

1.

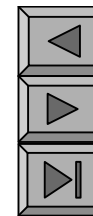
2.

3.

4.

5.

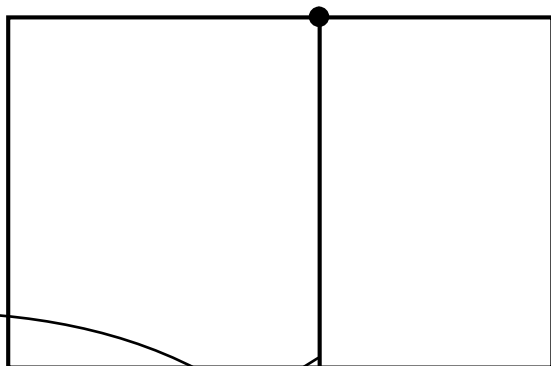
6.



1.

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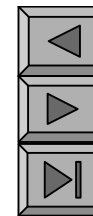


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2







2.

(1)

□

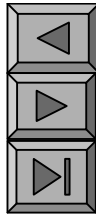
(2)

(3)

(4)

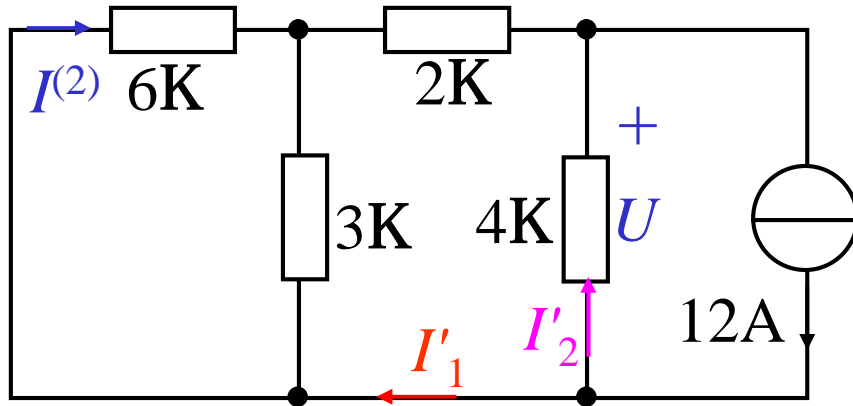
(5)

“ ”



3.

$I \quad U$



$$I'_1 = 1 \frac{4 \cdot 12}{4 + \left(2 + \frac{6 \cdot 3}{6+3} \right)}$$

1.6 A

$$I^{(1)} = \frac{120}{6 + \frac{3 \cdot (2+4)}{3 + (2+4)}} = 15 \text{ A}$$

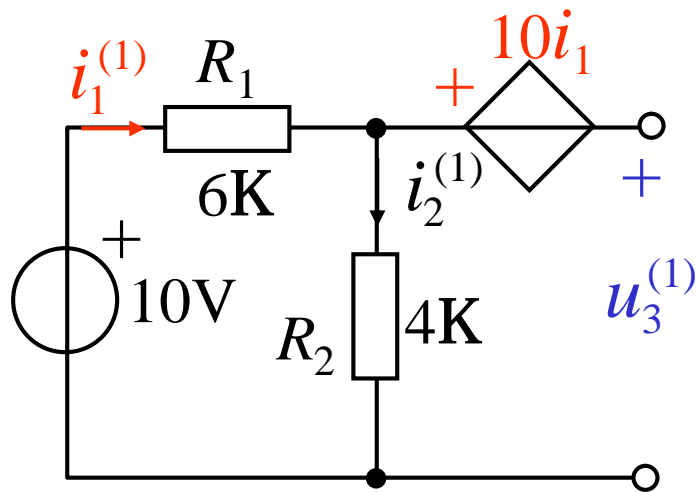
$$I^{(2)} = 1 \frac{3}{6+3} \cdot 6 \cdot 12 \text{ A}$$

$$U^{(2)} = 1 \cdot 6 \cdot 4 \cdot 12 \text{ V}$$

$$U^{(1)} = \frac{3 \cdot I^{(1)}}{3 + (2+4)} \cdot 4 = 20 \text{ V}$$

$$I = 17 \text{ A} \quad U = 4 \text{ A}$$

P85 4-2

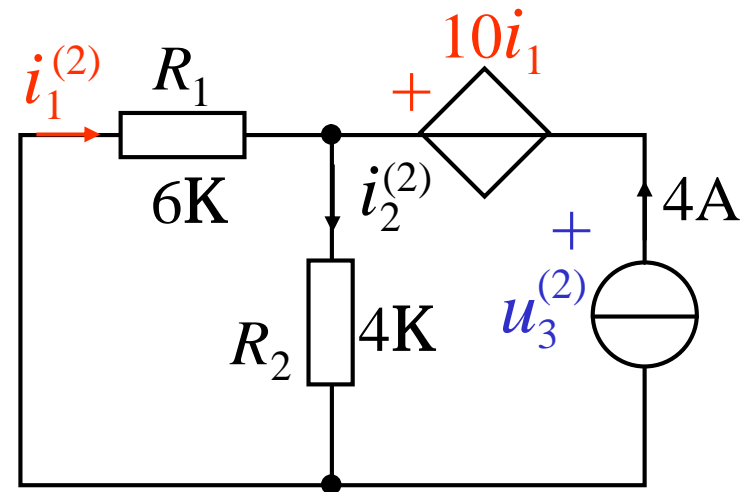
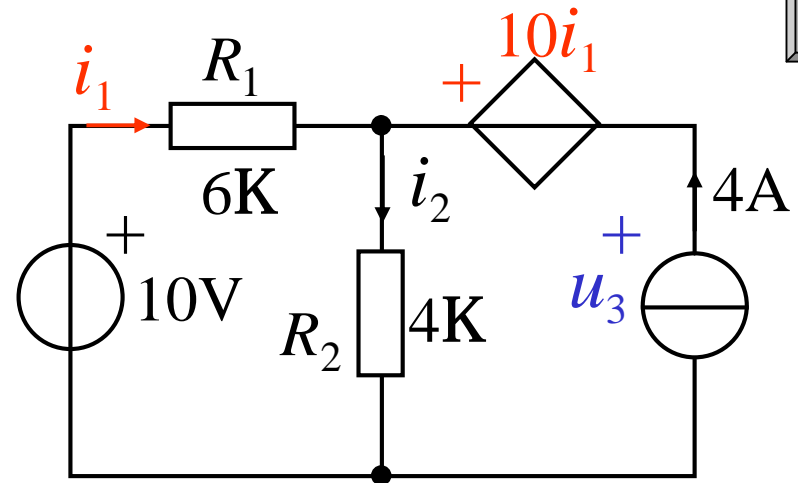


$$i_1^{(1)} = 1 \quad i_2^{(1)} = 1 \quad \frac{10}{6+4} = 1.1 \text{ A}$$

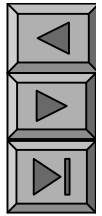
$$u_3^{(1)} = 10 i_1^{(1)} + 4 i_2^{(1)} = 11 \text{ V}$$

$$i_1^{(2)} = 1 \quad \frac{4}{6+4} = 0.4 \text{ A}$$

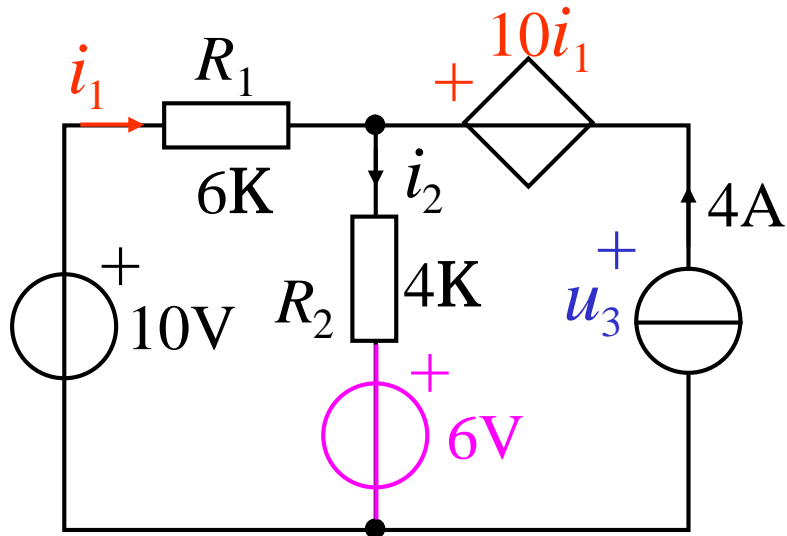
$$u_3^{(2)} = 10 i_1^{(2)} = 4 \text{ V}$$



$$u_3 = 11 + 4 = 15 \text{ V}$$



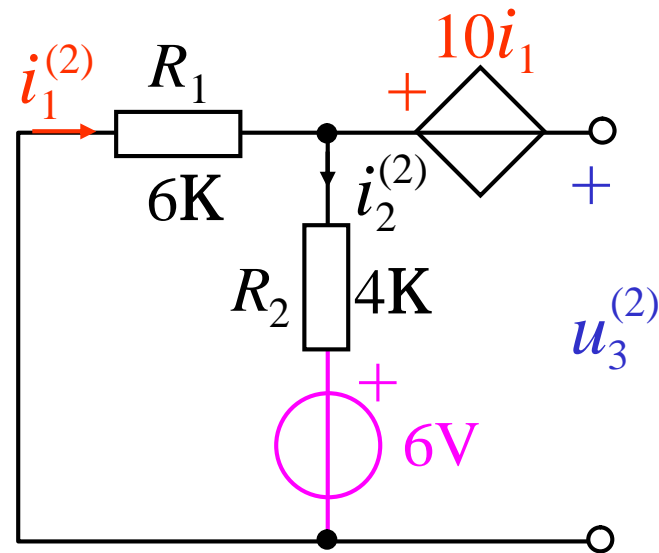
P86 4-3



10V

4A

$$u_3^{(1)} = 19.6V$$

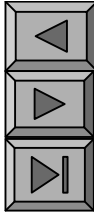


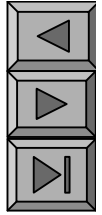
$$i_1^{(2)} = i_2^{(2)} = \frac{6}{6+4} = 0.6A$$

$$u_3^{(2)} = 10 i_1^{(2)} - 6 i_1^{(2)}$$

$$= 16 (0.6) = 9.6V$$

$$u_3 = u_3^{(1)} + u_3^{(2)} = 29.2V$$





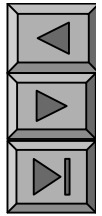
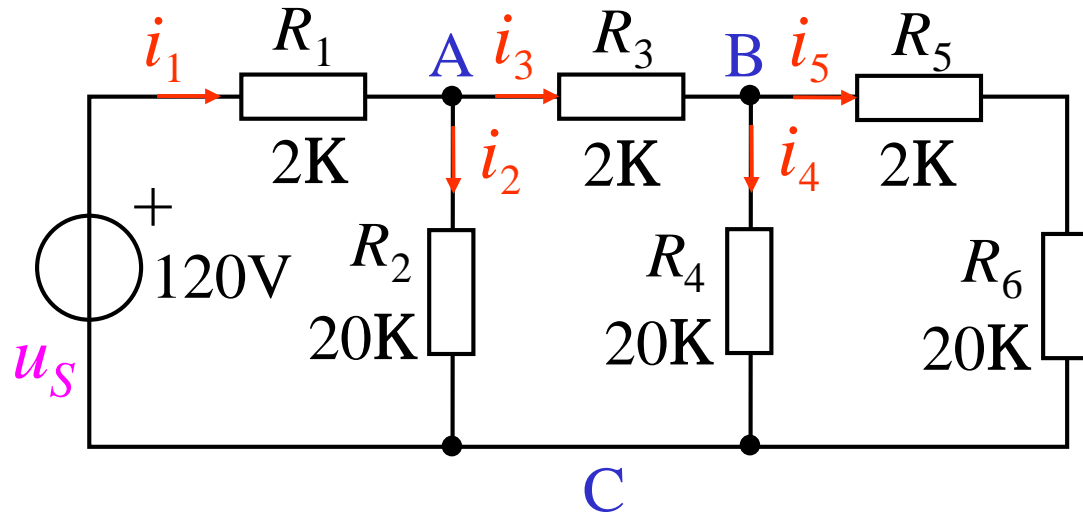
$$K u_f = \left[\sum_{m=1}^g k_{fm} u_s + \sum_{m=1}^h K_{fm} i_s \right] K$$

4. $f(Kx) = K f(x)$

• $(K \quad) \quad (\quad) \quad K$
 K

-
- K
-
-

P87 4-4



$$i_5 = i'_5 = 11\text{A}$$

$$u'_{BC} = (2\checkmark 20) i'_5 = 22\text{V}$$

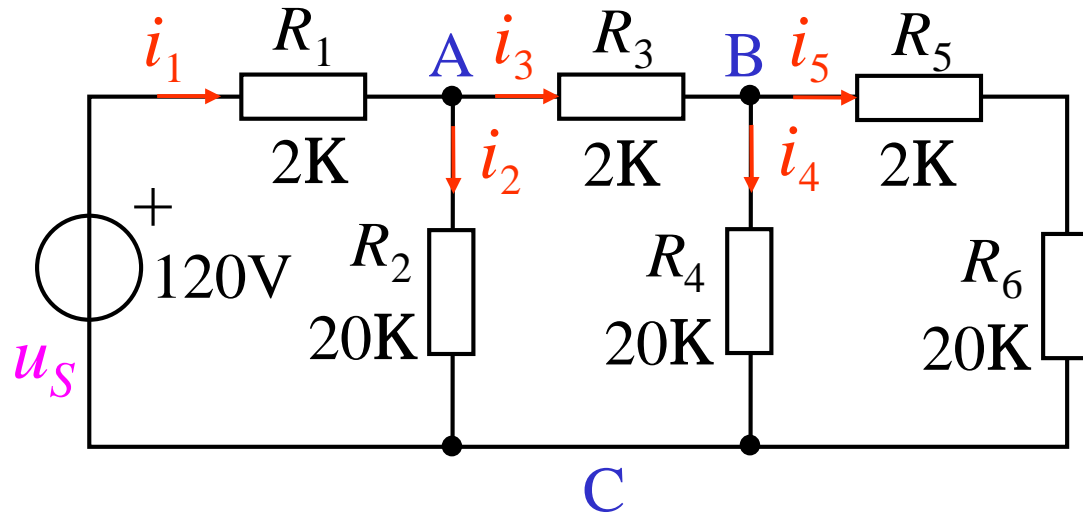
$$i'_4 = \frac{u'_{BC}}{R_4} = \frac{22}{20} = 11.1\text{A}$$

