

1.

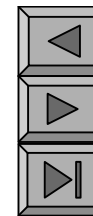
2.

3.

4.

5.

6.

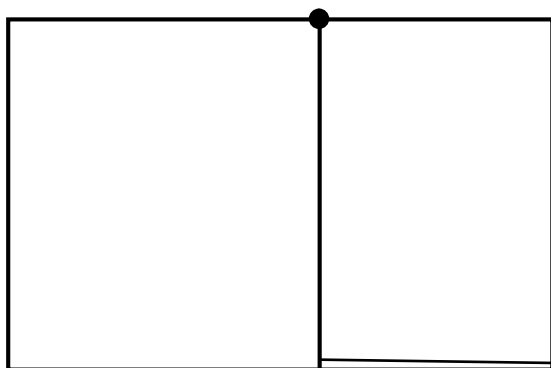


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1.

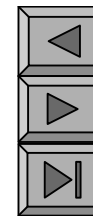
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2.

(1)

□

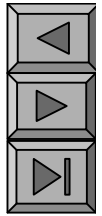
(2)

(3)

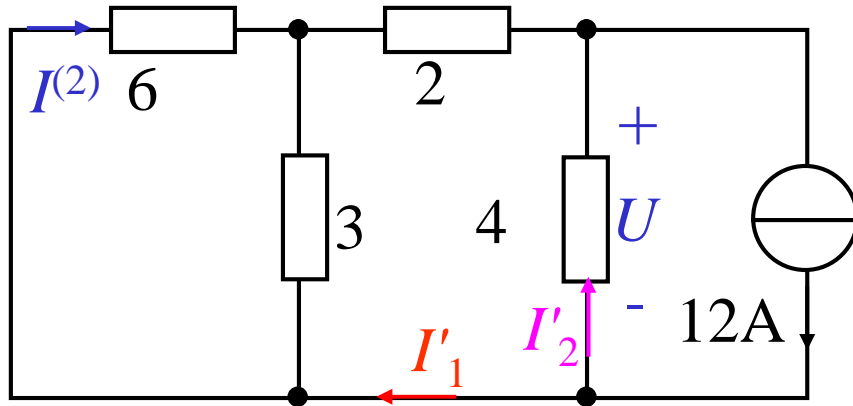
(4)

(5)

“ ”



3. $I \quad U$



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

6 A

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

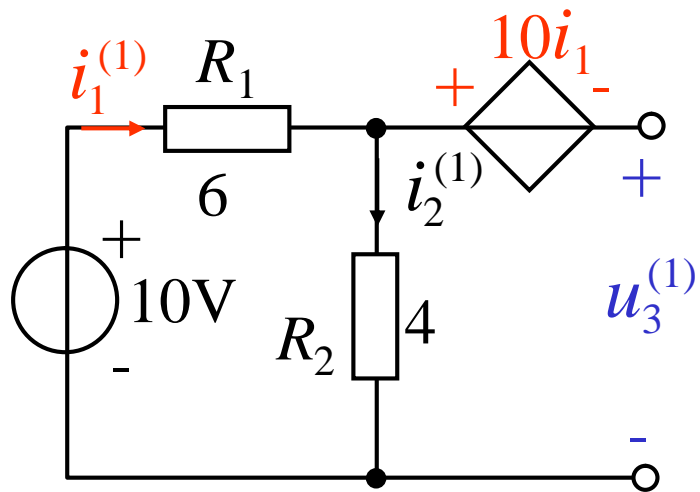
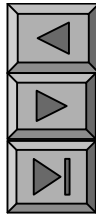
$$I^{(2)} = \frac{3}{6+3} \times 6 = 2 \text{ A}$$

$$U^{(2)} = 6 \times 4 = 24 \text{ V}$$

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

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

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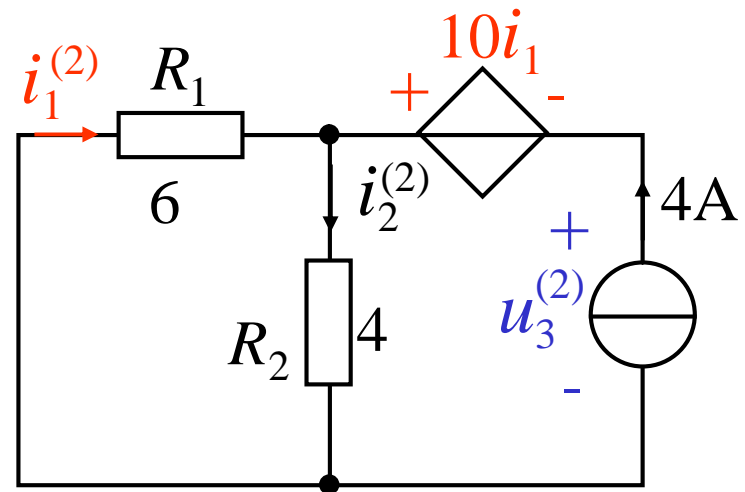
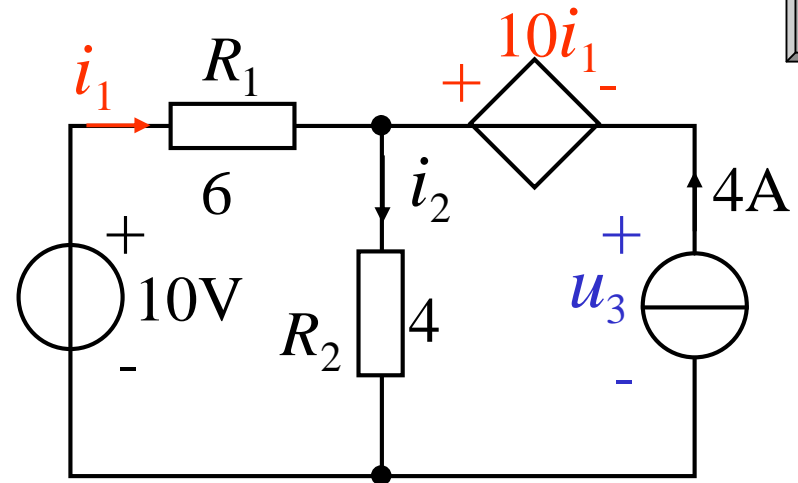


$$i_1^{(1)} \quad i_2^{(1)} \quad \frac{10}{6+4} \quad 1\text{A}$$

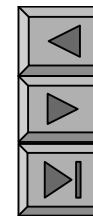
$$u_3^{(1)} = 10i_1^{(1)} - 4i_2^{(1)} = 6\text{V}$$

$$i_1^{(2)} = \frac{4}{6+4} \times 4 = 1.6\text{A}$$

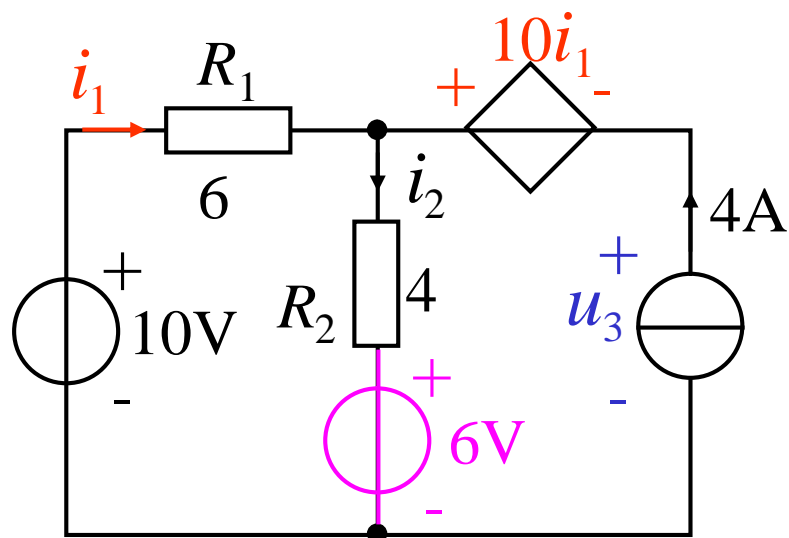
$$u_3^{(2)} = 10i_1^{(2)} - i_1^{(2)} = 25.6\text{V}$$



$$u_3 = 6 + 25.6 = 19.6\text{V}$$



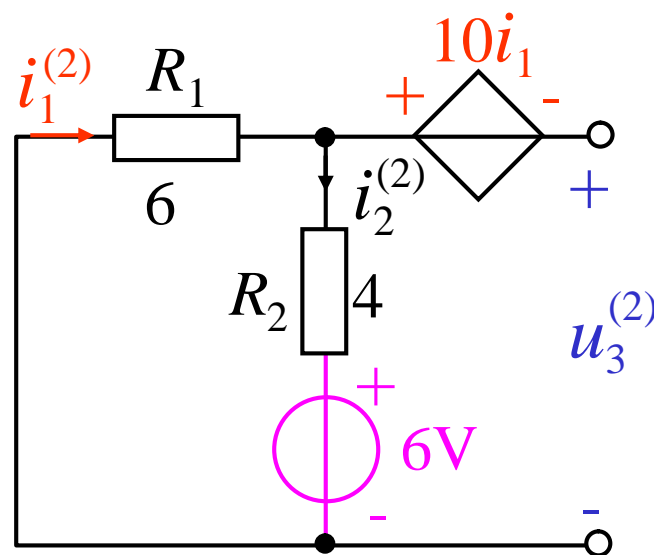
P86 4-3



10V

4A

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

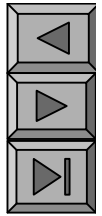


$$i_1^{(2)} \quad i_2^{(2)} \quad \frac{-6}{6+4} \quad 0.6\text{A}$$

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

$$= -16 \times (-0.6) = 9.6\text{V}$$

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



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

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

- $(K \quad) \quad (\quad) \quad K$
 K
-
- K
-
-

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" "

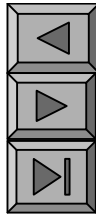
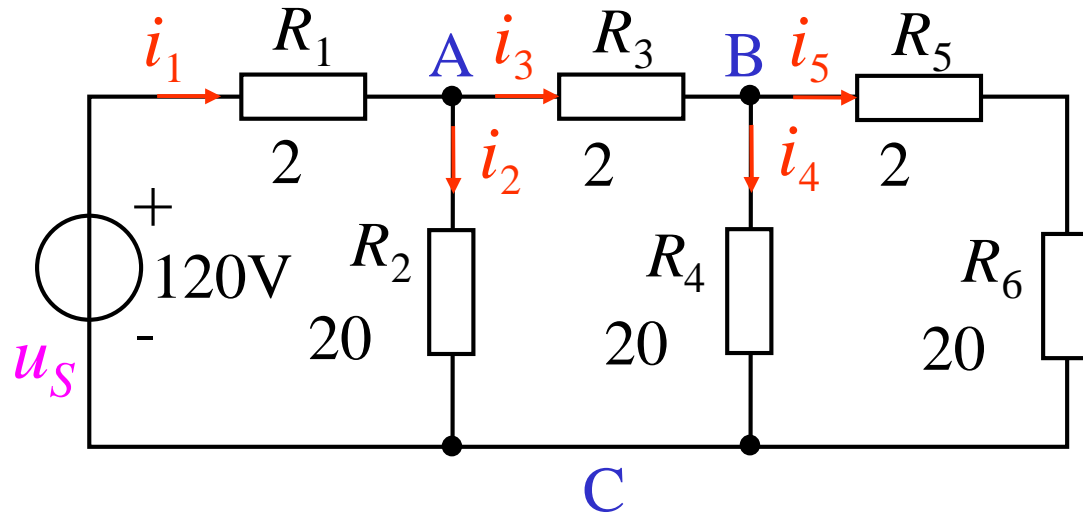
i_5 i'_5 1A

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

$$i'_4 = \frac{u'_{BC}}{R_4} = \frac{22}{20} = 1.1A$$

$$i'_3 = i'_4 + i'_5 = 2.1A$$

$$u'_{AC} = R_3 i'_3 = \frac{22}{2}$$

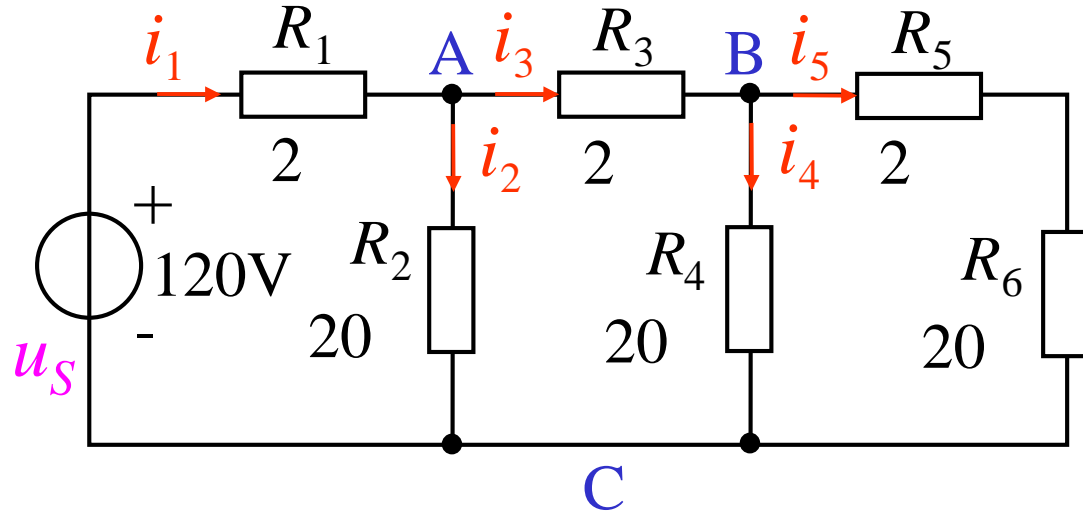


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" "

