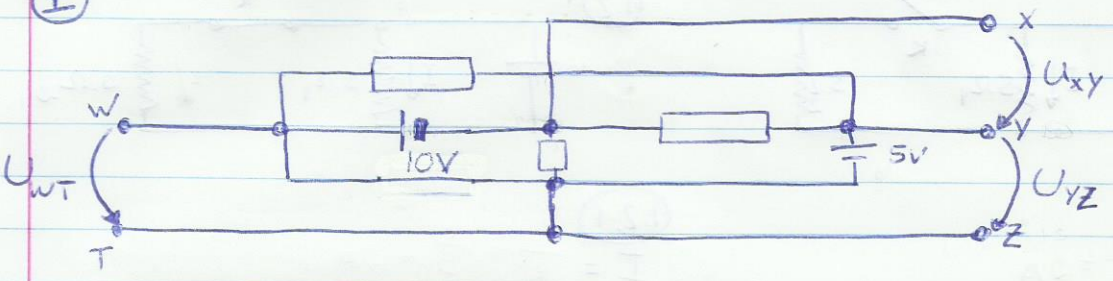
Caderno de Exercícios – Aulas TP

* 1ª Aula:

①



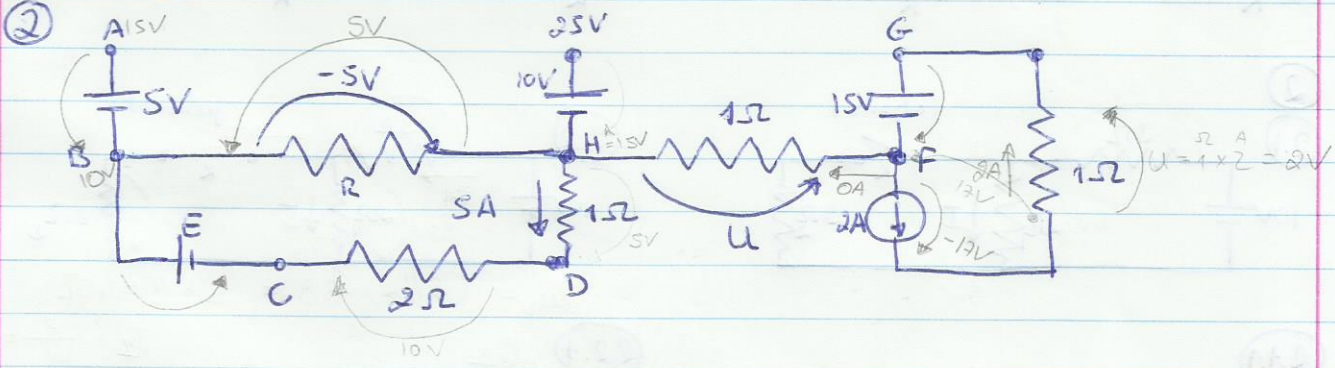
$U_W = U_T \rightarrow U_{WT} = U_W - U_T = 0\,V$

$U_{XY} = -15$

$U_{YZ} = +5$

U_Y = desconhecido

②



$U_A = 15\,V$

$U_B = 10\,V$

$U_C = 0\,V$

$U_D = 10\,V$

$U_F = U_H = 15\,V$

$U_G = 30\,V$

$U_H = 15\,V$

$E = 10\,V$

$U = 0\,V$ (não passa corrente na resistência)

$P_{2A} = U_{2A} \times I_{2A} = -17 \times 2 = -34\,W \leftrightarrow$ fornece energia

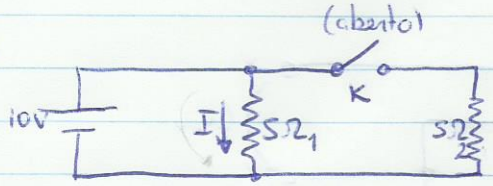
$U_{HD} = 1\,\Omega \times 5\,A = 5\,V$

$U_{DC} = 2\,\Omega \times 5\,A = 10\,V$

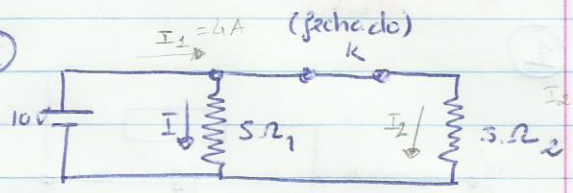
* 2ª Aula

(1)

(1.1)



(1.2)



(1.1.1)

$I = \frac{U}{R} = \frac{10}{5} = 2A$

(1.1.2)

$U_{10V} = 10V$ $\quad P_{10V} = 10 \times 2 = 20W$ (U × I)

$U_{5\Omega_1} = 10V$ $\quad P_{5\Omega_1} = 10 \times 2 = 20W$

$U_{5\Omega_2} = 0V$ $\quad P_{5\Omega_2} = 0 \times 0 = 0W$

$U_K = 10V$ (lei de Kirchoff) $\quad P_K = 10 \times 0 = 0W$

(1.2.1)

$I = \frac{U}{R} = \frac{10}{5} = 2A$

(1.2.2)

$U_{10V} = 10V$ $\quad P_{10V} = 10 \times I_1 = 10 \times 4 = 40W$

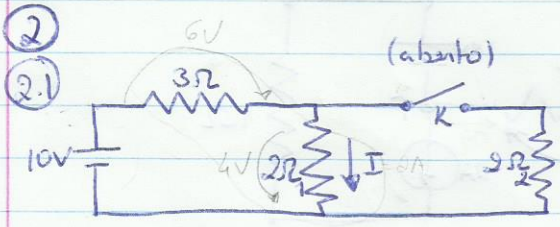
$U_{5\Omega_1} = 10V$ $\quad P_{5\Omega_1} = 10 \times I = 10 \times 2 = 20W$

$U_{5\Omega_2} = 10V$ $\quad P_{5\Omega_2} = 10 \times I_2 = 10 \times 2 = 20W$

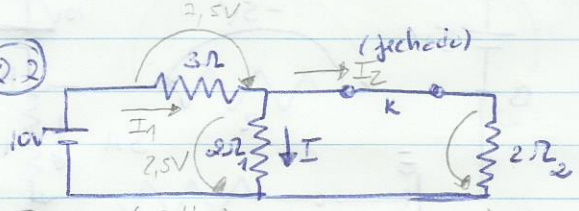
$U_K = 0V$ $\quad P_K = 0 \times I_2 = 0 \times 2 = 0W$