$$i'_3 = i'_4 \checkmark i'_5 = 2.1\text{A}$$

$$u'_{AC} = R_3 i'_3 \checkmark u'_{BC}$$

12

P87 4-4



$$i_5 = i'_5 = 1\text{A}$$

$$u'_S = 33.02\text{V}$$

$$u'_S = K1 \frac{120}{33.02}$$

$$K = 3.634$$

$$i_1 = K i'_1 = 12.39\text{A}$$

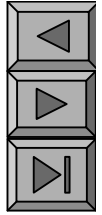
$$i_2 = K i'_2 = 4.76\text{A}$$

$$i_3 = K i'_3 = 7.63\text{A}$$

$$i_4 = K i'_4 = 4.00\text{A}$$

$$i_5 = K i'_5 = 3.63\text{A}$$

4 2



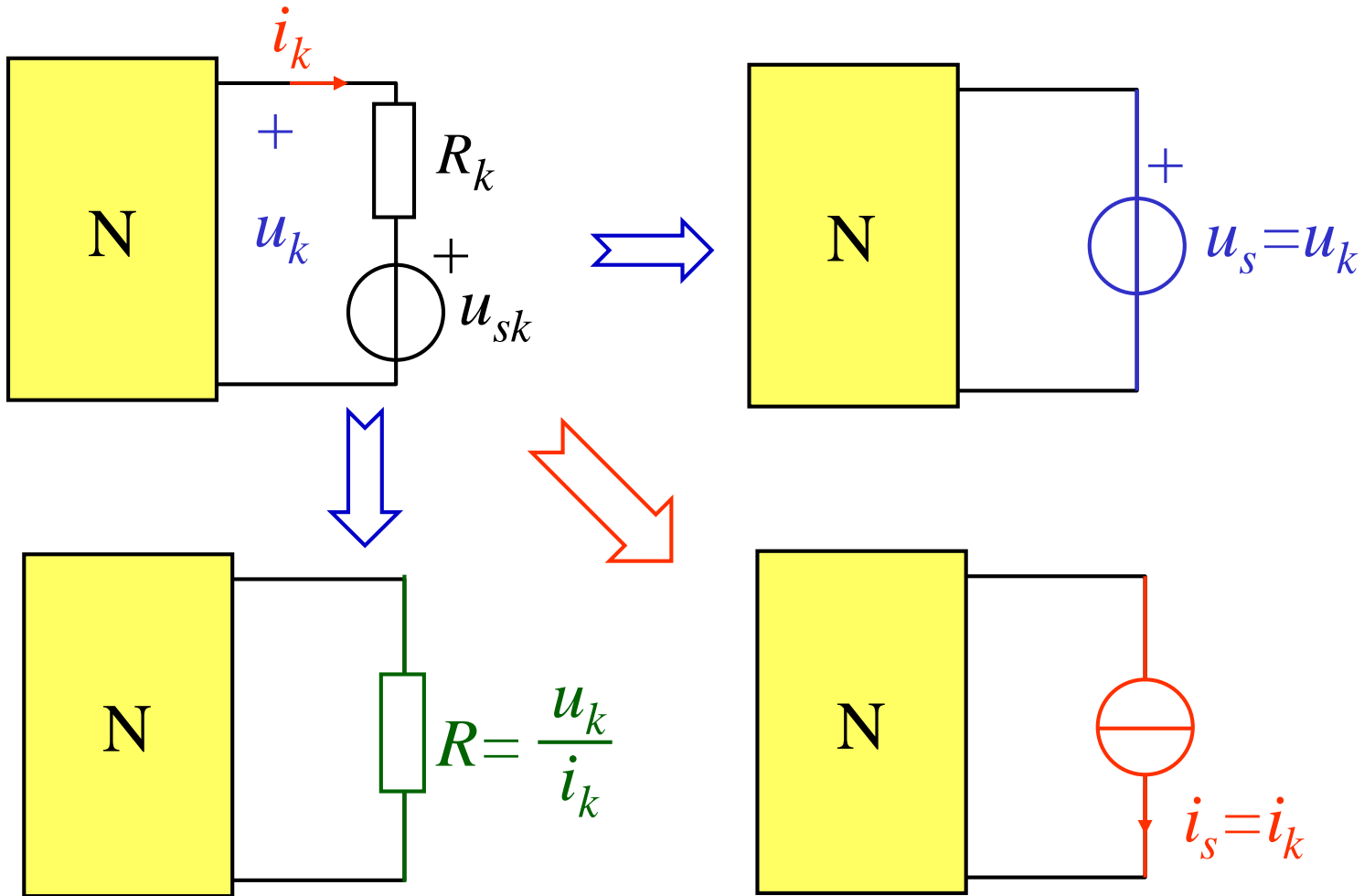
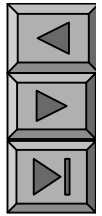
• u_k i_k k

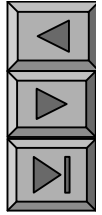
(1) u_k

(2) i_k

(3) $\frac{u_k}{i_k}$

•

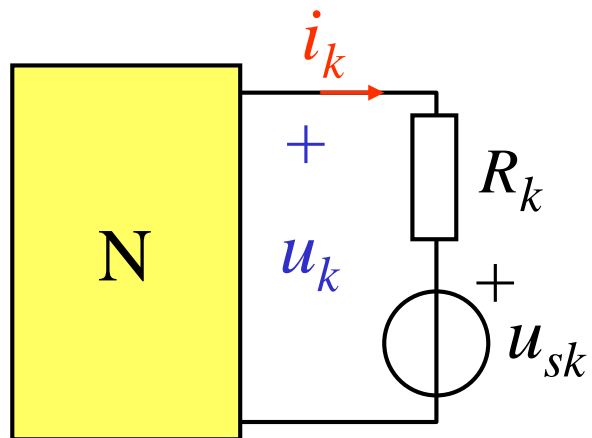
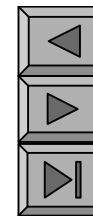




- ()

- KCL KVL

- $(\begin{matrix} u_k(& i_k) \\ &) \end{matrix} \quad u_k(\quad i_k)$



u_k

KCL

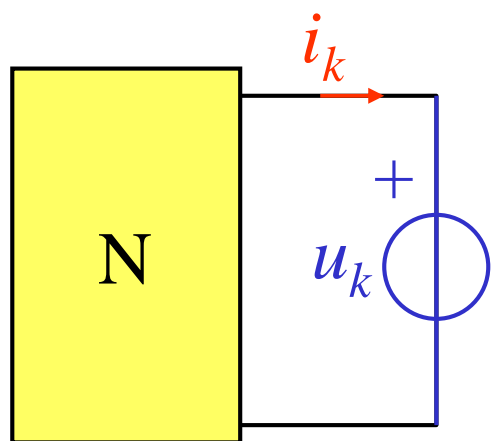
KVL

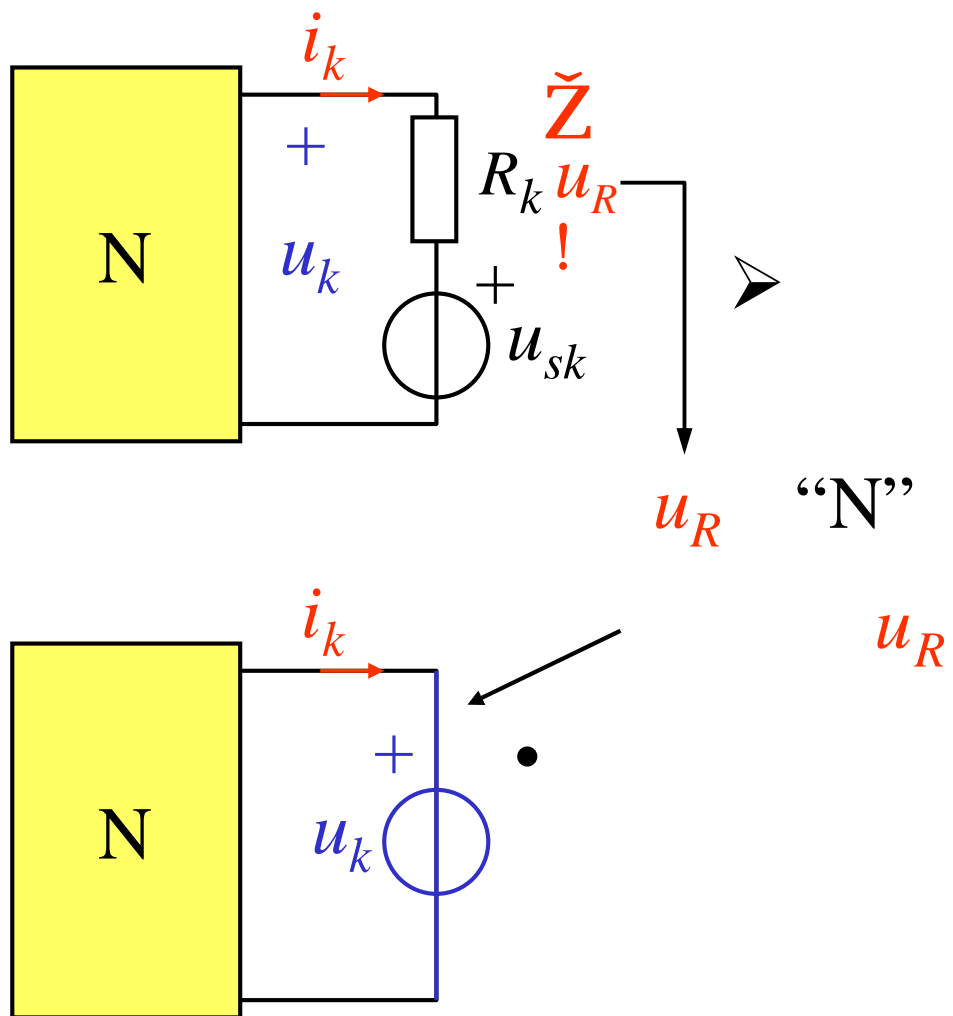
“N”

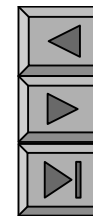
“N”

k

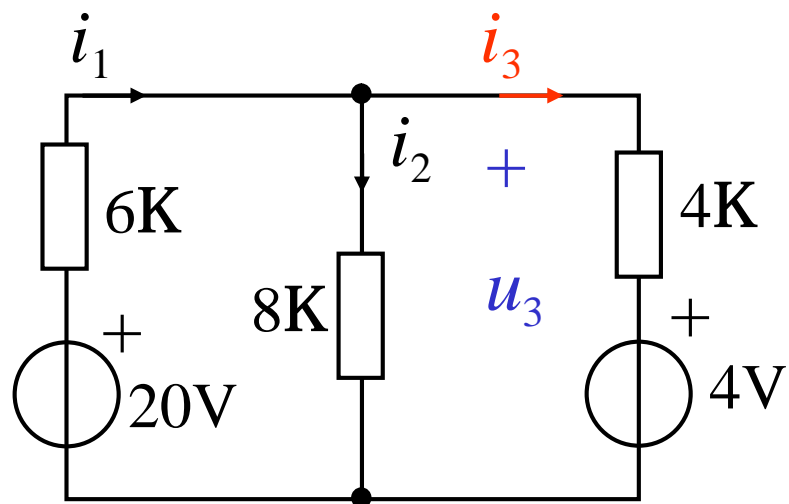
u_k







1



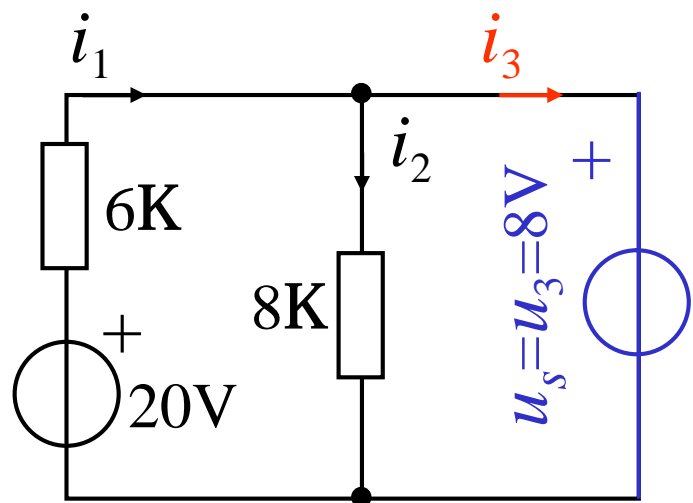
$$u_3 = 1.8V$$

$$i_1 \quad i_2 \quad i_3$$

$$i_2 = 1 \frac{8}{8} = 1.1A$$

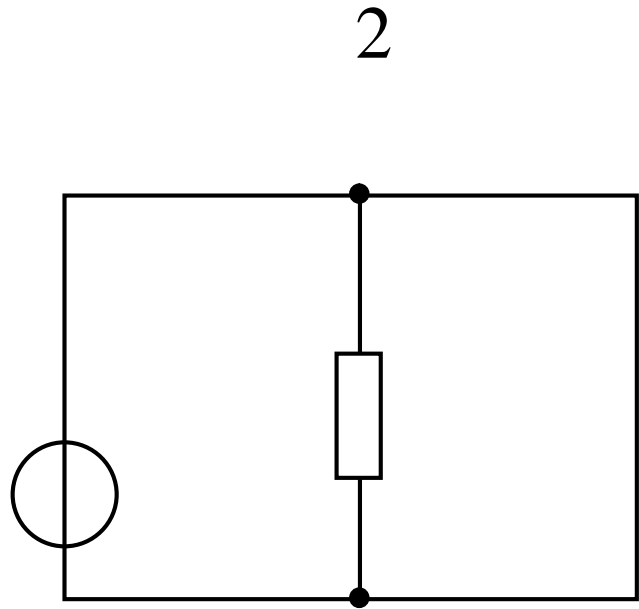
$$i_1 = 1 \frac{20 - 8}{6} = 1.2A$$

$$i_3 = 1 i_1 - i_2 = 1.1A$$



$$8V$$

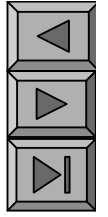
$$u_3$$

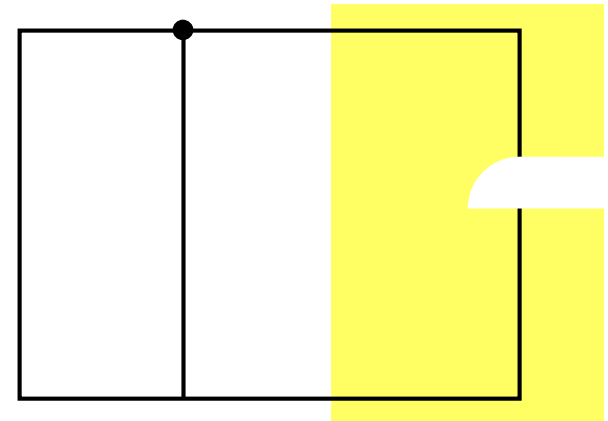
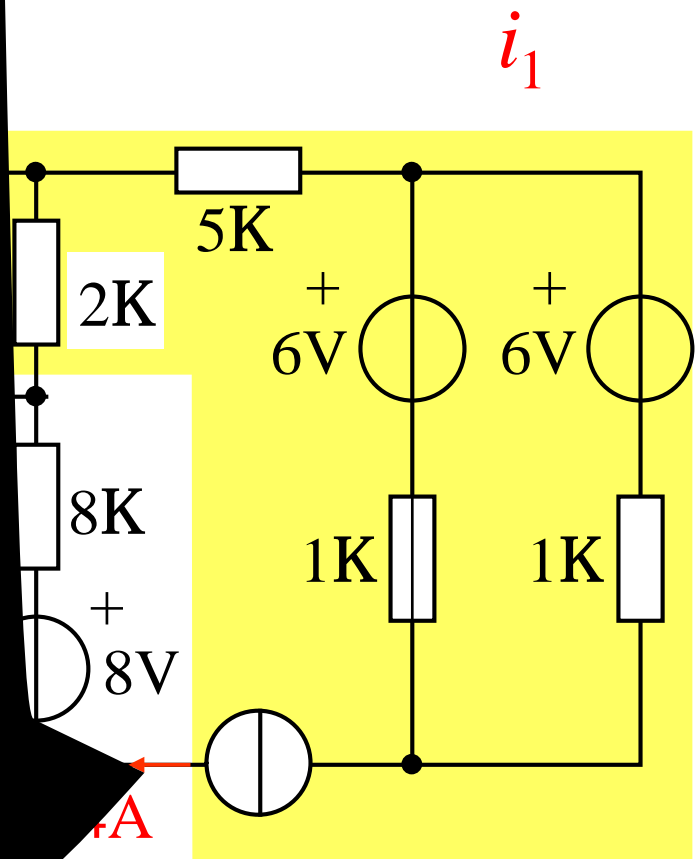
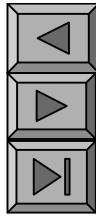