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

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



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

$$K = 3.634$$

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

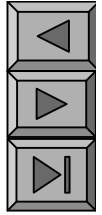
$$i_2 = K i'_2 = 4.76\text{A}$$

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

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

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

§ 4-2



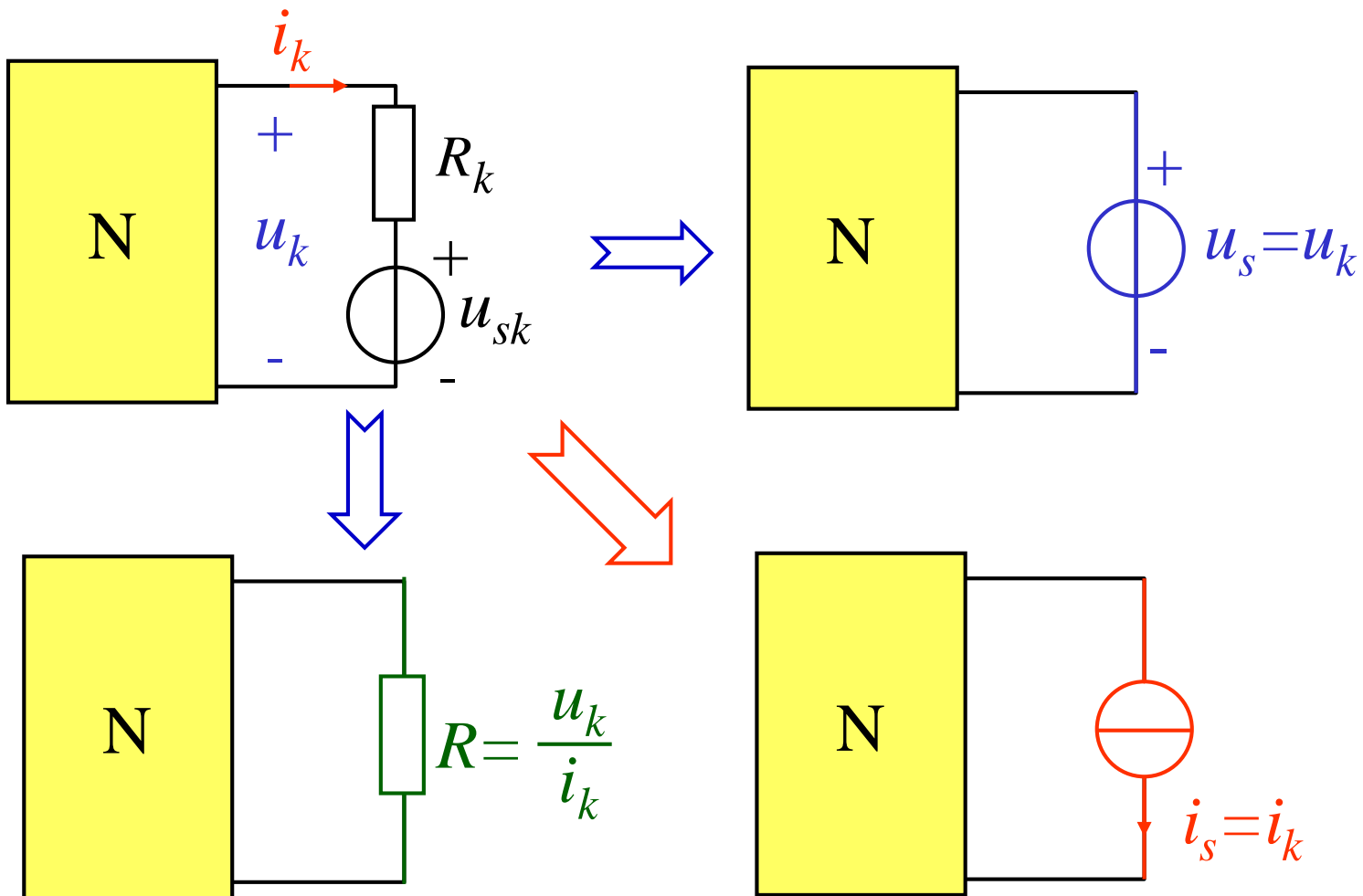
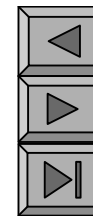
- u_k i_k k

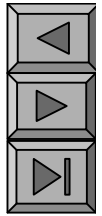
(1) u_k

(2) i_k

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

-

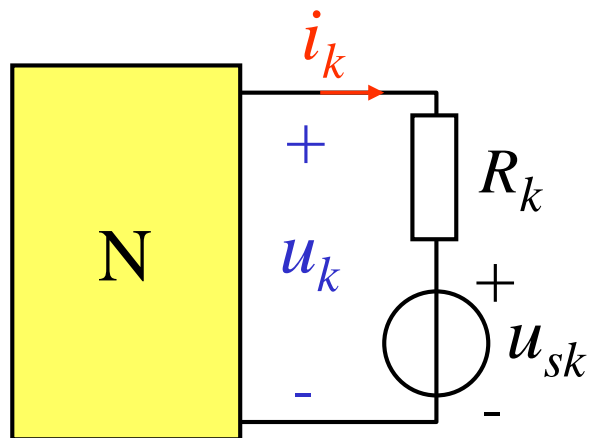
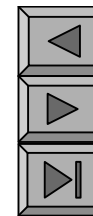




- ()

- KCL KVL

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



u_k

KCL

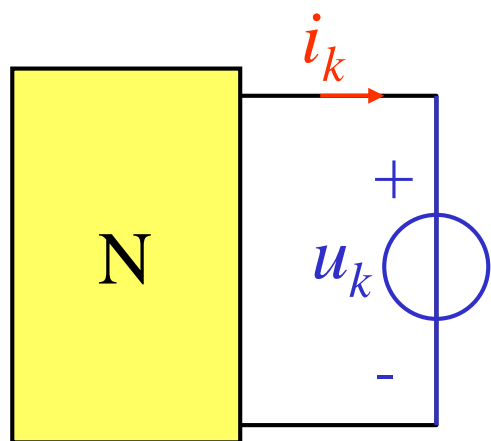
KVL

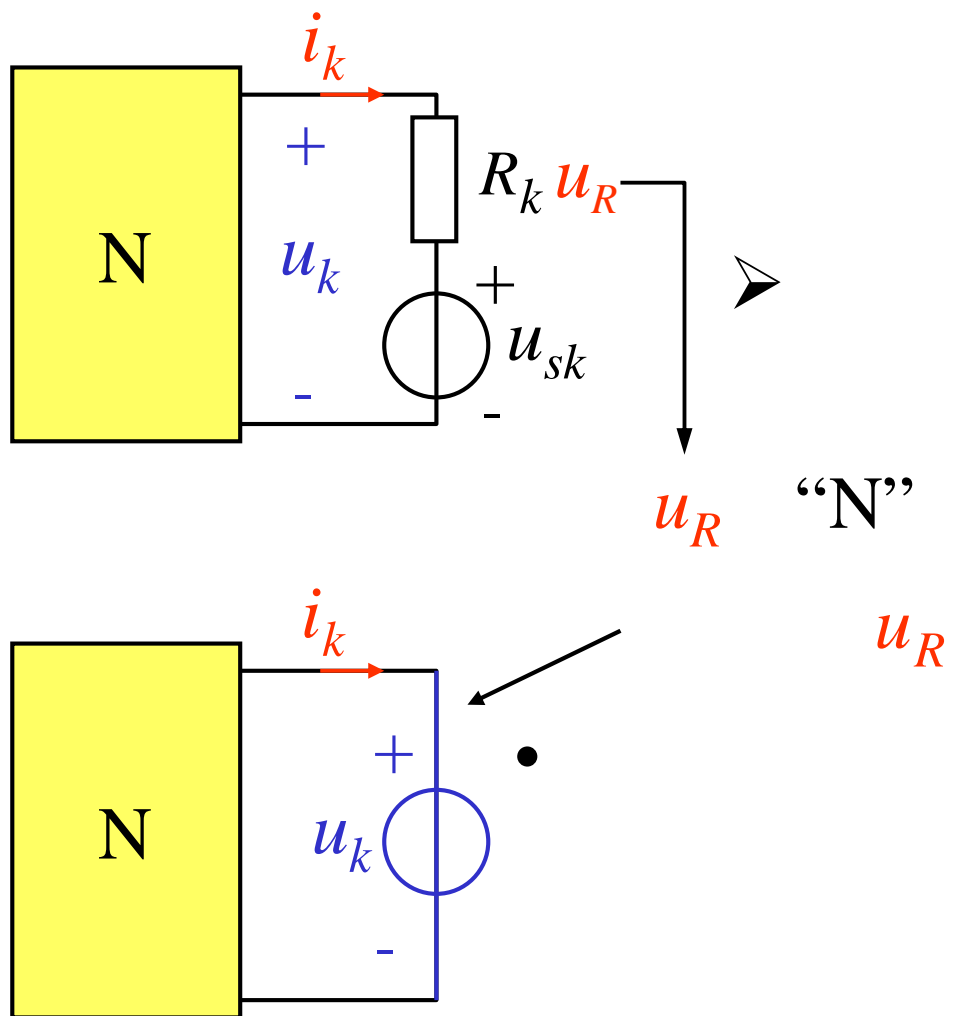
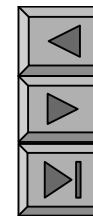
“N”

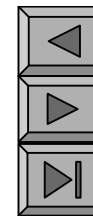
“N”

k

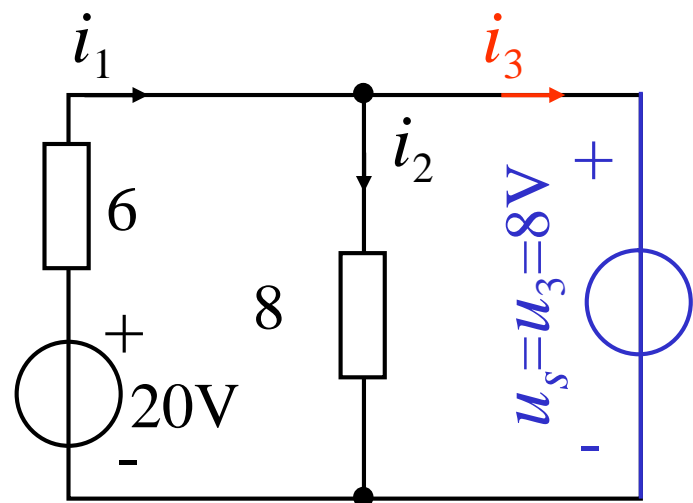
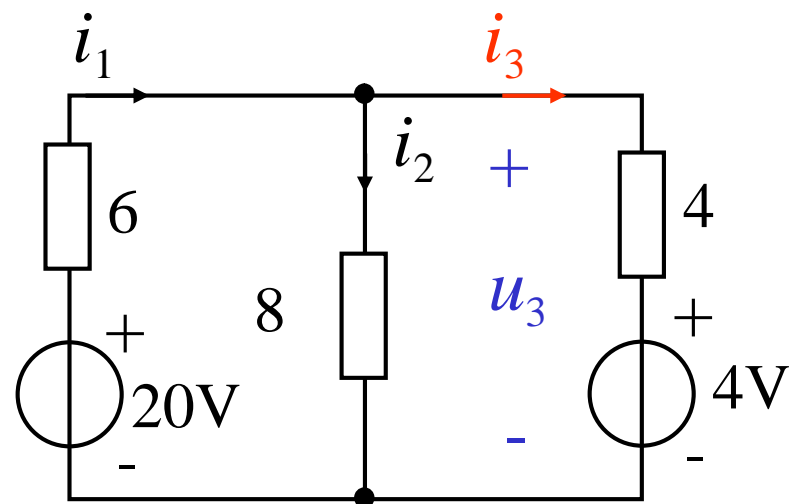
u_k







1



8V

u_3

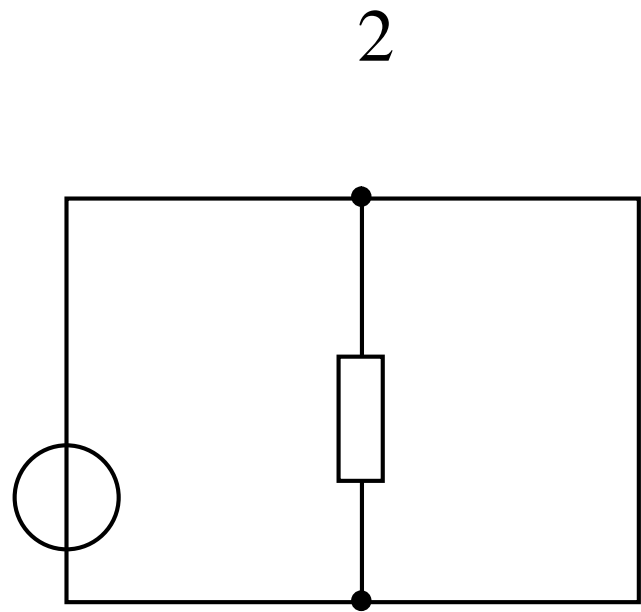
u_3 8V

i_1 i_2 i_3

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

i_1 $\frac{20-8}{6}$ 2A

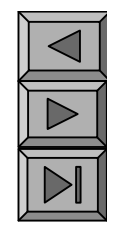
i_3 i_1 i_2 1A

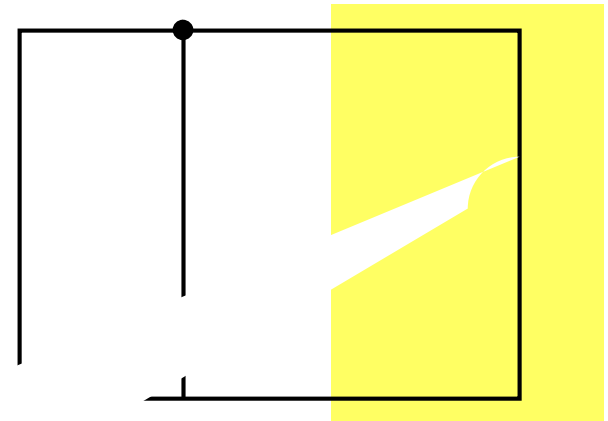
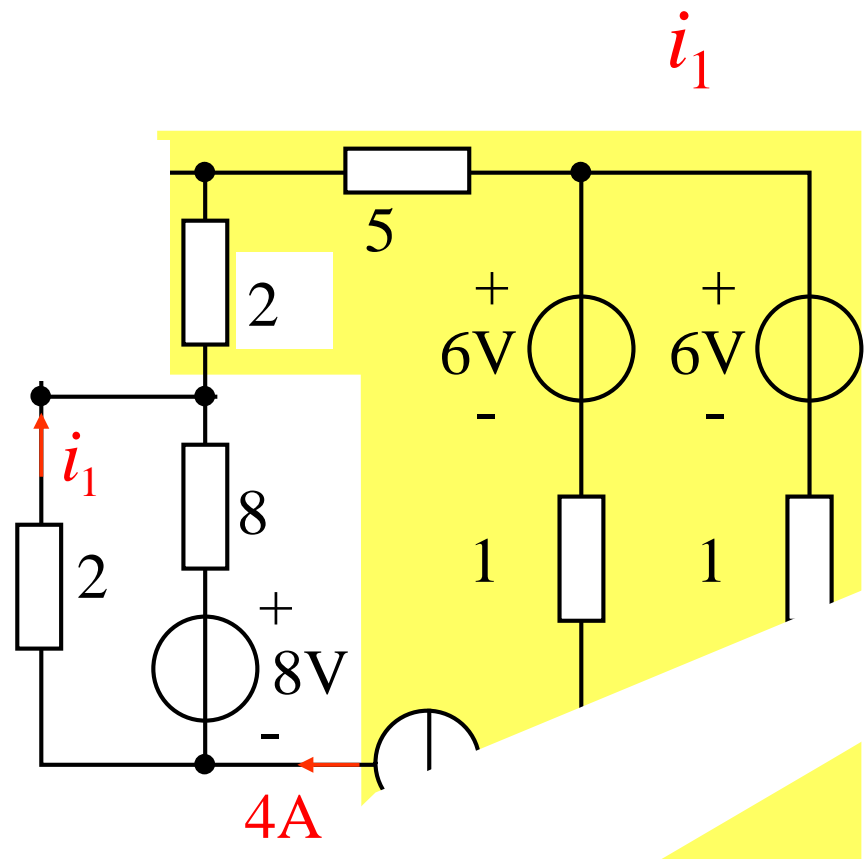
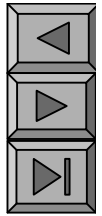


