1.1. Tot $e = -1,602 \cdot 10^{-19}$ C

$\Rightarrow (-1,602) \cdot 10^{-19} \cdot 6400$

$= -10\ 252,8 \cdot 10^{-19}$ C $= -10\ 25,28$ aC

1.2. $I = 2A$

$\Delta t = 10s$

$W = 4,6 \cdot 10^3$ J

$U = ?$

$U = I \cdot R$

$W = P \cdot \Delta t$

$P = \frac{W}{\Delta t} = \frac{4,6 \cdot \cancel{10^3}^{10^2}}{\cancel{10}} = 460$ W

$P = U \cdot I \Rightarrow U = \frac{460}{2} = 230$ V

1.3. $P = 80$ W

$\Delta t = 3h = 3 \cdot 3600s = 10800$ s

$W = ?$

$W = P \Delta t = 80 \cdot 10\ 800 = 864 \cdot 10^3$ J $= 864$ kJ

1.4. $I = 10A$

$U = 230$ V

$W = 80 \cdot 10^3$ J

$\Delta t = ?$

$P = U \cdot I = 230 \cdot 10 = 2300$ W

$W = P \cdot \Delta t \Rightarrow \Delta t = \frac{W}{P} = \frac{80 \cdot 10^{\cancel{3}}}{23 \cdot \cancel{10^2}} \approx 34,78$ s

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1.5. $q(t) = 10 \sin 4\pi t \ mC$

$U(t) = 2 \cos 4\pi t \ V$

a) $P = ?$ $t = 0,3 s$

b) $W = ?$ $\Delta t = 0,8 s$

$I(t) = \frac{dq}{dt} = 40\pi \cos 4\pi t \ mA$

$t = 0,3 s \Rightarrow I(0,3) = 40\pi \cos(4\pi \cdot 0,3) \ mA$ $\cdot 10^{-3} A$

$U(0,3) = 2 \cos(4\pi \cdot 0,3) \ V$

$P(0,3) = U(0,3) \cdot I(0,3) = 80\pi \cos^2(4\pi \cdot 0,3) \cdot 10^{-3} \ W$

b) $W = \int_0^{0,8} P dt$

$P(t) = U(t) \cdot I(t) = 2 \cos(4\pi t) \cdot 40\pi \cos(4\pi t) \cdot 10^{-3} =$

$= 80\pi \cdot 10^{-3} \cos^2(4\pi t)$

$W = 80 \cdot \pi \cdot 10^{-3} \int_0^{0,8} \cos^2(4\pi t)$

$\left.\begin{array}{l} x = 4\pi t ; dx = dt \\ t = 0 \rightarrow x = 0 \\ t = 0,8 \rightarrow x = \cancel{4} \cdot \frac{8}{\cancel{10}} \pi \end{array}\right\} \Rightarrow \frac{\overset{20}{\cancel{80}}\pi \cdot 10^{-3}}{\cancel{4\pi}} \int_0^{\frac{16}{5}\pi} \cos^2(x) dx =$

$= 20 \cdot 10^{-3} \cdot \frac{1}{2} \int_0^{\frac{16}{5}\pi} 1 + \cos 2x \, dx = 10^{-2} \left(x \Big|_0^{\frac{16}{5}\pi} + \frac{\sin 2x}{2} \Big|_0^{\frac{16}{5}\pi} \right) =$

$= 10^{-2} \left(\frac{16}{5}\pi + \frac{1}{2} \sin \frac{32\pi}{5} \right) =$

$= 10^{-2} \left(\frac{16}{5}\pi + \frac{1}{2} \sin \frac{2\pi}{5} \right) = 10^{-2} \frac{32\pi + 5 \sin \frac{2\pi}{5}}{10} =$

$= 10^{-1} \left(32\pi + 5 \sin \frac{2\pi}{5} \right)$

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1.6. $U = 12\,V$

$I = 150\,mA = 150 \cdot 10^{-3}\,A$

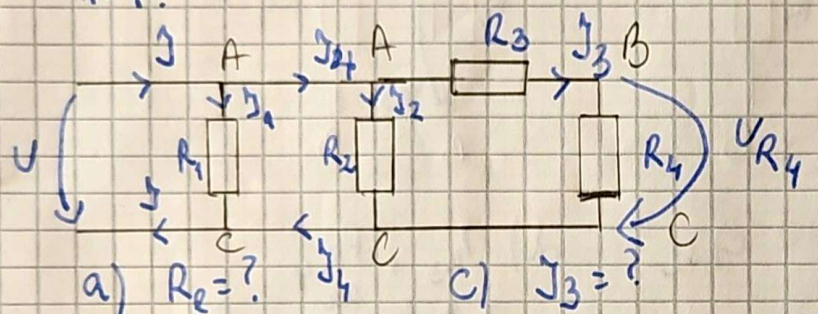
a) $P = ?$

b) $W = ?$ $\Delta t = 30\,min = 30 \cdot 60 = 1800\,s$

a) $P = U \cdot I = 12 \cdot 150 \cdot 10^{-3} = 1800 \cdot 10^{-3} = 1{,}8\,W$

b) $W = P \Delta t = 1{,}8 \cdot 1800 = 3240\,J$

1.7.



$R_1 = 15\,\Omega$ $R_2 = 10\,\Omega$

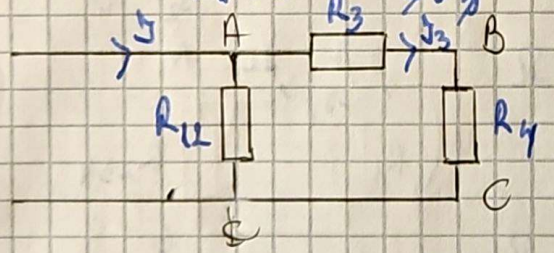
$R_3 = 7\,\Omega$ $R_4 = 5\,\Omega$

$U = 24\,V$

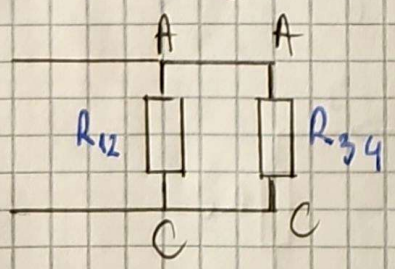
a) $R_e = ?$ c) $I_3 = ?$

b) $I = ?$ d) U_{R_4}, P_{R_2}

a) $R_{12} = \frac{R_1 R_2}{R_1 + R_2} = \frac{\cancel{15}^{3} \cdot \cancel{10}^{2}}{\cancel{25}\,\cancel{5}} = 6\,\Omega$



$R_{34} = R_3 + R_4 = 7 + 5 = 12\,\Omega$



$R_e = \frac{R_{12} \cdot R_{34}}{R_{12} + R_{34}} = \frac{\cancel{6} \cdot \cancel{12}^{4}}{\cancel{18}\,\cancel{3}} = 4\,\Omega$

b) $U = R_e \cdot I \Rightarrow I = \frac{U}{R_e} = \frac{24}{4} = 6\,A$

c) $U_{AC} = U = I_3 R_{34} \Rightarrow I_3 = \frac{U}{R_{34}} = \frac{24}{12} = 2\,A$

d) $U_{R_4} = I_3 R_4 = 2 \cdot 5 = 10\,V$

$I = I_1 + I_4 = I_1 + I_2 + I_3 \Leftrightarrow 6 = I_1 + I_2 + 2 \Rightarrow I_1 + I_2 = 4\,A$

$U_{AC} = I_1 R_1 = I_2 R_2 \Leftrightarrow I_1 = I_2 \frac{R_2}{R_1} = I_2 \frac{10}{15} = \frac{2}{3} I_2$

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$\frac{2}{3} I_2 + I_2 = 4 \quad | \cdot 3$

$5 I_2 = 12$

$I_2 = \frac{12}{5} = 2{,}4A$

$\Rightarrow P_{R_2} = I_2^2 R_2 = \frac{144}{25} \cdot 10 = 57{,}6 W$

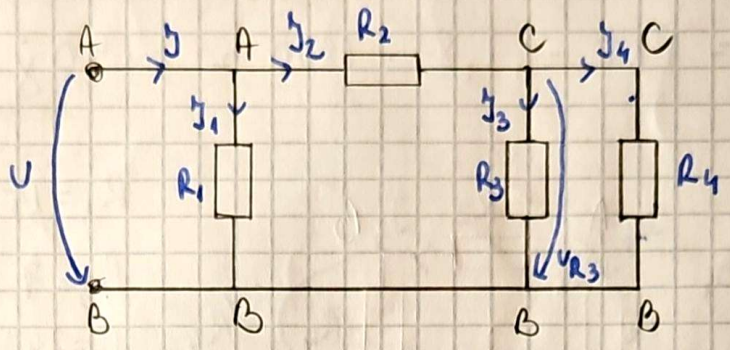
1.8. $R_1 = 10\Omega$

$R_2 = 9\Omega$

$R_3 = 15\Omega$

$R_4 = 10\Omega$

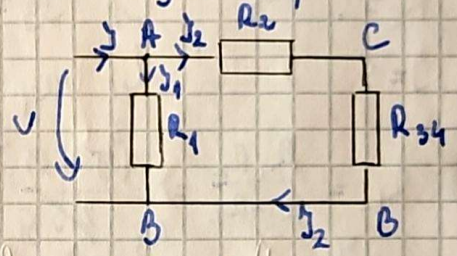
$U = 60V$



a) $R_e = ?$ b) $I = ?$ c) I_2 d) U_{R_3}, P_{R_4}

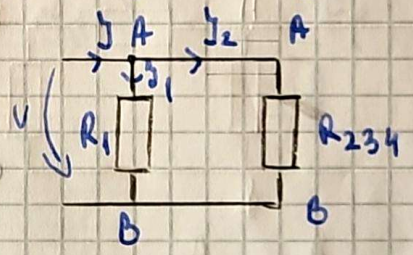
a) R_3, R_4 - paralel

$R_{34} = \frac{R_3 R_4}{R_3 + R_4} = \frac{\cancel{15}^{3} \cdot \cancel{10}^{2}}{\cancel{25}_{\cancel{5}}} = 6\Omega$



R_2, R_{34} - serie

$R_{234} = R_2 + R_{34} = 9 + 6 = 15\Omega$

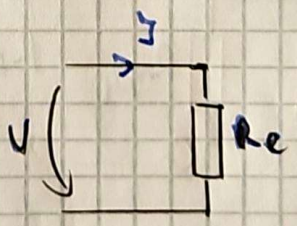


R_1, R_{234} - paralel

$R_e = \frac{R_1 R_{234}}{R_1 + R_{234}} = \frac{10 \cdot 15}{10 + 15} = \frac{150}{25} = 6\Omega$

b) $U = I \cdot R_e$

$\Rightarrow I = \frac{U}{R_2} = \frac{60}{6} = 10A$



c) $U = U_{AB} = I_2 R_{234}$

$\Rightarrow I_2 = \frac{U}{R_{234}} = \frac{60}{15} = 4A$

d) $U_{CB} = U_{R_3} = I_3 R_3 = I_4 R_4 \Leftrightarrow 15 I_3 = 10 I_4 \Leftrightarrow I_4 = \frac{15}{10} I_3 = \frac{3}{2} I_3$

dar $I_3 + I_4 = I_2 \Leftrightarrow I_3 + \frac{3}{2} I_3 = \frac{5}{2} I_3 = I_2 = 4 \Rightarrow I_3 = \frac{8}{5} A$

$\Rightarrow U_{R_3} = I_3 R_3 = \frac{8}{5} 15 = 8 \cdot 3 = 24V$

$I_4 = \frac{3}{2} \cdot \frac{8}{5} = \frac{3 \cdot 4}{5} = \frac{12}{5} A \Rightarrow P_{R_4} = I_4^2 R_4 = \frac{144}{25} \cdot 10 = 57{,}6 W$

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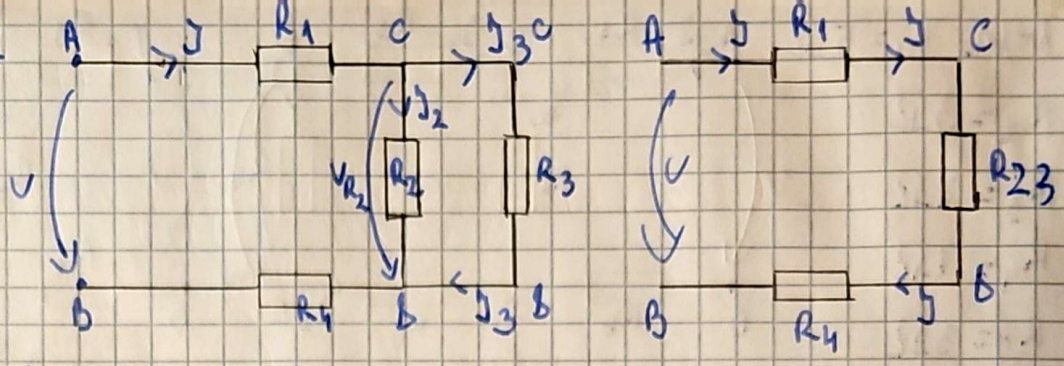
1.9. $R_1 = 4\,\Omega$