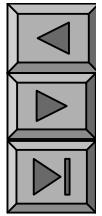
$$i_3 = 1A$$

i_2 u_3

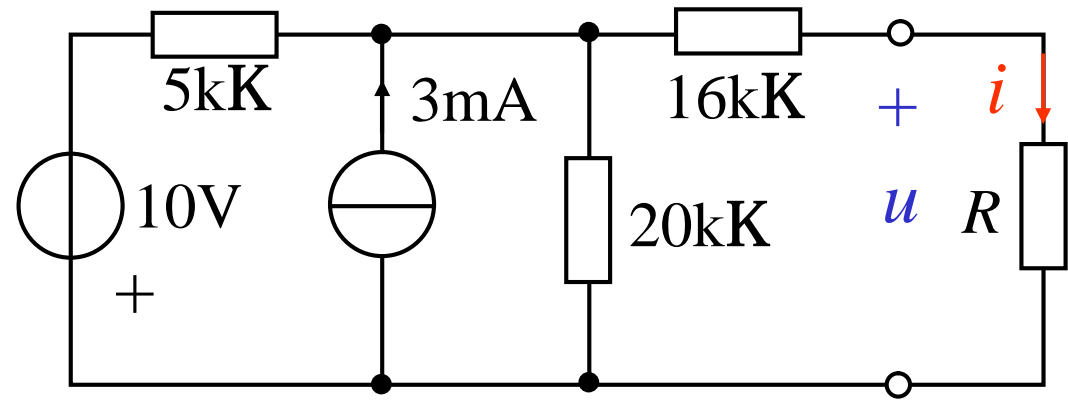
i_1







•



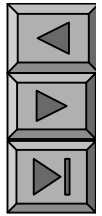
$i=?$

$u=?$

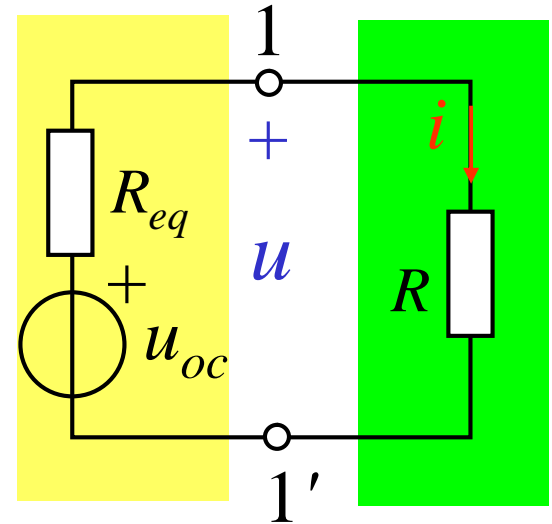
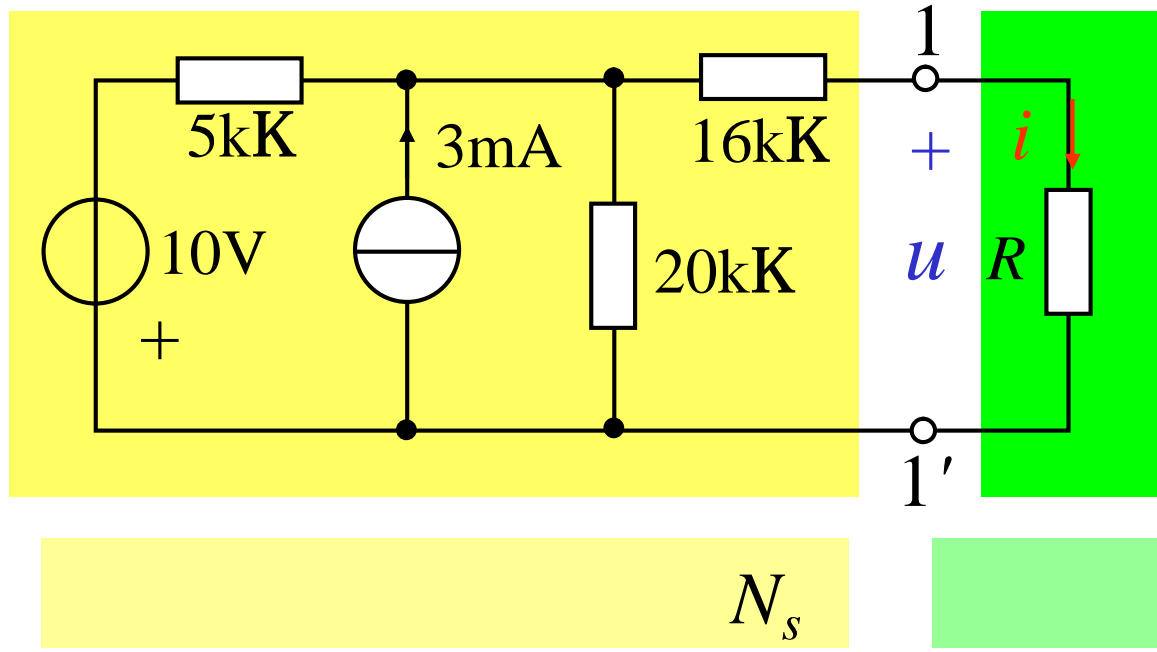
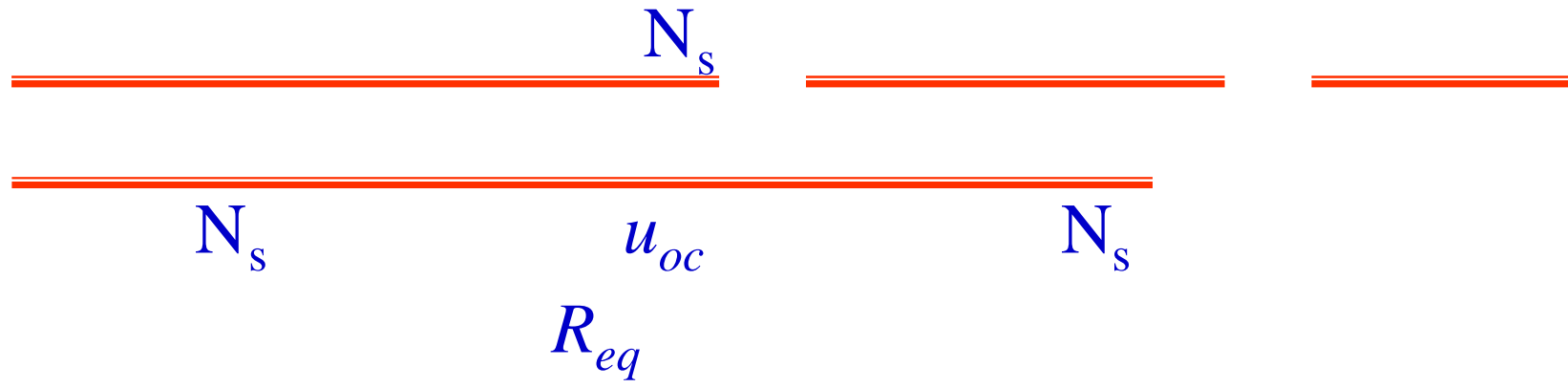
$R=?$

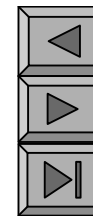
?

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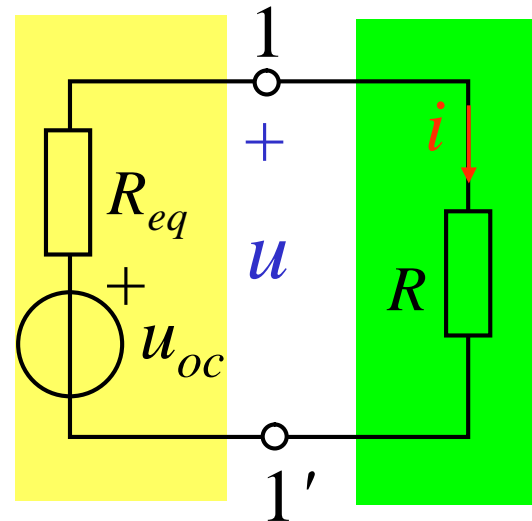
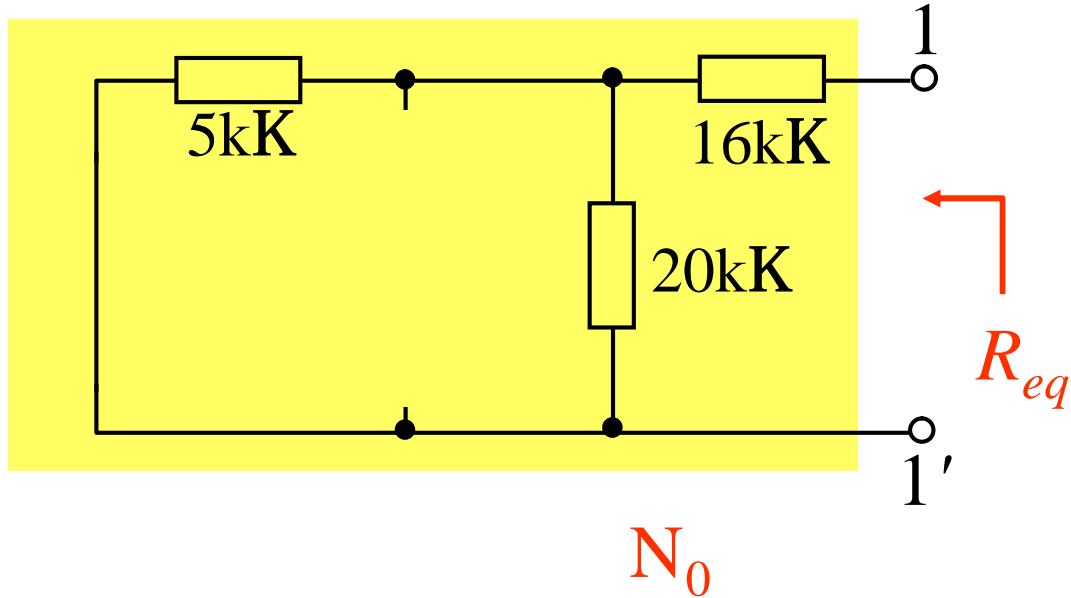
N_s

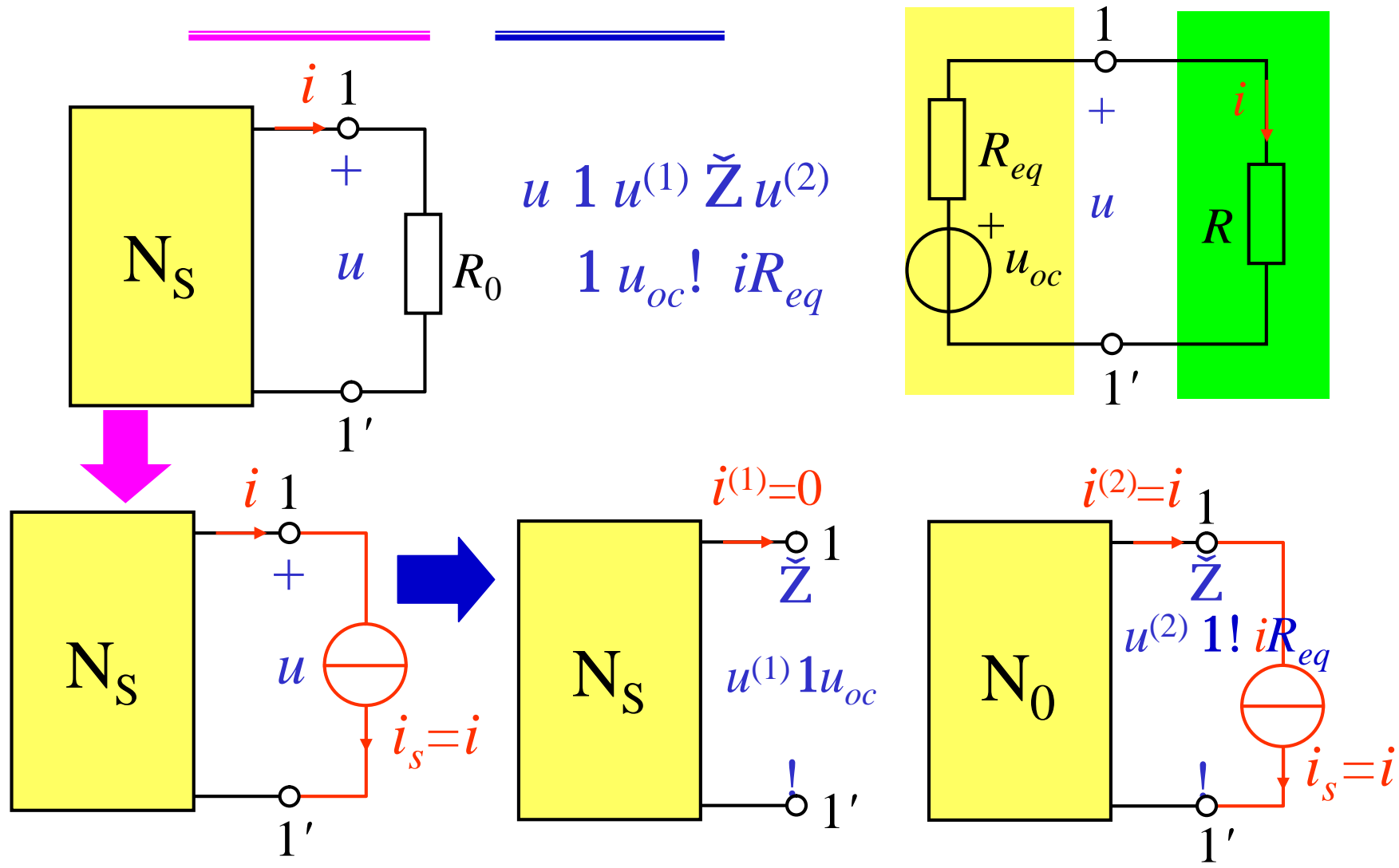
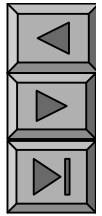
N_s