$$i_3 = 1A$$

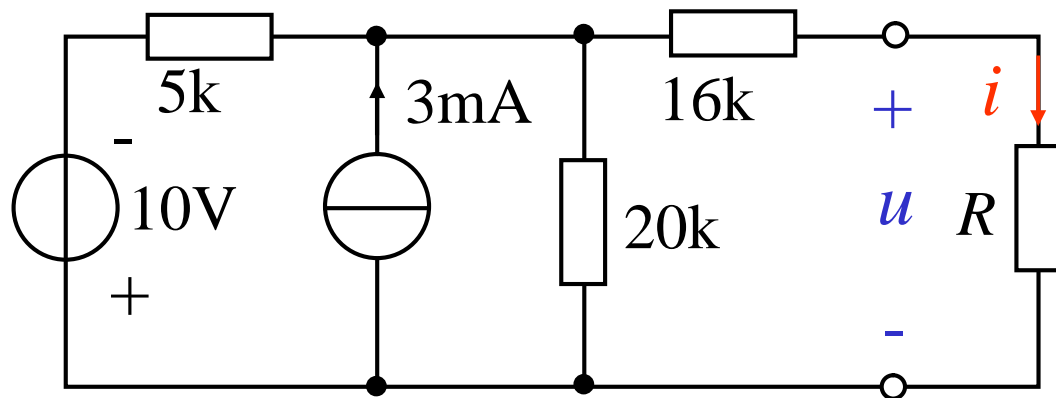
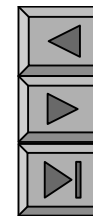
i_2 u_3

i_1



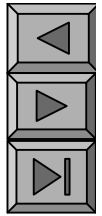


§ 4-3

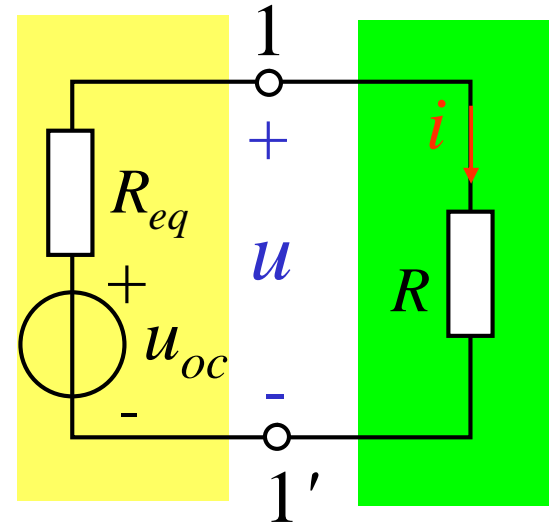
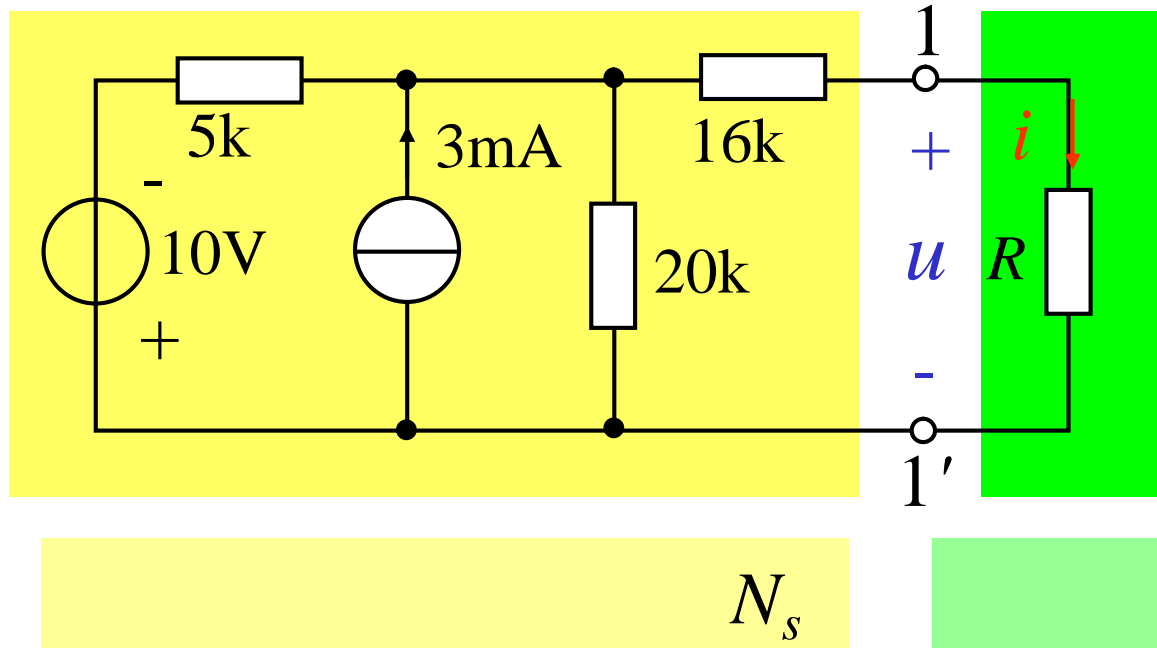
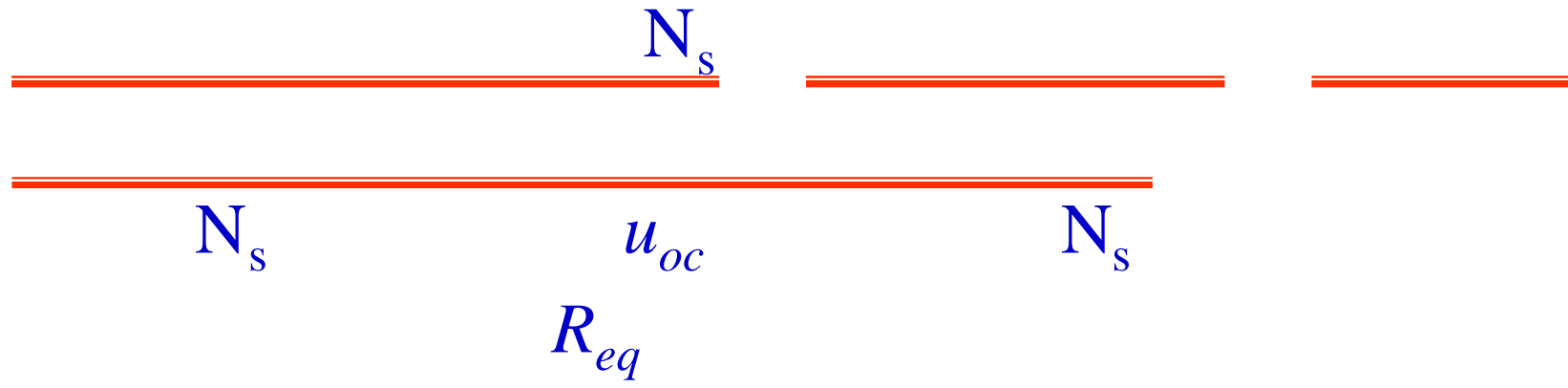


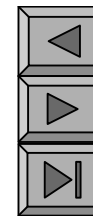
$i=?$
 $u=?$
 $R=?$

?



1.





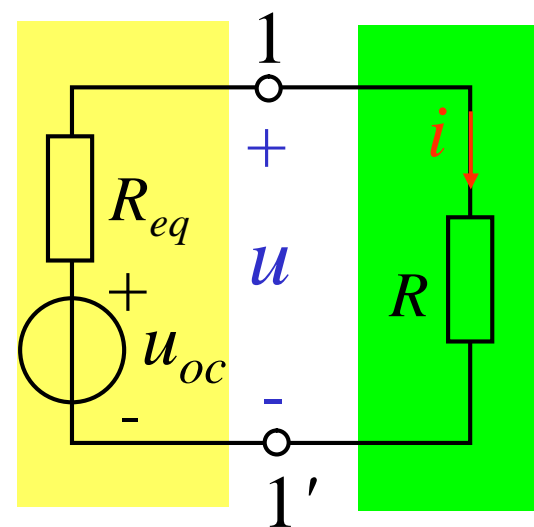
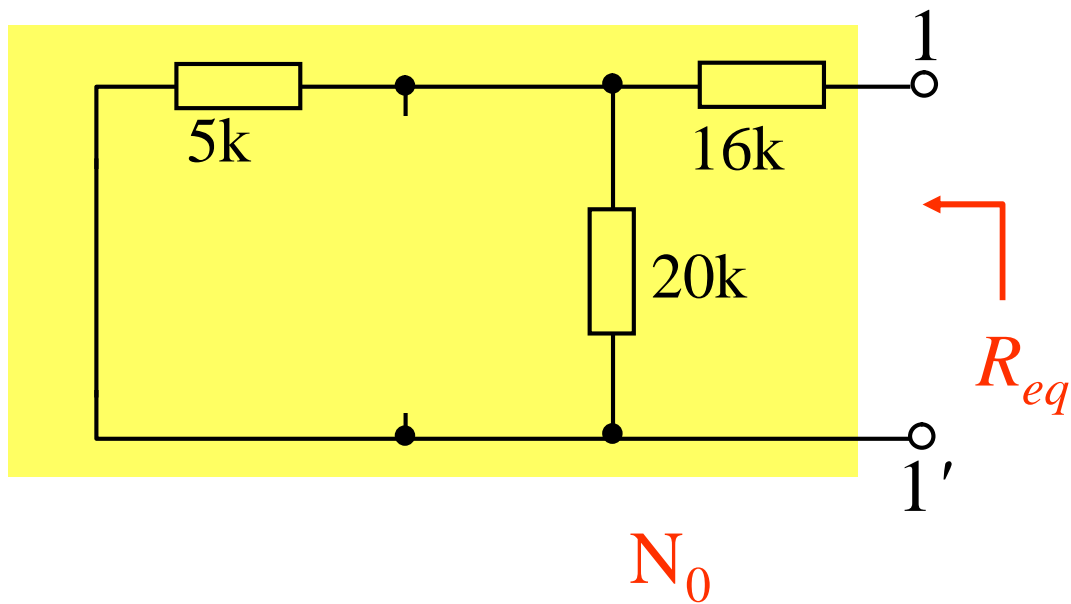
N_s