$R_2 = 10\,\Omega$

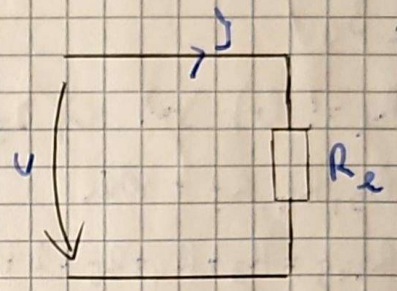
$R_3 = 15\,\Omega$

$R_4 = 5\,\Omega$

$U = 75\,V$



a) $R_e = ?$ b) $I = ?$ c) I_3 d) U_{R_2}, P_{R_4}



a) R_2, R_3 - paralel

$$R_{23} = \frac{R_2 R_3}{R_2 + R_3} = \frac{10 \cdot 15}{25} = 6\,\Omega$$

R_1, R_{23}, R_4 - serie

$$R_e = R_1 + R_{23} + R_4 = 4 + 6 + 5 = 15\,\Omega$$

b) $U = I \cdot R_e \Rightarrow I = \frac{U}{R_e} = \frac{75}{15} = 5\,A$

c) în nodul C : $I = I_2 + I_3$

$$U_{CB} = I_2 R_2 = I_3 R_3 \Leftrightarrow 10 I_2 = 15 I_3 \Rightarrow I_2 = \frac{15}{10} I_3 = \frac{3}{2} I_3$$

$$\Rightarrow I_2 + I_3 = \frac{3}{2} I_3 + I_3 = \frac{5}{2} I_3 = I = 5$$

$$\Rightarrow I_3 = \frac{5 \cdot 2}{5} = 2\,A$$

d) $\Rightarrow I_2 = I - I_3 = 5 - 2 = 3\,A$

$$U_{R_2} = I_2 R_2 = 3 \cdot 10 = 30\,V$$

$$P_{R_4} = I^2 R_4 = 25 \cdot 5 = 125\,W$$

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A-10. $R_1 = 5\,\Omega$

$R_2 = 3\,\Omega$

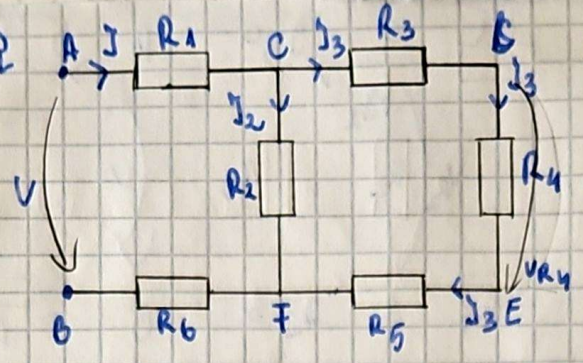
$R_3 = 2\,\Omega$

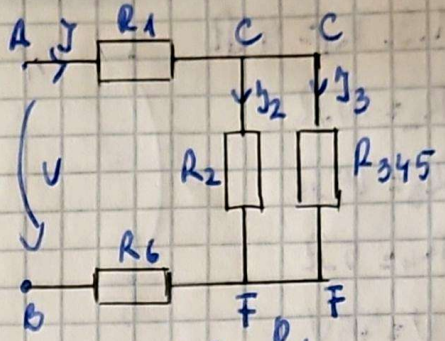
$R_4 = 1\,\Omega$

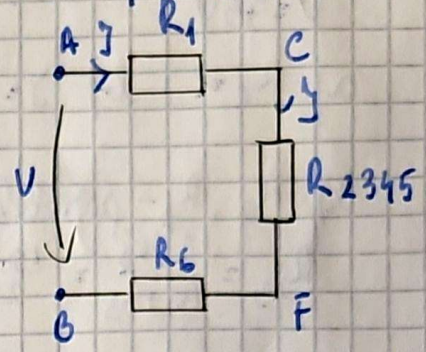
$R_5 = 3\,\Omega$

$R_6 = 3\,\Omega$

$U = 30\,V$







a) $R_e = ?$ b) $I = ?$ c) $I_3 = ?$ d) $U_{R_4} = ?$ $P_{R_5} = ?$

a) R_3, R_4, R_5 - serie

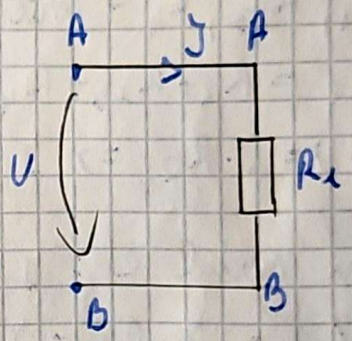
$R_{345} = R_3 + R_4 + R_5 = 2 + 1 + 3 = 6\,\Omega$

R_2, R_{345} - paralel

$R_{2345} = \frac{R_2 R_{345}}{R_2 + R_{345}} = \frac{3 \cdot 6}{9} = 2\,\Omega$

R_1, R_{2345}, R_6 - serie

$R_e = R_1 + R_{2345} + R_6 = 5 + 2 + 3 = 10\,\Omega$



b) $U = I \cdot R_e \Rightarrow I = \frac{U}{R_e} = \frac{30}{10} = 3A$

c) $U_{CF} = I_2 R_2 = I_3 R_{345} \Rightarrow 3 I_2 = 6 I_3 \Rightarrow I_2 = 2 I_3$

în nodul C : $I = I_2 + I_3 = 2 I_3 + I_3 = 3 I_3 \Rightarrow I_3 = \frac{I}{3} = 1A$

d) $U_{R_4} = I_3 \cdot R_4 = 1 \cdot 1 = 1\,V$

$P_{R_5} = I_3^2 R_5 = 1 \cdot 3 = 3\,W$

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1-11.

$R_1 = 60\,\Omega$

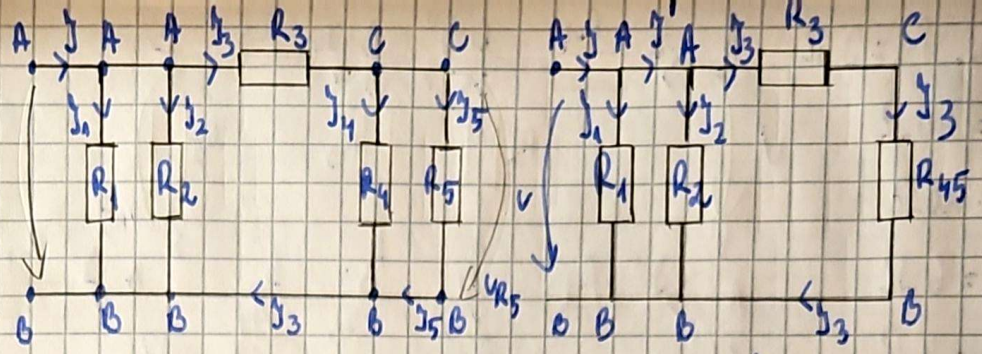
$R_2 = 20\,\Omega$

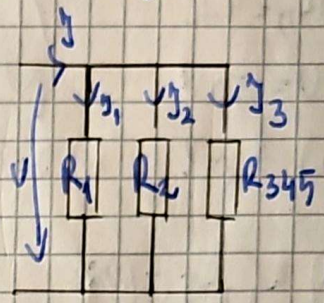
$R_3 = 8\,\Omega$

$R_4 = 3\,\Omega$

$R_5 = 6\,\Omega$

$U = 120\,V$

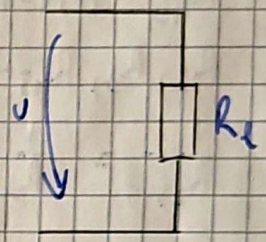




a) $R_e = ?$ b) $I = ?$ c) $I_4 = ?$ d) $U_{R_5} = ?$, $P_{R_2} = ?$

a) R_4, R_5 - paralel

$$R_{45} = \frac{R_4 R_5}{R_4 + R_5} = \frac{3 \cdot 6}{9} = 2\,\Omega$$



R_3, R_{45} - serie

$$R_{345} = R_3 + R_{45} = 8 + 2 = 10\,\Omega$$

R_1, R_2, R_{345} - paralel

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_{345}} = \frac{1}{60} + \overset{3/}{\frac{1}{20}} + \overset{6/}{\frac{1}{10}} = \frac{10}{60} = \frac{1}{6}$$

$\Rightarrow R_e = 6\,\Omega$

b) $U = I R_e \Rightarrow I = \frac{U}{R_e} = \frac{120}{6} = 20\,A$

c) $U = I_3 \cdot R_{345} \Rightarrow I_3 = \frac{U}{R_{345}} = \frac{120}{10} = 12\,A$

$U_{CB} = I_4 R_4 = I_5 R_5 \Rightarrow 3 I_4 = 6 I_5 \Rightarrow I_5 = \frac{1}{2} I_4$

în nodul C: $I_3 = I_4 + I_5 = I_4 + \frac{1}{2} I_4 = \frac{3}{2} I_4 \Rightarrow I_4 = \frac{2}{3} I_3 = \frac{2}{\cancel{3}} \cdot \overset{4}{\cancel{12}} = 8\,A$

d) $I_5 = I_3 - I_4 = 12 - 8 = 4\,A$

$U_{R_5} = I_5 \cdot R_5 = 4 \cdot 6 = 24\,V$

$U = I_2 \cdot R_2 \Rightarrow I_2 = \frac{U}{R_2} = \frac{120}{20} = 6\,A$

$\Rightarrow P_{R_2} = I_2^2 R_2 = 36 \cdot 20 = 720\,W$

0,52A

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1-12. $R_1 = 9\,\Omega$

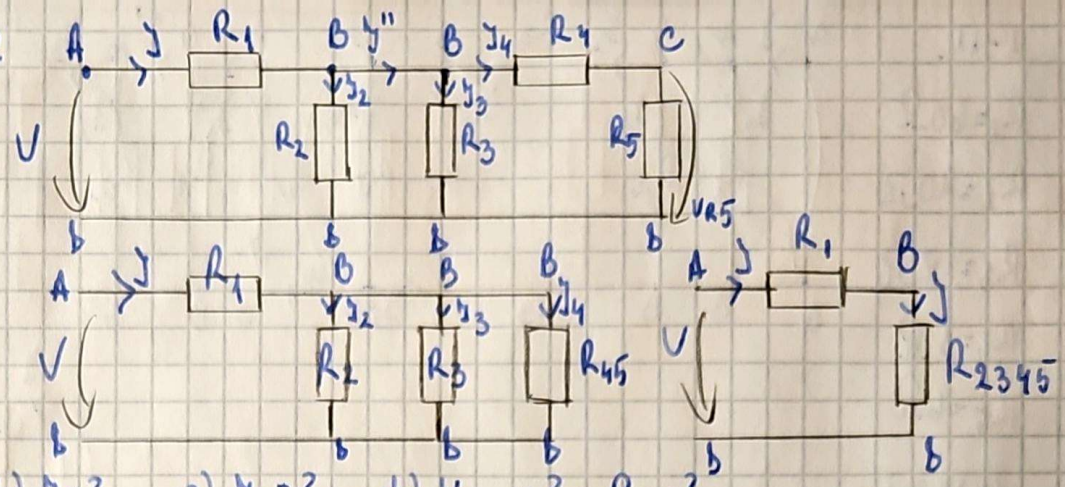
$R_2 = 60\,\Omega$

$R_3 = 20\,\Omega$

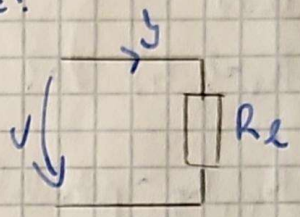
$R_4 = 6\,\Omega$

$R_5 = 4\,\Omega$

$U = 150\,V$



a) $R_e = ?$ b) $I = ?$ c) $I_3 = ?$ d) $V_{R_5} = ?$ $P_{R_4} = ?$



a) R_4, R_5 - serie

$R_{45} = 6 + 4 = 10\,\Omega$

R_2, R_3, R_{45} - paralel

$$\frac{1}{R_{2345}} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_{45}} = \frac{1}{60} + \frac{1}{20} + \frac{1}{10} = \frac{10}{60} = \frac{1}{6}$$

$\Rightarrow R_{2345} = 6\,\Omega$

R_1, R_{2345} - serie

$R_e = R_1 + R_{2345} = 9 + 6 = 15\,\Omega$

b) $U = I \cdot R_e \Rightarrow I = \frac{U}{R_e} = \frac{150}{15} = 10\,A$

c) $U_{Bb} = I \cdot R_{2345} = 10 \cdot 6 = 60\,V$

dar $U_{Bb} = I_3 R_3 \Rightarrow I_3 = \frac{U_{Bb}}{R_3} = \frac{60}{20} = 3\,A$

d) $U_{Bb} = I_4 R_{45} \Rightarrow I_4 = \frac{U_{Bb}}{R_{45}} = \frac{60}{10} = 6\,A$

$\Rightarrow U_{R_5} = I_4 R_5 = 6 \cdot 4 = 24\,V$

$P_{R_4} = I_4^2 R_4 = 36 \cdot 6 = 216\,W$

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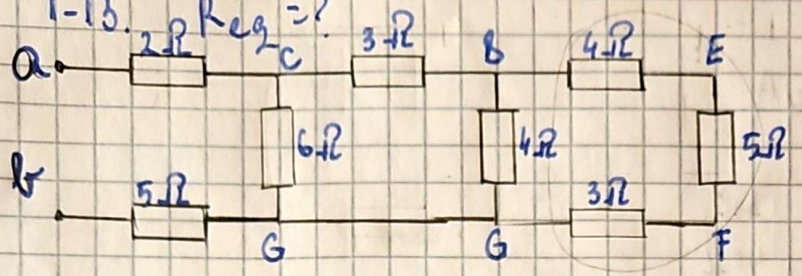
1-13. $R_{eq} = ?$



$R_{s_1} = 4+5+3 = 12\,\Omega$

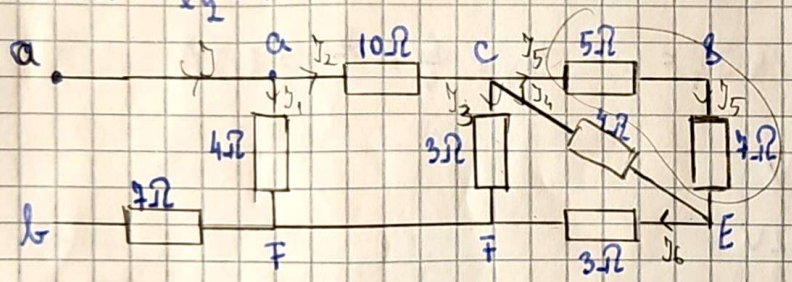
R_{s_1}, 4Ω - paralel $\quad R_{p_1} = \frac{12 \cdot 4}{16} = 3\,\Omega$