u_{oc}

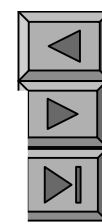
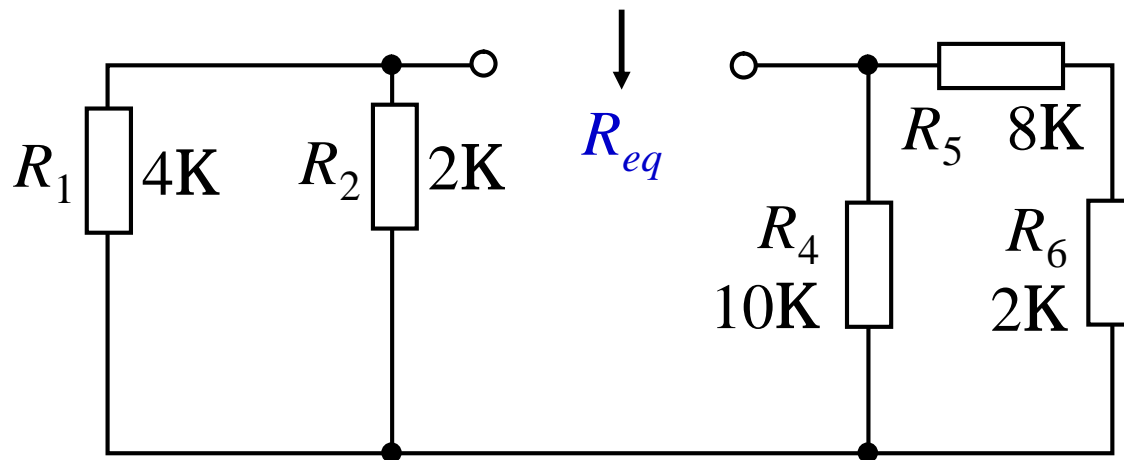
N_s

R_{eq}





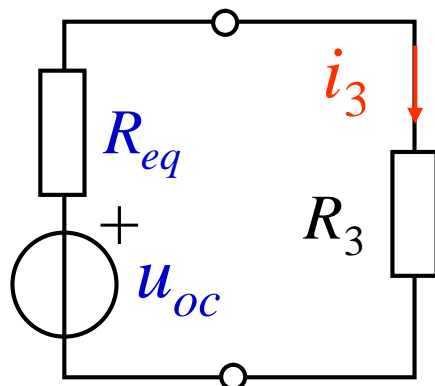
P93 4-5 ¹



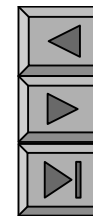
$$u_{oc} = \frac{\frac{u_{s1}}{R_1} + \frac{u_{s2}}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}$$

$$R_{eq} = \frac{4 \cdot 2}{4+2} + \frac{10 \cdot (8+2)}{10+(8+2)} = 1.33 + 5 = 6.33K$$

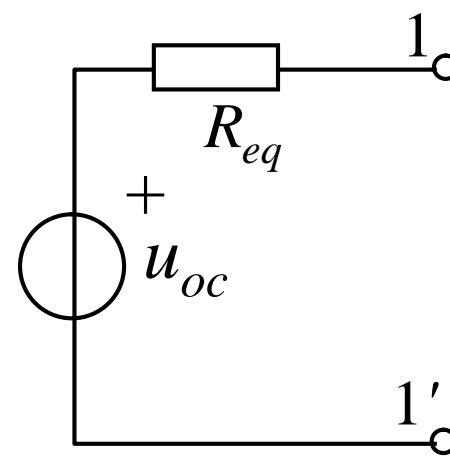
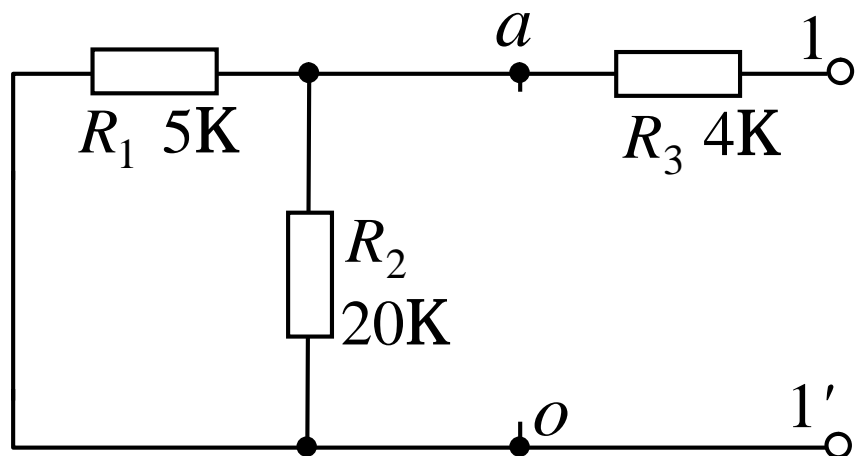
$$= \frac{10+20}{0.25+0.5} = 40V$$



$$i_3 = \frac{40}{6.33+5} = 3.53A$$



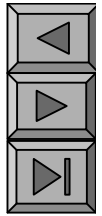
2



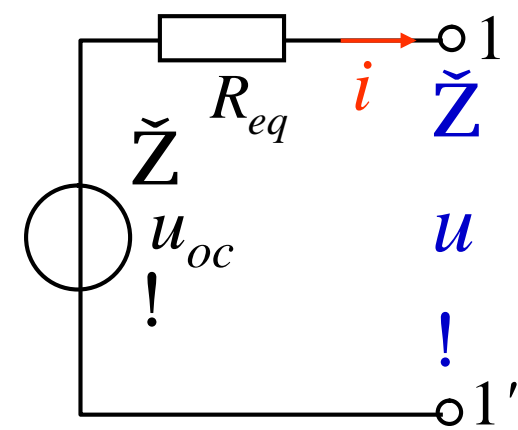
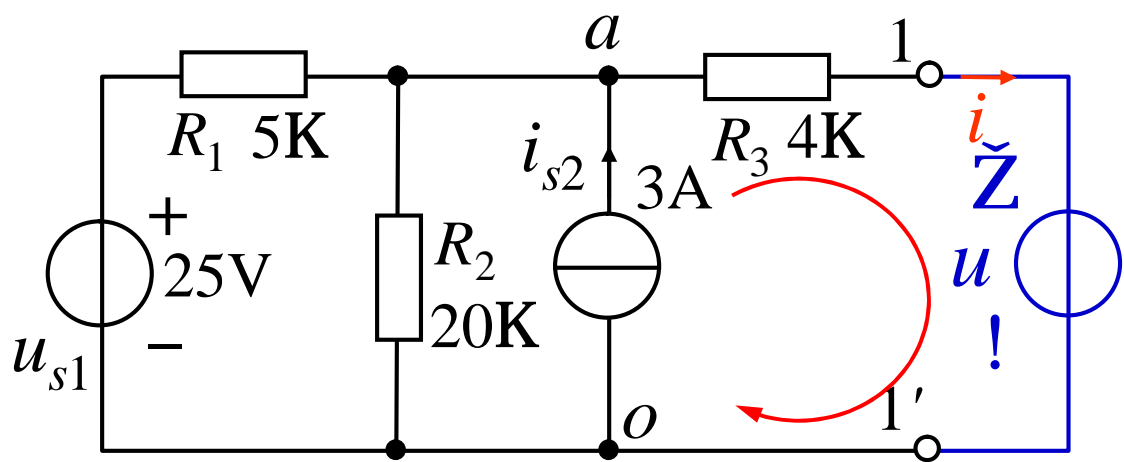
$$u_{oc} = u_{ao}$$

$$u_{oc} = 1 \cdot \frac{\frac{25}{5} \checkmark 3}{\frac{1}{5} \checkmark \frac{1}{20}} = 1 \cdot \frac{100 \checkmark 60}{4 \checkmark 1} = 132V$$

$$R_{eq} = 1 \cdot 4 \checkmark \frac{5 \cdot 20}{5 \checkmark 20} = 1 \cdot 8K$$



2



➤ 2 u u i

$$u_{ao} = \frac{\frac{25}{5} \check{Z} + \check{Z} \frac{u}{4}}{\frac{1}{5} \check{Z} + \frac{1}{20} \check{Z} + \frac{1}{4}} = \frac{u}{2} \check{Z} 16$$

$$\underline{u = 1 u_{oc} + R_{eq} i}$$

$$u_{ao} = 4 i \check{Z} u$$

$$u_{oc} = 132V$$

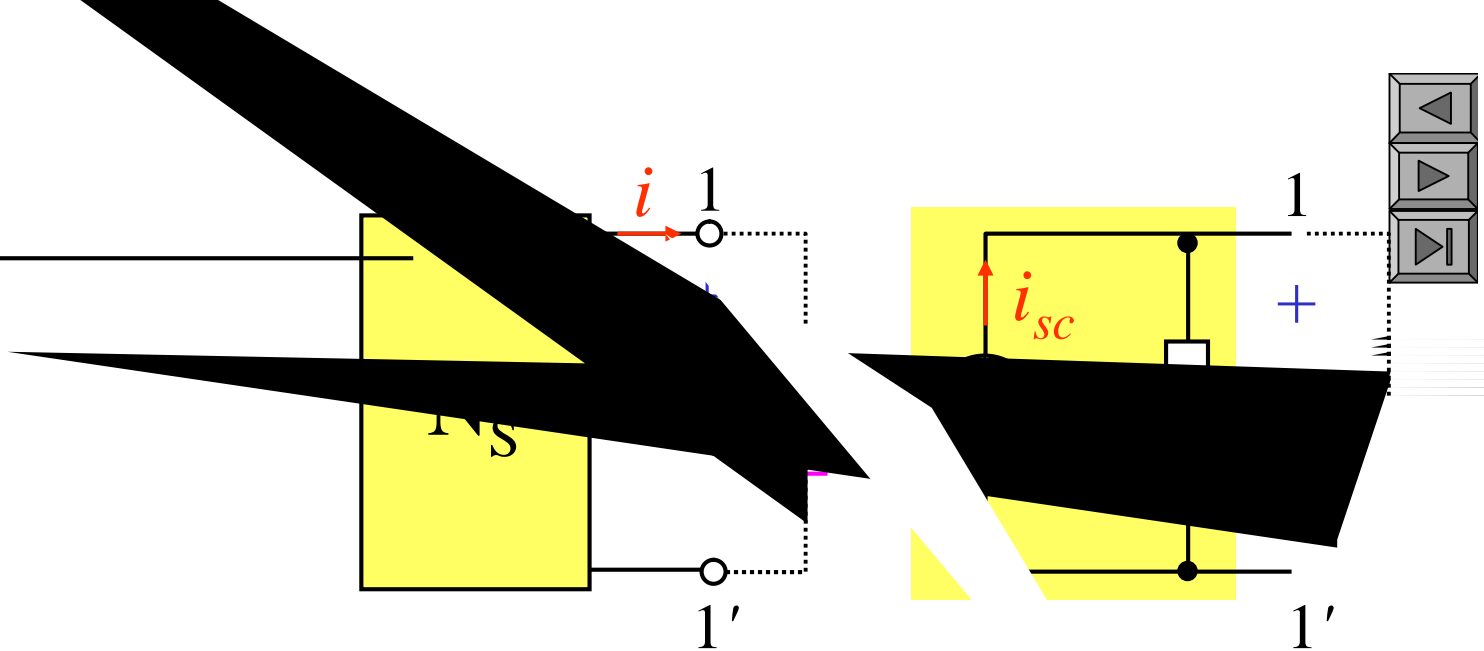
$$u_{ao} = \underline{u = 132 + 8 i}$$

$$R_{eq} = 18K$$

2.



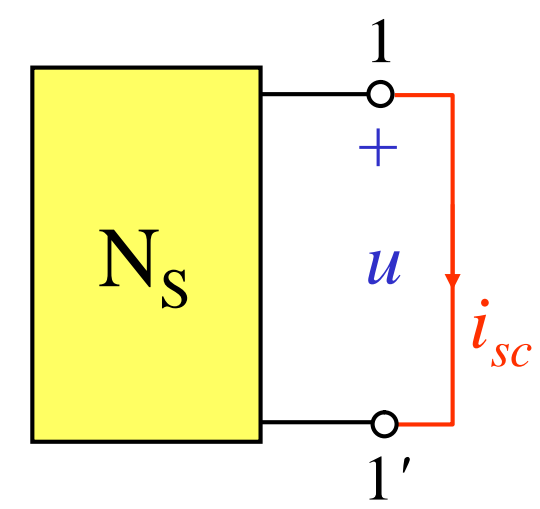
N_s



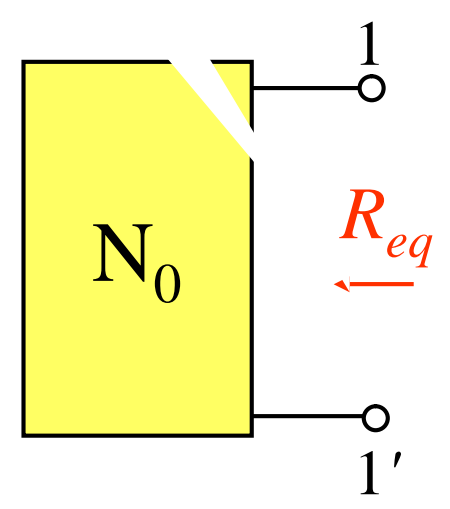
N_s

i_{sc}

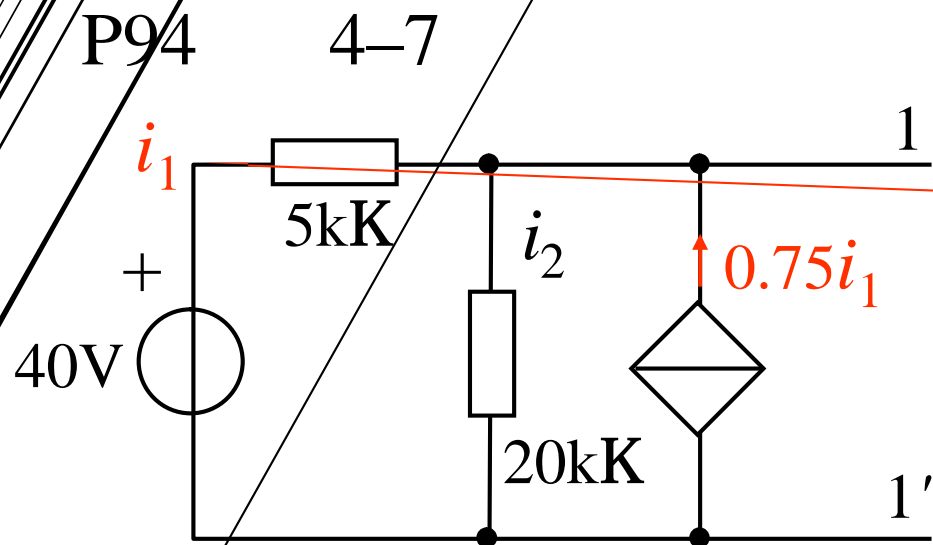
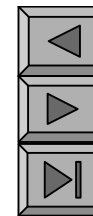
N_s