(2)

(2.1)



(2.2)



$R_{eq} = (2 // 2) + 3 = 1 + 3 = 4\Omega$

(2.1.1)

$I = \frac{U}{R} = \frac{10}{R_{eq}} = \frac{10}{3+2} = \frac{10}{5} = 2A$

(2.1.2)

$U_{10V} = 10V$ $\quad P_{10V} = 10 \times 2 = 20W$ (U × I)

$U_{3\Omega} = 6V$ $\quad P_{3\Omega} = 6 \times 2 = 12W$

$U_{2\Omega_1} = 4V$ $\quad P_{2\Omega_1} = 4 \times 2 = 8W$

$U_{2\Omega_2} = 0V$ $\quad P_{2\Omega_2} = 0 \times 0 = 0W$

$U_K = 4V$ $\quad P_K = 4 \times 0 = 0W$

(2.2.1)

$I_1 = \frac{U}{R_{eq}} = \frac{10}{4} = 2,5A$

$I = \frac{\text{Divisor de corrente}}{\frac{1}{R_{2\Omega_1}} + \frac{1}{R_{2\Omega_2}}} \times I_1 = \frac{\frac{1}{2}}{\frac{1}{2} + \frac{1}{2}} \times 2,5 = \frac{1}{2} \times 2,5 = 1,25A$

(2.2.2)

$U_{10V} = 10V$ $\quad P_{10V} = 10 \times I_1 = 10 \times 2,5 = 25W$ (U × I)

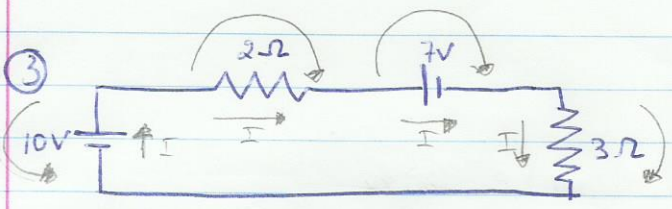
$U_{3\Omega} = 7,5V$ $\quad P_{3\Omega} = 7,5 \times I_1 = 7,5 \times 2,5 = 18,75W$

$U_{2\Omega_1} = 2,5V$ $\quad P_{2\Omega_1} = 2,5 \times 1,25 = 3,125W$

$U_{2\Omega_2} = 2,5V$ $\quad P_{2\Omega_2} = 2,5 \times 1,25 = 3,125W$

$U_K = 0V$ $\quad P_K = 0 \times 1,25 = 0W$

③



3.1) 1 corrente

3.2) 4 Tensões

3.3) $-10 + (2 \times I) + 7 + 3 \times I = 0$

$\Leftrightarrow -10 + 7 + 2I + 3I = 0$

$\Leftrightarrow -3 + 5I = 0$

$\Leftrightarrow I = \frac{3}{5} \simeq 0,6\ A$ ← Corrente igual em todos os componentes

$U_{10V} = 10V$ $\quad P_{10V} = -10 \times 0,6 = -6W$

$U_{2\Omega} = 2 \times 0,6 = 1,2V$ $\quad P_{2\Omega} = 1,2 \times 0,6 = +0,72W$

$U_{7V} = 7V$ $\quad P_{7V} = 7 \times 0,6 = +4,2W$

$U_{3\Omega} = 3 \times 0,6 = 1,8V$ $\quad P_{3\Omega} = 1,8 \times 0,6 = +1,08\ W$

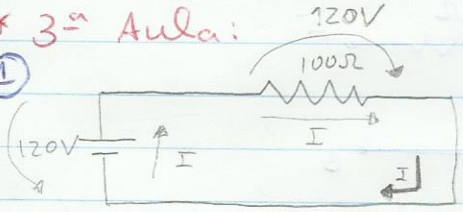
3.4)

Absorve energia: Resistências (2Ω e 3Ω) e Fonte (7V)

Fornece energia: Fonte (10V)

* 3ª Aula:

①



$P_{120V} = -(120 \times -1,2) = -144\ W$

$I = \frac{U}{R} = \frac{120V}{100V} = 1,2\ A$

②

$E = P \times \Delta t$

$\Leftrightarrow E = U \times I \times \Delta t$

$\Leftrightarrow E = U \times \frac{U}{R} \times 2$

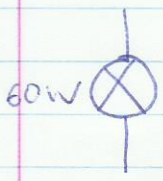
$\Leftrightarrow E = \frac{U^2}{R} \times 2$

$\Leftrightarrow E = \frac{(54)^2}{22K} \times 2$

$\Leftrightarrow E = 1,3255 \times 10^{-1} \times 2$

$\Leftrightarrow E = 2,6509 \times 10^{-1}\ Wh$

③ 0,15 €/kWh



$\Delta t = 8h \times 5d \times 4(sem) = 160h$

$E = P \times \Delta t = 60 \times 160 = 9,6\ kWh$

Custo mensal → $E \times 0,15 €/kWh$

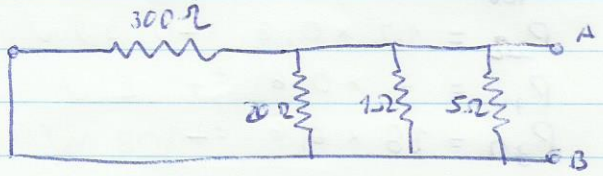
$= \frac{9,6\ kWh \times 0,15 €}{kWh}$

$= 9,6 \times 0,15\ €$

$= 1,44\ €$

④

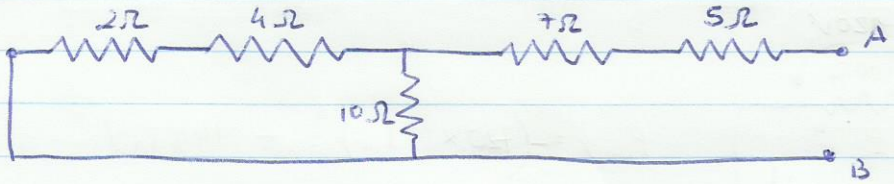
a)



$\frac{1}{R_{eq}} = \frac{1}{300} + \frac{1}{20} + \frac{1}{1} + \frac{1}{5} \Leftrightarrow \frac{1}{R_{eq}} = 1,2533$