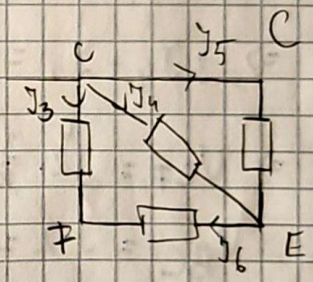
R_{p_1}, 3Ω - serie $\quad R_{s_2} = 3+3 = 6\,\Omega$

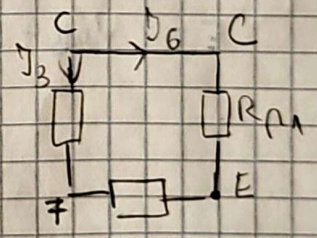
R_{s_2}, 6Ω - paralel $\quad R_{p_2} = \frac{6 \cdot 6}{12} = 3\,\Omega$

R_{p_2}, 2Ω, 5Ω - serie $\quad R_{eq} = 2+3+5 = 10\,\Omega$

1-14. $R_{eq} = ?$







5Ω, 7Ω - serie $\quad R_{s_1} = 5+7 = 12\,\Omega$

R_{s_1}, 4Ω - paralel $\quad R_{p_1} = \frac{12 \cdot 4}{16} = 3\,\Omega$

R_{p_1}, 3Ω - serie $\quad R_{s_2} = 3+3 = 6\,\Omega$

R_{s_2}, 3Ω - paralel $\quad R_{p_2} = \frac{6 \cdot 3}{9} = 2\,\Omega$

R_{p_2}, 2Ω - serie $\quad R_{s_3} = 10+2 = 12\,\Omega$

R_{s_3}, 4Ω - paralel $\quad R_{p_3} = \frac{12 \cdot 4}{16} = 3\,\Omega$

R_{p_3}, 7Ω serie $\quad R_{eq} = 3+7 = 10\,\Omega$

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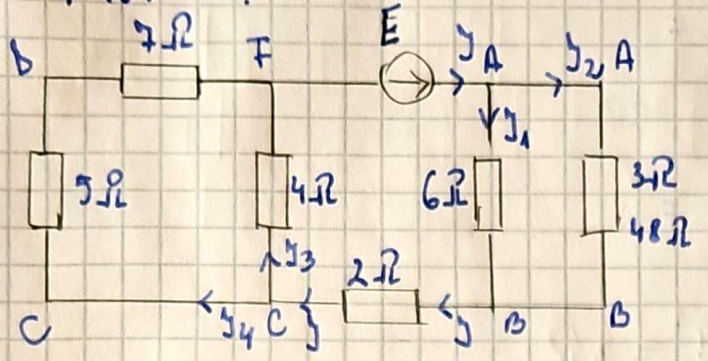
1-15. $E = ?$



$48 = I_2^2 \cdot 3 \Rightarrow I_2^2 = 16 \Rightarrow I_2 = 4A$

$U_{AB} = I_2 \cdot 3 = 4 \cdot 3 = 12\ V$

dar $U_{AB} = I_1 \cdot 6 \Rightarrow I_1 = 2A$

$\Rightarrow I = 6A$

în nodul C: $I = I_3 + I_4 \Rightarrow I_3 + I_4 = 6$

$U_{CF} = I_3 \cdot 4 = (7+5) I_4 \Rightarrow I_3 = \frac{12}{4} I_4 = 3 I_4$

$\Rightarrow 3 I_4 + I_4 = 6 \Rightarrow 4 I_4 = 6 \quad I_4 = \frac{6}{4} = \frac{3}{2} = 1{,}5A$

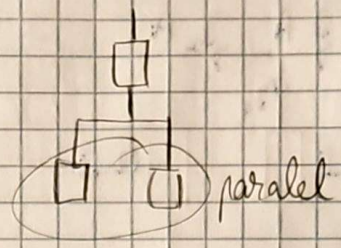
$\Rightarrow U_{CF} = \cancel{12}^{6} \cdot \frac{3}{\cancel{2}} = 18\ V$

$U_{BC} = I \cdot 2 = 6 \cdot 2 = 12V$

$E = U_{AB} + U_{BC} + U_{CF} = 12 + 12 + 18 = 42V$

Scanat cu CamScanner

1-16.



$64 = I_4^2 \cdot 4 \Rightarrow I_4^2 = 16 \Rightarrow I_4 = 4A$

$U_{Cb} = I_4 \cdot 4 = 16V$

dar $U_{Cb} = I_3 \cdot 8 \Rightarrow I_3 = \frac{16}{8} = 2A$

$\Rightarrow I_1 = I_4 + I_3 = 4 + 2 = 6A$

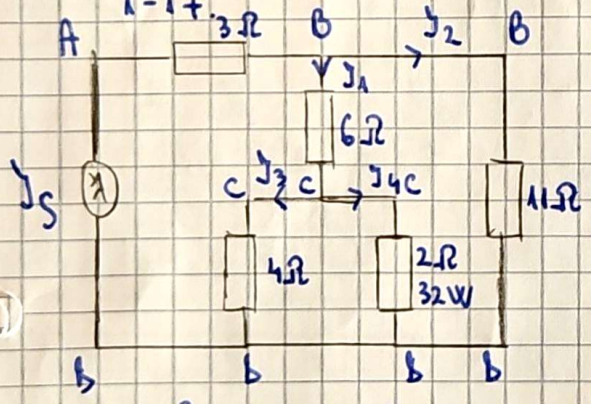
$U_{BC} = I_1 \cdot 2 = 6 \cdot 2 = 12V$

$U_{Bb} = U_{BC} + U_{Cb} = 12 + 16 = 28V$

dar $U_{Bb} = I_2 \cdot 7 \Rightarrow I_2 = \frac{28}{7} = 4A$

$\Rightarrow I_S = I_1 + I_2 = 6 + 4 = 10A$

1-17.



$32 = I_4^2 \cdot 2 \Rightarrow I_4^2 = 16 \quad I_4 = 4A$

$U_{Cb} = I_4 \cdot 2 = 8V$

dar $U_{Cb} = I_3 \cdot 4 \Rightarrow I_3 = \frac{8}{4} = 2\Omega$

$I_1 = I_3 + I_4 = 2 + 4 = 6A$

$U_{BC} = I_1 \cdot 6 = 6 \cdot 6 = 36V$

$U_{Bb} = U_{BC} + U_{Cb} = 36 + 8 = 44V$

dar $U_{Bb} = I_2 \cdot 11 \Rightarrow I_2 = \frac{44}{11} = 4A$

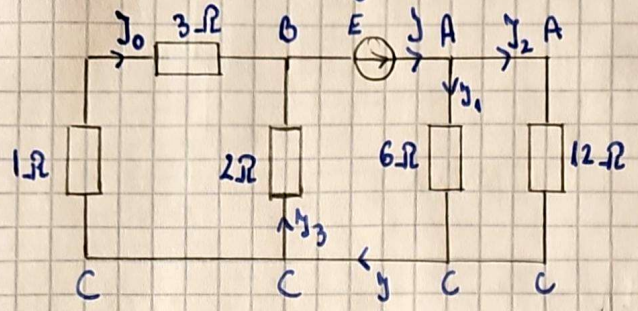
$\Rightarrow I_S = I_1 + I_2 = 6 + 4 = 10A$

Scanat cu CamScanner

2-1. $R_1 = 5\Omega$

1-20 $E = ?$

1-18. $E = ?$ $\quad J_0 = 4A$



$U_{CB} = J_0(3+1) = 4 \cdot 4 = 16V$

dar $U_{CB} = J_3 \cdot 2 \Rightarrow J_3 = \frac{16}{2} = 8A$

dar $J = J_3 + J_0 = 8 + 4 = 12A$

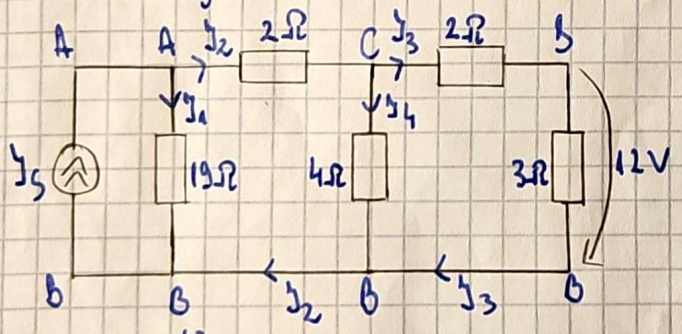
$U_{AC} = J_1 \cdot 6 = J_2 \cdot 12 \Rightarrow J_1 = 2J_2$

$J_1 + J_2 = 2J_2 + J_2 = 3J_2 = J \Rightarrow J_2 = \frac{J}{3} = \frac{12}{3} = 4A$

$\Rightarrow U_{AC} = J_2 \cdot 12 = 4 \cdot 12 = 48V$

$\Rightarrow E = U_{AC} + U_{CB} = 48 + 16 = 64V$

1-19. $J_S = ?$



$J_3 = \frac{12}{3} = 4A$

$U_{CB} = J_3(2+3) = 4 \cdot 5 = 20V$

dar $U_{CB} = 4 \cdot J_4 \Rightarrow J_4 = \frac{20}{4} = 5A$

$\Rightarrow J_2 = J_3 + J_4 = 4 + 5 = 9A$

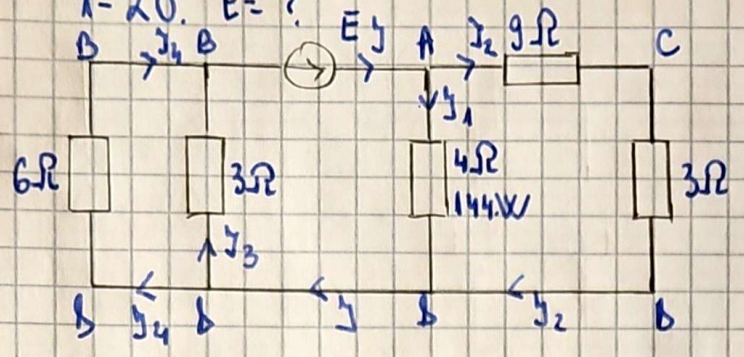
$U_{AB} = U_{AC} + U_{CB} = J_2 \cdot 2 + U_{CB} = 18 + 20 = 38V$

dar $U_{AB} = J_1 \cdot 19 \Rightarrow J_1 = \frac{38}{19} = 2A$

$\Rightarrow J_S = J_1 + J_2 = 2 + 9 = 11A$

Scanat cu CamScanner

1-20. $E = ?$



$144 = I_1^2 \cdot 4 \Rightarrow I_1^2 = 36 \Rightarrow I_1 = 6A$

$U_{AB} = I_1 \cdot 4 = 6 \cdot 4 = 24V$

dar $U_{AB} = I_2 (9+3) = 12 I_2 \Rightarrow I_2 = \frac{24}{12} = 2A$

în nodul B $\quad I = I_1 + I_2 = 6 + 2 = 8A$

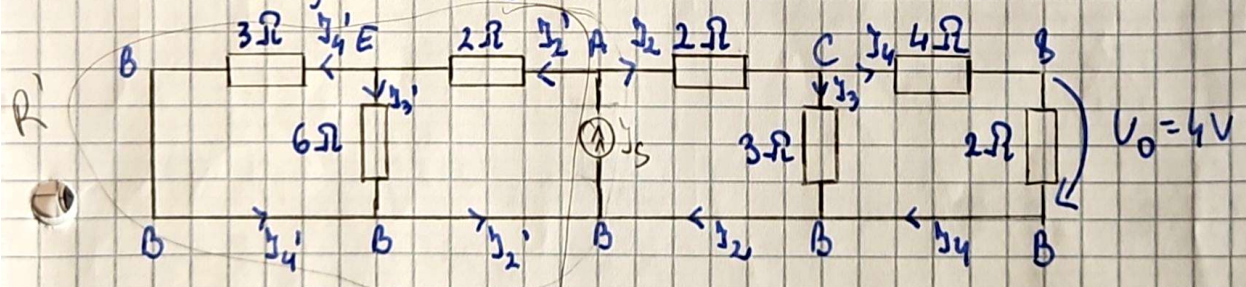
$U_{BB} = 3 I_3 = 6 I_4 \Rightarrow I_3 = 2 I_4$

dar $I_3 + I_4 = 2 I_4 + I_4 = 3 I_4 = I \Rightarrow I_4 = \frac{8}{3} A$

$\Rightarrow U_{BB} = I_4 \cdot 6 = 6 \cdot \frac{8}{3} = 2 \cdot 8 = 16V$

$E = U_{AB} + U_{BB} = 24 + 16 = 40V$

1-21. $I_S = ?$ $\quad U_0 = 4V$



$I_4 = \frac{U_0}{2} = \frac{4}{2} = 2A \Rightarrow U_{CB} = I_4 (4+2) = 2 \cdot 6 = 12V$

$U_{CB} = 3 \cdot I_3 \Rightarrow I_3 = \frac{12}{3} = 4A \Rightarrow I_2 = I_3 + I_4 = 2 + 4 = 6A$

