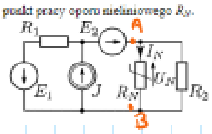
09.06.2021

Oświadczam, że niniejsza praca stanowiąca podstawę do uznania efektów uczenia się została wykonana przeze mnie samodzielnie.

Zadanie 1.

Zad. 1 (4,5 p.)

Obliczyć punkt pracy oporu nieliniowego R_N.

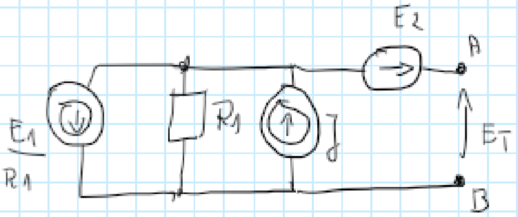


$E_1 = 2{,}5$ V
$E_2 = 10$ V
$J = 1.5$ mA
$R_1 = 5$ kΩ
$R_2 = 10$ kΩ

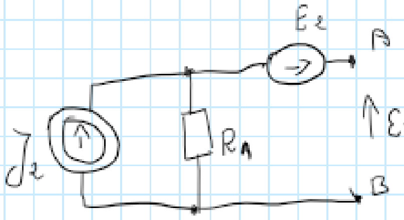
R_N:
$i = a\, u_N |u_N|$
$a = 0.06$ mA/V^2

=>

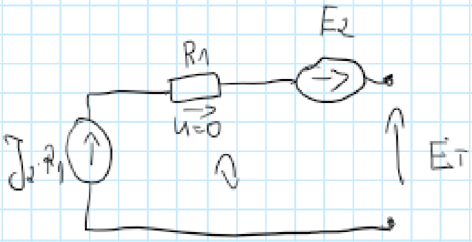
E_T:



$$J_2 = \frac{E_1}{R_1} + J = \frac{-2{,}5}{5} + 1{,}5 = -0{,}5 + 1{,}5 = 1\,mA$$



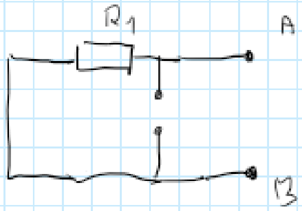
$\uparrow E_T$ =>



$$J_2 R_1 + E_2 = E_T$$

$$E_T = 1 \cdot 5 + 10 = 15\,[V].$$

R_w:

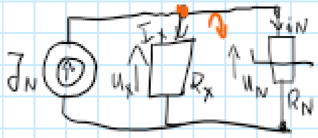


$$R_w = R_1 = 5\,k\Omega$$

=>

$$J_N = \frac{E_T}{R_w} = \frac{15}{5} = 3\ mA$$

$$R_x = (R_w \| R_2) = \frac{R_w \cdot R_2}{R_w + R_2} = \frac{10 \cdot 5}{10+5} = \frac{50}{15} = \frac{10}{3}\ k\Omega$$



$$J_N = I_x + i_N = I_x + a\,u_N^2$$

$$u_x = u_N \Rightarrow I_x = \frac{u_N}{R_x}$$

R_N:
$i = a\,u_N|u_N|$
$a = 0{,}06\ mA/V^2$

$$J_N = \frac{u_N}{R_x} + a\,u_N^2$$

$$0{,}06\,u_N^2 + \frac{3}{10}u_N - 3 = 0 \quad / \cdot 100$$

$$6\,u_N^2 + 30\,u_N - 300 = 0$$

$$\Delta = 900 + 4 \cdot 6 \cdot 300 = 900 + 7200 = 8100$$

$$\sqrt{\Delta} = 90 \qquad u_N = \frac{-30+90}{12} = \frac{60}{12} = \boxed{5\ V}$$

Liczymy tylko dodatnie u_N, bo nasze i_N w układzie jest $i_N > 0$.

$$i_N = 0{,}06 \cdot 5^2 = 0{,}06 \cdot 25 = 1{,}5\ mA$$

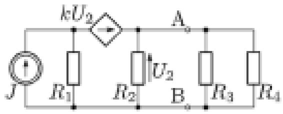
Pkt. pracy: W(5V, 1,5 mA)

Zadanie 2.