$\Leftrightarrow R_{eq} = 7,9787 \times 10^{-1}\ \Omega$ //

b)



$R_{eq} = [(2+4) // 10] + (7+5)$

$= (6 // 10) + 12$

$= 3,75 + 12$

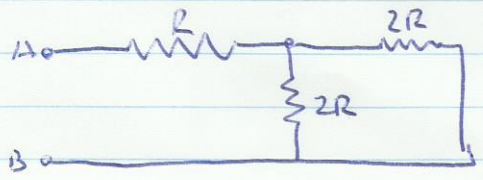
$= 15,75\ \Omega$ //

$\frac{1}{R_{paralelo}} = \frac{1}{6} + \frac{1}{10}$

$\frac{1}{R_{paralelo}} = 2,6667 \times 10^{-1}$

$R_{paralelo} = 3,75\ \Omega$

c)



$R_{eq} = (2R // 2R) + R$

$= R + R$

$= 2R\ \Omega$ //

$\frac{1}{R_{paralelo}} = \frac{1}{2R} + \frac{1}{2R}$

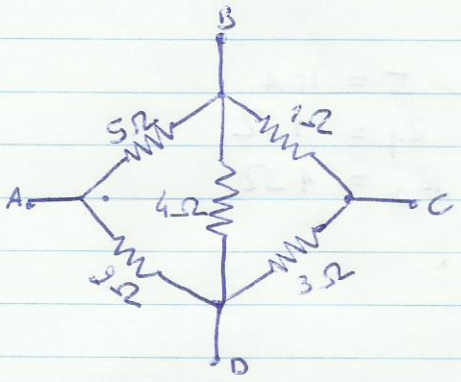
$\frac{1}{R_{paralelo}} = \frac{2}{2R}$

$R_{paralelo} = \frac{1 \times R}{1} = R$

d) Repete-se 3 vezes o conjunto da alínea c), logo $R_{eq} = 2R\ \Omega$ //

e) Repete-se 5 vezes o conjunto da alínea c), logo $R_{eq} = 2R\ \Omega$ //

⑤



$R_{AB} = \left(\left[(1+3) \,//\, 4\right] + 2\right) \,//\, 5$

$= \left((4 \,//\, 4) + 2\right) \,//\, 5$

$= (2 + 2) \,//\, 5$

$= 4 \,//\, 5$

$= 2,2222\ \Omega$

$4//4: \frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{4}$

$\Leftrightarrow \frac{1}{R_{eq}} = \frac{2}{4} = \frac{1}{2}$

$\Leftrightarrow R_{eq} = \frac{1 \times 2}{1} = 2\ \Omega$

$4//5: \frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{5}$

$\Leftrightarrow R_{eq} = 0,45$

$\Leftrightarrow R_{eq} = 2,2222\ \Omega$

$R_{BD} = (5+2) \,//\, 4 \,//\, (1+3)$

$= 7 \,//\, 4 \,//\, 4$

$= 1,5556\ \Omega$

$\frac{1}{R_{eq}} = \frac{1}{7} + \frac{1}{4} + \frac{1}{4}$

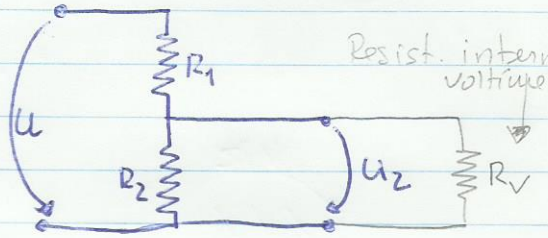
$\frac{1}{R_{eq}} = 0,64286$

$R_{eq} = 1,5556\ \Omega$

$R_{AC} =$ Eq. Δ e Y

*4ª Aula

①



$U = 50\ V$

$R_1 = 1\ k\Omega$

$R_2 = 1\ k\Omega$

Divisor de Tensão

①.① $R_V = 1\ \Omega$

$R_{eq} = R_2 \,//\, R_V \Leftrightarrow \frac{1}{R_{eq}} = \frac{1}{1000} + \frac{1}{1}$

$\Leftrightarrow \frac{1}{R_{eq}} = 1,001$

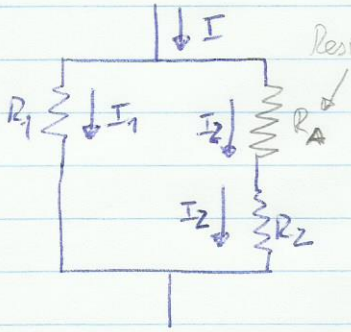
$\Leftrightarrow R_{eq} = 0,999\ \Omega$

$U_2 = \frac{R_{eq}}{R_1 + R_{eq}} \times U = \frac{0,999}{1000 + 0,999} \times 50$

$= 0,0499\ V$

①.② $R_V = 1\ k\Omega$ $\quad R_{eq} = 500\ \Omega$ $\quad U_2 = \frac{500}{1000 + 500} \times 50 = 16,667\ V$

①.③ $R_V = 1\ M\Omega$ $\quad R_{eq} = 999\ \Omega$ $\quad U_2 = \frac{999}{1000 + 999} \times 50 = 24,988\ V$

② 

Resist Intern. do Amperímetro

$I = 10A$

$R_1 = 1\Omega$

$R_2 = 1\Omega$

②.1 $R_A = 0,1\ \Omega$

$R_{eq} = R_A + R_2 \Leftrightarrow R_{eq} = 0,1 + 1$

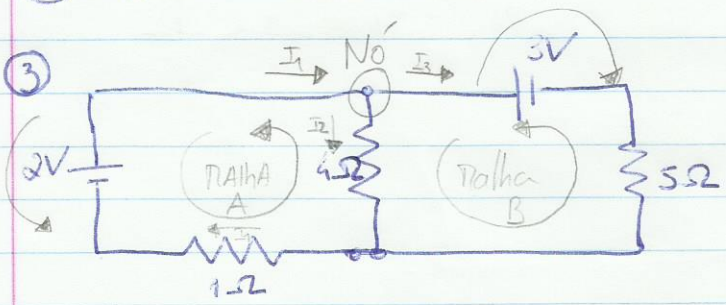
$\Leftrightarrow R_{eq} = 1,1\ \Omega$

Divisor de corrente

$$I_2 = \frac{\frac{1}{R_{eq}}}{\frac{1}{R_1} + \frac{1}{R_{eq}}} \times I = \frac{\frac{1}{1,1}}{\frac{1}{1} + \frac{1}{1,1}} \times 10 = 4,7619\ A$$