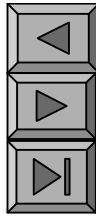
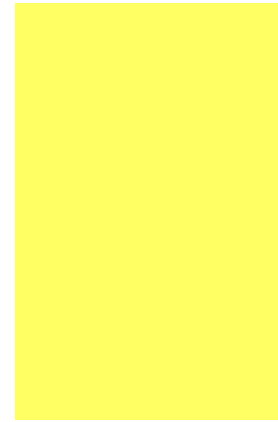
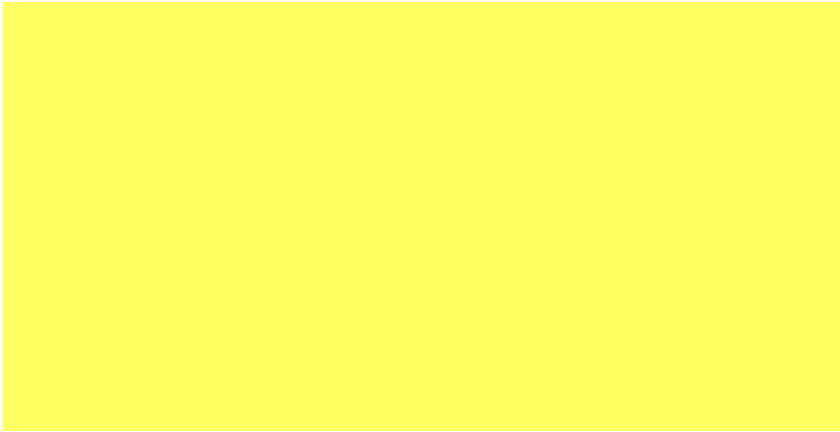
R_{eq}







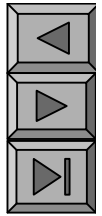
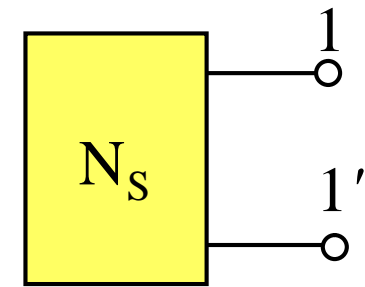
4-4



R *R_{eq}*

1.
 $R_{eq} 10$

N_S



2.

N_S

R_{eq}

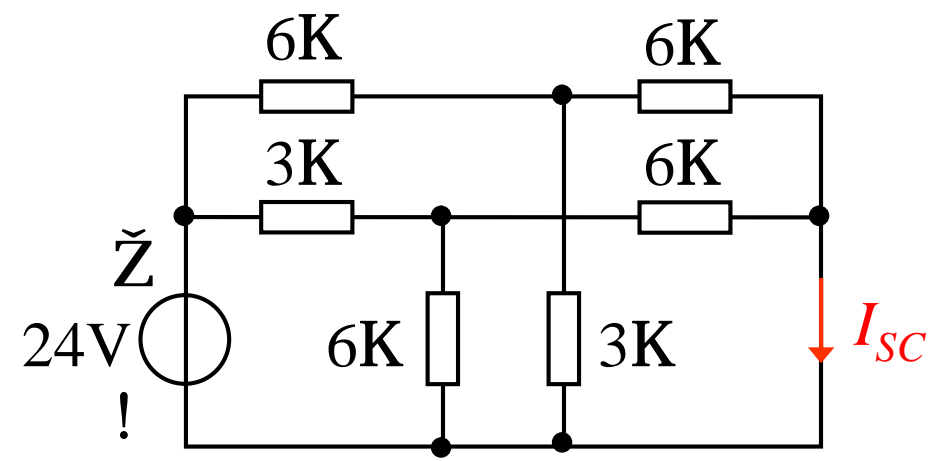
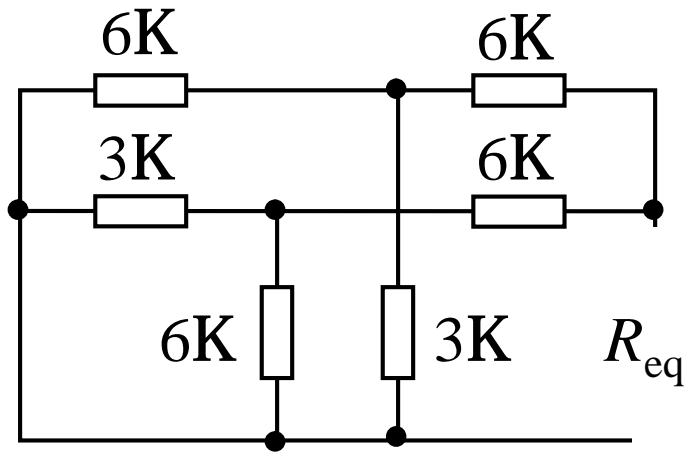
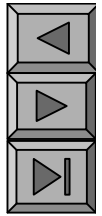
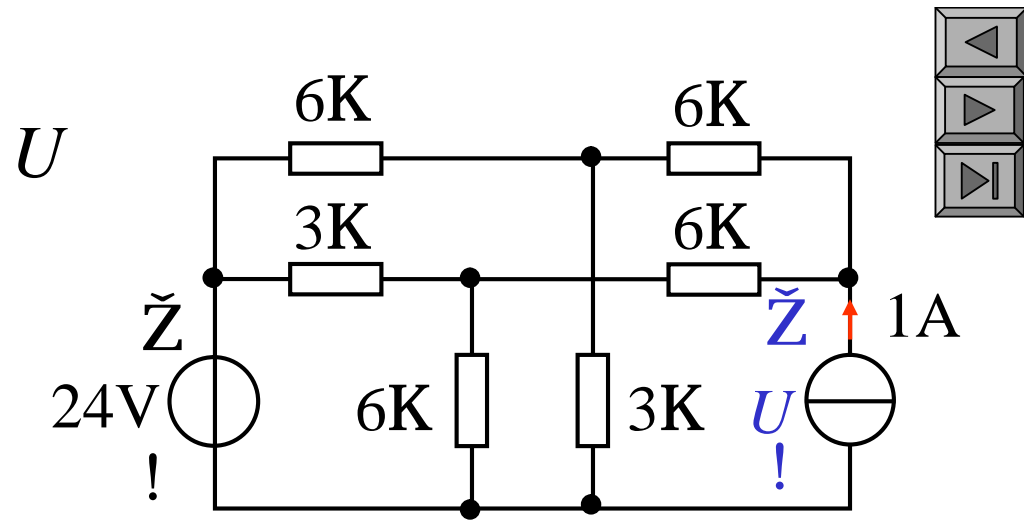
$P110$

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3.

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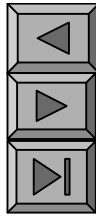
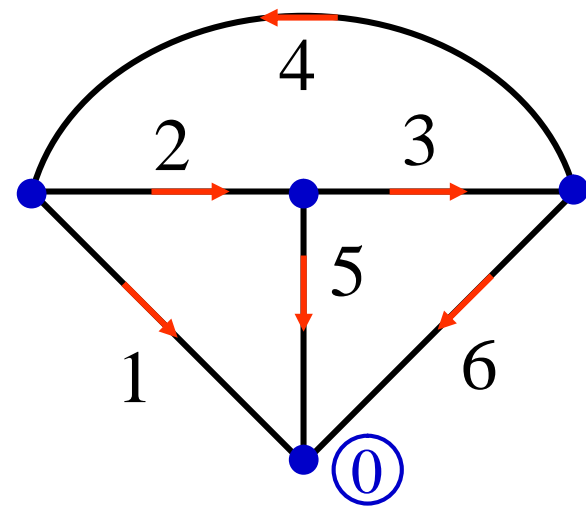
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n b

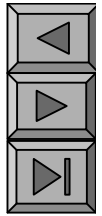
(u_1, u_2, \dots, u_b)
 (i_1, i_2, \dots, i_b)

t

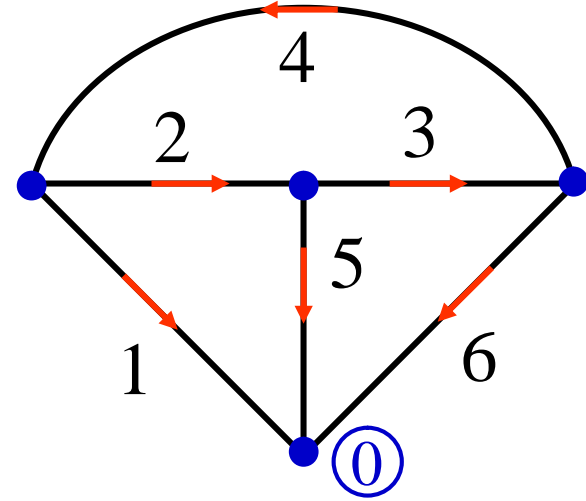
$\sum_{k=1}^b u_k i_k$



$u_{n1} = u_1$
 $u_{n2} = u_5$
 $u_{n3} = u_6$
 $u_2 = u_{n1}$ u_{n2}
 $u_3 = u_{n2}$ u_{n3}
 $u_4 = u_{n3}$ u_{n1}



$$\begin{aligned}
 & \overset{6}{u_k i_k} \quad \mathbf{1} u_1 i_1 \check{Z} u_2 i_2 \check{Z} u_3 i_3 \\
 & \overset{k=1}{\check{Z} u_4 i_4 \check{Z} u_5 i_5 \check{Z} u_6 i_6}
 \end{aligned}$$



$$\begin{aligned}
 & \mathbf{1} u_{n1} i_1 \check{Z}(u_{n1} ! u_{n2}) i_2 \check{Z}(u_{n2} ! u_{n3}) i_3 \\
 & \check{Z}(u_{n3} ! u_{n1}) i_4 \check{Z} u_{n2} i_5 \check{Z} u_{n3} i_6
 \end{aligned}$$

$$\mathbf{1} u_{n1} \underbrace{(i_1 \check{Z} i_2 ! i_4)}_{\check{Z} u_{n2}} \underbrace{(! i_2 \check{Z} i_3 \check{Z} i_5)}_{\check{Z} u_{n3}}$$

$$\check{Z} u_{n3} \underbrace{(! i_3 \check{Z} i_4 \check{Z} i_6)}_{\mathbf{10}}$$

•

$$u_{n1} = u_1$$

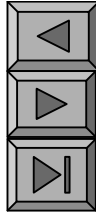
$$u_{n2} = u_5$$

$$u_{n3} = u_6$$

$$u_2 = u_{n1} \quad u_{n2}$$

$$u_3 = u_{n2} \quad u_{n3}$$

$$u_4 = u_{n3} \quad u_{n1}$$



$$\sum_{k=1}^b u_k i_k = 1$$

$$\begin{matrix} u_k & i_k \\ u_k & i_k \end{matrix}$$

$$\sum u_k i_k = 1$$

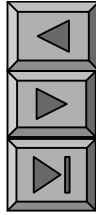
1

•

_____ (power theorem)

•

1



• 2

n b

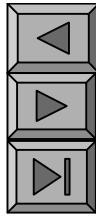
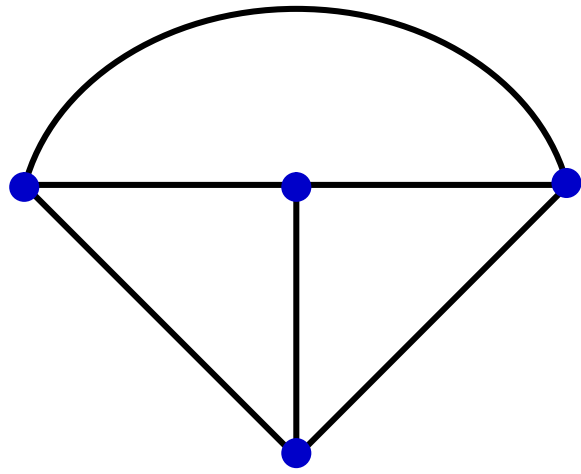
$$\begin{array}{ll} (i_1, i_2, \dots, i_b) & (u_1, u_2, \dots, u_b) \\ (\hat{i}_1, \hat{i}_2, \dots, \hat{i}_b) & (\hat{u}_1, \hat{u}_2, \dots, \hat{u}_b) \end{array}$$

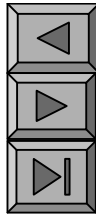
b

t

$$\begin{array}{l} b \\ \hat{u}_k i_k \mathbf{1} \cdot \mathbf{0} \\ k=1 \end{array}$$

$$\begin{array}{l} b \\ u_k \hat{i}_k \mathbf{1} \cdot \mathbf{0} \\ k=1 \end{array}$$





$$\begin{matrix} b \\ \hat{u}_k i_k \mathbf{1} \cdot \mathbf{0} \\ k=1 \end{matrix}$$

$$\begin{matrix} b \\ u_k \hat{i}_k \mathbf{1} \cdot \mathbf{0} \\ k=1 \end{matrix} \longrightarrow$$

$$\hat{u}_k \quad i_k$$

“ $\check{Z} \hat{u}_k i_k$ ”

“ $! \hat{u}_k i_k$ ”