$U_{AB} = U_{AC} + U_{CB} = I_2 \cdot 2 + U_{CB} = 12 + 12 = 24V$

$3\Omega, 6\Omega$ - paralel $\Rightarrow R_p = \frac{3 \cdot 6}{9} = 2\Omega$

$R_p, 2\Omega$ - serie $\Rightarrow R' = 2 + 2 = 4\Omega$

$\Rightarrow I_2' = \frac{U_{AB}}{R'} = \frac{24}{4} = 6A$

$\Rightarrow I_S = 6 + 6 = 12A$

Scanat cu CamScanner

2-1. $R_1 = 5\,\Omega$

$R_2 = 10\,\Omega$

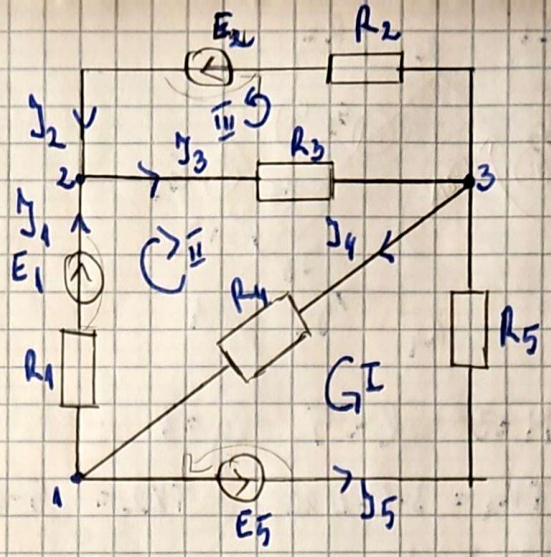
$R_3 = 6\,\Omega$

$R_4 = 3\,\Omega$

$R_5 = 2\,\Omega$

$E_1 = 10V$

$E_2 = E_5 = 5V$



$N = 3$

$l = 5$

$l_g = 0$

TK1 → $3 - 1 = 2$ ec

TK2 → $5 - (3-1) = 3$ ec

① $J_1 + J_5 = J_4$

② $J_1 + J_2 = J_3$

$$\begin{cases} \text{I}: & J_5 R_5 + J_4 R_4 = E_5 \\ \text{II}: & J_1 R_1 + J_3 R_3 + J_4 R_4 = E_1 \\ \text{III}: & J_2 R_2 + J_3 R_3 = E_2 \end{cases} \Rightarrow \begin{cases} 2J_5 + 3J_4 = 5 \\ 5J_1 + 6J_3 + 3J_4 = 10 \\ 10J_2 + 6J_3 = 5 \end{cases}$$

Înlocuim J_3 și J_4 în sistemul de ecuații

$$\begin{cases} 5J_5 + 3J_4 = 5 & |\cdot 3 \\ 14J_1 + 6J_2 + 3J_5 = 10 & |\cdot 5 \\ 16J_2 + 6J_1 = 5 \ (1) \end{cases} \Rightarrow \begin{cases} 9J_1 + 15J_5 = 15 \\ 70J_1 + 30J_2 + 15J_5 = 50 \end{cases} \ominus$$

$$61J_1 + 30J_2 = 35 \ (2)$$

$$\begin{matrix} (1)\cdot 15 \\ (2)\cdot 8 \end{matrix} \Leftrightarrow \begin{cases} 240J_2 + 90J_1 = 75 \\ 240J_2 + 488J_1 = 280 \end{cases} \ominus \Rightarrow 398J_1 = 205 \Rightarrow J_1 = 0{,}515 \approx 0{,}52A$$

$$\Rightarrow J_2 = \frac{5 - 6J_1}{16} = 0{,}119 \approx 0{,}12A \Rightarrow J_3 \approx 0{,}64A$$

$$J_5 = \frac{15 - 9J_1}{15} = \frac{5 - 3J_1}{5} = 0{,}69A \Rightarrow J_4 \approx 1{,}21A$$

$$P_g = J_1E_1 + J_2E_2 + J_3E_3 \approx 9{,}2W$$

$$P_c = J_1^2R_1 + J_2^2R_2 + J_3^2R_3 + J_4^2R_4 + J_5^2R_5 \approx 9{,}2W$$

$$\Rightarrow P_g = P_c$$

Scanat cu CamScanner

2-2. $R_1 = 2\Omega$

$R_2 = 2\Omega$

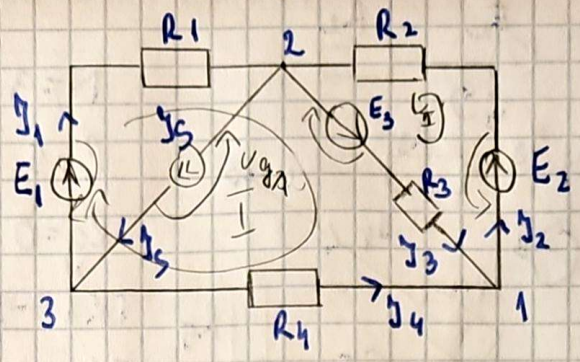
$R_3 = 6\Omega$

$R_4 = 2\Omega$

$E_1 = 12V$

$E_2 = 10V$

$E_3 = 6V$ $\quad J_s = 4A$



$N = 3 \quad l = 5 \quad lg = 1$

$TK_1 = 3-1 = 2$ ec $\quad TK_2 = 5-1-(3-1) = 2$ ec

(1): $J_3 + J_4 = J_2 \Rightarrow J_4 = J_2 - J_3$

(2): $J_1 + J_2 = J_3 + J_5 \Rightarrow J_1 = J_3 + 4 - J_2$

$$\begin{matrix} \text{I}: & J_1R_1 + J_3R_3 - J_4R_4 = E_1 + E_3 \\ \text{II}: & J_2R_2 + J_3R_3 = E_3 + E_2 \end{matrix} \Rightarrow \begin{cases} 2J_1 + 6J_3 - 2J_4 = 18 \ (1) \\ 2J_2 + 6J_3 = 16 \ (2). \end{cases}$$

Înlocuim J_1 în prima ec (1)

$-2J_2 + 8J_3 - 2J_4 + 8 = 18$

Înlocuim J_4

$\Rightarrow 8J_3 - 2(J_2 - J_3) - 2J_2 = 10$

$\Leftrightarrow 10J_3 - 4J_2 = 10$

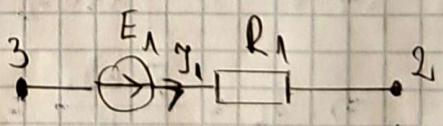
$(2)\cdot 2 \Leftrightarrow 12J_3 + 4J_2 = 32 \quad \oplus$

$22J_3 = 42 \Rightarrow J_3 = 1,909 \cong 1,91 A$

$J_2 = \frac{16 - 6J_3}{2} = 8 - 3J_3 \simeq 2,273 A \simeq 2,27 A$

$J_4 = J_2 - J_3 = 0,364 A \simeq 0,36 A$

$J_1 = J_3 + 4 - J_2 = 3,636 A \simeq 3,64 A$



$u_{g_1} = U_{32} = V_3 - V_2 \big|_{2\to 3} = -E_1 - (-J_1R_1) = -E_1 + J_1R_1 \simeq -4,72 V$ consumă putere

$P_{g_1} = J_5 |u_{g_1}| \simeq 18,91 W$

$P_C = P_{g_1} + J_1^2R_1 + J_2^2R_2 + J_3^2R_3 + J_4^2R_4 = 77,81 W$

$P_g = E_1 \cdot J_1 + E_2 J_2 + E_3 J_3 = 77,81 W$

$\Rightarrow P_C = P_g$

Scanat cu CamScanner

2.1.

b) $V_1 = 0$

$$\begin{cases} V_2\left(\frac{1}{5}+\frac{1}{6}+\frac{1}{10}\right) - V_3\left(\frac{1}{6}+\frac{1}{10}\right) = \frac{10}{5}+\frac{5}{10} & |\cdot 30 \\ V_3\left(\frac{1}{6}+\frac{1}{10}+\frac{1}{3}+\frac{1}{2}\right) - V_2\left(\frac{1}{6}+\frac{1}{10}\right) = -\frac{5}{10}+\frac{5}{2} & |\cdot 30 \end{cases}$$

$$\begin{cases} V_2 \cdot 14 - 8V_3 = 60+15 & |\cdot 4 \\ V_3 \cdot 33 - 8V_2 = 60 & |\cdot 7 \end{cases}$$

$$\Rightarrow \begin{array}{l} 56V_2 - 32V_3 = 300 \\ -56V_2 + 231V_3 = 420 \\ \hline 199V_3 = 720 \end{array}$$

$$V_3 = 3,61\,V \Rightarrow V_2 = 7,39\,V$$

$$V_1 - V_3 = -J_4 R_4 \Rightarrow J_4 = \frac{V_3 - V_1}{R_4} = 1,2A$$

$$V_1 - V_3 = -E_5 + J_5 R_5 \Rightarrow J_5 = \frac{V_1 - V_3 + E_5}{R_5} = 0,69A$$

$$V_1 - V_2 = J_1 R_1 - E_1 \Rightarrow J_1 = \frac{V_1 - V_2 + E_1}{R_1} = 0,52A$$

$$V_2 - V_3 = J_3 R_3 \Rightarrow J_3 = \frac{V_2 - V_3}{R_3} = 0,64A$$

$$V_2 - V_3 = E_2 - J_2 R_2 \Rightarrow J_2 = \frac{E_2 + V_3 - V_2}{R_2} = 0,12A$$

Scanat cu CamScanner

2-2. $V_2 = 0$

$$\begin{cases} V_1\left(\frac{1}{R_4} + \frac{1}{R_3} + \frac{1}{R_2}\right) - V_3\left(\frac{1}{R_4}\right) = \frac{E_3}{R_3} - \frac{E_2}{R_2} \\ V_3\left(\frac{1}{R_4} + \frac{1}{R_1}\right) - V_1\left(\frac{1}{R_4}\right) = J_5 - \frac{E_1}{R_1} \end{cases}$$

$$\begin{cases} V_1\left(\frac{1}{2} + \frac{1}{6} + \frac{1}{2}\right) - V_3 \cdot \frac{1}{2} = \frac{6}{6} - \frac{10}{2} \quad | \cdot 6 \\ V_3\left(\frac{1}{2} + \frac{1}{2}\right) - V_1 \cdot \frac{1}{2} = 4 - \frac{12}{2} \quad | \cdot 2 \end{cases}$$

$$\begin{cases} V_1(3 + 1 + 3) - V_3 \cdot 3 = 6 - 30 \\ V_3 \cdot 2 - V_1 = 8 - 12 \end{cases}$$

$$\begin{cases} 7V_1 - 3V_3 = -24 \\ -V_1 + 2V_3 = -4 \quad | \cdot 7 \end{cases} \Rightarrow \begin{cases} 7V_1 - 3V_3 = -24 \\ -7V_1 + 14V_3 = -28 \end{cases}$$

$$11V_3 = -42$$

$$V_3 = 3{,}81\,V$$

$$V_1 = 2V_3 + 4 = -3{,}62\,V$$

$$V_1 - V_2 = E_3 - J_3 R_3 = V_1 \Rightarrow J_3 = \frac{E_3 - V_1}{R_3} = \frac{6 + 3{,}62}{6} = 1{,}6$$

$\Rightarrow$ ceilalți curenți

Scanat cu CamScanner

2-3. $R_1 = 2\Omega$

$R_2 = 2\Omega$

$R_3 = 6\Omega$

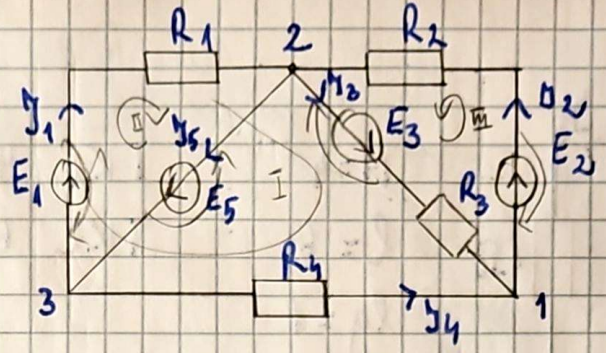
$R_4 = 2\Omega$

$E_1 = 12V$

$E_2 = 10V$

$E_3 = 6V$

$E_5 = 10V$



$N = 3$ TK1 $3-1 = 2$ ec

$l = 5$ TK2 $5-(3-1) = 3$ ec

① $J_4 + J_3 = J_2 \Rightarrow J_4 = J_2 - J_3$

② $J_1 + J_2 = J_3 + J_5$

(I) : $J_1R_1 + J_3R_3 - J_4R_4 = E_1 + E_3$

(II) : $J_1R_1 = E_1 + E_5$

(III) : $J_2R_2 + J_3R_3 = E_2 + E_3$

$$\Rightarrow \begin{cases} 2J_1 + 6J_3 - 2J_4 = 18 & (1) \\ 2J_1 = 22 \Rightarrow \boxed{J_1 = 11A} \\ 2J_2 + 6J_3 = 16 \end{cases}$$

Înlocuim J_4 în (1): $22 + 6J_3 - 2J_2 + 2J_3 = 18$

$\Leftrightarrow 8J_3 - 2J_2 = -4$

dar $6J_3 + 2J_2 = 16$

$14J_3 = 12 \Rightarrow \boxed{J_3 = 0,857 \simeq 0,86A}$

$\Rightarrow \boxed{J_2 = \frac{16 - 6J_3}{2} \simeq 5,429 \simeq 5,43V}$

$\boxed{J_4 = J_2 - J_3 = 4,572 \simeq 4,57A}$

$\boxed{J_5 = J_1 + J_2 - J_3 = 15,572 \simeq 15,57A}$

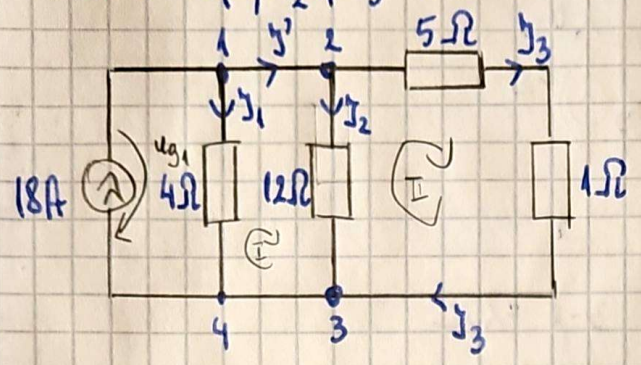
$P_g = E_1 \cdot J_1 + E_2J_2 + E_3J_3 + E_5J_5 = 347,2W$