②.2 $R_A = 1\ \Omega$ $\quad R_{eq} = 2\ \Omega$ $\quad I_2 = 3,3333\ A$

②.3 $R_A = 1\ K\Omega$ $\quad R_{eq} = 1001\ \Omega$ $\quad I_2 = 0,00998\ A$

③ 

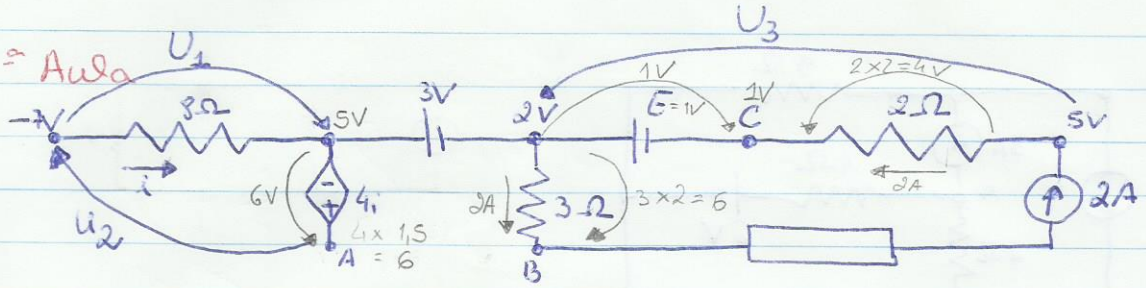
$$\begin{cases} A: & 2 + (-1 \times I_1) + (-4 \times I_2) = 0 \\ B: & 4 \times I_2 + (-5 \times I_3) + (-3) = 0 \\ Nó: & I_1 = I_2 + I_3 \end{cases}$$

$$\Leftrightarrow \begin{cases} 2 - I_1 - 4I_2 = 0 \\ 4I_2 - 5I_3 - 3 = 0 \\ I_1 = I_2 + I_3 \end{cases} \Leftrightarrow \begin{cases} -I_1 = -2 + 4I_2 \\ -5I_3 = 3 - 4I_2 \\ \text{---} \end{cases} \Leftrightarrow \begin{cases} I_1 = 2 - 4I_2 \\ I_3 = -\frac{3}{5} + \frac{4}{5}I_2 \\ 2 - 4I_2 = I_2 + (-\frac{3}{5} + \frac{4}{5}I_2) \end{cases}$$

$$\Leftrightarrow \begin{cases} \text{---} \\ \text{---} \\ -4I_2 - I_2 - \frac{4}{5}I_2 = -2 - \frac{3}{5} \end{cases} \Leftrightarrow \begin{cases} \text{---} \\ \text{---} \\ -\frac{25}{5}I_2 - \frac{4}{5}I_2 = \frac{-10}{5} - \frac{3}{5} \end{cases}$$

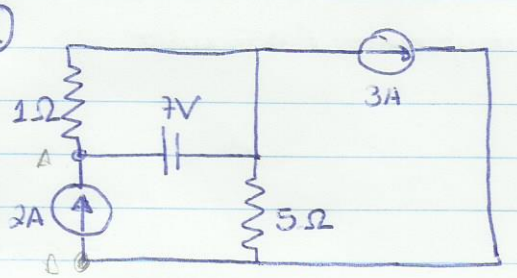
$$\begin{cases} \text{---} \\ \text{---} \\ -\frac{29}{5}I_2 = \frac{-13}{5} \end{cases} \quad -29I_2 = -13 \quad \begin{cases} I_1 = 2 - \frac{4 \times 13}{29} = 0,20690\ A \\ I_3 = -\frac{3}{5} + \frac{4 \times 13}{5 \times 29} = -0,24138\ A \\ I_2 = \frac{13}{29} = 0,44828\ A \end{cases}$$

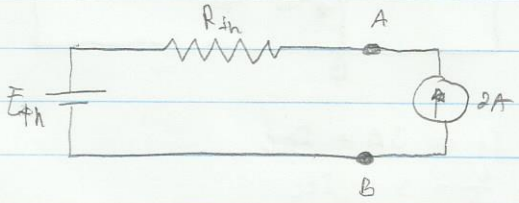
* 5ª Aula

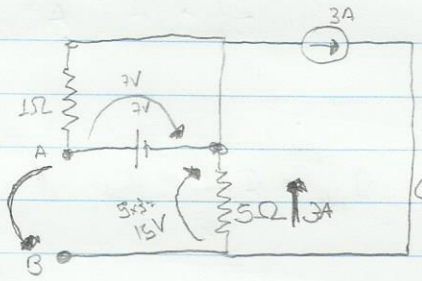
① 

$U_A = (5) - (6) = -1\ V$
$U_B = (2) - (6) = -4\ V$
$U_C = (5) - (4) = 1\ V$
$i = \frac{U_1}{R} = \frac{-12}{8} = 1{,}5\ A$

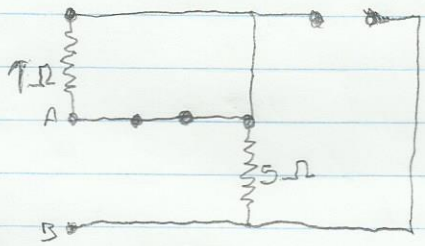
$E = 1\ V$
$U_1 = (-7) - (5) = -12\ V$
$U_2 = (-1) - (-7) = 6\ V$
$U_3 = (5) - (2) = 3\ V$

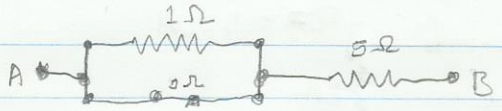
② 



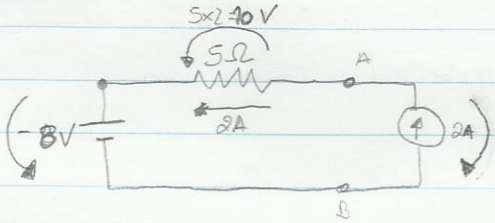


$U_{AB} - 7V + 15V = 0 \Leftrightarrow$
$\Leftrightarrow U_{AB} = +7 - 15$
$\Leftrightarrow U_{AB} = -8V = E_{th}$





