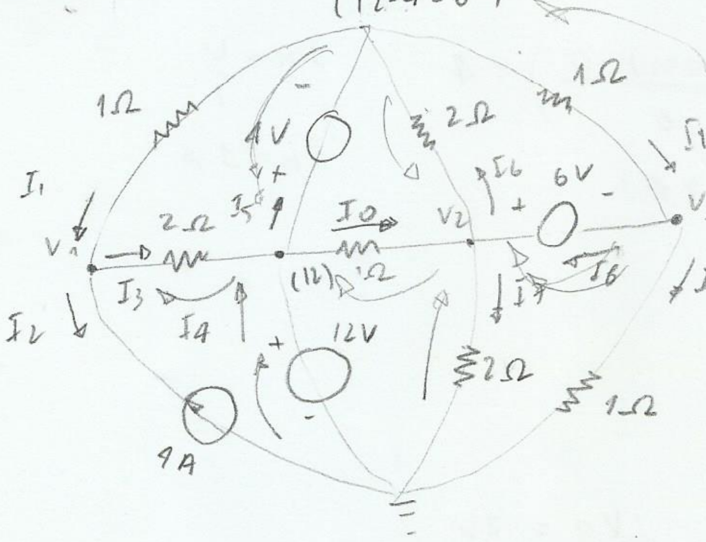
$-3V_0+2V_0-12=-6$

$-V_0=12 \quad \therefore \quad V_0=-6V$

3.30



Determine Io



$Io = \frac{12-V}{1} = \frac{12-6}{1} = 6V$

nós: $-Io - \cancel{I_8} + I_6 + I_7 = 0$

$\cancel{I_8} + I_9 - I_{10} = 0$

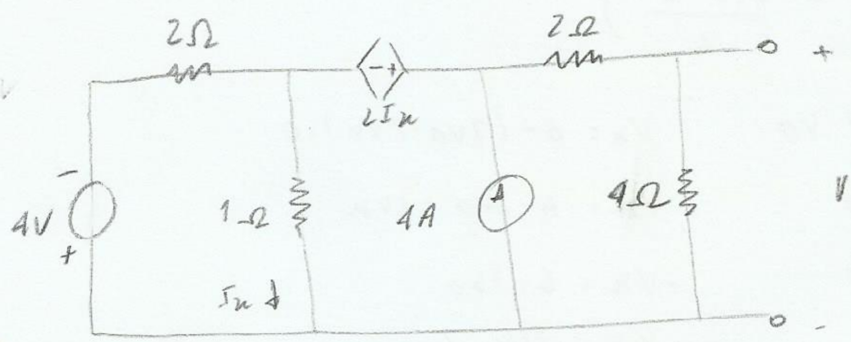
$\frac{2-V}{1}$

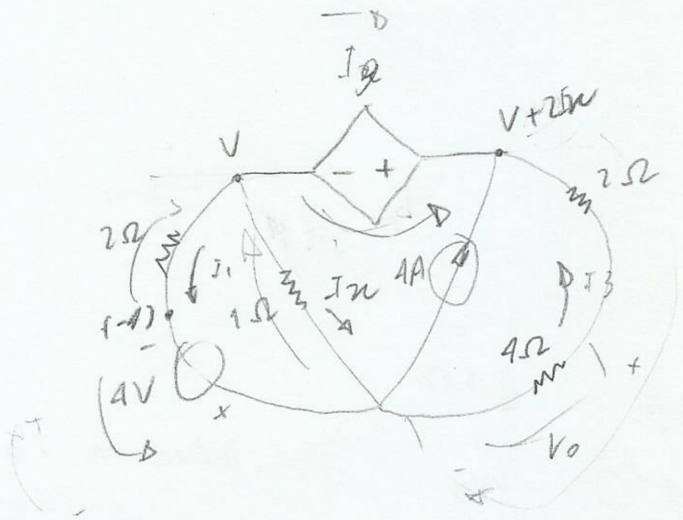
$-Io + I_6 + I_7 + I_9 - I_{10} = 0$

$$-\left(\frac{12-V}{1}\right) + \frac{V-8}{2} + \frac{V}{2} + \frac{V-6}{1} - \left(\frac{8-(V-6)}{1}\right) = 0$$

$-24+2V+V-8+V+2V-12+2V-4=0 \qquad 8V=48 \qquad V=6V$

3.31





$Vo = \frac{4}{2+4} Vt$

$Vt = \frac{6Vo}{4} = \frac{3Vo}{2}$

nós: $I_1 + Ix + \cancel{Ig} = 0$

$-\cancel{Ig} - 4 - I3 = 0$ +

$I_1 + Ix - I3 = 4$

$\frac{V+4}{2} + \frac{V-0}{1} - \left(-\frac{(V+2x)-0}{6}\right) = 4$

$Ix = \frac{V}{1}$

$Ix = 1A$

$3V + 12 + 6V + V + 2Ix = 24$

$10V + 2V = 12$

$12V = 12$

$V = 1$

$Vo = \frac{4}{2+4} \cdot (1+2)$ $\therefore$ $Vo = \underline{2V}$