$P_c = J_1^2R_1 + J_2^2R_2 + J_3^2R_3 + J_4^2R_4 = 347,2W$

$\Rightarrow P_c = P_g$

Scanat cu CamScanner

2-4 $I_1, I_2, I_3 = ?$



$N = 4$

$l = 6$

$l_g = 1$

TK1 $4-1 = 3$ ec

TK2 $6-1-(4-1) = 2$ ec

① $18 = I_1 + I'$ => $I' = 18 - I_1$

② $I' = I_2 + I_3$ => $I_1 = 18 - I_2 - I_3$

③ $I' = I_2 + I_3$

$$\begin{cases} (I) & I_2 12 - I_1 4 = 0 \\ (II) & I_3(5+1) - 12 I_2 = 0 \quad (1) \end{cases}$$

(1) Înlocuim I_1 => $12 I_2 - 4(18 - I_2 - I_3) = 0$

$16 I_2 + 4 I_3 = 72 \mid \cdot 3$

$48 I_2 + 12 I_3 = 216$

$(1)\cdot(-2)$ $24 I_2 - 12 I_3 = 0$

$72 I_2 = 216$

$I_2 = 3A$ => $I_3 = \frac{12 I_2}{6} = 2 I_2 = 6A$

=> $I_1 = 18 - I_2 - I_3 = 9A$

$u_{g_1} = U_{14} = V_1 - V_4 \big|_{4 \to 1} = 0 - (-I_1 \cdot 4) = 36V$ generează

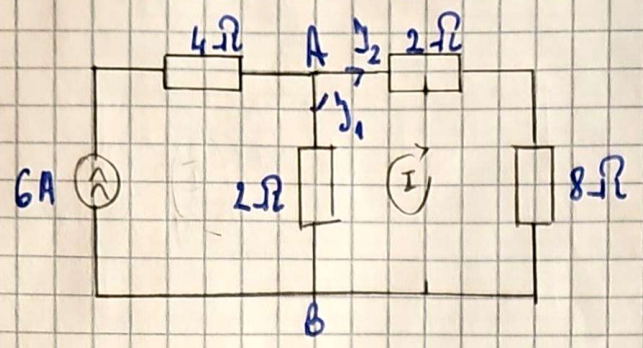
$P_g = I_5 \, u_{g_1} = 18 \cdot 36 = 648W$

$P_C = I_1^2 4 + I_2^2 \cdot 12 + I_3^2 (5+1) = 81 \cdot 4 + 9 \cdot 12 + 36 \cdot 6 = 648W$

=> $P_g = P_C$

Scanat cu CamScanner

2-5. $P = ?$ 8Ω



$N = 2$

$l = 3$

$l_g = 1$

TK_1 $2-1 = 1$ ec

TK_2 $3-1-(2-1) = 1$ ec.

(A): $J_S = J_1 + J_2 \Rightarrow J_1 = 6 - J_2$

(I): $-2J_1 + J_2(2+8) = 0$

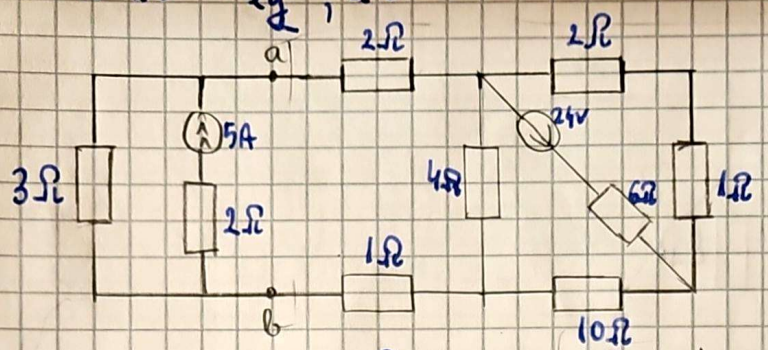
$10J_2 - 12 + 2J_2 = 0$

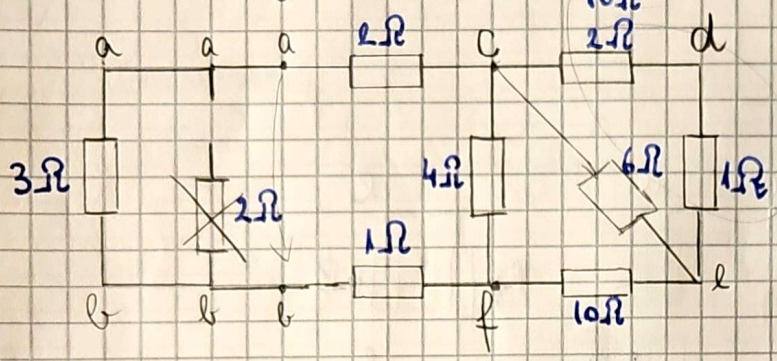
$12J_2 = 12 \Rightarrow J_2 = 1A \Rightarrow J_1 = 5A$

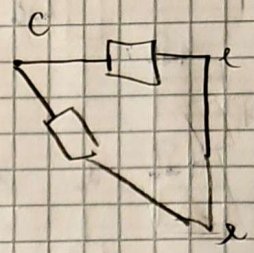
$P_8 = J_2^2 \cdot 8 = 8\,W$

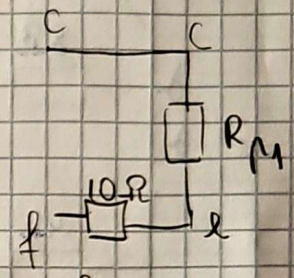
Scanat cu CamScanner

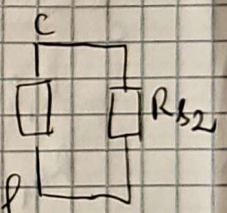
2-16 R_{eq}, ab

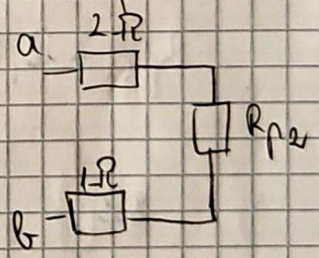












2, 1 - serie => $R_{s1} = 2+1 = 3\Omega$

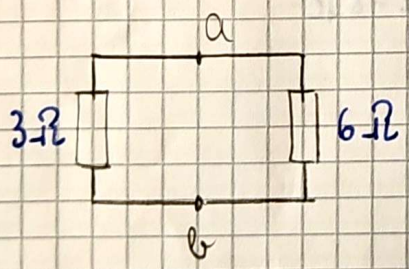
R_{s1}, 6Ω - paralel => $R_{p1} = \frac{3\cdot 6}{9} = 2\Omega$

R_{p1}, 10Ω - serie => $R_{s2} = 2+10 = 12\Omega$

R_{s2}, 4Ω - paralel => $R_{p2} = \frac{12\cdot 4}{16} = 3\Omega$

R_{p2}, 2Ω, 1Ω - serie

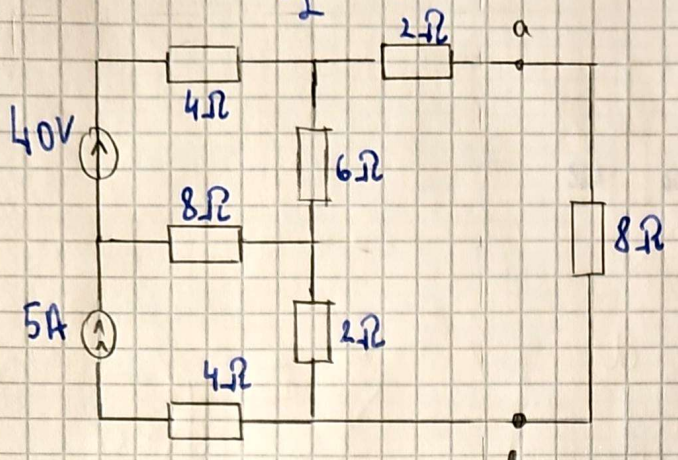
$R_{s3} = 2+3+1 = 6\Omega$

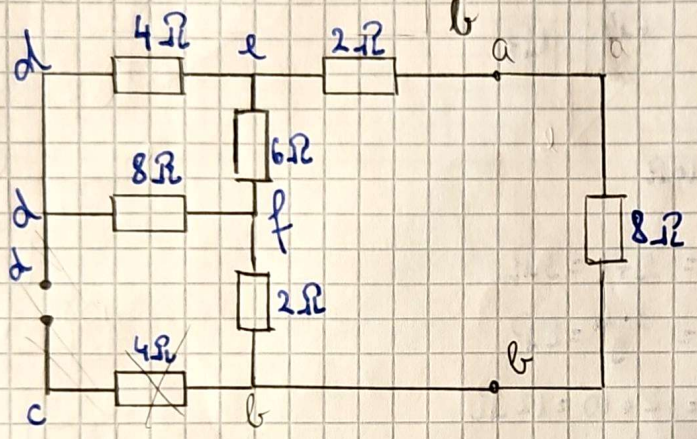


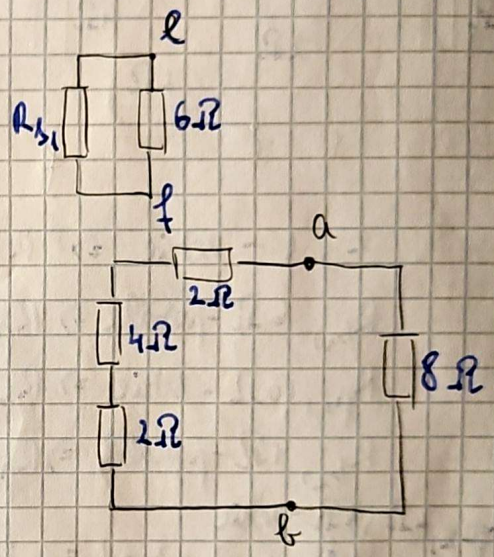
$$R_{eq} = \frac{3\cdot 6}{9} = 2\Omega$$

Scanat cu CamScanner

2-17. R_{eg} a, b



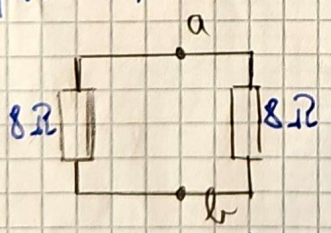




4, 8 - serie $\Rightarrow R_{s_1} = 4+8 = 12\,\Omega$

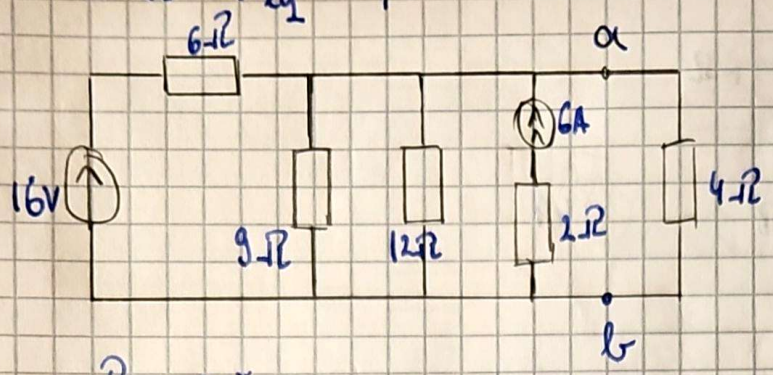
R_{s_1}, 6Ω - paralel $\Rightarrow R_{p_1} = \frac{\cancel{12}^{4} \cdot \cancel{6}}{\cancel{18}_{\cancel{3}}} = 4\,\Omega$

R_{p_1}, 2 Ω, 2Ω - serie $\Rightarrow R_{s_2} = 4+2+2 = 8\,\Omega$

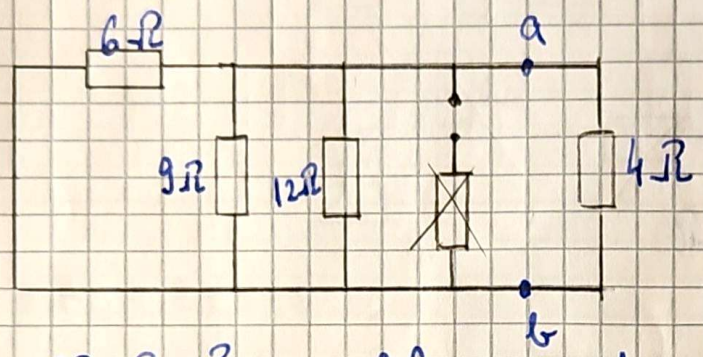


$$R_{eg} = \frac{8 \cdot \cancel{8}}{\cancel{16}_{2}} = 4\,\Omega$$

2-18 R_{eq} a, b



Pasivizăm:



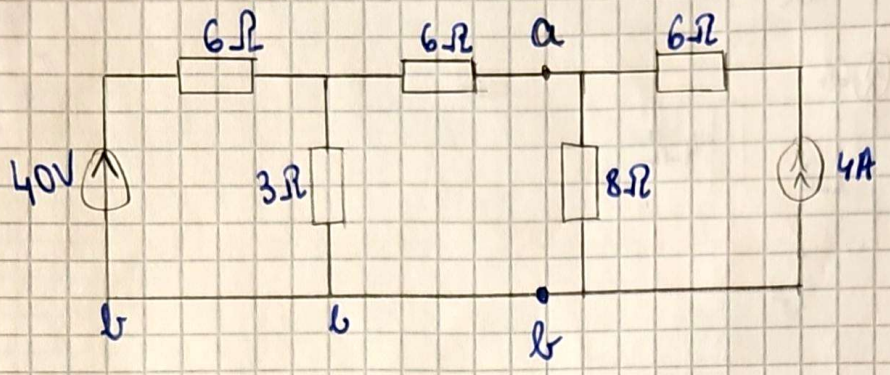
$6\Omega, 9\Omega, 12\Omega$ - paralel pe partea stângă a-b
și paralele toate cu 4Ω de pe partea dreaptă

$$\frac{1}{R_{eq}} = \frac{1}{6} + \frac{1}{9} + \frac{1}{12} + \frac{1}{4} = \frac{6+4+3+9}{36} = \frac{22}{36} = \frac{11}{18}$$