$R_{AB} = (1 // 0) + 5 = 0 + 5 = 5\ \Omega = R_{th}$

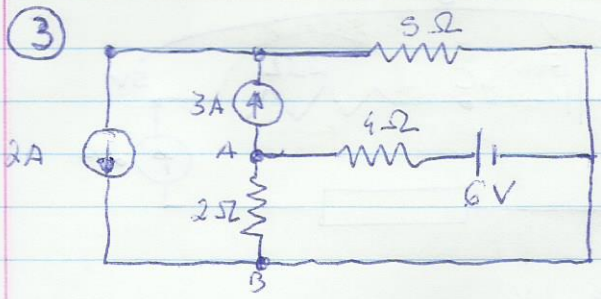


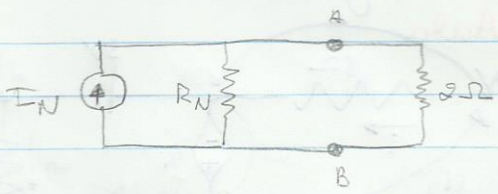
$10 + (-8) + U_{2A} = 0$
$\Leftrightarrow U_{2A} = 2\ V$

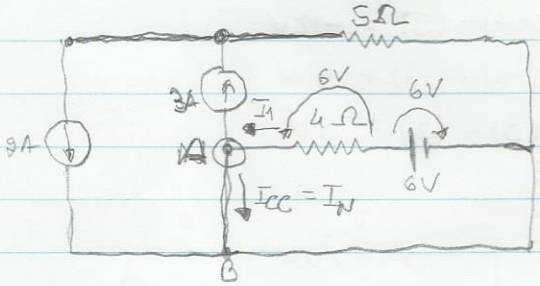
$P_{2A} = U_{2A} \times I_{2A} = -(2 * 2) = -4\ W$

A fonte de 2A tem uma potência negativa, logo fornece energia.

(3)







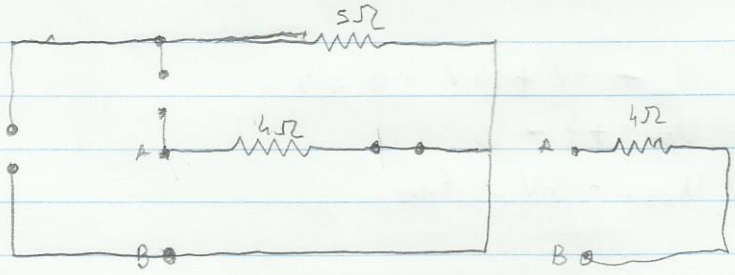
Os terminais da resistência são os mesmos da fonte de 6V logo a tensão existente entre os terminais dos dois componentes é o mesmo.

A: $I_1 = 3A + I_{CC}$

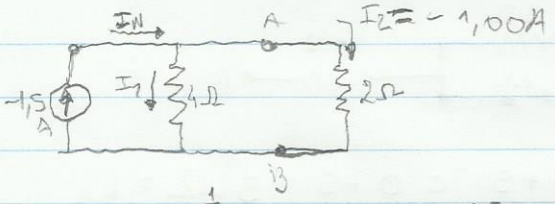
$\Leftrightarrow \frac{6}{4} = 3 + I_{CC}$

$\Leftrightarrow 1,5 = 3 + I_{CC}$

$\Leftrightarrow I_{CC} = -1,5A = I_N$



$R_{AB} = 4\,\Omega = R_N$

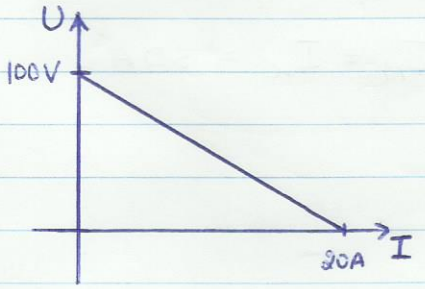


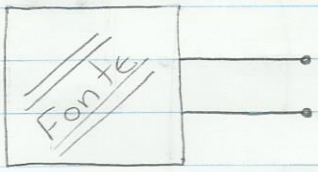
$$I_2 = \frac{\frac{1}{2}}{\frac{1}{4} + \frac{1}{2}} \times (-1,5) = \frac{0,5}{0,75} \times (-1,5) = -1,00\,A$$

$$P_{2\Omega} = U \times I_2 = R \times I \times I = 2 \times (-1)^2 = 2\,W$$

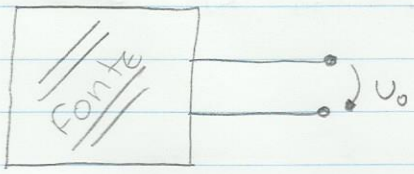
* 6ª Aula

(1)





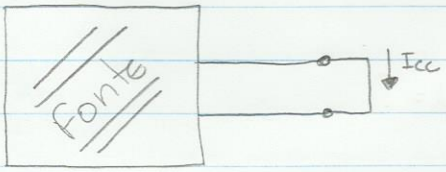
(1.1)



($I = 0A \rightarrow$ circuito aberto)

$\therefore U_0 = 100V$

(1.2)

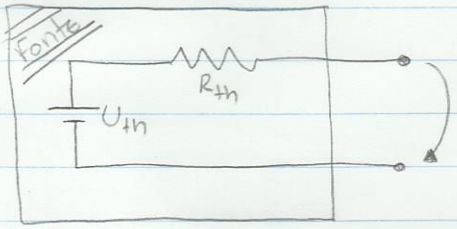


($U = 0V \rightarrow$ curto circuito)

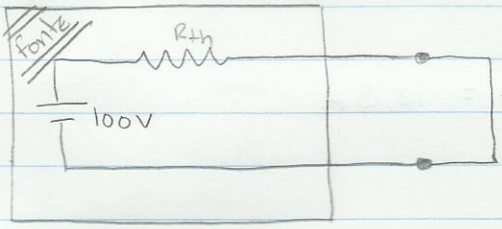
$\therefore I_{cc} = 20A$

(1.3) $R_i = \frac{U_0}{I_{cc}} = \frac{100}{20} = 5\Omega$ $\left(R_i = m = \frac{\Delta U}{\Delta I}\right)$

(1.4)