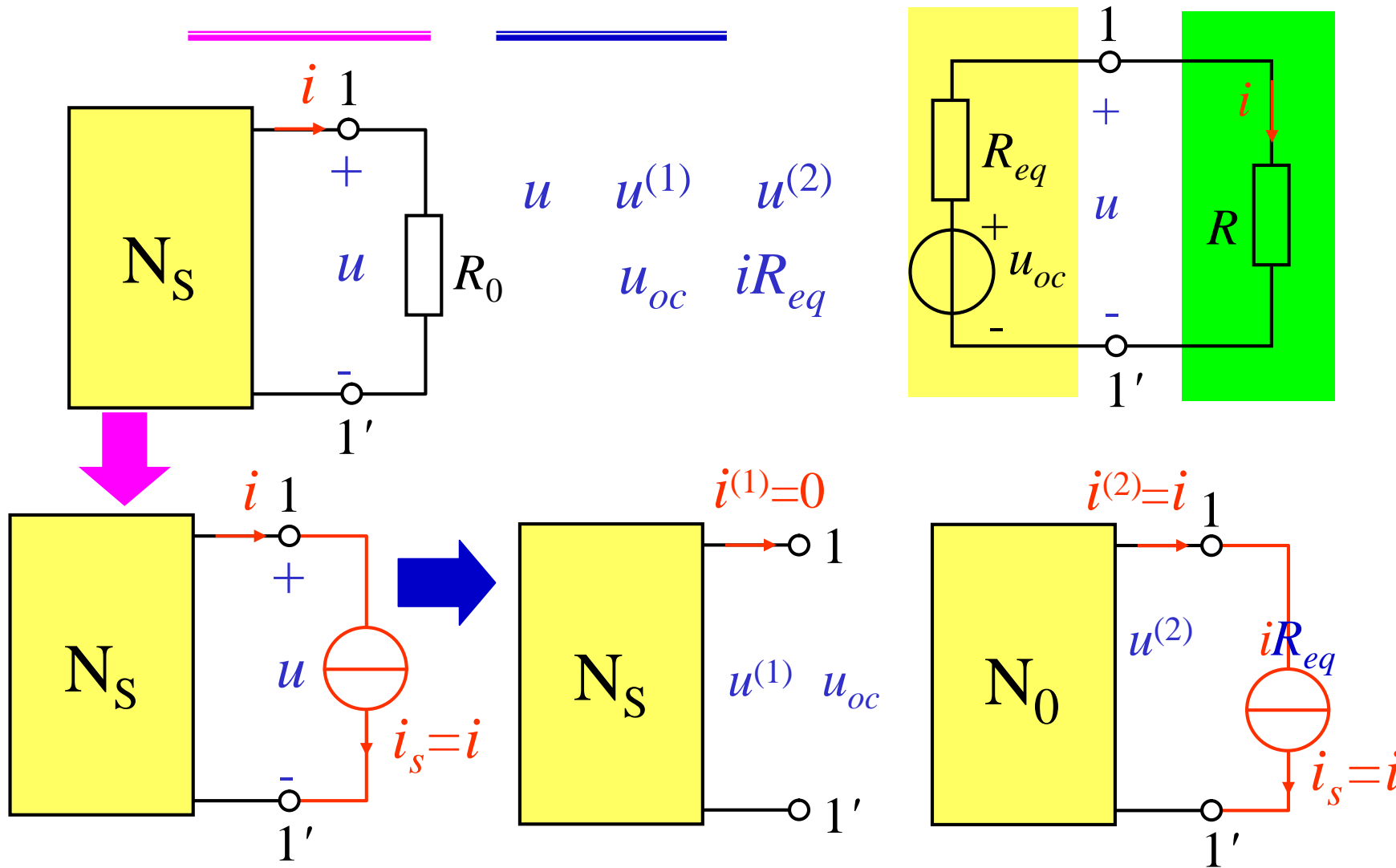
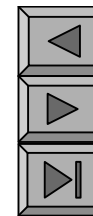
N_s

u_{oc}

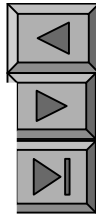
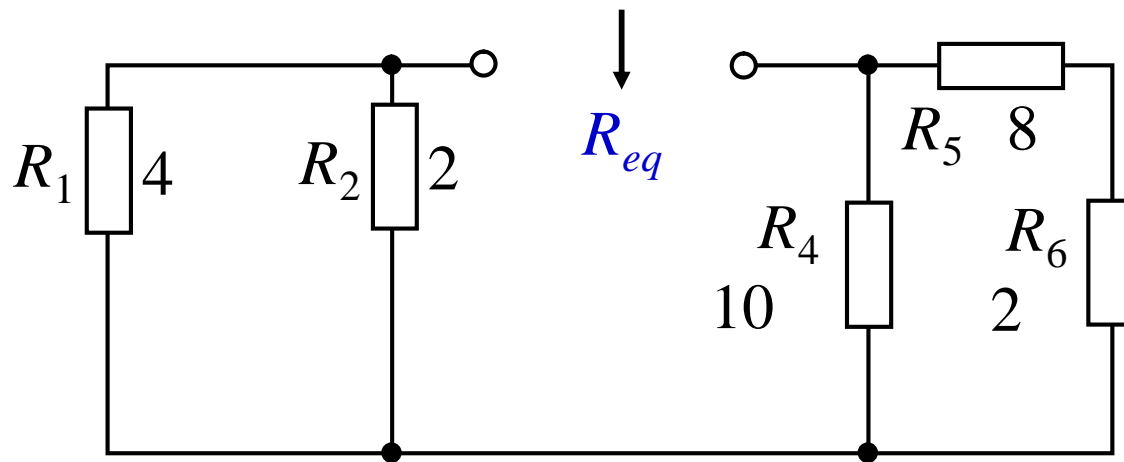
N_s

R_{eq}





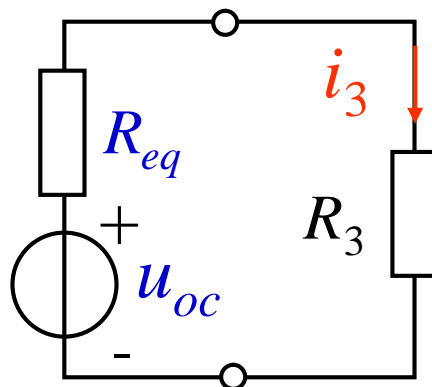
P93 4-5 ¹



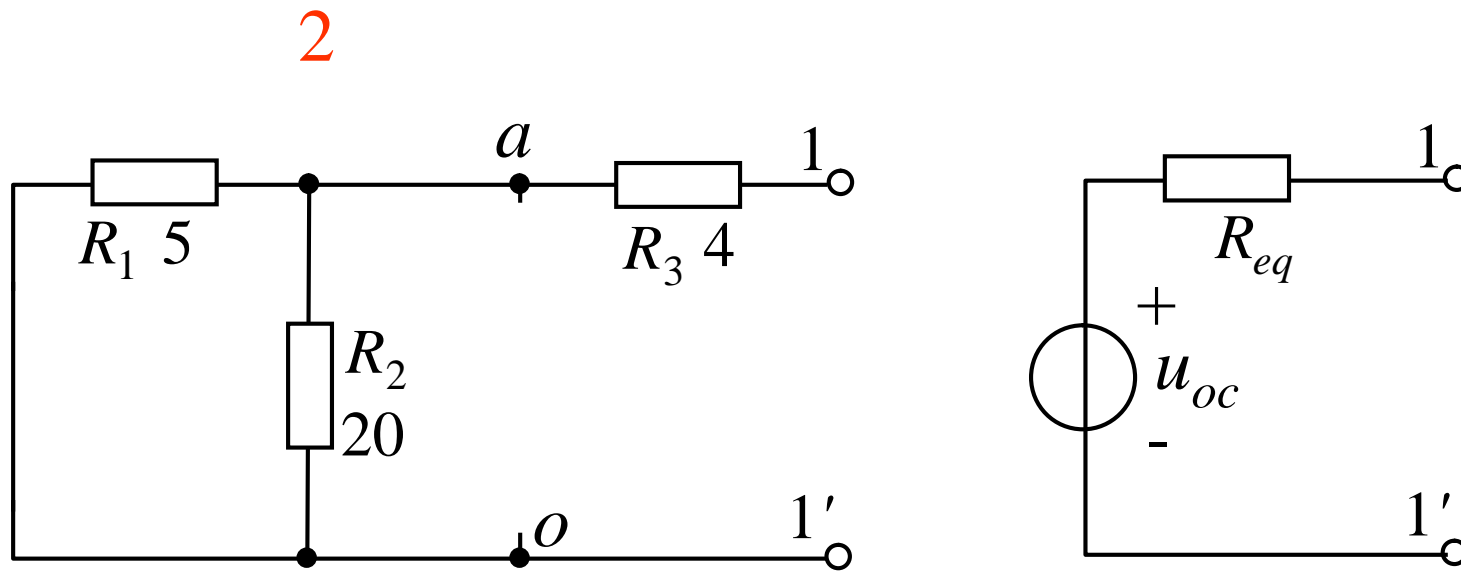
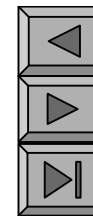
$$u_{oc} = \frac{\frac{u_{s1}}{R_1} + \frac{u_{s2}}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}$$

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

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



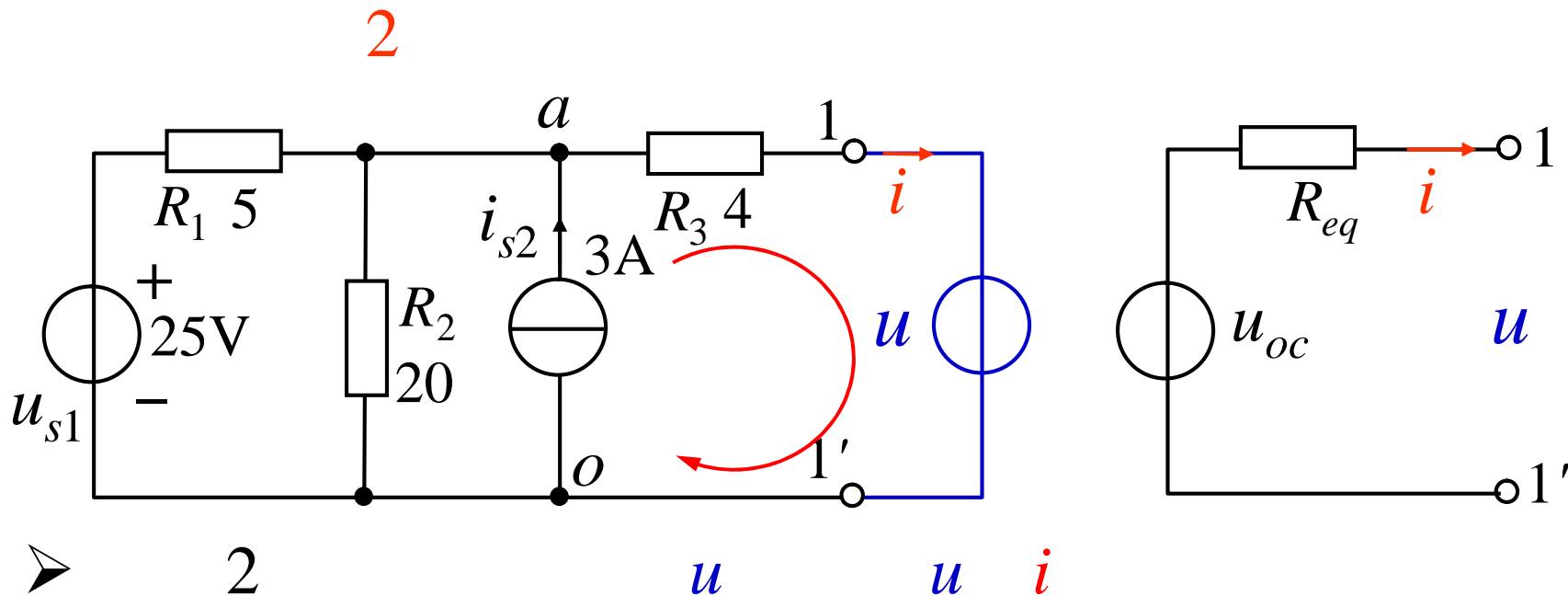
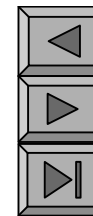
$$i_3 = \frac{40}{6.33+5} = 3.53A$$



➤

$$u_{oc} = \frac{R_3}{R_1 + R_3} \cdot \frac{100}{4} = \frac{4}{5+4} \cdot \frac{100}{4} = \frac{100}{5} = 20\text{V}$$

$$R_{eq} = R_3 + \frac{R_1 \cdot R_2}{R_1 + R_2} = 4 + \frac{5 \cdot 20}{5 + 20} = 4 + \frac{100}{25} = 4 + 4 = 8\Omega$$



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

$$u_{ao} = 4i + u$$

$$u_{ao} = \underline{\underline{u + 32 + 8i}}$$

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

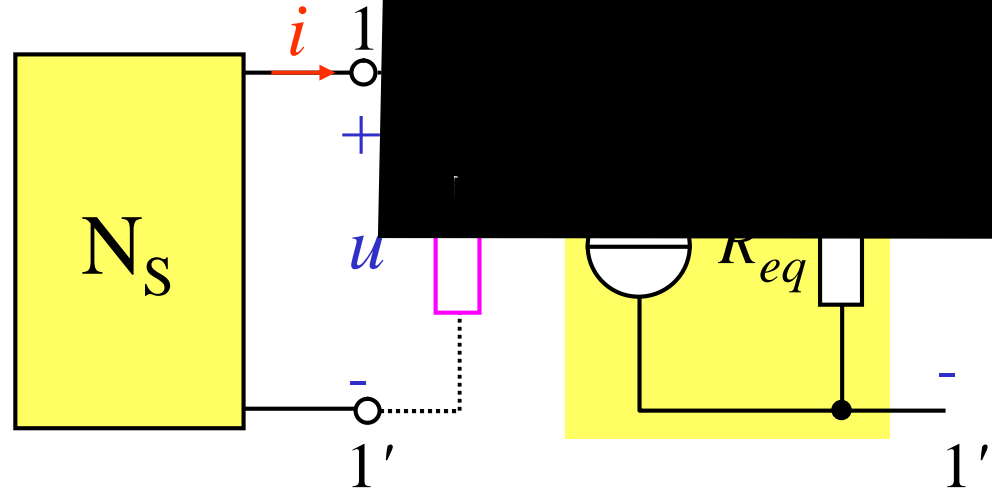
$$u_{oc} = 32V$$

$$R_{eq} = 8$$

2.