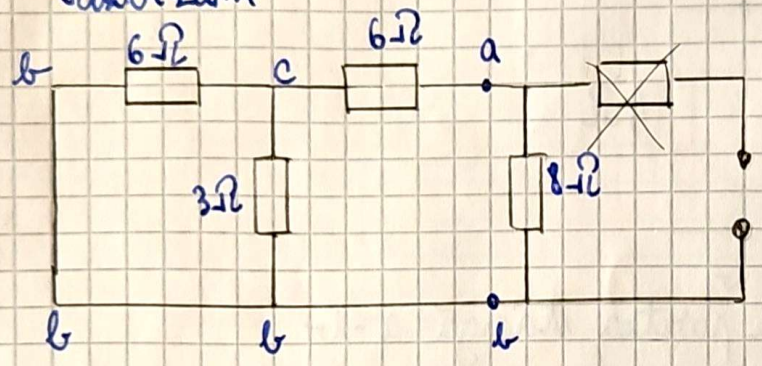
$$\Rightarrow R_{eq} = \frac{18}{11}\ \Omega$$

Scanat cu CamScanner

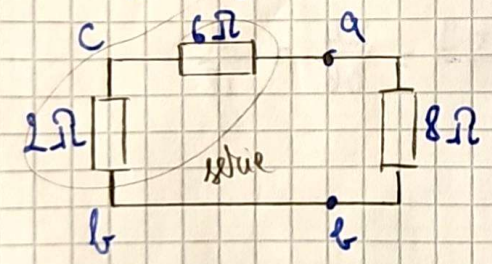
2-19 R_{eq} a,b



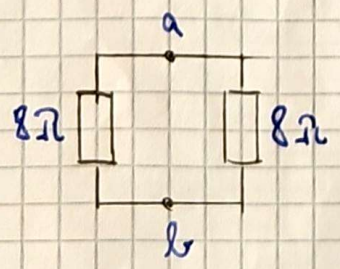
Pasivizăm



$R_{cb} = \frac{6 \cdot 3}{9} = 2\,\Omega$

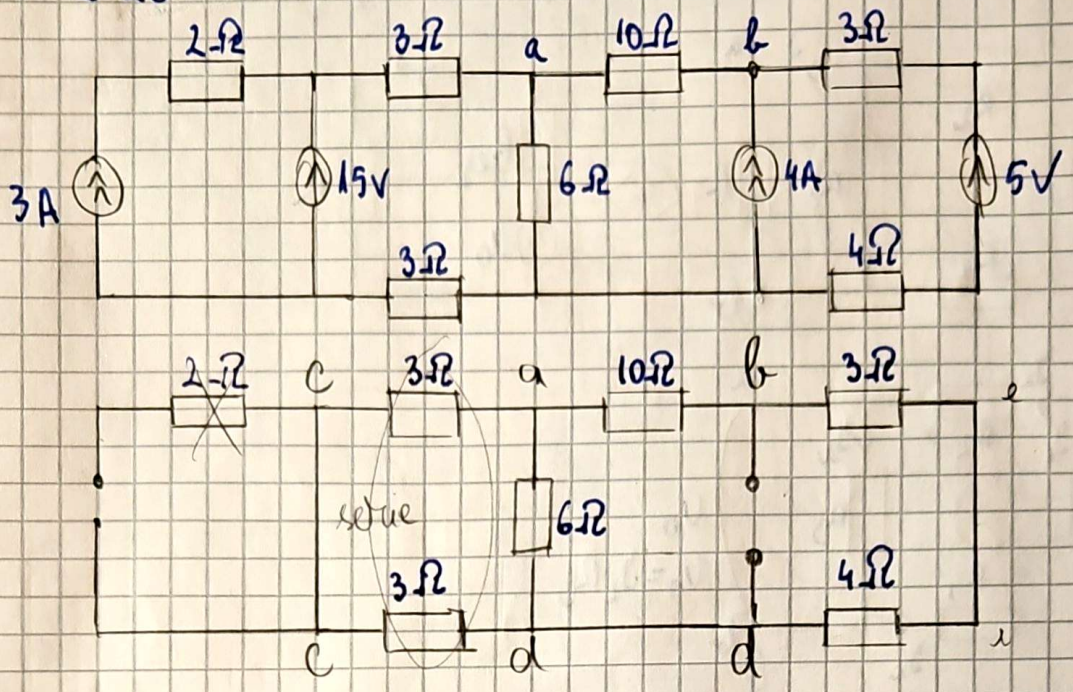


$R_s = 2 + 6 = 8\,\Omega$



$R_{eq} = \frac{8 \cdot 8}{16} = 4\,\Omega$

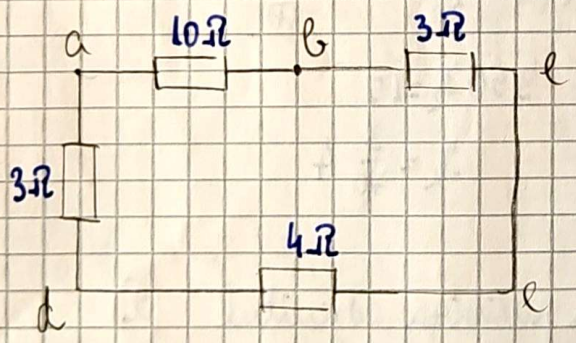
2-20



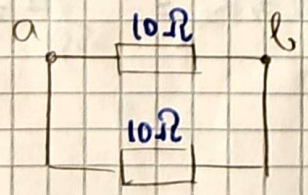
$R_{s_1} = 3+3 = 6\ \Omega$

paralel cu 6Ω

$R_{p_1} = \frac{6 \cdot \cancel{6}}{\cancel{12}_2} = 3\Omega$

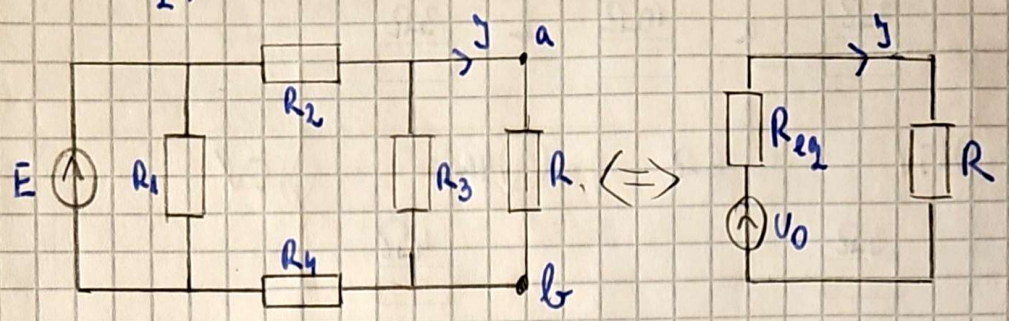


3,4,3 serie $\Rightarrow R_{s_2} = 3+4+3 = 10\Omega$

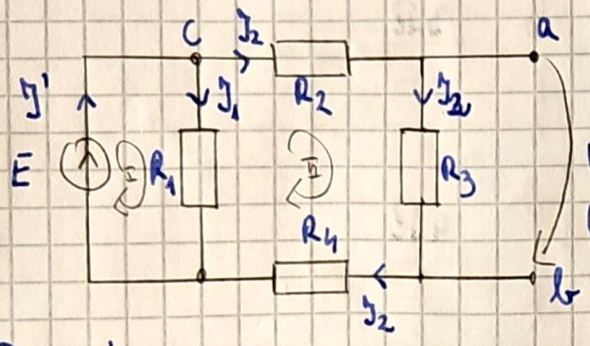


$R_e = \frac{10 \cdot \cancel{10}}{2\cancel{0}} = 5\ \Omega$

2-21. R_{eq}, U_0 = ? I = ? $E = 15V$ $R_1 = 220\,\Omega$ $R_2 = 150\,\Omega$ $R_3 = R_4 = R = 100\,\Omega$



2



$U_0 = I_2 R_3$

(C): $I' = I_1 + I_2$

(I): $I_1 R_1 = E$

(II): $I_2(R_2 + R_3 + R_4) - I_1 R_1 = 0$

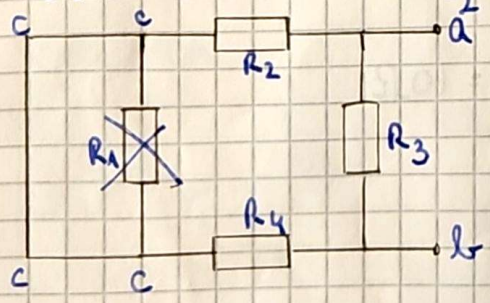
$$\Rightarrow \begin{cases} 220 I_1 = 15 \\ 350 I_2 - 220 I_1 = 0 \end{cases} \quad (+)$$

$$350 I_2 = 15$$

$$I_2 = \frac{3}{70} A$$

$$\Rightarrow U_0 = \frac{3}{7\cancel{0}} \cdot 10\cancel{0} = \frac{30}{7} = 4{,}28V$$

Pentru a calcula R_{eq} vom pasiviza circuitul 2



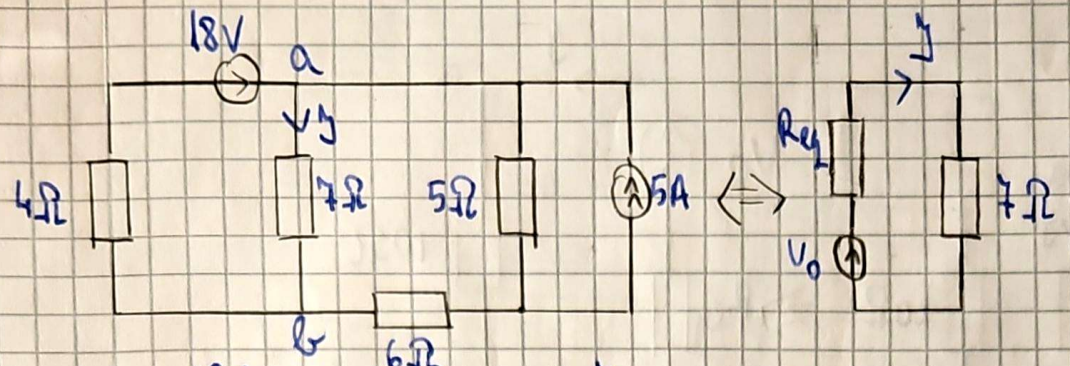
R_2, R_4 - serie $\Rightarrow R_{24} = R_2 + R_4 = 250\,\Omega$

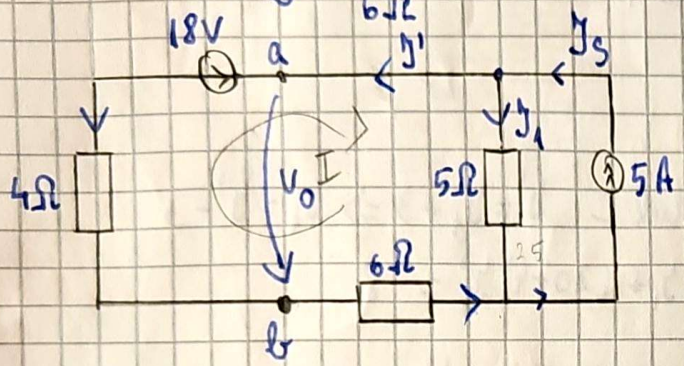
R_{24}, R_3 - paralel $\Rightarrow R_{eq} = \frac{250 \cdot 10\cancel{0}}{35\cancel{0}} = \frac{500}{7} = 71{,}4\,\Omega$

$$I = \frac{U_0}{R_{eq} + R} = \frac{\frac{30}{7}}{\frac{500}{7} + 100} = \frac{3\cancel{0}}{\cancel{7}} \cdot \frac{\cancel{7}}{12\cancel{0}} = \frac{1}{40} = 0{,}025A$$

Scanat cu CamScanner

2-22. $R_{eq}, V_0 = ?$ $\quad I = ?$ 7Ω





$N = 2$ $\quad TK_1 \to 1$

$l = 3$ $\quad TK_2 \quad 3-1-(2-1) = 1$

$l_g = 1$

(A) $I' + I_1 = I_s \Rightarrow I_1 = 5 - I'$

(I): $-I' \cdot 4 + 5 I_1 - 6 I' = 18 \Rightarrow -10 I' + 5(-I' + 5) = 18$

$-15 I' + 25 = 18$

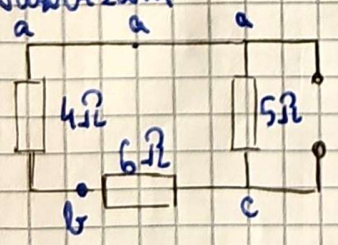
$7 = 15 I' \Rightarrow I' = \frac{7}{15} = 0{,}46A$