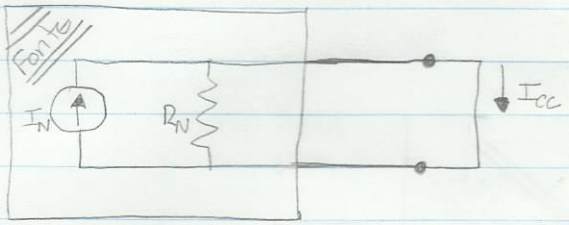


$U_{th} = U_0 = 100V$

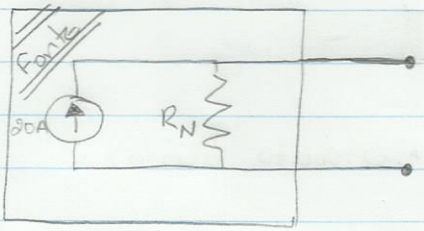


$R_{th} = \frac{U_{th}}{I_{cc}} = \frac{100}{20} = 5\Omega = R_i$

15

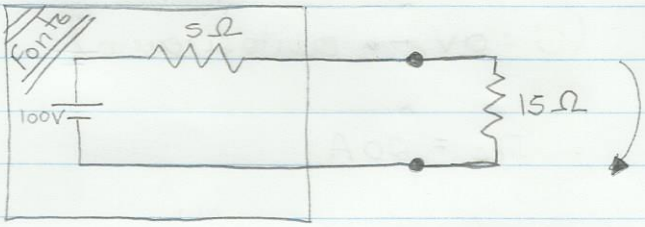


$I_N = I_{cc} = 20\,A$



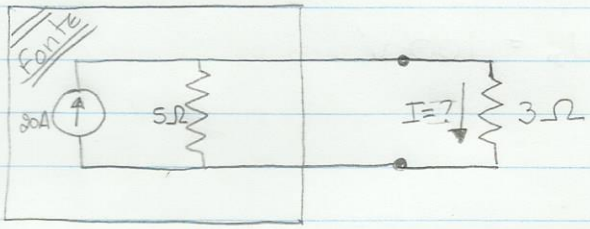
$R_N = R_{th} = R_i = 5\,\Omega$

16



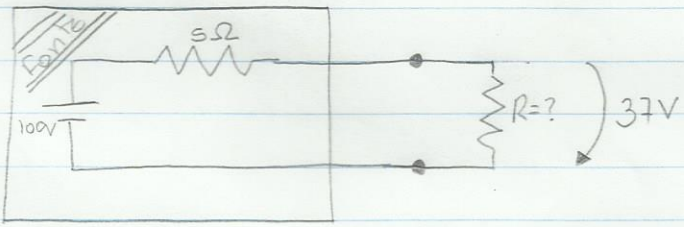
Divisor de tensão: $U = \frac{15}{15+5} \times 100 = 75\,V$

17



Divisor de corrente: $I = \frac{\frac{1}{3}}{\frac{1}{3}+\frac{1}{5}} \times 20 = 12{,}5\,A$

18



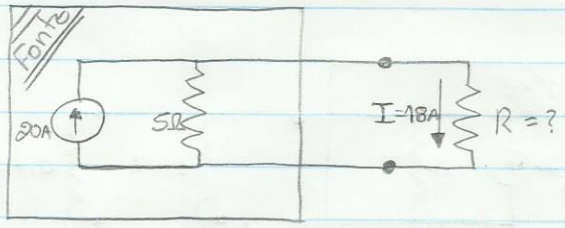
Divisor de tensão: $37 = \frac{R}{R+5} \times 100 \Leftrightarrow \frac{37}{100} = \frac{R}{R+5}$

$\Leftrightarrow R = \frac{37(R+5)}{100} \Leftrightarrow R = \frac{37R}{100} + \frac{185}{100}$

$\Leftrightarrow \frac{100R}{100} - \frac{37R}{100} = 1{,}85 \Leftrightarrow \frac{63R}{100} = 1{,}85$

$\Leftrightarrow 63R = 1{,}85 \times 100 \Leftrightarrow R = \frac{185}{63} = 2{,}9365\,\Omega$

1.9



Divisor de corrente: $18 = \frac{\frac{1}{R}}{\frac{1}{R}+\frac{1}{5}} \times 20 \Leftrightarrow \frac{18}{20} = \frac{1/R}{1/R + 1/5}$

$\Leftrightarrow \frac{1}{R} = \frac{18(1/R + 1/5)}{20}$

$\Leftrightarrow \frac{1}{R} = \frac{0,9}{R} + \frac{0,9}{5}$

$\Leftrightarrow \frac{1}{R} - \frac{0,9}{R} = \frac{0,9}{5}$

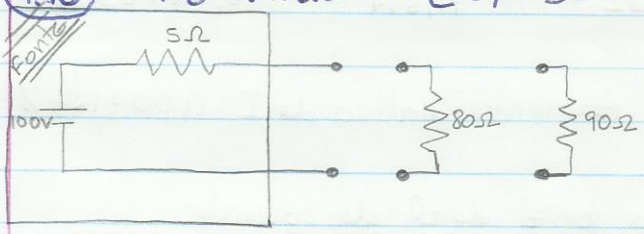
$\Leftrightarrow \frac{0,1}{R} = \frac{0,9}{5}$

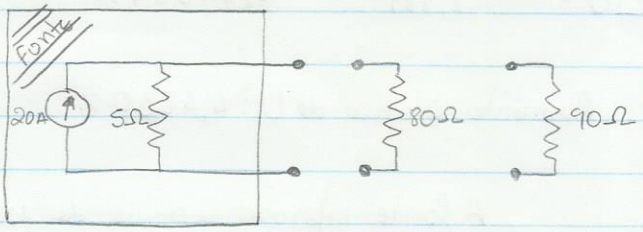
$\Leftrightarrow R = \frac{0,1 \times 5}{0,9}$