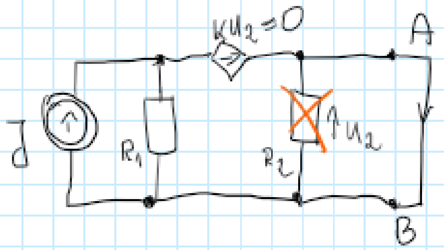
Zad. 2 (4,5 p.)

Obliczyć dla jakiej wartości oporu R_4 w całym obciążeniu (na prawo od zacisków AB) wydzieli się największa moc. Obliczyć tę moc.

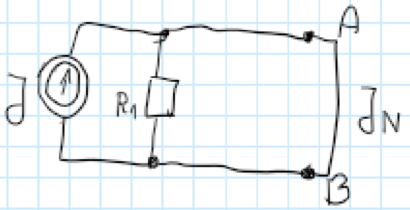
$J = 5$ mA
$k = 0.25$ V/V
$R_1 = 9$ kΩ
$R_2 = 6$ kΩ
$R_3 = 6$ kΩ



J_N:

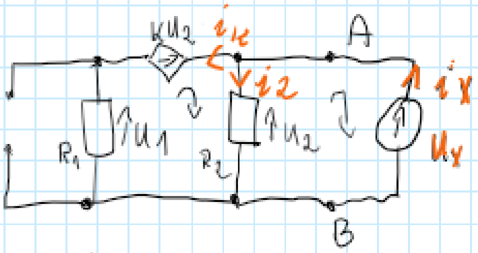


R_2 wyrzucamy, bo $U_2 = 0$



$= J$ $\quad J_N = J = 5mA$

R_W:



$$i_x = i_R + i_2$$

$$U_1 + kU_2 - U_2 = 0 \Rightarrow 4U_1 - 3U_2 = 0$$

$$U_2 = U_x \Leftrightarrow i_2 = \frac{U_x}{R_2}$$

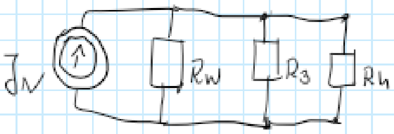
$$4U_1 = 3U_2$$

$$4 \cdot R_1 \cdot i_R = 3 \cdot R_2 \cdot i_2$$

$$i_R = \frac{3R_2 i_2}{4R_1}$$

$$i_x = \left(\frac{3R_2}{4R_1}+1\right) i_2 = \left(\frac{3R_2}{4R_1}+1\right)\cdot\frac{u_y}{R_2} = \left(\frac{3R_2}{4R_1R_2}+\frac{1}{R_2}\right)u_y$$

$$R_w = \frac{u_y}{i_x} = \frac{1}{\frac{3R_2}{4R_1R_2}+\frac{1}{R_2}} = \frac{1}{\frac{\cancel{3}\cdot\cancel{6}}{4\cdot\cancel{6}\cdot\cancel{9}_3}+\frac{1}{6}} = \frac{1}{\frac{1}{12}+\frac{2}{12}} = \frac{12}{3} = 4\,k\Omega$$



Największa moc wydzieli się jeśli

$$R_w = \underbrace{(R_3 \| R_4)}_{R_0}$$

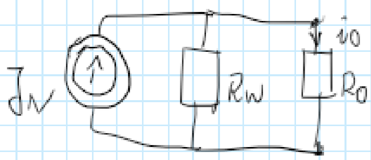
$$\frac{R_3\cdot R_4}{R_3+R_4} = 4$$

$$\frac{6R_4}{6+R_4} = 4 \quad /\cdot(6+R_4)$$

$$6R_4 = 24 + 4R_4$$

$$2R_4 = 24$$

$$\underbrace{R_4 = 12\,k\Omega}$$



Z dzielnika prądowego:

$$i_0 = J_N\cdot\frac{R_w}{R_0+R_w} = 5\cdot\frac{4}{8} = \frac{5}{2}\ mA$$

$$P_0 = U_0\cdot I_0 = I_0^2\cdot R_0 = \left(\frac{5}{2}\right)^2\cdot 4 = \frac{25}{4}\cdot 4 = 25\ mW$$

$U = I\cdot R$

$$\underbrace{P_0 = 25\ mW}$$