$\Rightarrow I_1 = 5 - \frac{7}{15} = \frac{68}{15} = 4{,}53A$

$V_0 = V_{ab} = V_a - V_b|_{b \to a} =$

$= 18 - (4 \cdot I') = 18 + \frac{28}{15} = \frac{298}{15} = 19{,}87 V$

Pasivizăm

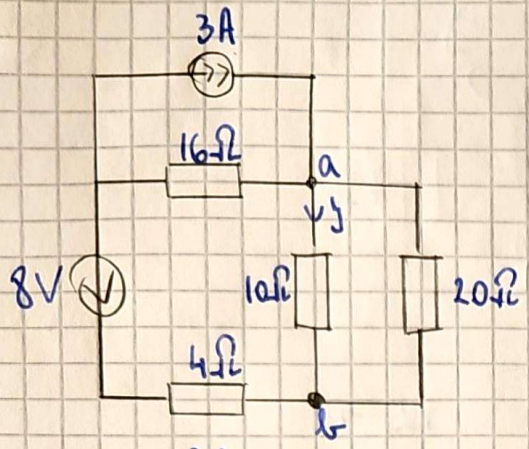


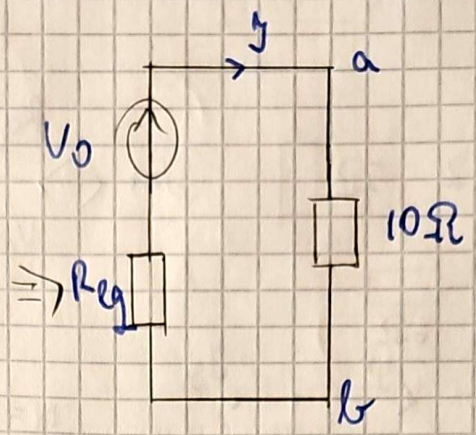
$R_s = 5 + 6 = 11\Omega$

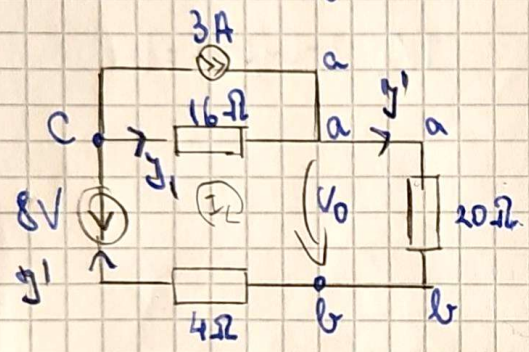
$R_{eq} = \frac{11 \cdot 4}{15} = \frac{44}{15}\Omega$

$I = \frac{V_0}{R_{eq} + 7} = \frac{298}{15} \cdot \frac{15}{149} = \cancel{5{,}84A} = 2A$

2-23 $R_{eq}, U_0 = ?$ 10Ω (a, b) $I = ?$







în nodul C $I' = I_1 + 3 \Rightarrow I_1 = I' - 3$

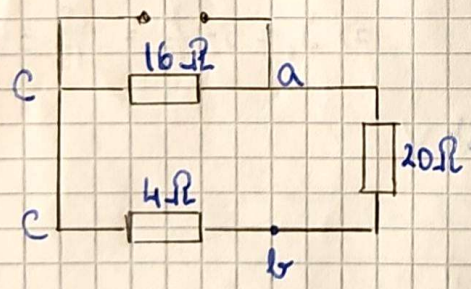
(I): $16 I_1 + (20+4) I' = -8$

$16 I' - 16 \cdot 3 + 24 I' = -8$

$40 I' = 40 \Rightarrow I' = 1A$

$U_0 = I' \cdot 20 = 20V$

Pasivizăm circuitul

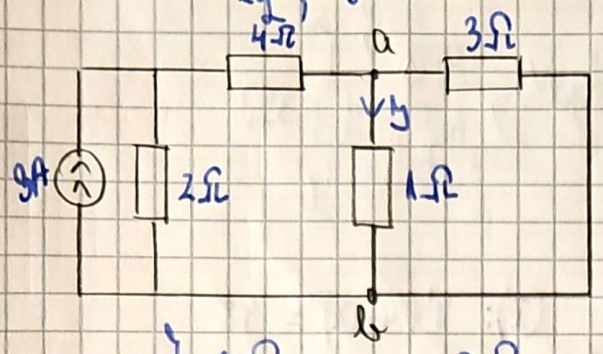


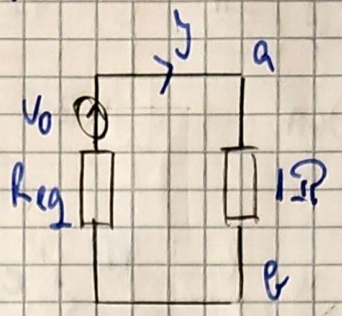
$R_b = 16 + 4 = 20\Omega$

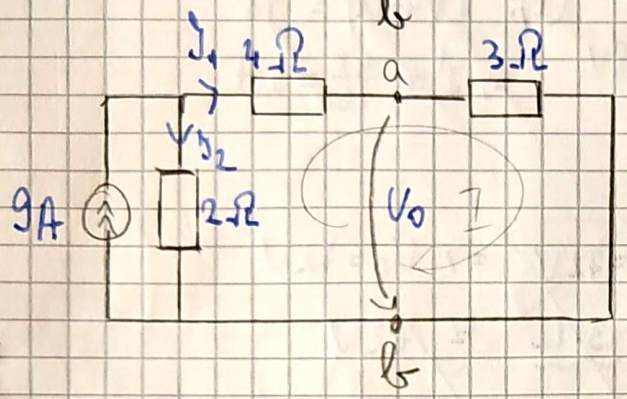
$R_{eq} = \frac{\cancel{20}^{5} \cdot \cancel{20}}{\cancel{40}} = 10\Omega$

$I = \frac{U_0}{R_{eq} + R} = \frac{20}{10+10} = 1A$

2-24 R_{eq}, $V_0 = ?$ 1Ω $I = ?$







$I_1 + I_2 = 9 \qquad I_2 = 9 - I_1$

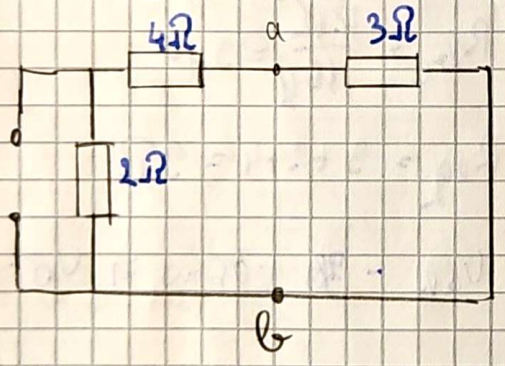
$7I_1 - 2I_2 = 0$

$7I_1 - 18 + 2I_1 = 0$

$9I_1 = 18 \Rightarrow I_1 = 2A \Rightarrow I_2 = 7A$

$V_0 = I_1 \cdot 3 = 6V$

Pasivizăm



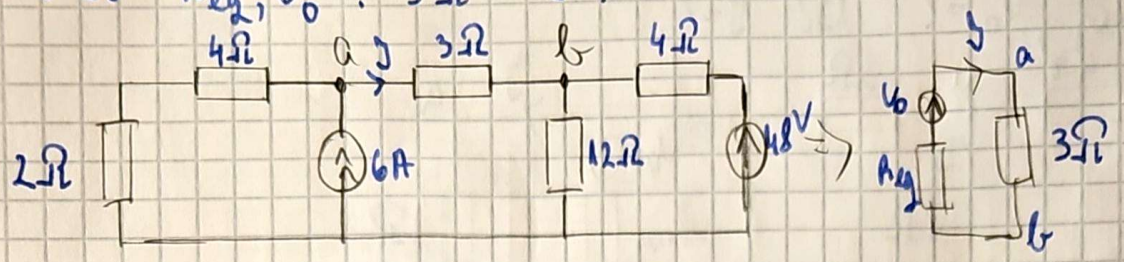
$R_b = 4 + 2 = 6\Omega$

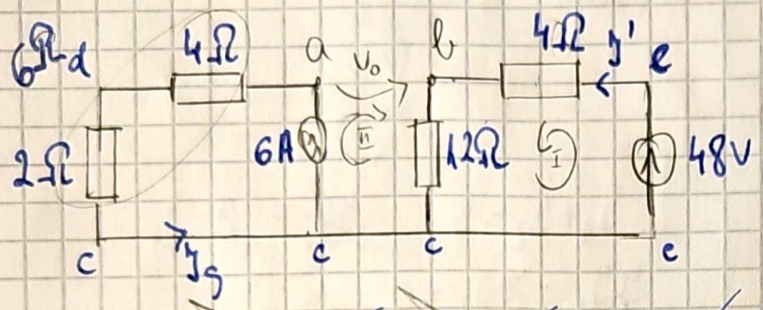
$R_{ab} = \frac{6 \cdot 3}{9} = 2\Omega$

$$I = \frac{V_0}{R_{eq} + 1} = \frac{6}{2+1} = \frac{6}{3} = 2A$$

Scanat cu CamScanner

2-25 $R_{eq}, U_0 = ?$ 3Ω $y = ?$





(I): $y'(4+12) = 48$

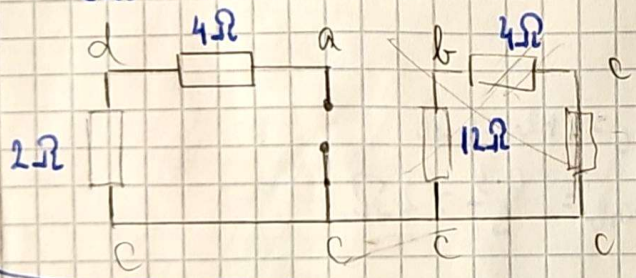
$\Rightarrow y' = \frac{48}{16} = 3\,A$

$\cancel{(II): y' \cdot 12 + 6 \cdot (2+4) = 36 + 36 = 72V \Rightarrow U_0 = 72V}$

$\cancel{\text{sau } U_0 = U_{ab} = U_{ac} + U_{cb} = 6 \cdot (2+4) + 3 \cdot 12 = 72V}$

$\cancel{\text{sau } 48 - 3 \cdot 4}$

Pasivizăm

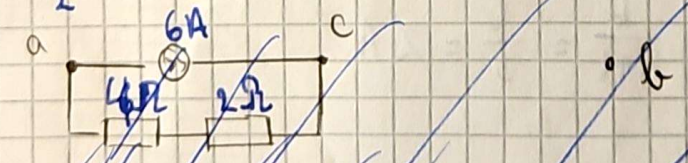


$R_{bc} = \frac{\cancel{4} \cdot \cancel{12}^{3}}{\cancel{16}\,\cancel{4}} = 3\Omega$

$R_{eq} = 3 + 2 + 4 = 9\Omega$

$\cancel{II: U_{ab} - 36 + 36 = 0 \Rightarrow U_0 = 0V}$

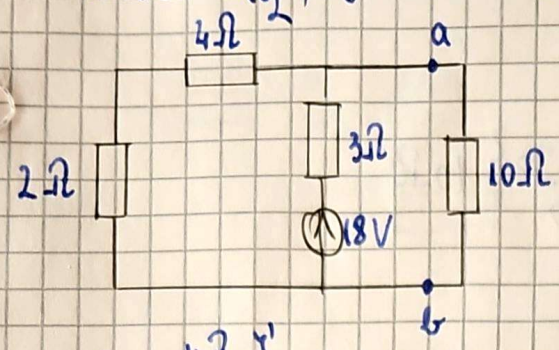
$\cancel{y = \frac{U_0}{R_{eq} + 3} = \frac{72}{12} = 6A}$



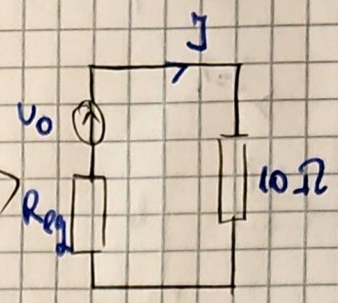
$\cancel{U_{ab} = V_a - V_b|_{b \to a} = -48 - 36 + 3 \cdot 16 + 6 \cdot 6 = 0V}$

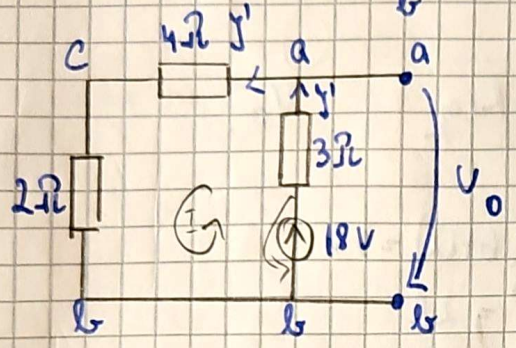
$\Rightarrow y_0 = \frac{0}{12} = 0A$

2-26. R_{eq}, U_0 = ? $\quad J$, 10Ω



$\Rightarrow$





I $\quad 3J' + 6J' = 18$

$\Rightarrow J' = 2\,A$

$U_0 = 18 - 2\cdot 3 = 12\,V$

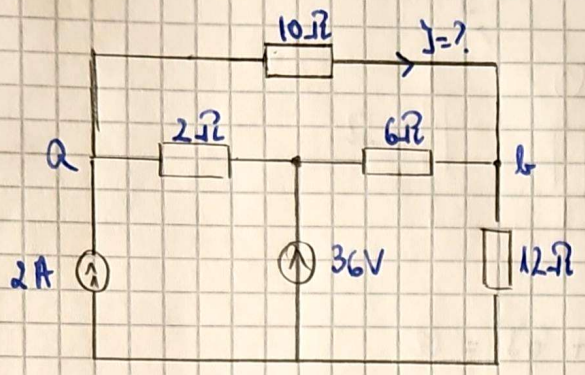
Pasivizăm

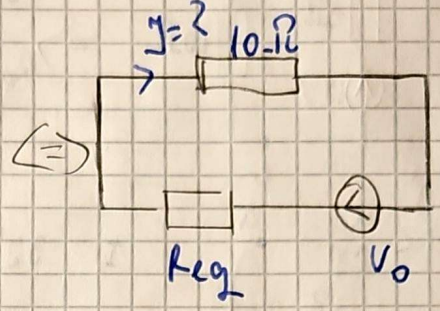
$R_{acb} = 4 + 2 = 6\,\Omega$

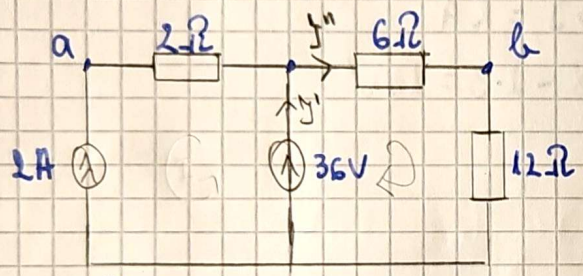
$R_{eq} = \frac{6\cdot 3}{9} = 2\,\Omega$

$$J = \frac{U_0}{R_{eq} + R} = \frac{12}{10+2} = 1\,A$$

2-27. R_{eq}, U_0 10Ω, $I=?$







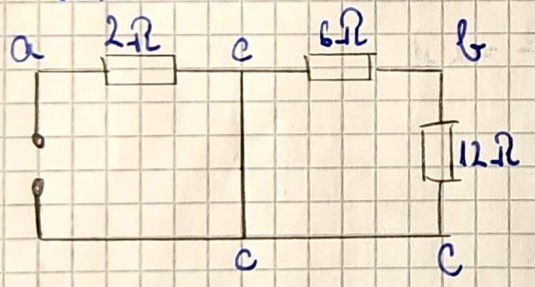
(I): $I''(6+12)=36$

$I''=2A$

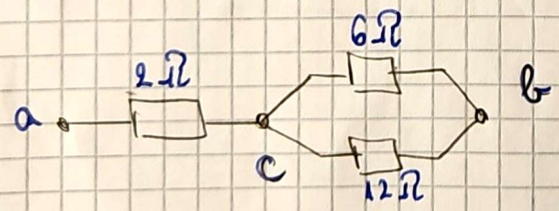
$\Rightarrow I'=2-2=0A$

$U_0=2\cdot2+2\cdot6=16V$

Pasivizăm



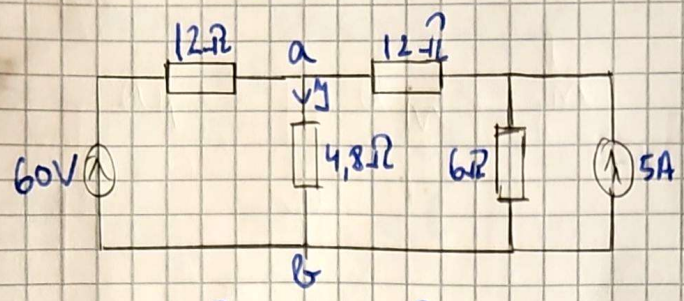
$R_{cb}=\frac{\cancel{6}\cdot\cancel{12}^{4}}{\cancel{18}_{\cancel{3}}}=4\Omega$