-
-
-

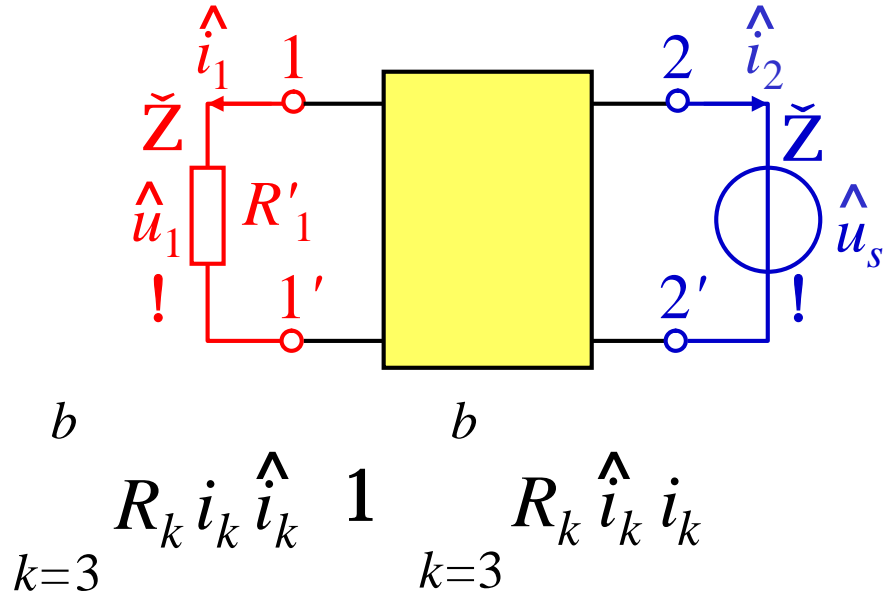
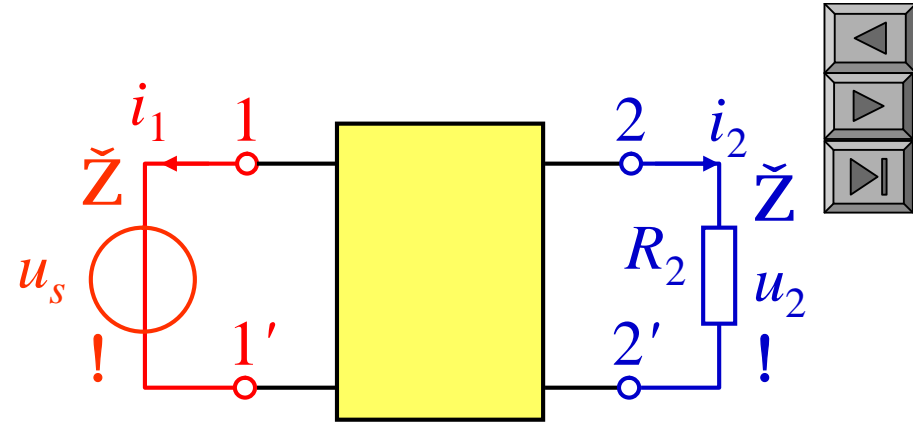
(quasi-power theorem)

2

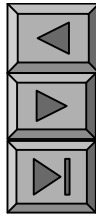
2

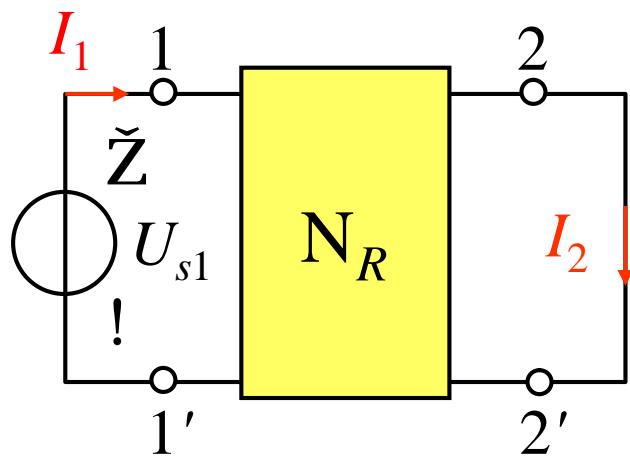
$$\begin{array}{c}
 \begin{array}{c}
 \overset{2}{u_s} \overset{\hat{i}_1}{\check{Z}} \overset{u}{\hat{i}_2} \check{Z} \overset{b}{u_k} \overset{\hat{i}_k}{1} \overset{0}{0} \\
 \overset{k=3}{\quad}
 \end{array} \\
 \begin{array}{c}
 \overset{\hat{u}}{u} \overset{\hat{i}_1}{\check{Z}} \overset{\hat{u}_s}{\hat{i}_2} \check{Z} \overset{b}{\hat{u}_k} \overset{\hat{i}_k}{1} \overset{0}{0} \\
 \overset{k=3}{\quad}
 \end{array} \\
 \begin{array}{c}
 3 \quad b
 \end{array}
 \end{array}$$

$$u_k = R_k i_k \quad \hat{u}_k = R_k \hat{i}_k$$

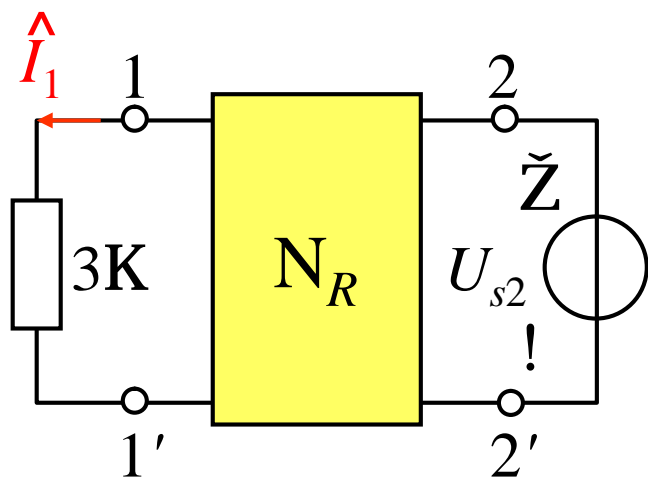


$$\underline{\underline{u_s \hat{i}_1 \check{Z} u_2 \hat{i}_2 \quad 1 \quad \hat{u}_1 \hat{i}_1 \check{Z} \hat{u}_s \hat{i}_2}}$$



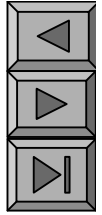


$$\begin{array}{l}
 N_R \\
 U_{s1} \ 120V \\
 I_2 \ 12A \\
 3K \\
 \hat{I}_1 \ 1.4A \\
 I_1 \ 110A \\
 U_{s2} \ 2 \ 2' \\
 1 \ 1' \\
 U_{s2} \ 1
 \end{array}$$



$$\begin{array}{l}
 N_R \\
 2 \\
 U_{s1} \ \hat{I}_1 \ \checkmark \ 0 \\
 I_2 \ 1 \ U_{s2} \ I_2 - (3 \hat{I}_1) \ I_1 \\
 20 \ 4 \ 1 \ 2 \ U_{s2} \ ! \ 3 \ 4 \ 10 \\
 U_{s2} \ 1100V
 \end{array}$$

4 6

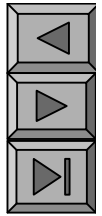
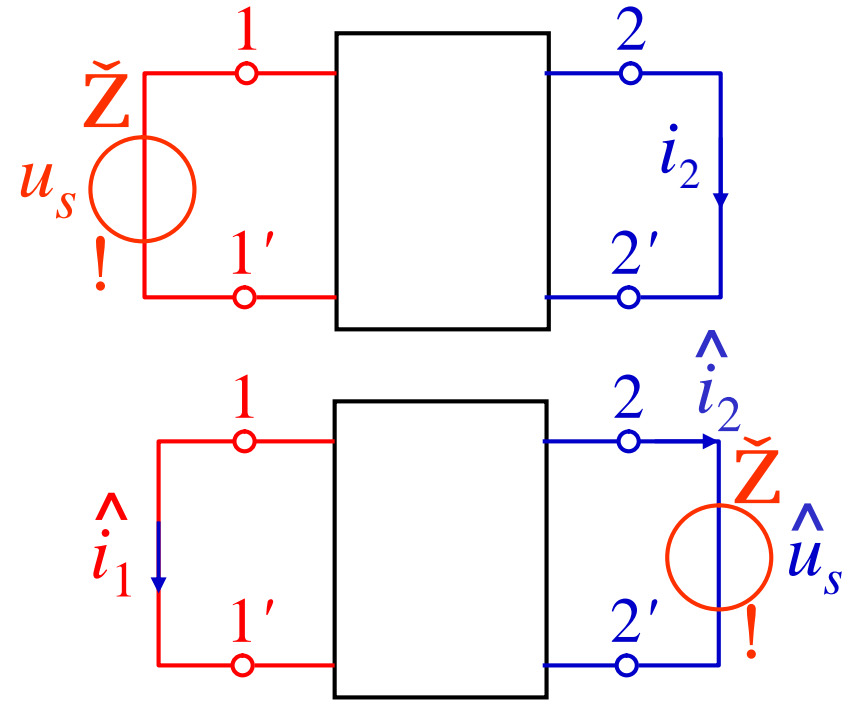


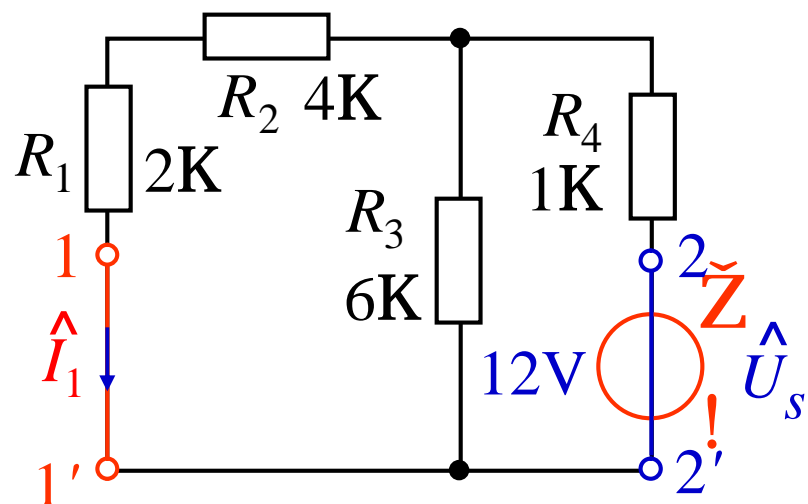
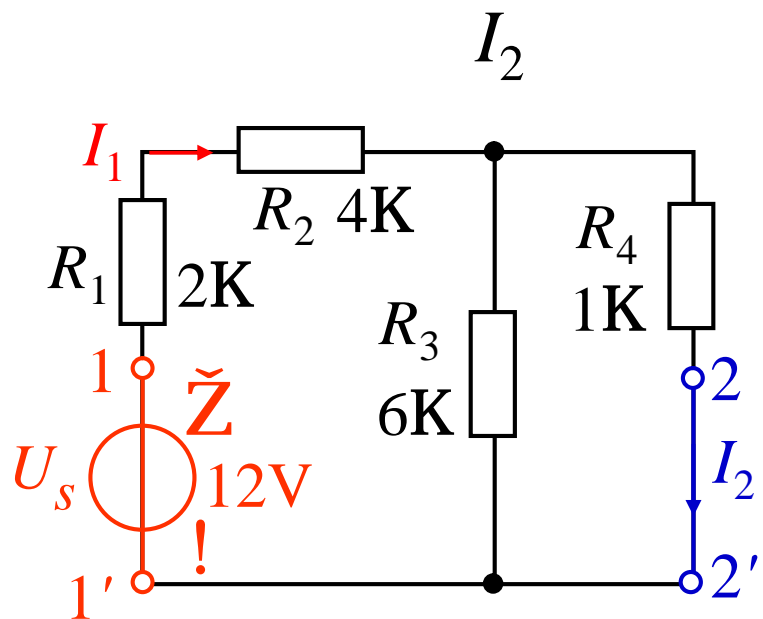
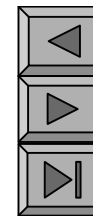
$$R_{ik}^{-1} R_{ki} = G_{ik}^{-1} G_{ki}$$

— (reciprocity)

3.

$$\begin{array}{r}
 2 \\
 u_s \hat{i}_1 \check{Z} u_2 \hat{i}_2 \quad 1 \hat{u}_1 i_1 \check{Z} \hat{u}_s i_2 \\
 R'_1 \quad 1 \quad R_2 \quad 1 \quad 0 \\
 u_2 \quad 1 \quad 0 \quad \hat{u}_1 \quad 1 \quad 0 \\
 \hline
 \frac{i_2}{u_s} \quad 1 \quad \frac{\hat{i}_1}{\hat{u}_s} \\
 u_s \quad 1 \quad \hat{u}_s \quad i_2 \quad 1 \quad \hat{i}_1
 \end{array}$$





$$I_1 = \frac{12}{4 + \frac{6 \cdot 1}{6 + 1}} = \frac{12}{\frac{48}{7}} = \frac{7}{4} \text{ A}$$

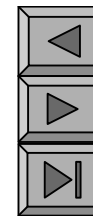
$$I_2 = \frac{6}{6 + 1} \cdot \frac{7}{4} = 1.5 \text{ A}$$

$$\hat{U}_s = U_s = 12 \text{ V}$$

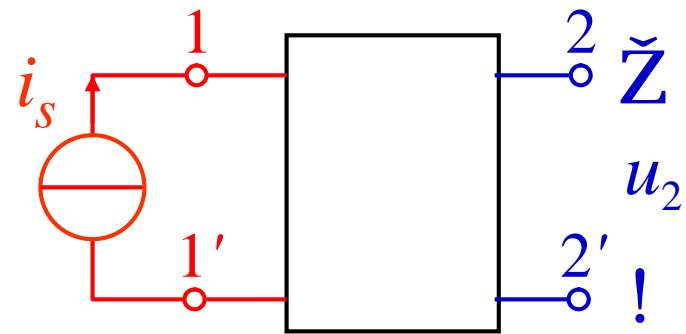
$$I_2 = \hat{I}_1$$

$$R_1 + R_2 = 6 \text{ K} + 1 \text{ K}$$

$$I_2 = \hat{I}_1 = \frac{12}{\frac{6}{2} + 1} = 1.5 \text{ A}$$

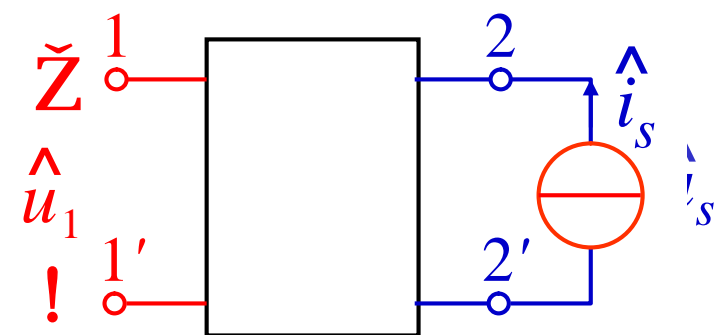


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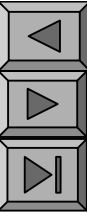
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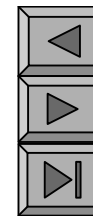
2



$$i_s \hat{u}_1 \check{Z} \quad u_2 \hat{i}_s \check{Z}$$

$$\frac{u_2}{i_s} \mathbf{1} \frac{\hat{u}_1}{\hat{i}_s} \Rightarrow \begin{matrix} i_s \mathbf{1} \hat{i}_s \\ u_2 \mathbf{1} \hat{u}_1 \end{matrix}$$