$\Leftrightarrow R = \frac{0,5}{0,9}$

$\Leftrightarrow R = 0,55556\ \Omega$

1.10 • R_e varia em $[80,90]\ \Omega$





Divisor de tensão: $U = \frac{R_e}{R_e + R_i} \times U_0$

$U_{80\Omega} = \frac{80}{80+5} \times 100 = 94,12\ V$

$U_{90\Omega} = \frac{90}{90+5} \times 100 = 94,74\ V$

$\Delta U = \frac{|94,12 - 94,74|}{94,12} = 0,7\ \%$

$\Delta U = \frac{|94,12 - 94,74|}{94,74} = 0,7\ \%$

Aumento Relativo de U = 0%

Divisor de corrente: $I = \frac{1/R_e}{1/R_e + 1/R_i} \times I_{cc}$

$I_{80\Omega} = \frac{1/80}{1/80 + 1/5} \times 20 = 1,18\ A$

$I_{90\Omega} = \frac{1/90}{1/90 + 1/5} \times 20 = 1,05\ A$

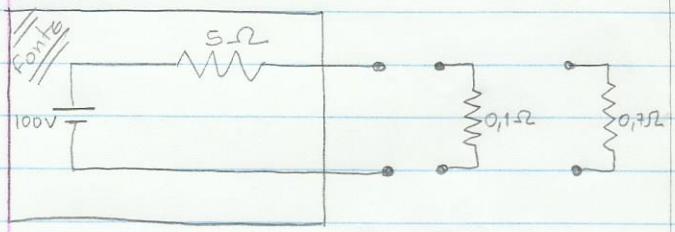
$\Delta I = \frac{|1,18 - 1,05|}{1,18} = 11\ \%$

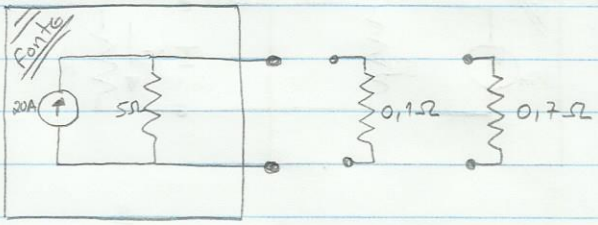
$\Delta I = \frac{|1,18 - 1,05|}{1,05} = 12\ \%$

Aumento Relativo de I = 1%

A fonte aproxima-se de uma fonte ideal de tensão, quando as cargas variam $[80,90]\ \Omega$

(1.10) • R_e varia em $[0,1 ; 0,7]\ \Omega$





Divisor de tensão: $U = \frac{R_e}{R_e + R_i} \times U_0$

$U_{0,1\Omega} = \frac{0,1}{0,1 + 5} \times 100 = 1,9608\ V$

$U_{0,7} = \frac{0,7}{0,7 + 5} \times 100 = 12,281\ V$

$\Delta U = \frac{|1,9608 - 12,281|}{1,9608} = 5,2633\ \%$

$\Delta U = \frac{|1,9608 - 12,281|}{12,281} = 0,84034\ \%$

Aumento Relativo de U: 4,4230 %

Divisor de corrente: $I = \frac{1/R_e}{1/R_e + 1/R_i} \times I_{cc}$

$I_{0,1\Omega} = \frac{1/0,1}{1/0,1 + 1/5} \times 20 = 19,608\ A$

$I_{0,7\Omega} = \frac{1/0,7}{1/0,7 + 1/5} \times 20 = 17,544\ A$

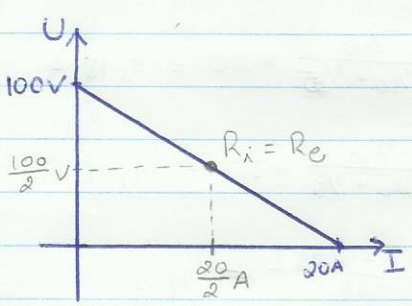
$\Delta I = \frac{|19,608 - 17,5441|}{19,608} = 0,10526\ \%$

$\Delta I = \frac{|19,608 - 17,5441|}{17,544} = 0,11765\ \%$

Aumento Relativo de I: 0,007124 %

A fonte aproxima-se de uma fonte ideal de corrente quando as cargas variam em $[0,1 ; 0,7]\ \Omega$

(1.11)