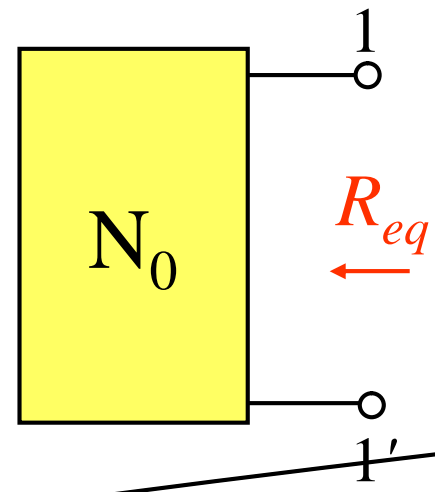
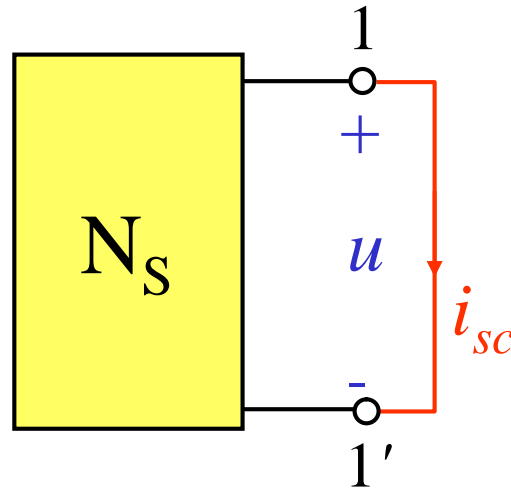
N_s



N_s

i_{sc}

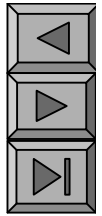
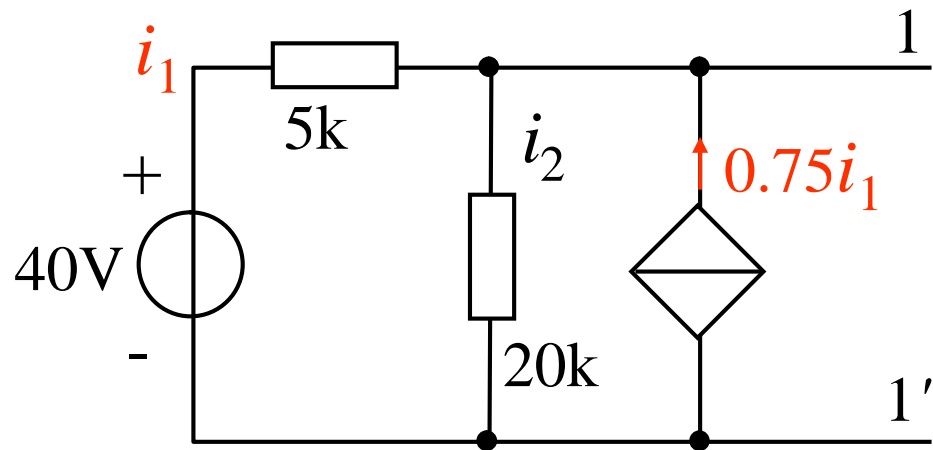
N_s



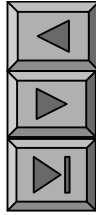
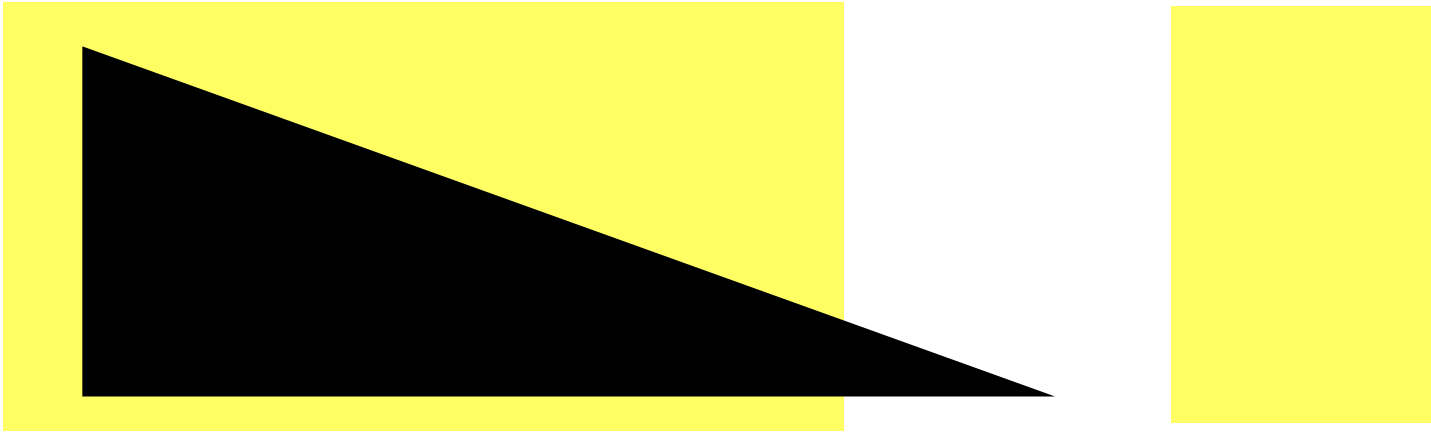
R_{eq}



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4-4



$$R = R_{eq}$$

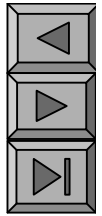
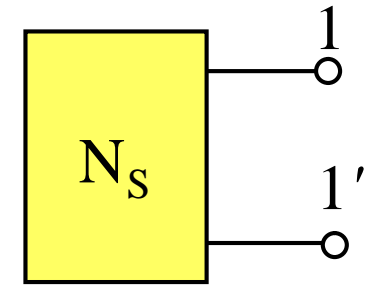
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1.

$R_{eq} = 0$

N_S



2.

N_S

R_{eq}

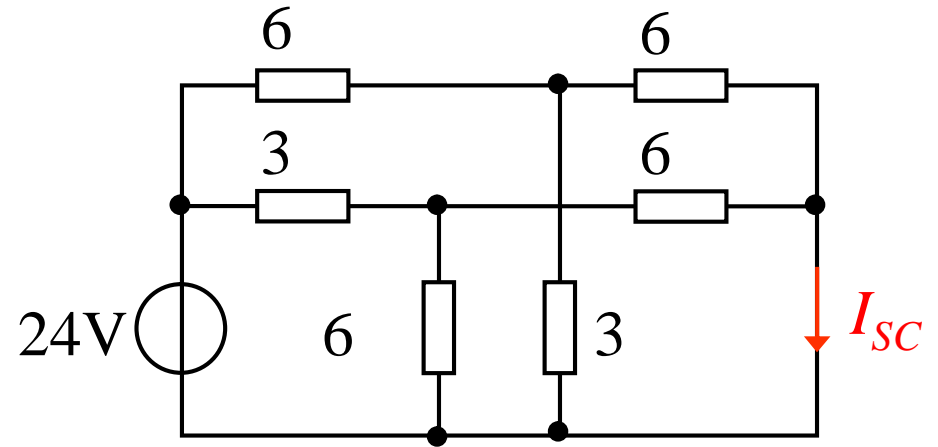
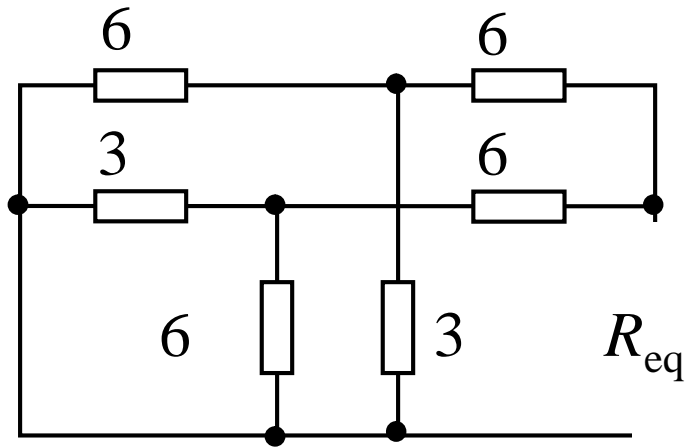
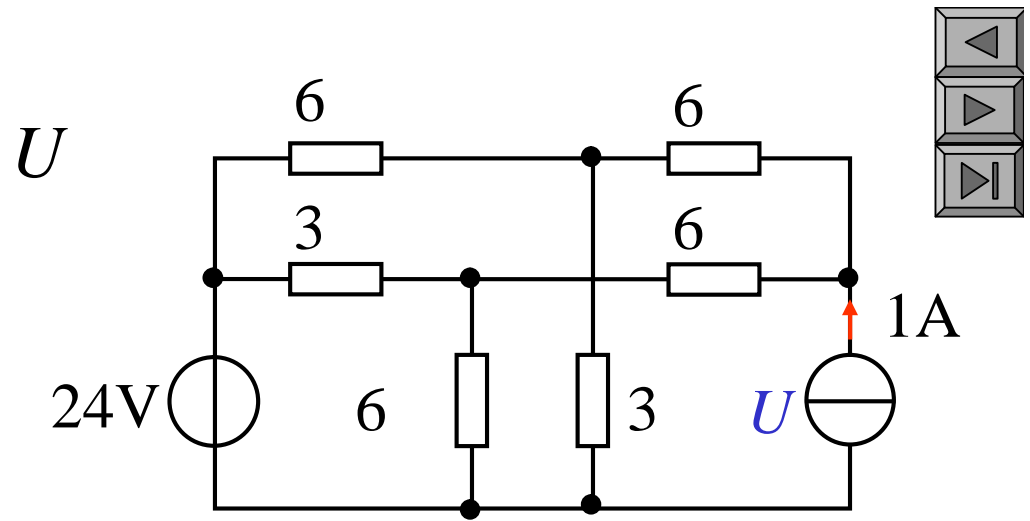
P110

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3.

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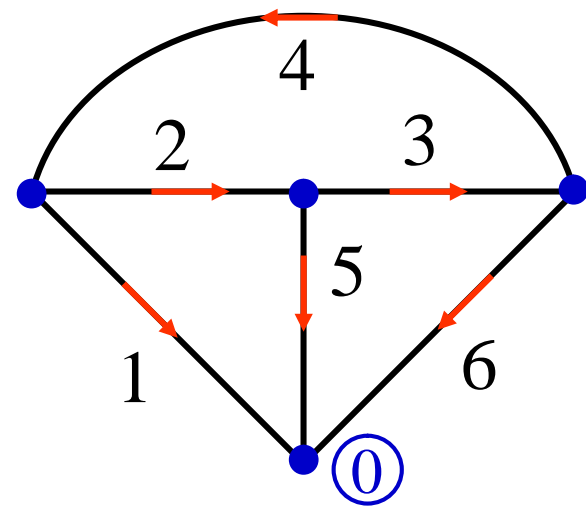
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§ 4 5
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n b

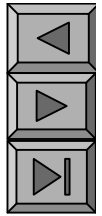


_____ (i_1, i_2, \dots, i_b) •
_____ (u_1, u_2, \dots, u_b)

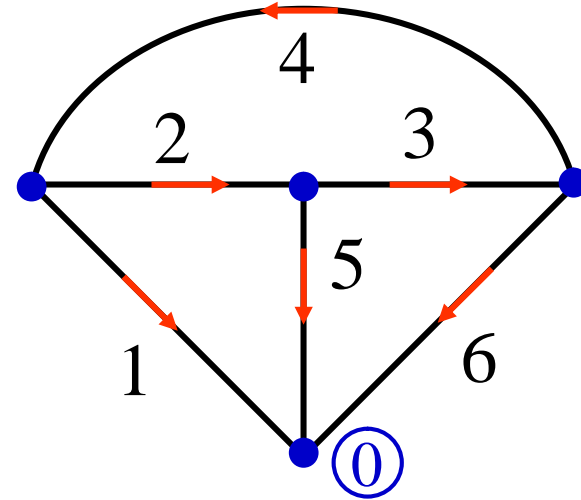
t

$$\sum_{k=1}^b u_k i_k = 0$$

$$\begin{aligned} u_{n1} &= u_1 \\ u_{n2} &= u_5 \\ u_{n3} &= u_6 \\ u_2 &= u_{n1} - u_{n2} \\ u_3 &= u_{n2} - u_{n3} \\ u_4 &= u_{n3} - u_{n1} \end{aligned}$$



$$\begin{array}{l}
 6 \\
 u_k i_k \quad u_1 i_1 \quad u_2 i_2 \quad u_3 i_3 \\
 k=1 \\
 \quad \quad u_4 i_4 \quad u_5 i_5 \quad u_6 i_6
 \end{array}$$



$$\begin{array}{l}
 u_{n1} i_1 \quad (u_{n1} \quad u_{n2}) i_2 \quad (u_{n2} \quad u_{n3}) i_3 \\
 \quad \quad (u_{n3} \quad u_{n1}) i_4 \quad u_{n2} i_5 \quad u_{n3} i_6
 \end{array}$$

$$u_{n1} \underbrace{(i_1 \quad i_2 \quad i_4)} \quad u_{n2} \underbrace{(i_2 \quad i_3 \quad i_5)}$$

$$u_{n3} \underbrace{(i_3 \quad i_4 \quad i_6)} \quad 0$$

•

$$u_{n1} = u_1$$

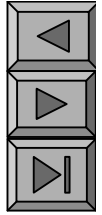
$$u_{n2} = u_5$$

$$u_{n3} = u_6$$

$$u_2 = u_{n1} - u_{n2}$$

$$u_3 = u_{n2} - u_{n3}$$

$$u_4 = u_{n3} - u_{n1}$$



$$\sum_{k=1}^b u_k i_k = 0 \quad u_k i_k \quad u_k i_k \quad u_k i_k$$

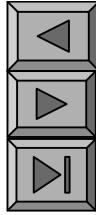
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_____ (power theorem)

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• 2

n b

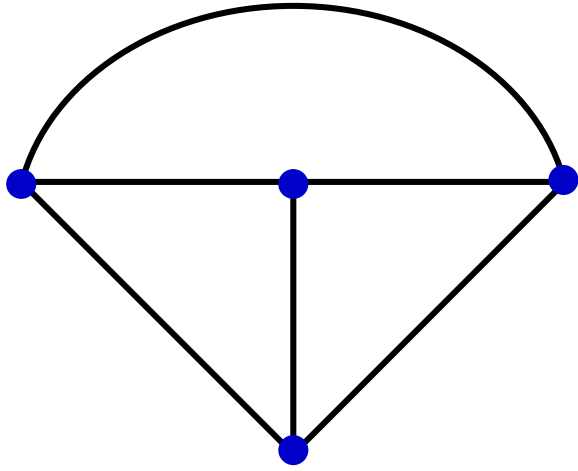
$$\begin{aligned} & (i_1, i_2, \dots, i_b) & (u_1, u_2, \dots, u_b) \\ & (\hat{i}_1, \hat{i}_2, \dots, \hat{i}_b) & (\hat{u}_1, \hat{u}_2, \dots, \hat{u}_b) \end{aligned}$$

b

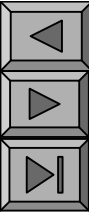
t

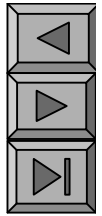
$$\sum_{k=1}^b \hat{u}_k i_k = 0$$

$$\sum_{k=1}^b u_k \hat{i}_k = 0$$



3^{\wedge}





$$\sum_{k=1}^b \hat{u}_k i_k = 0$$

$$\sum_{k=1}^b u_k \hat{i}_k = 0 \longrightarrow$$

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

“ $\hat{u}_k i_k$ ”