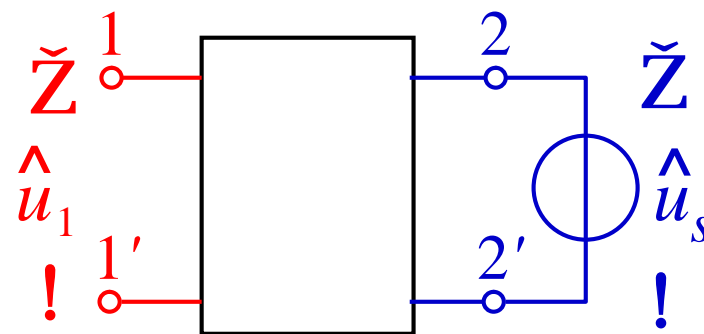
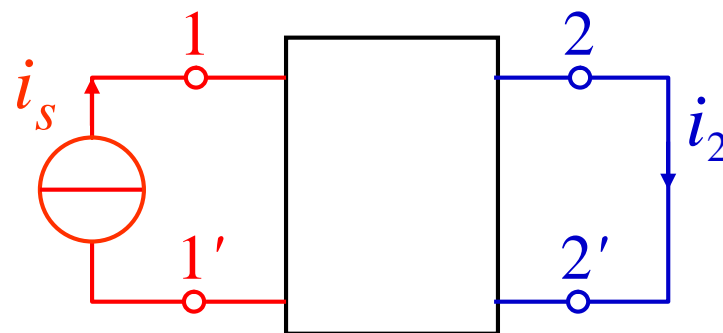
2

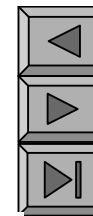
$$! i_s \hat{u}_1 \check{Z} i_2 \hat{u}_s \mathbf{1} \cdot \mathbf{0} \check{Z} \mathbf{0}$$

$$\frac{i_2}{i_s} \mathbf{1} \frac{\hat{u}_1}{\hat{u}_s}$$

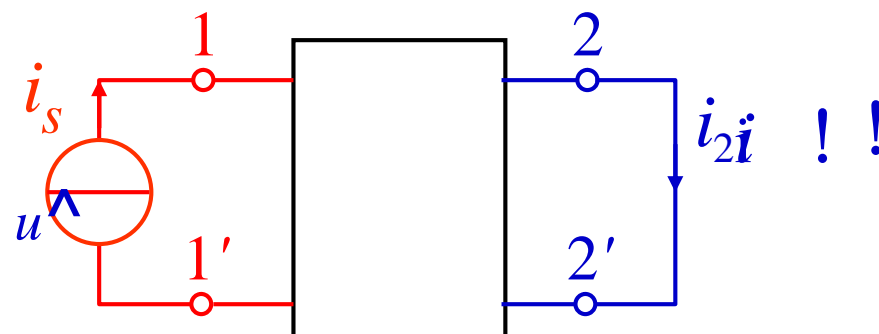
$$i_s \mathbf{1} \hat{u}_s$$

$$i_2 \mathbf{1} \hat{u}_1$$





1.



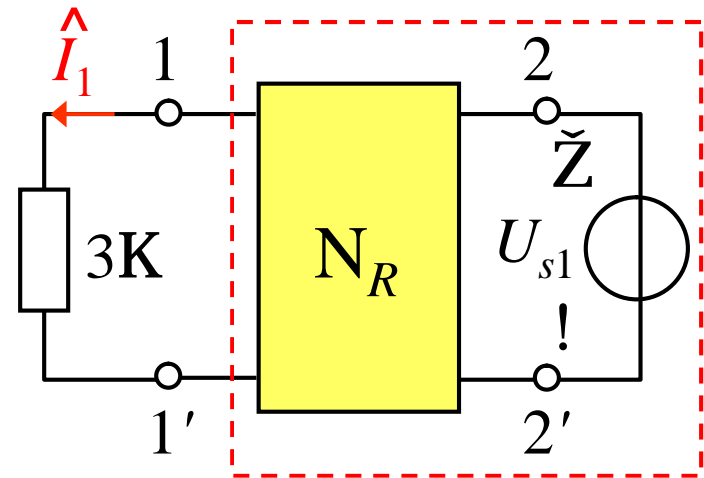
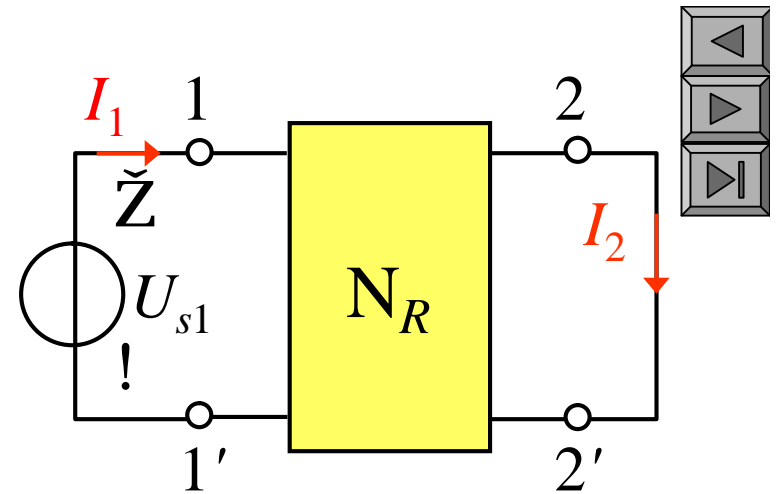
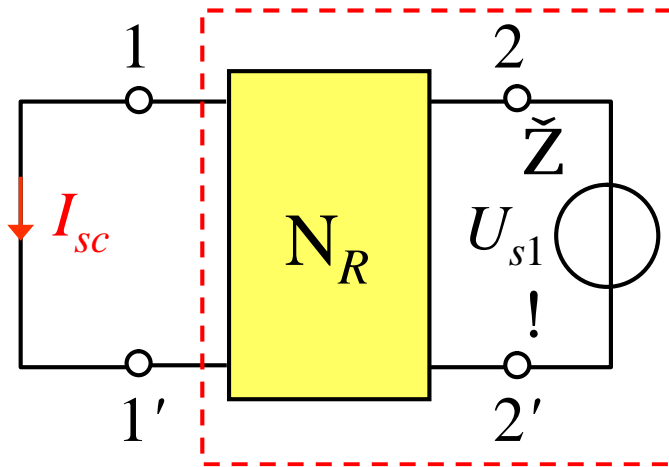
2.

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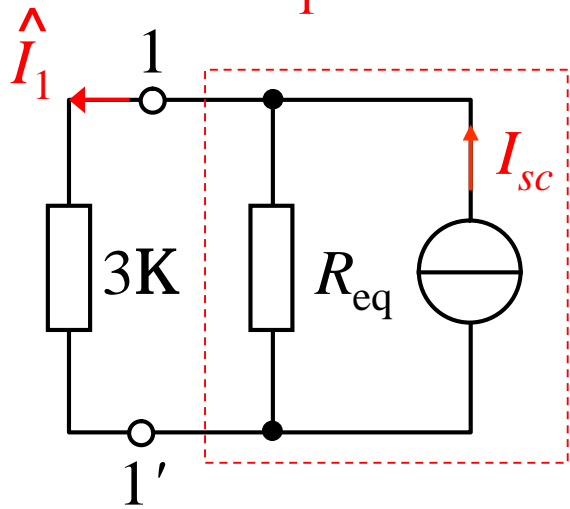
3.

N_R $U_{s1} 120V$
 $I_1 110A$ $I_2 12A$ U_{s1}
 $2 2'$ $1 1'$
 $3K$ $\hat{I}_1 1$

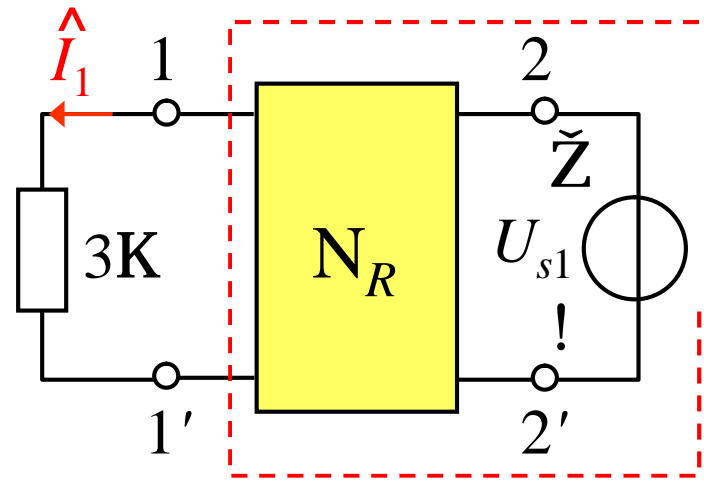
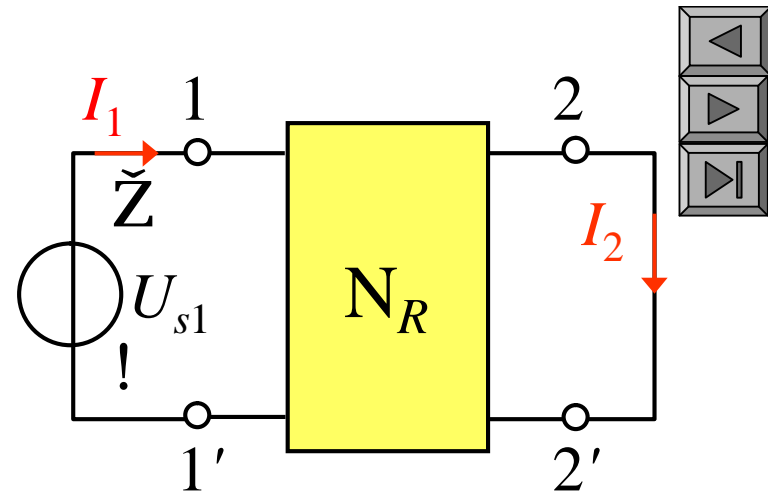


$I_{sc} 1 I_2 1 2A$

$$R_{eq} = \frac{U_{s1}}{I_1} = \frac{20}{10} = 2 \text{ k}\Omega$$

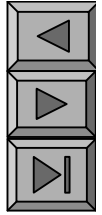


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49

4!7



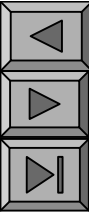
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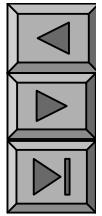
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“

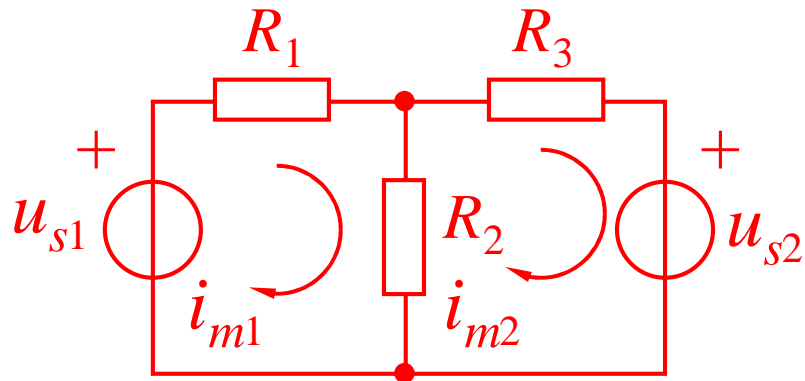
”







• n

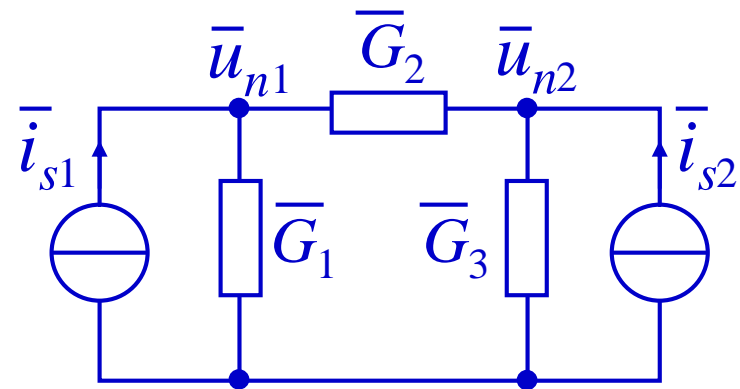


$$(R_1 + R_2) i_{m1} - R_2 i_{m2} = u_{s1}$$

$$R_2 i_{m1} + (R_2 + R_3) i_{m2} = u_{s2}$$

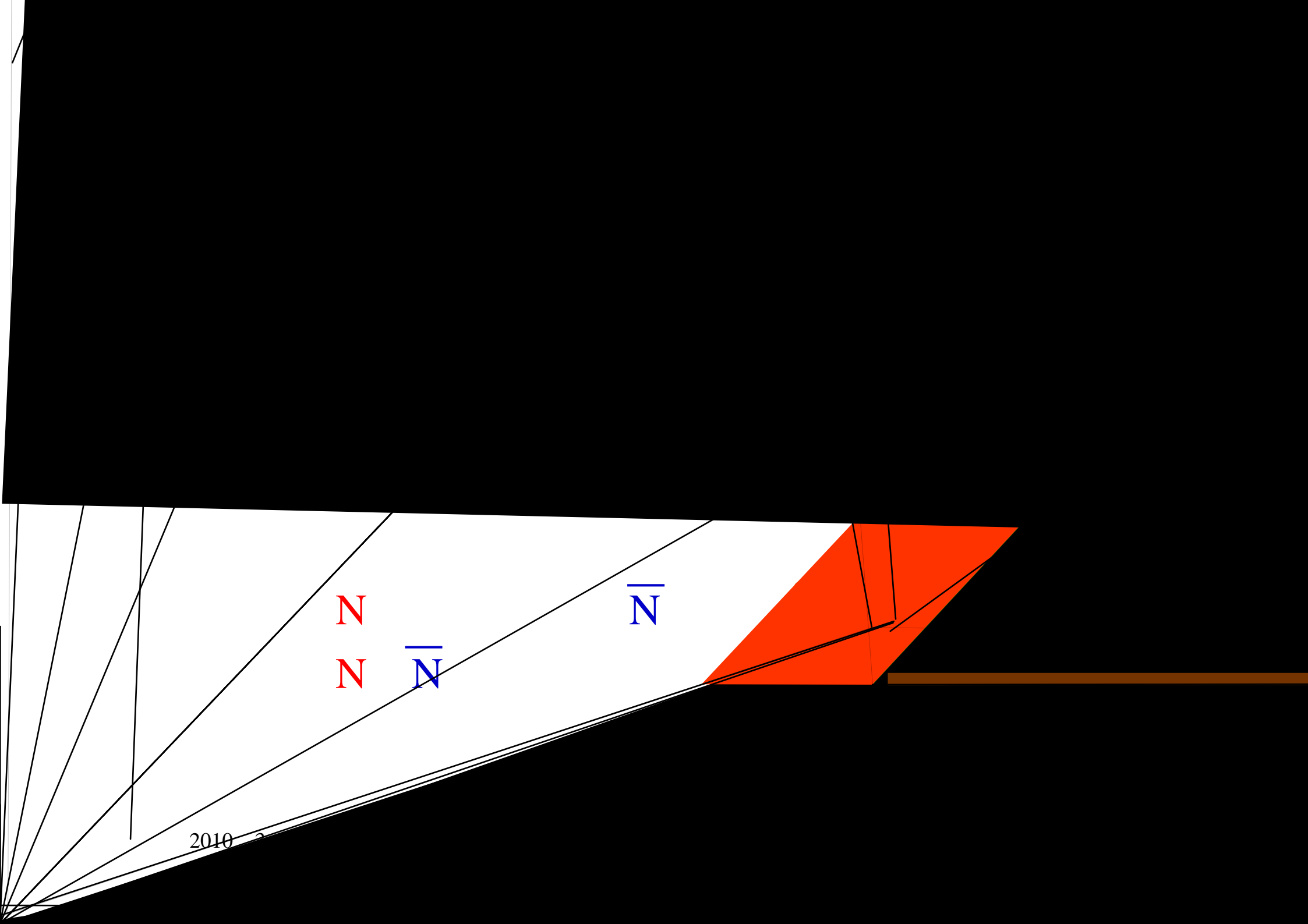
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o