$P_{MÁX} = U \times I = \frac{U_0}{2} \times \frac{I_{cc}}{2}$

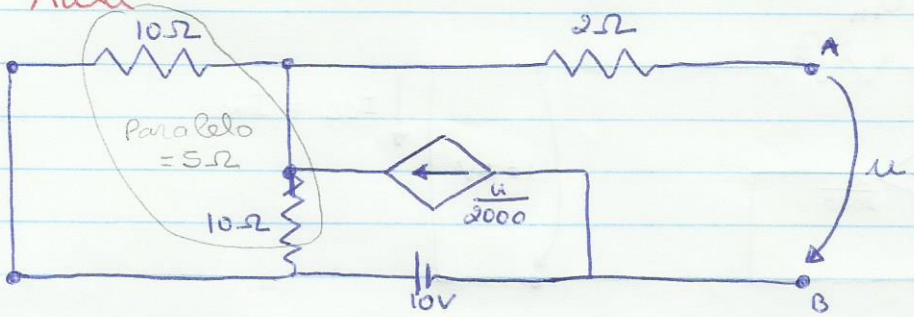
$= \frac{100}{2} \times \frac{20}{2}$

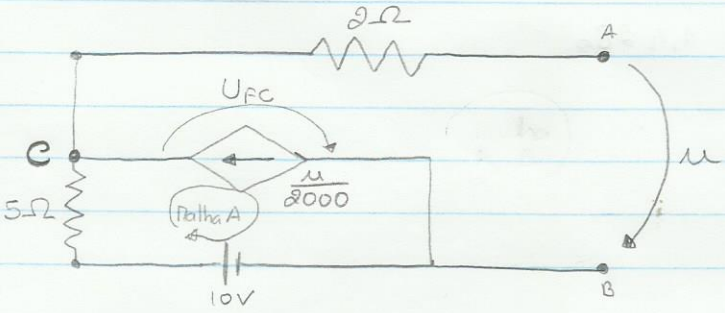
$= \frac{100 \times 20}{2 \times 2}$

$= \frac{2000}{4}$

$= 500\ W$

* 7ª Aula

① 



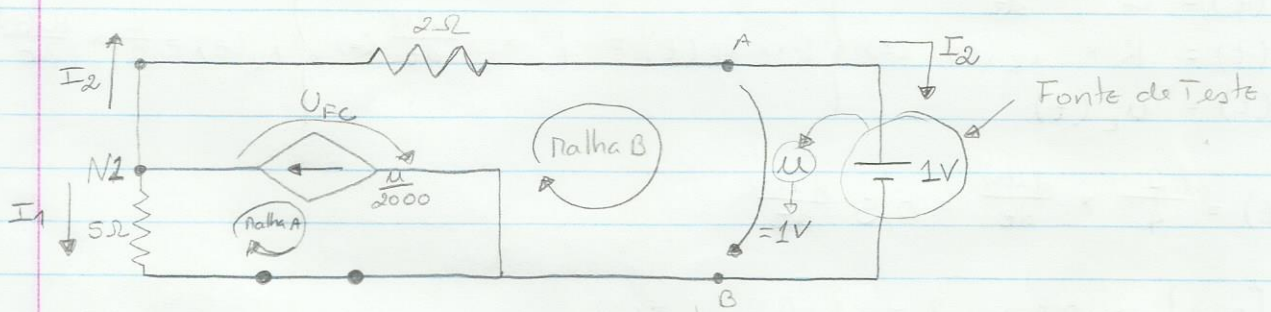
$U_{AC} = 0V$

$U_{th} = U_{AB} = u$

Malha A: $\begin{cases} -5 \cdot \frac{u}{2000} + U_{FC} - 10 = 0 \\ u = U_{FC} \end{cases} \Leftrightarrow \begin{cases} -5 \cdot \frac{u}{2000} + u - 10 = 0 \\ \text{---} \end{cases}$

$\Leftrightarrow \begin{cases} \frac{-5u}{2000} + u = 10 \\ \text{---} \end{cases} \Leftrightarrow \begin{cases} \frac{-5u + 2000u}{2000} = 10 \\ \text{---} \end{cases}$

$\Leftrightarrow \begin{cases} 1995u = 2000 \times 10 \\ \text{---} \end{cases} \Leftrightarrow \begin{cases} u = \frac{20\,000}{1995} = 10{,}025V \end{cases}$



$R_{th} = R_{AB}$ →

Malha A: $-5 \cdot I_1 + U_{FC} = 0$

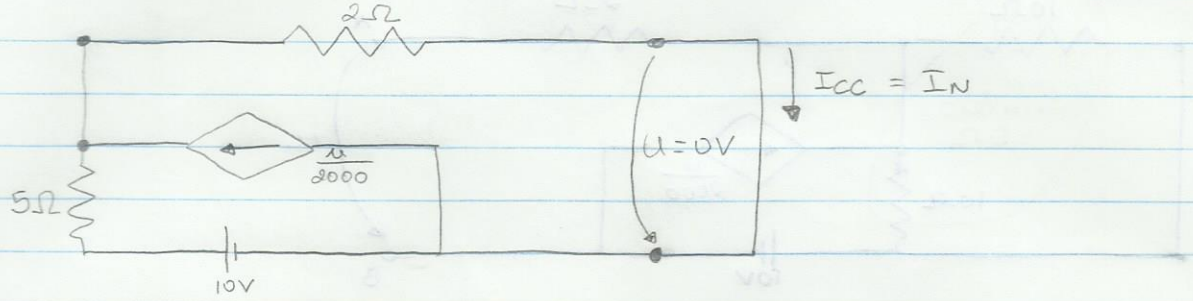
Malha B: $-5 \cdot I_1 + 2I_2 + 1 = 0$ ... $\begin{cases} U_{FC} = 0{,}715 \\ I_1 = 0{,}143 \\ I_2 = -0{,}1425 \end{cases}$

Nó 1: $\frac{1}{2000} = I_1 + I_2$

$R_{th} = R_{AB} = \frac{1}{-I_2}$

(4)

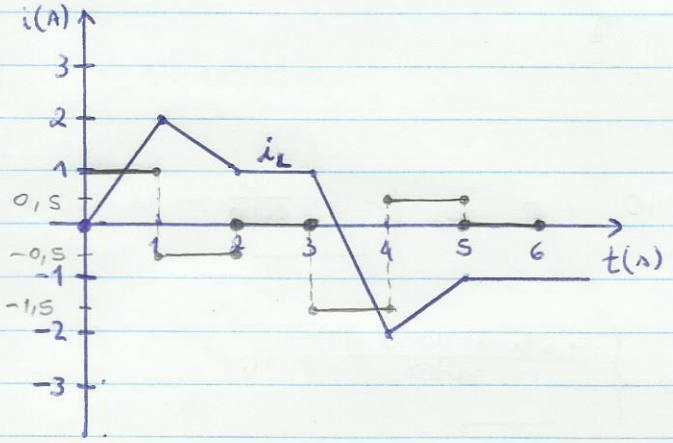
$$R_{th} = \frac{I_N}{U_{th}} = \frac{I_{cc}}{U_{th}}$$

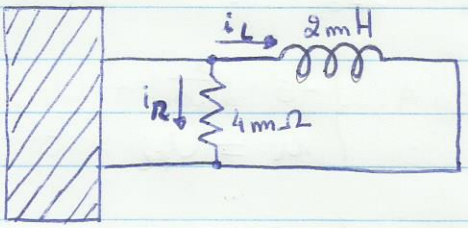


$$I_{cc} = \frac{U}{R_{eq}} = \frac{10}{5+2} = \frac{10}{7} = 1,4286$$

$$R_{th} = \frac{10,025}{1,4286} = 7,0175\ \Omega$$

(2)





$$u_L = f(i_L)$$

$$\left.\begin{array}{l} u_L(t) = L \times \frac{di(t)}{dt} \\ u_R(t) = R \times i_R(t) \\ u_R(t) = u_L(t) \end{array}\right\} \Leftrightarrow \left\{ R \times i_R(t) = L \times \frac{di(t)}{dt} \right. \Leftrightarrow \left\{ i_R(t) = \frac{L}{R} \times \frac{di(t)}{dt} \right.$$

$$i_R(t) = \frac{2}{4} \times \frac{di(t)}{dt} = 0,5\ \frac{di(t)}{dt}$$

$t \in [0,1] \rightarrow 0,5 \times 2 = 1\ A$
$t \in [1,2] \rightarrow 0,5 \times (-1) = -0,5A$
$t \in [2,3] \rightarrow 0,5 \times 0 = 0\ A$
$t \in [3,4] \rightarrow 0,5 \times (-3) = -1,5A$
$t \in [4,5] \rightarrow 0,5 \times 1 = 0,5A$
$t \in [5,6] \rightarrow 0,5 \times 0 = 0\ A$