“ $\hat{u}_k i_k$ ”

-
-
-

(quasi-power theorem)

2

2

$$u_s \hat{i}_1 \quad u \hat{i}_2$$

$$\hat{u} i_1 \quad \hat{u}_s i_2$$

3 b

2

$$b \quad u_k \hat{i}_k$$

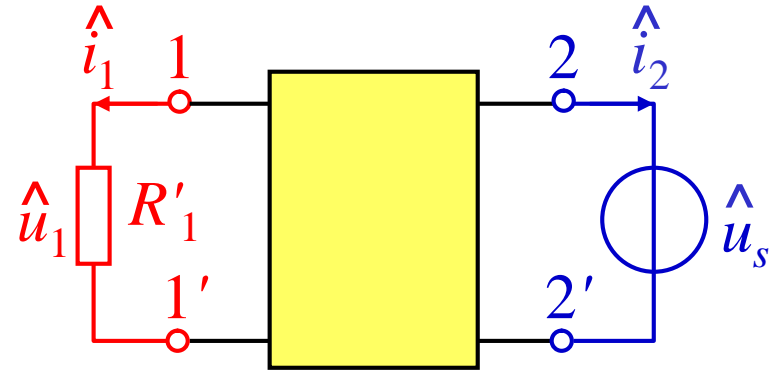
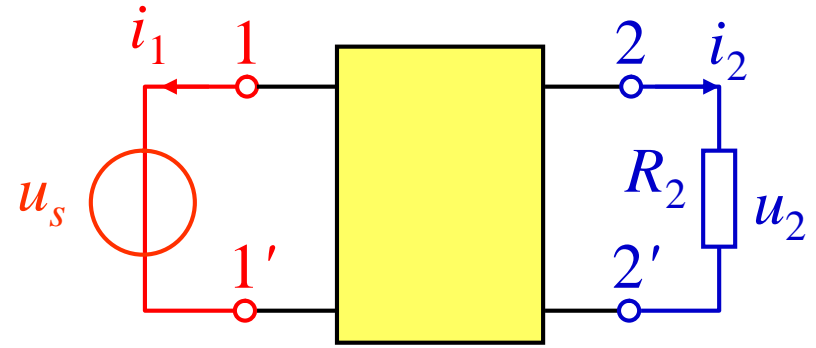
$k=3$

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

$k=3$

$$u_k = R_k i_k$$

$$\hat{u}_k = R_k \hat{i}_k$$



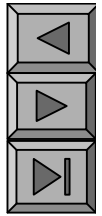
$$b \quad R_k i_k \hat{i}_k$$

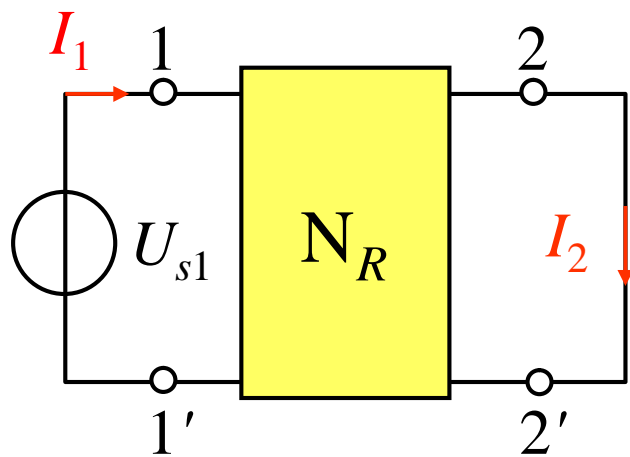
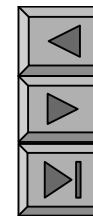
$k=3$

$$b \quad R_k \hat{i}_k i_k$$

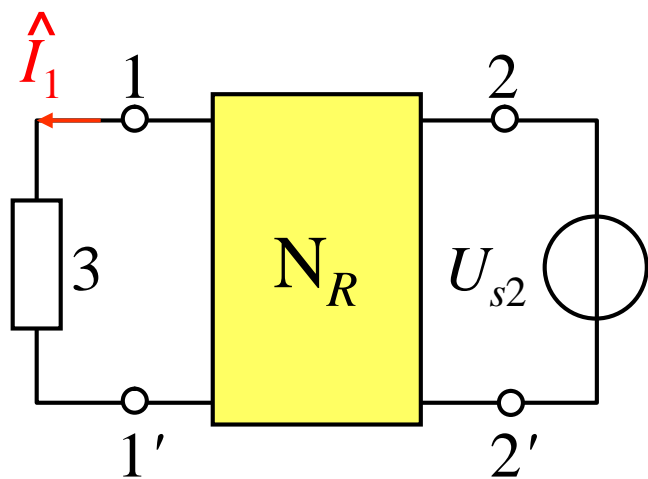
$k=3$

$$u_s \hat{i}_1 \quad u_2 \hat{i}_2 \quad \hat{u}_1 i_1 \quad \hat{u}_s i_2$$



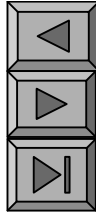


$$\begin{array}{l}
 N_R \\
 U_{s1} \quad 20V \\
 I_2 \quad 2A \\
 \quad \quad 3 \\
 \hat{I}_1 \quad 4A \\
 \end{array}
 \qquad
 \begin{array}{l}
 I_1 \quad 10A \\
 U_{s2} \quad 2-2' \\
 \quad \quad 1-1' \\
 U_{s2}
 \end{array}$$



$$\begin{array}{l}
 N_R \\
 \quad \quad 2 \\
 U_{s1} \hat{I}_1 \quad 0 \times I_2 \\
 20 \times 4 \quad 2U_{s2} \\
 U_{s2} \quad 100V
 \end{array}
 \qquad
 \begin{array}{l}
 U_{s2} I_2 - (3 \hat{I}_1) I_1 \\
 3 \times 4 \times 10
 \end{array}$$

§ 4-6

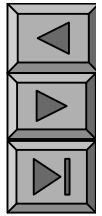
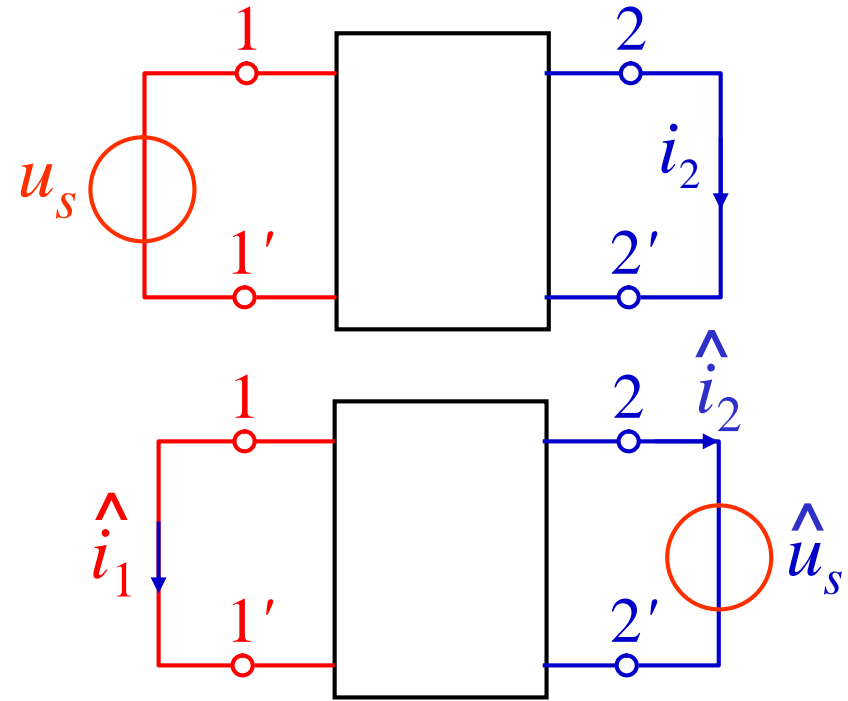


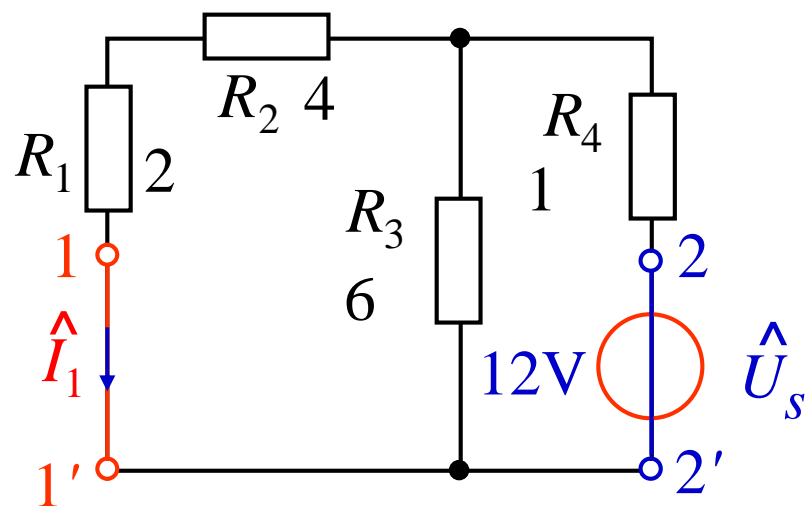
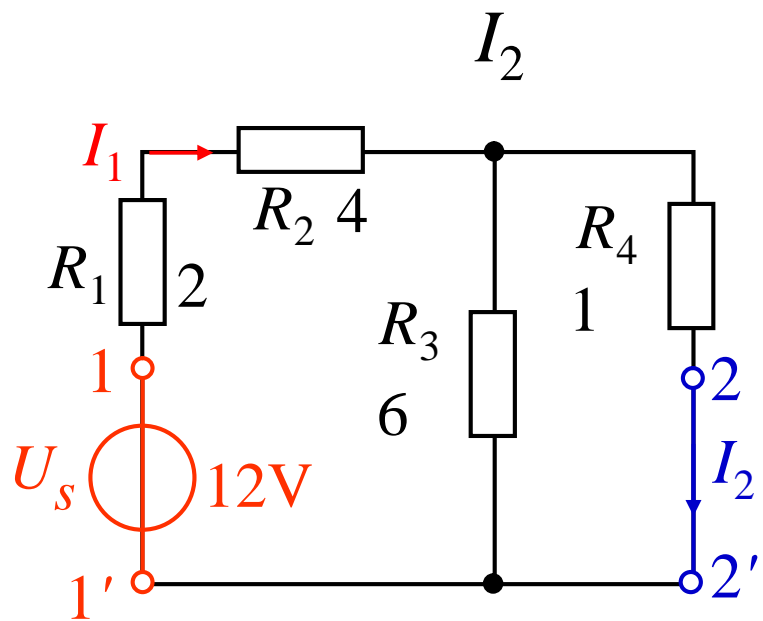
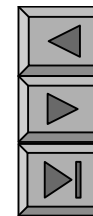
$$R_{ik} \quad R_{ki} \quad G_{ik} \quad G_{ki}$$

— (reciprocity)

3.

$$\begin{array}{cccc}
 & & & 2 \\
 u_s \hat{i}_1 & u_2 \hat{i}_2 & \hat{u}_1 i_1 & \hat{u}_s i_2 \\
 R'_1 & R_2 & 0 & \\
 u_2 & 0 & \hat{u}_1 & 0 \\
 \hline
 & & \frac{i_2}{u_s} & \frac{\hat{i}_1}{\hat{u}_s} \\
 u_s & \hat{u}_s & i_2 & \hat{i}_1
 \end{array}$$





$$I_1 = \frac{12}{4 + 2 + \frac{6 \times 1}{6 + 1}} = \frac{12}{\frac{48}{7}} = \frac{7}{4} \text{ A}$$

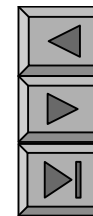
$$I_2 = \frac{6}{6 + 1} \times \frac{7}{4} = 1.5 \text{ A}$$

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

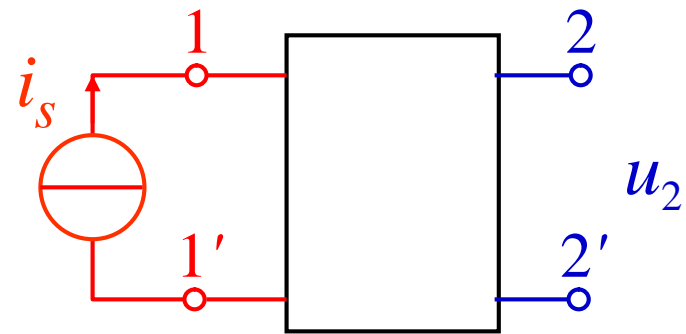
$$I_2 = \hat{I}_1$$

$$R_1 = R_2 = 6 + R_3$$

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

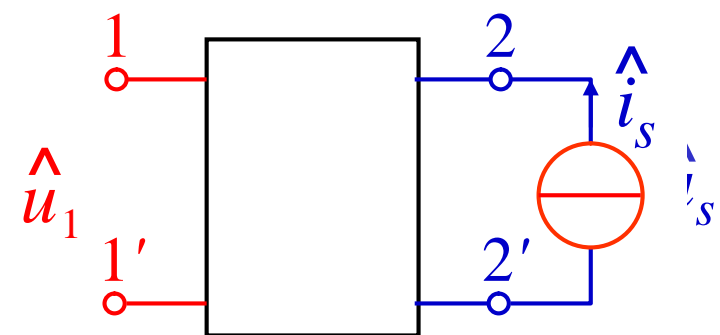


•



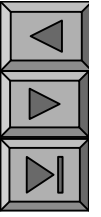
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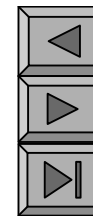
2