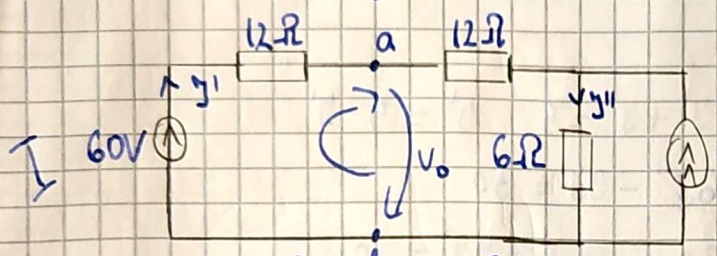


$R_{eq}=2+4=6\Omega$

$I=\frac{U_0}{R_{eq}+10}=\frac{16}{6+10}=1A$

2-28. R_{eq}, V_0 $4,8\Omega$ $J=?$



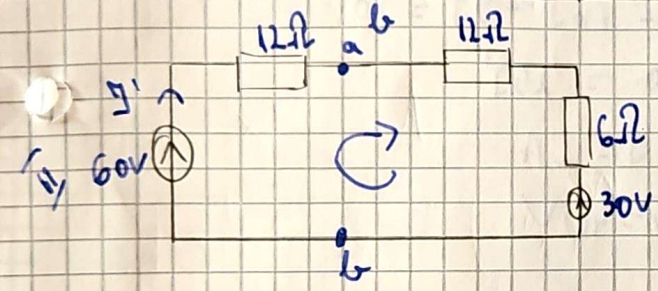


$24J' + 6J'' = 60$

$J' + 5 = J'' \Rightarrow 24J' + 6J' + 30 = 60$

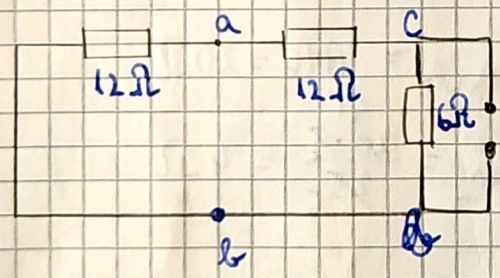
$30J' = 30 \Rightarrow J' = 1A$

$V_{ab} = V_a - V_b|_{b \to a} = 60 - 12 = 48V$



$J' \cdot 30 = 60 - 30 = 30$

$J' = 1A \Rightarrow V_{ab} = 60 - 12 = 48V$



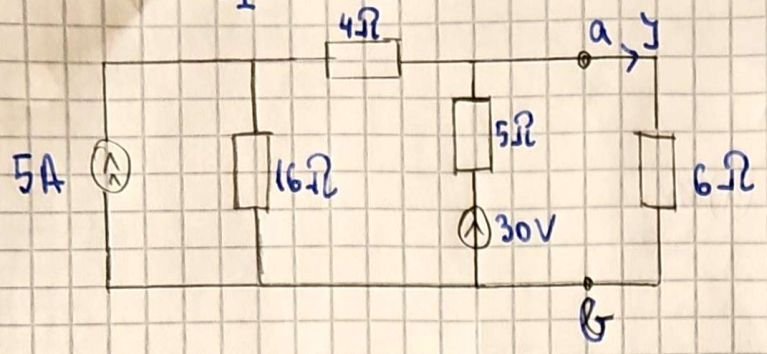
$R_{acb} = 12 + 6 = 18\Omega$

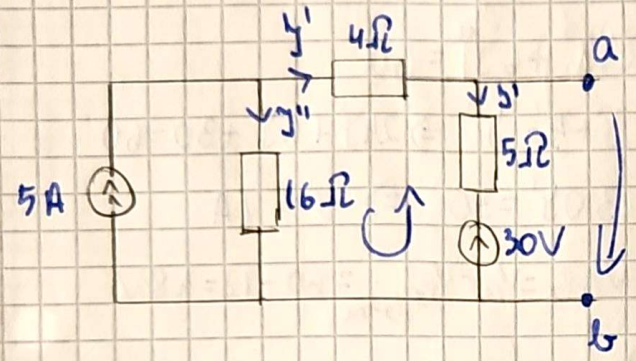
$R_{eq} = \frac{12 \cdot \cancel{18}^{6}}{\cancel{30}_{10}} = \frac{72}{10} = 7,2\Omega$

$$J = \frac{V_{ab}}{R_{eq} + 4,8} = \frac{48}{7,2 + 4,8} = \frac{48}{12} = 4A$$

Scanat cu CamScanner

2-29. $R_{eq} = ?$ $U_0 = ?$ $6\,\Omega$, $I = ?$





$I' + I'' = 5 \qquad I'' = 5 - I'$

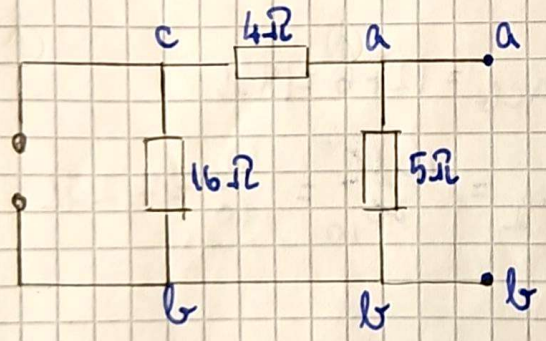
$16I'' - 9I' = 30$

$80 - 16I' - 9I' = 30$

$50 = 25I'$

$I' = 2A$

$U_0 = V_a - V_b|_{b \to a} = 30 + 2 \cdot 5 = 40V$



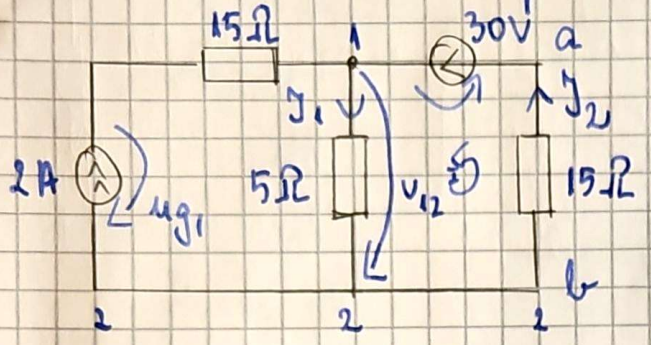
$R_{acb} = 4 + 16 = 20\,\Omega$

$R_{eq} = \frac{\cancel{30}^{4} \cdot \cancel{5}}{\cancel{25}_{5}} = 4\,\Omega$

$I = \frac{40}{4+6} = 4\,A$

2-30. a) curenții b) J_2, 5Ω Thevenin, U_{12}

Teorema conservării puterii

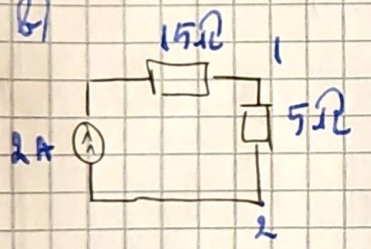


(I) $15J_2 + 5J_1 = 30$

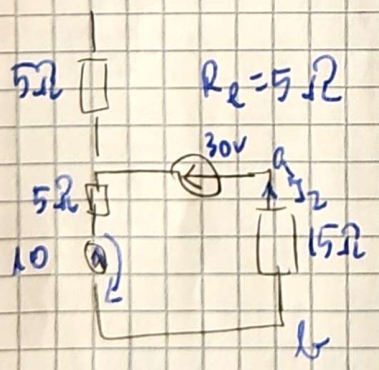
$2 + J_2 = J_1$

$\Rightarrow 15J_2 + 10 + 5J_2 = 30 \Rightarrow J_2 = 1A \Rightarrow J_1 = 3A$

b)



$U_{12} = 2 \cdot 5 = 10V$



$\Rightarrow J_2 = \frac{30-10}{5+15} = 1A$

$u_{g_1} = U_{cd} = V_c - V_d = 30 + 15 = 45$ V

$P_{g_1} = 2 \cdot 45 = 90W$

$P_u = 1 \cdot 30 = 30W$

$\Rightarrow P_g = 120W$

$P_c = 4 \cdot 15 + 9 \cdot 5 + 1 \cdot 15 = 120W$

$\Rightarrow P_g = P_c$

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2-31.

$R_1 = R_4 = 4\,\Omega$

$R_2 = 2\,\Omega$

$R_3 = 6\,\Omega$

$R_5 = 3\,\Omega$

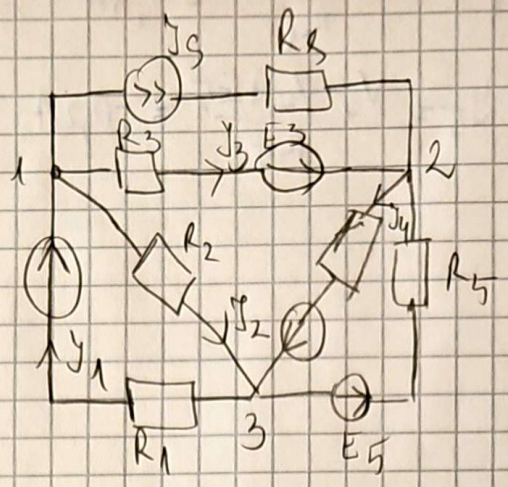
$R_S = 10\,\Omega$

$E_1 = E_3 = 6V$

$E_4 = 3V$

$E_5 = 4V$

$J_S = 2A \qquad V_3 = 0$



$$\begin{cases} V_1\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right) - V_2\cdot\frac{1}{R_3} = \frac{E_1}{R_1} - \frac{E_3}{R_3} - J_S \\ V_2\left(\frac{1}{R_3}+\frac{1}{R_4}+\frac{1}{R_5}\right) - V_1\frac{1}{R_3} = \frac{E_3}{R_3} - \frac{E_4}{R_4} + \frac{E_5}{R_5} + J_S \end{cases}$$

$$\begin{cases} V_1\left(\frac{1}{4}+\frac{1}{2}+\frac{1}{6}\right) - V_2\frac{1}{6} = \frac{6}{4} - \frac{6}{6} - 2 \quad |\cdot 12 \\ V_2\left(\frac{1}{6}+\frac{1}{4}+\frac{1}{3}\right) - V_1\cdot\frac{1}{6} = \frac{6}{6} - \frac{3}{4} + \frac{4}{3} + 2 \quad |\cdot 12 \end{cases}$$

$$\begin{cases} V_1(3+6+2) - 2V_2 = 18 - \frac{6\cdot 12}{6} - 24 = 18-12-24 = -18 \\ V_2(2+3+4) - 2V_1 = 12 - 9 + 16 + 24 = 43 \end{cases}$$

$$\begin{cases} 11V_1 - 2V_2 = -18 \quad |\cdot 2 \\ 9V_2 - 2V_1 = 43 \quad |\cdot 11 \end{cases} \Rightarrow \begin{cases} 22V_1 - 4V_2 = -36 \\ -22V_1 + 99V_2 = 473 \end{cases}$$

$$95V_2 = 437$$

$$V_2 = \frac{23}{5} = 4{,}6V$$

$$\Rightarrow V_1 = -0{,}8V$$

$$V_1 - V_2 = -E_3 + J_3R_3 \Rightarrow J_3 = \frac{V_1 - V_2 + E_3}{R_3} = 0{,}1A$$

$$V_1 - V_3 = J_2R_2 \Rightarrow J_2 = \frac{V_1 - V_3}{R_2} = -0{,}4A$$

$$V_2 - V_3 = J_2R_4 - E_4 \Rightarrow J_4 = \frac{V_2 - V_3 + E_4}{R_4} = 1{,}9A$$

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$$V_1 - V_3 = E_1 - J_1 R_1 \Rightarrow J_1 = \frac{V_3 - V_1 + E_1}{R_1} = 1,7A$$

$$V_2 - V_3 = E_5 - J_5 R_5 \Rightarrow J_5 = \frac{V_3 - V_2 + E_5}{R_5} = -0,2A$$

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