$$(\bar{G}_1 + \bar{G}_2) \bar{u}_{n1} - \bar{G}_2 \bar{u}_{n2} = \bar{i}_{s1}$$

$$\bar{G}_2 \bar{u}_{n1} + (\bar{G}_2 + \bar{G}_3) \bar{u}_{n2} = \bar{i}_{s2}$$



N

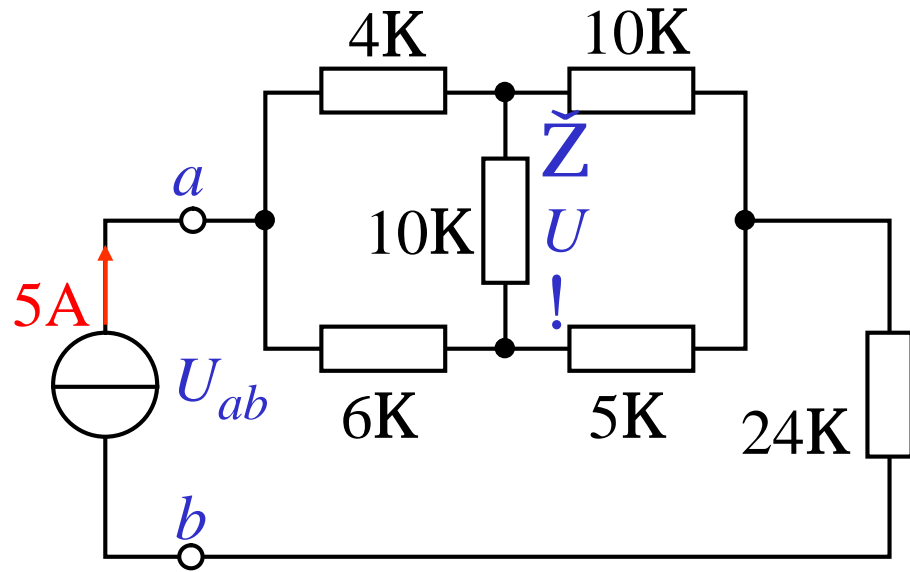
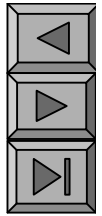
N

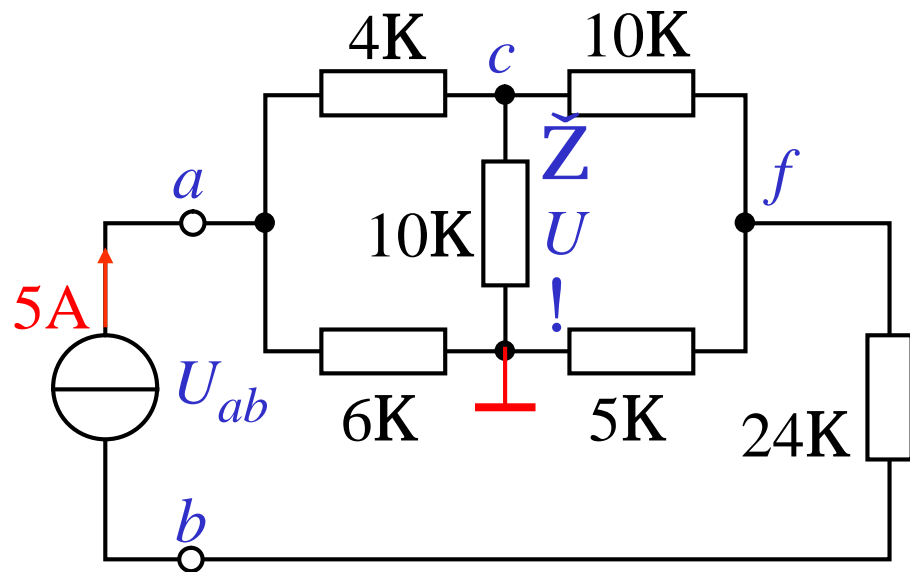
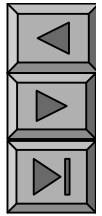
\overline{N}

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U_{ab} (P49 2-8)





$$U_a = 115V, \quad U_c = 15V,$$

$$U_f = 115V$$

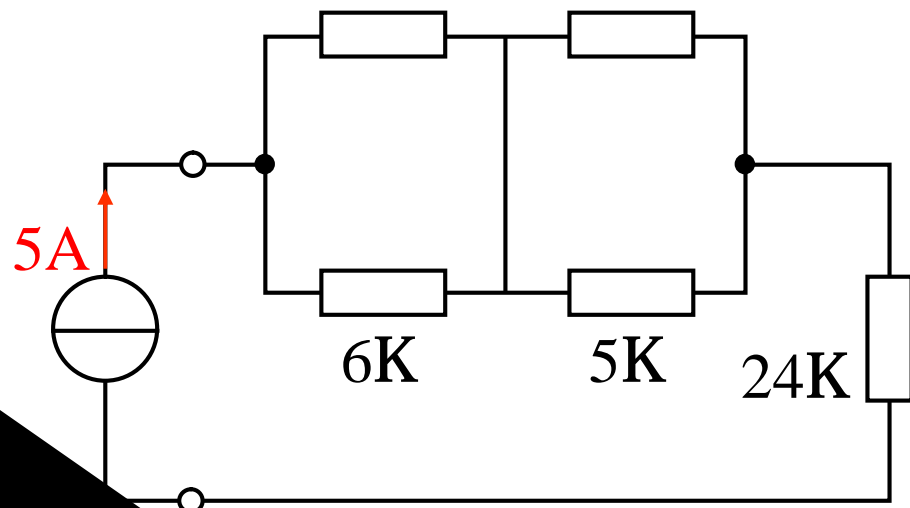
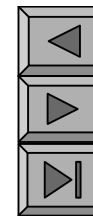
$$U_{ab} = \frac{1}{6} U_a + \frac{1}{5} U_c + \frac{1}{10} U_f$$

$$U_a + U_f = 230V$$

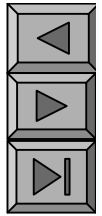
$$U_c = 15V$$

$$\begin{cases} \left(\frac{1}{4} + \frac{1}{6}\right) U_a + \frac{1}{4} U_c = 5 \\ \frac{1}{4} U_a + \left(\frac{1}{4} + \frac{1}{10} + \frac{1}{10}\right) U_c + \frac{1}{10} U_f = 5 \\ \frac{1}{10} U_c + \left(\frac{1}{5} + \frac{1}{10}\right) U_f = 5 \end{cases}$$

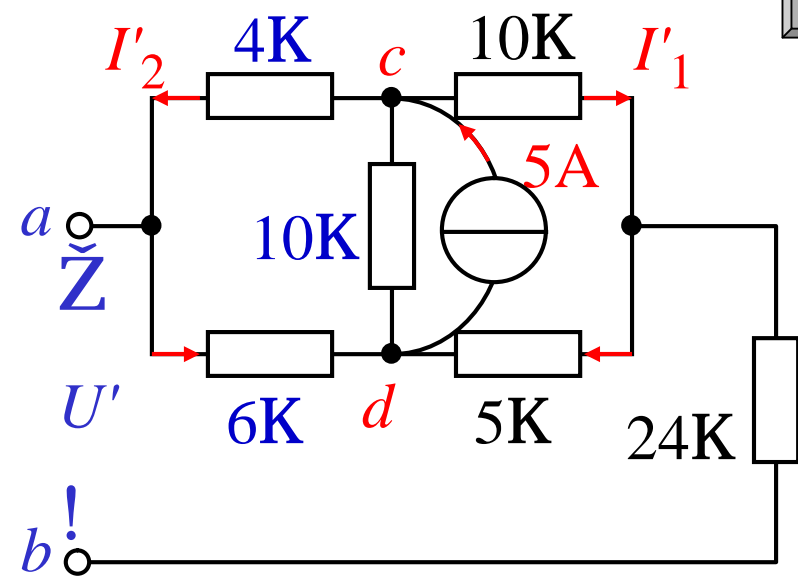
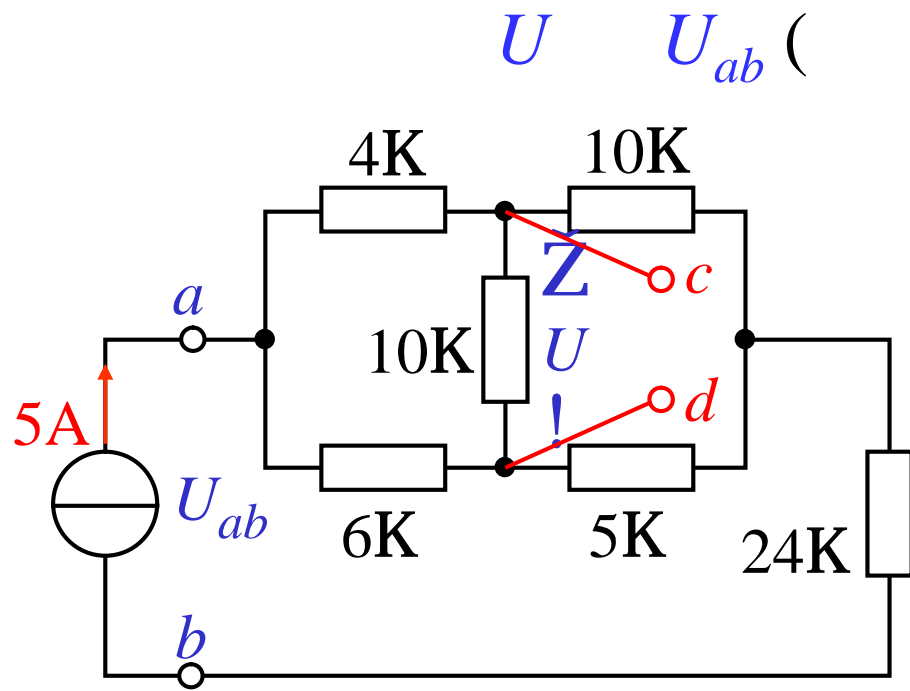
U U_{ab} (P49 2-8)



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P49 2-8)



U_{cd}

$$I'_1 = \frac{5 \times 5}{(10+5)+5} = 1 \frac{2.5}{2} \text{ A}$$

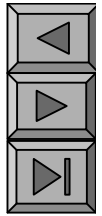
$$I'_2 = \frac{5-1.25}{2} = 1 \frac{3.75}{2} \text{ A}$$

U'

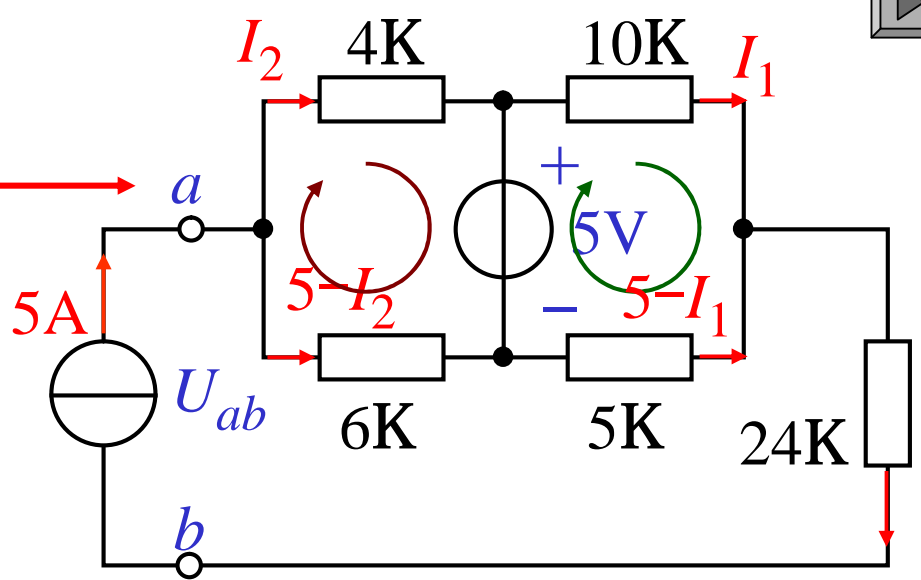
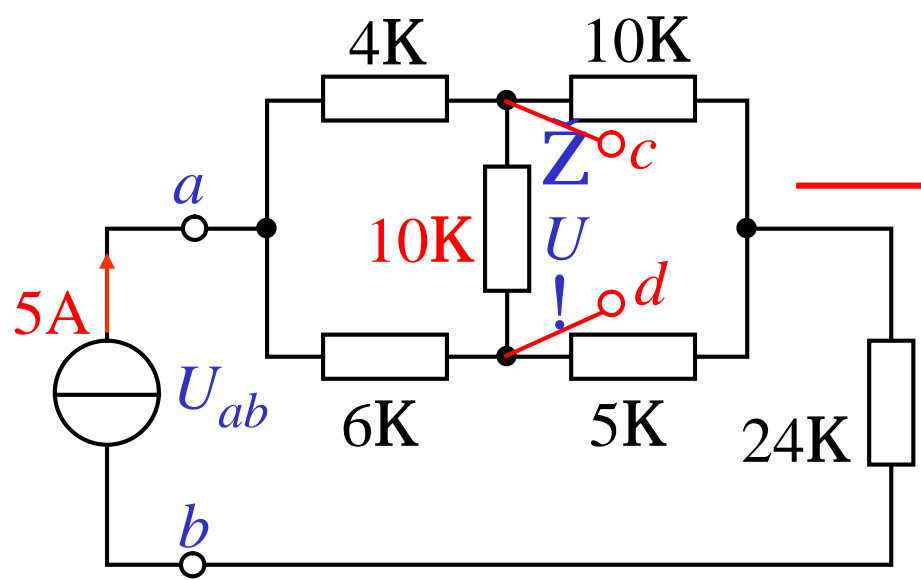
$$U' = 1 \times \frac{3.75}{2} - 4 \times \frac{2.5}{2} = 10$$

$$1 \times 7.5 - 12.5 = 15 \text{ V}$$

$U = 15 \text{ V}$



U_{ab} (P49 2-8)



$U_{ab} = 5V$

10K

$4I_2 + 6(5 - I_2) = 5$

$I_2 = 12.5A$

$10I_1 + 5(5 - I_1) = 15$

$I_1 = 2A$

$U_{ab} = 10I_1 + 5(5 - I_1) = 15V$

$10 \times 2 + 5(5 - 2) = 20 + 15 = 35V$