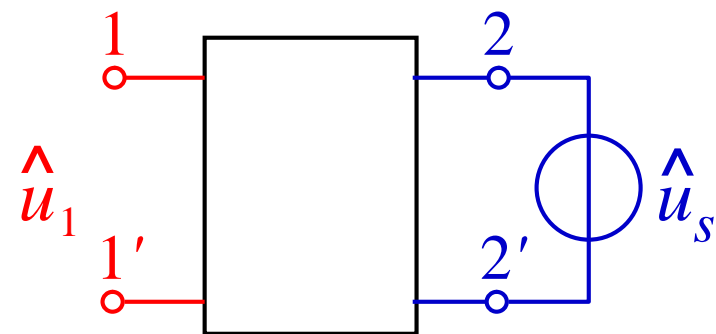
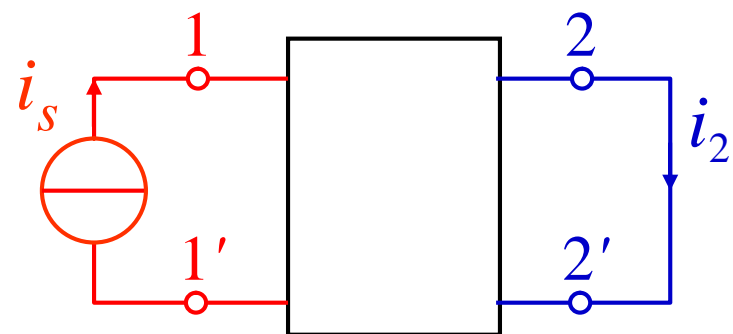
$$i_s \hat{u}_1 = 0 \quad u_2 \hat{i}_s = 0$$

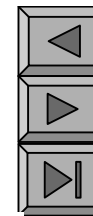
$$\frac{u_2}{i_s} \quad \frac{\hat{u}_1}{\hat{i}_s} \Rightarrow \begin{matrix} i_s & \hat{i}_s \\ u_2 & \hat{u}_1 \end{matrix}$$



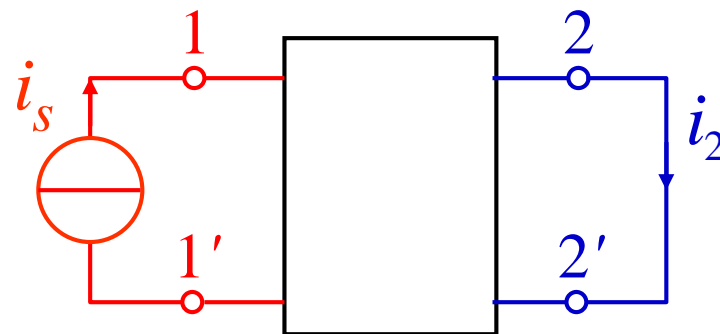


$$\begin{array}{cc}
 & 2 \\
 i_s \hat{u}_1 & i_2 \hat{u}_s & 0 & 0 \\
 \frac{i_2}{i_s} & \frac{\hat{u}_1}{\hat{u}_s} & & \\
 & & i_s & \hat{u}_s \\
 & & i_2 & \hat{u}_1
 \end{array}$$





1.



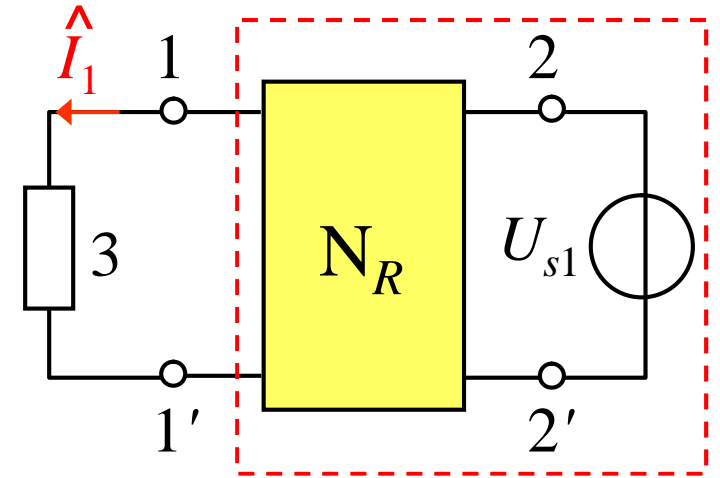
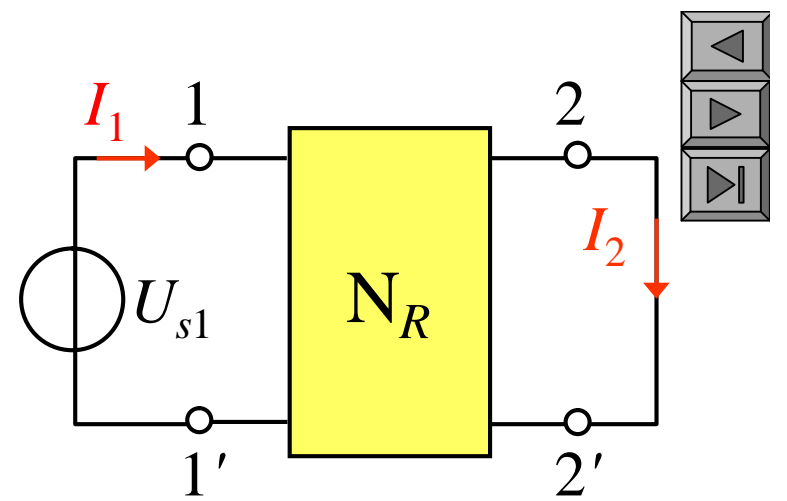
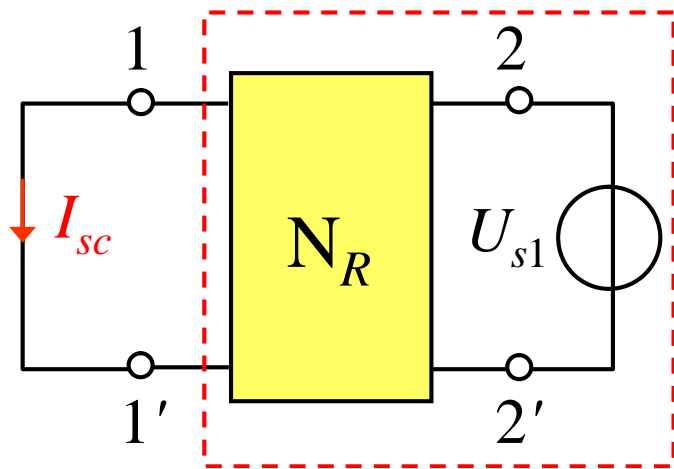
2.

()

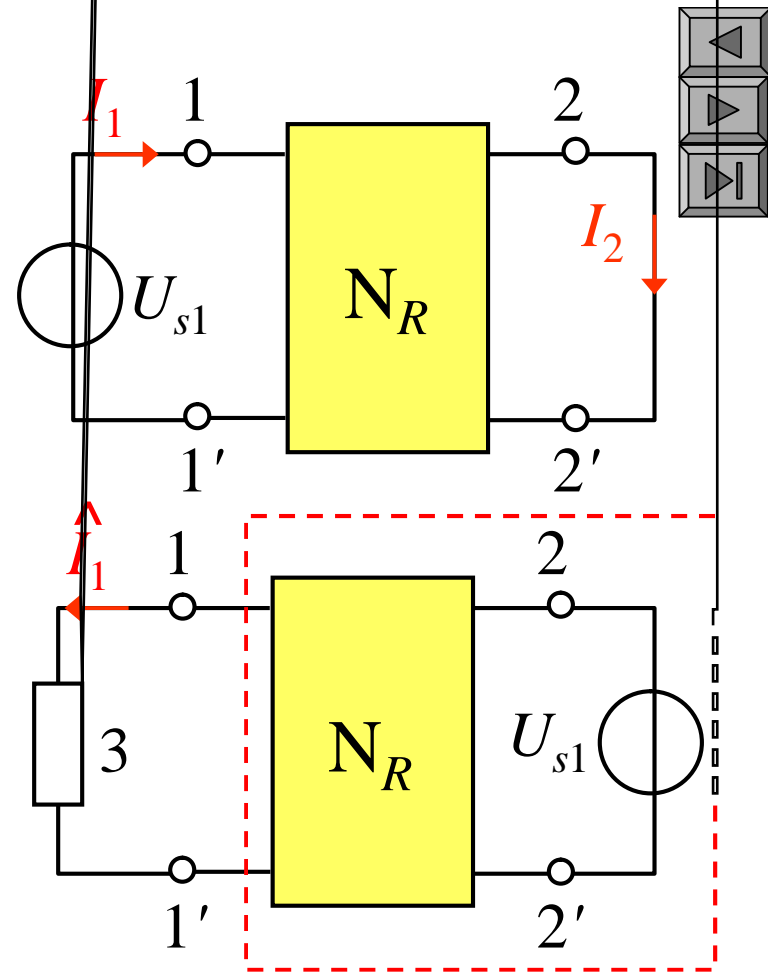
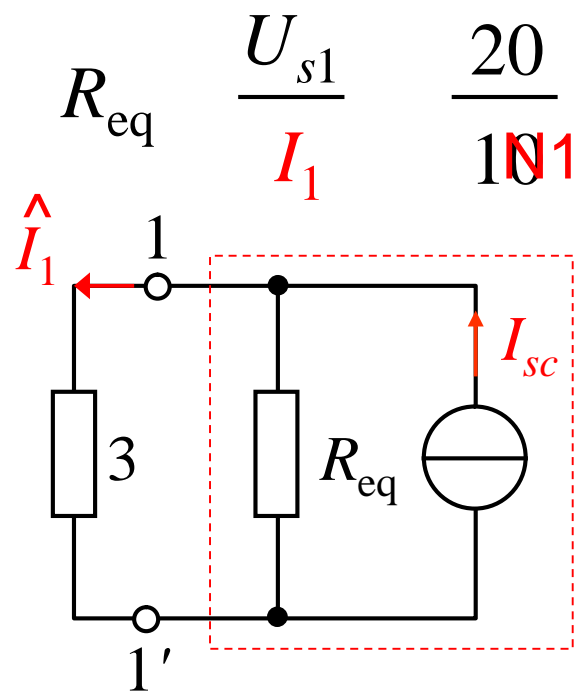
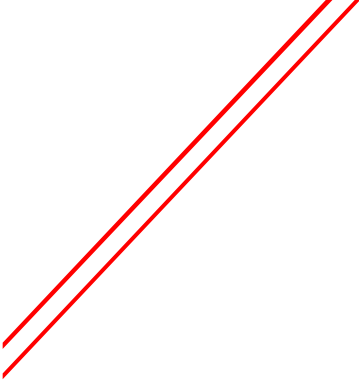
()

3.

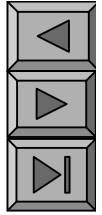
N_R $U_{s1} \ 20V$
 $I_1 \ 10A$ $I_2 \ 2A$ U_{s1}
 2-2' 1-1'
 3 \hat{I}_1



$I_{sc} \ I_2 \ 2A$



§ 4 7



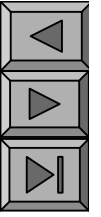
•

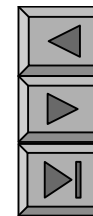
“ ”

“ ”

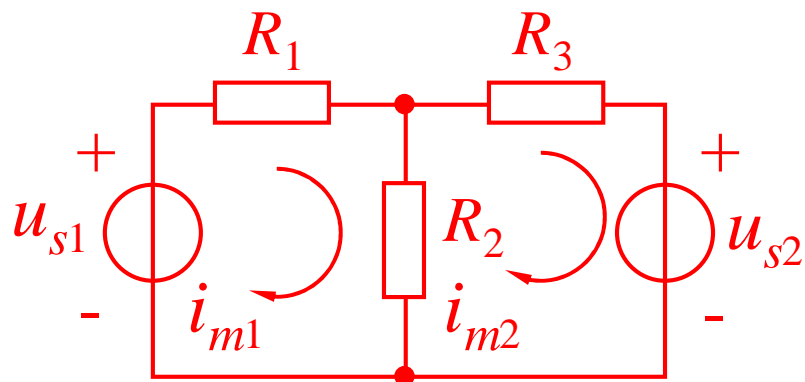


N									





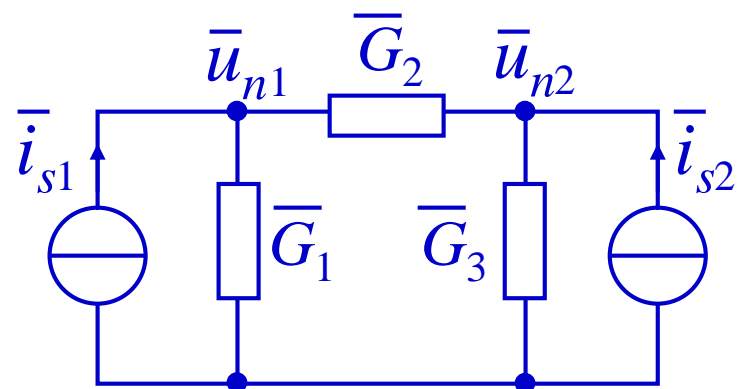
• n



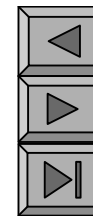
$$\begin{aligned}(R_1 + R_2) i_{m1} - R_2 i_{m2} &= u_{s1} \\ -R_2 i_{m1} + (R_2 + R_3) i_{m2} &= u_{s2}\end{aligned}$$

n

o



$$\begin{aligned}(\bar{G}_1 + \bar{G}_2) \bar{u}_{n1} - \bar{G}_2 \bar{u}_{n2} &= \bar{i}_{s1} \\ -\bar{G}_2 \bar{u}_{n1} + (\bar{G}_2 + \bar{G}_3) \bar{u}_{n2} &= \bar{i}_{s2}\end{aligned}$$

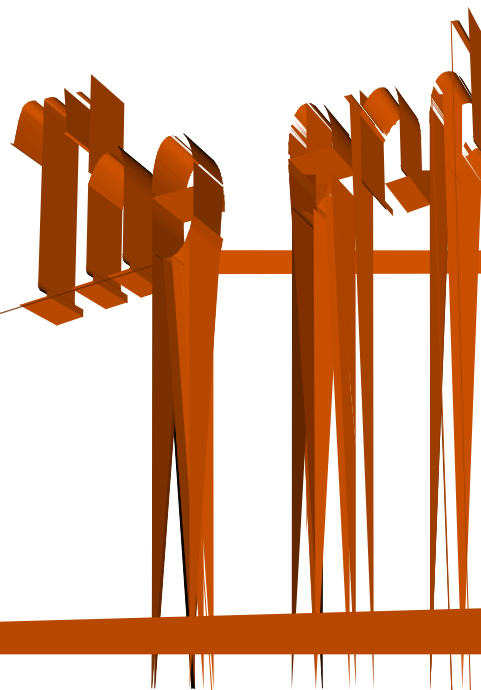


N

N

\bar{N}

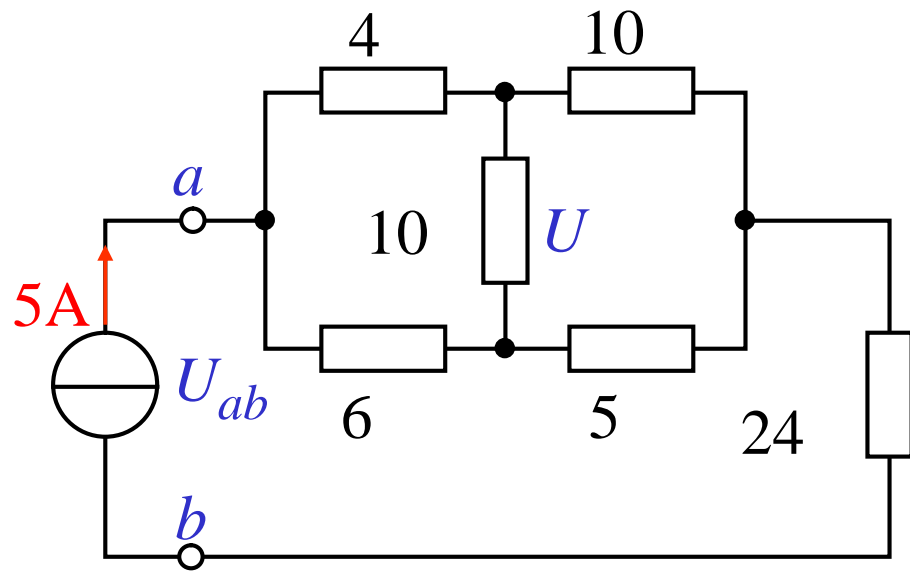
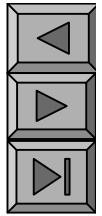
\bar{N}

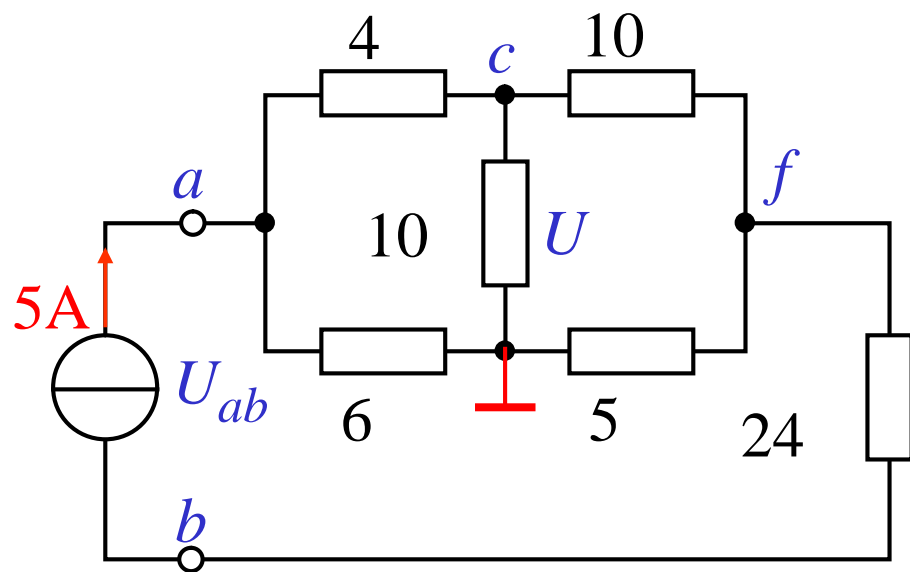
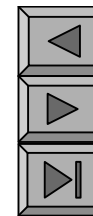


2010 3 3

53

U U_{ab} (P49 2-8)

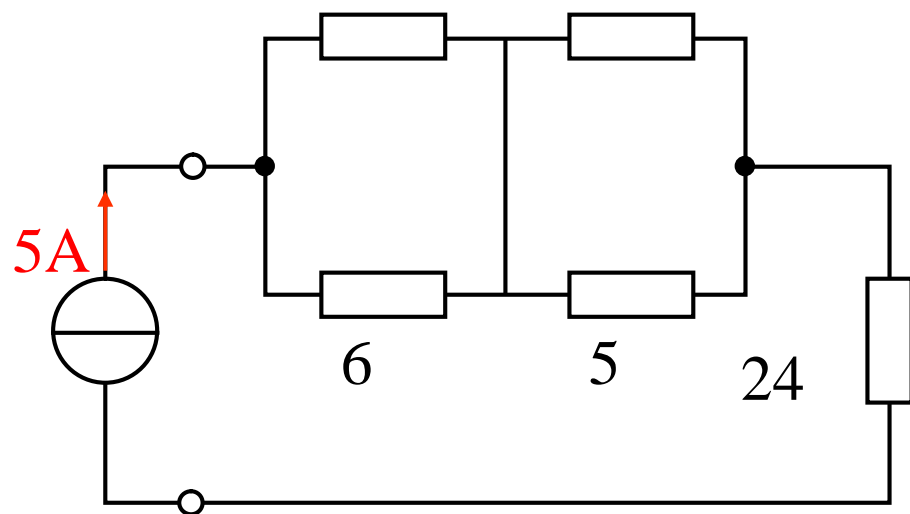
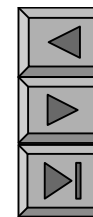




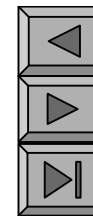
$$\begin{array}{r}
 U_a \quad 15\text{V}, \quad U_c \quad 5\text{V}, \\
 U_f \quad 5\text{V} \\
 U_{ab} \quad U_a \quad U_c \quad U_c \quad U_f \\
 \quad \quad \quad \times \\
 U_a \quad U_f \quad \times \\
 \quad \quad \quad 150 \text{ (V)}
 \end{array}$$

$$\left\{ \begin{array}{l}
 \left(\frac{1}{4} \quad \frac{1}{6} \right) U_a \quad \frac{1}{4} U_c \quad 5 \\
 \frac{1}{4} U_a \quad \left(\frac{1}{4} \quad \frac{1}{10} \quad \frac{1}{10} \right) U_c \quad \frac{1}{10} U_f \\
 \frac{1}{10} U_c \quad \left(\frac{1}{5} \quad \frac{1}{10} \right) U_f
 \end{array} \right.$$

U U_{ab} (P49 2-8)

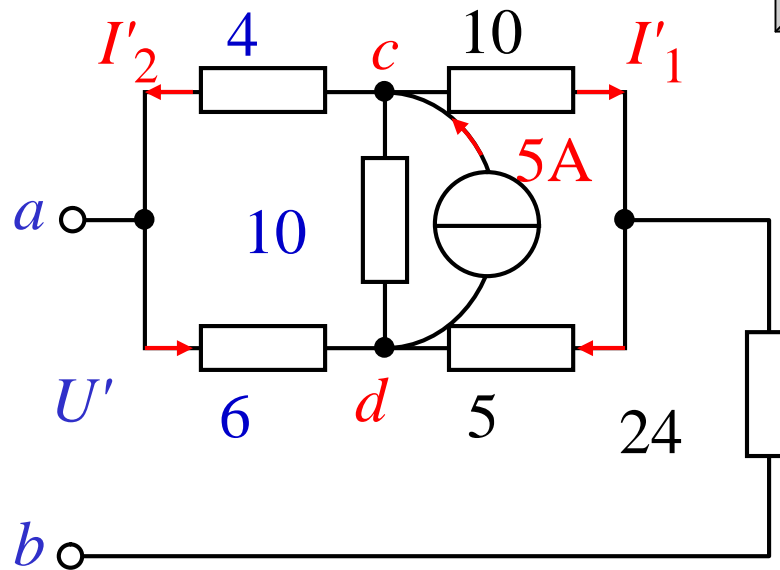
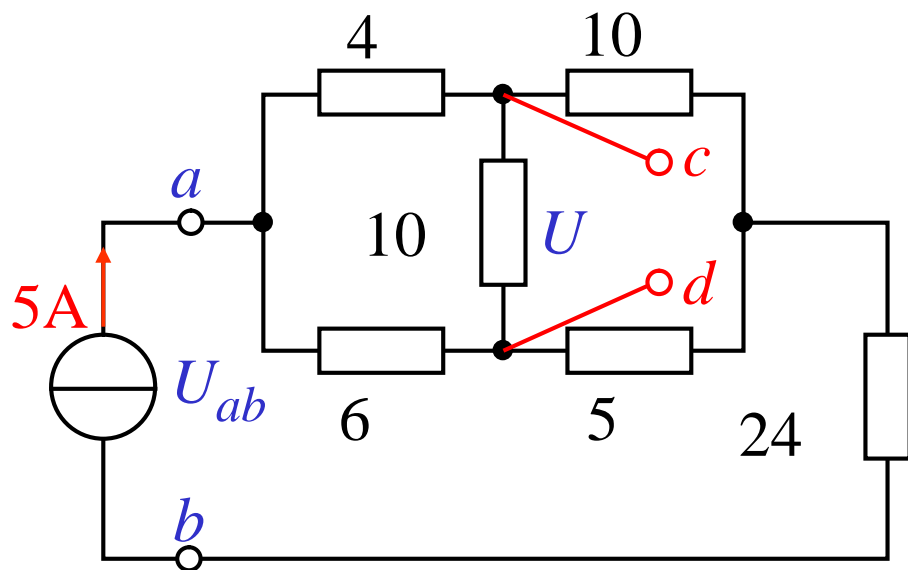


()



P49 2-8)

U U_{ab} (



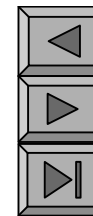
U c d

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

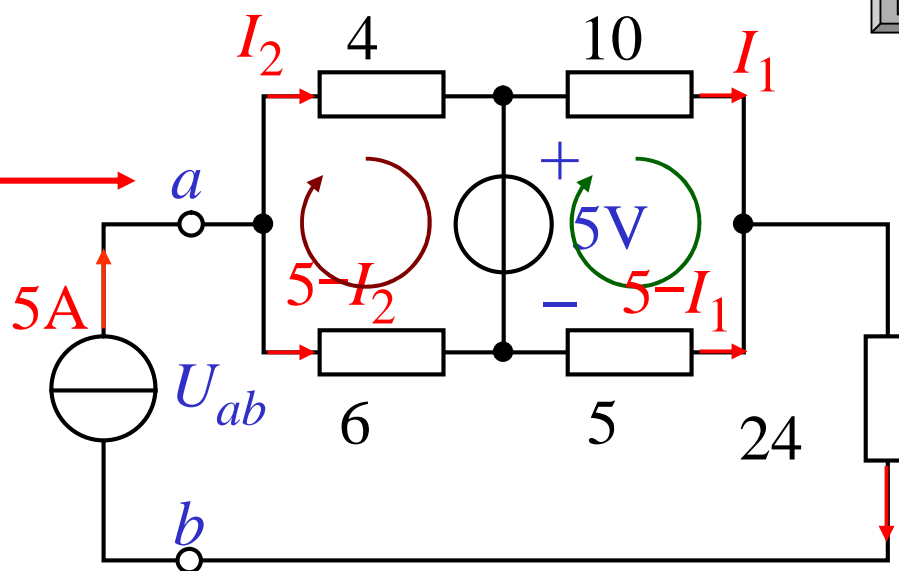
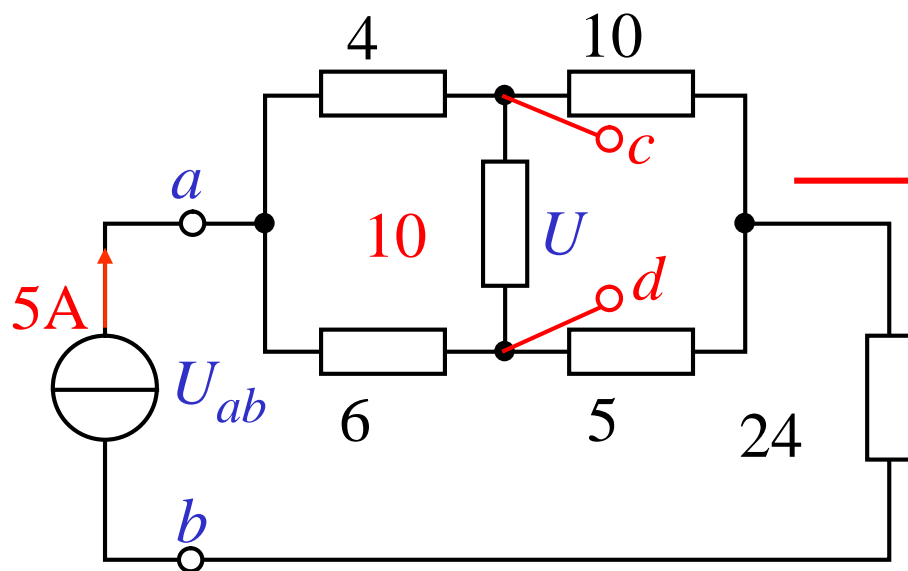
$$I'_2 = \frac{5-1.25}{2} = \frac{3.75}{2} \text{ A}$$

$$U' = \frac{3.75}{2} \times 4 + \frac{2.5}{2} \times 10 = 7.5 + 12.5 = 20 \text{ V}$$

$U = U' = 5 \text{ V}$



U_{ab} (P49 2-8)



$$U_{ab} = 5V$$

$$10$$

$$4I_2 + 6 \cdot 5 + 5I_2 = 5$$

$$I_2 = 2.5A$$

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

$$I_1 = 2A$$

$$\underline{U_{ab}} = 4I_2 + 10I_1 + 24 \times 5 = 10 + 20 + 120 = \underline{150V}$$