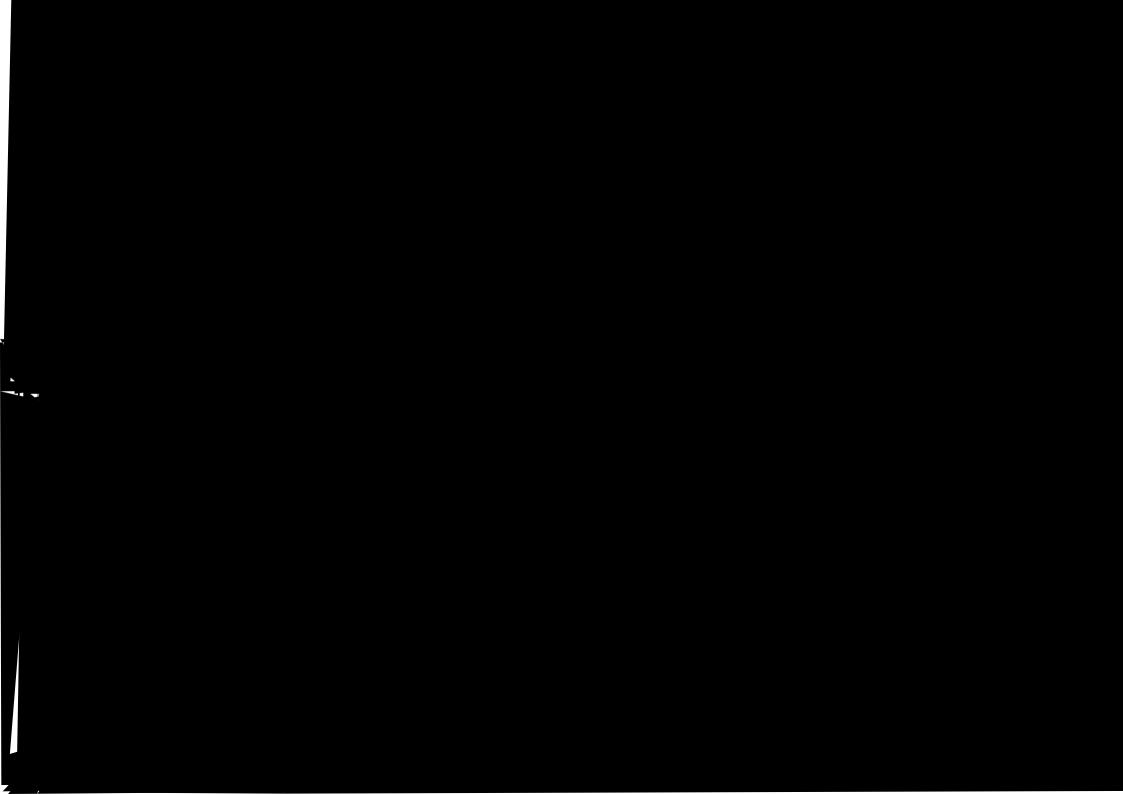
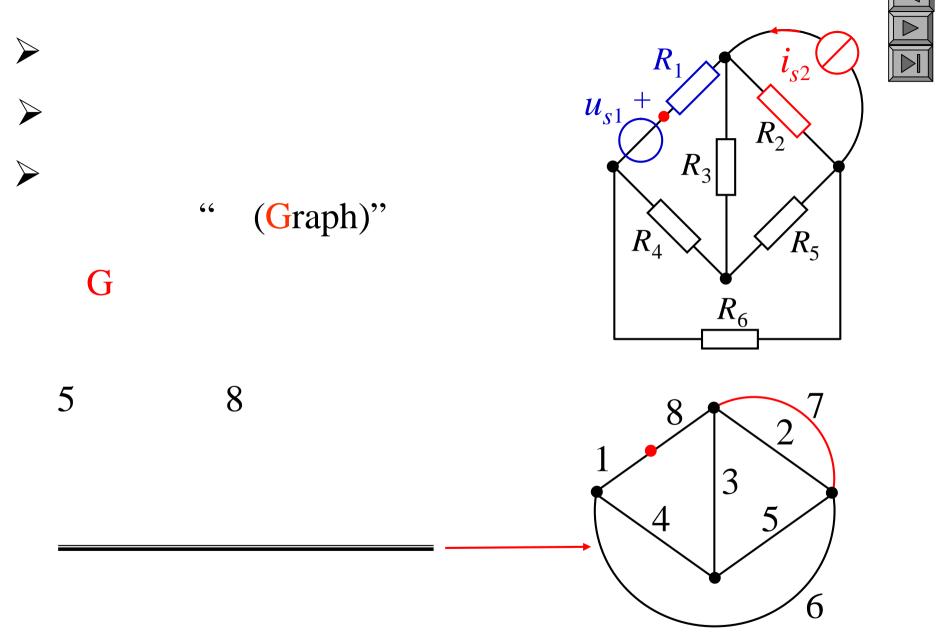


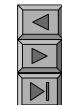
•

( / ) KCL KVL VCR

2010 3 3



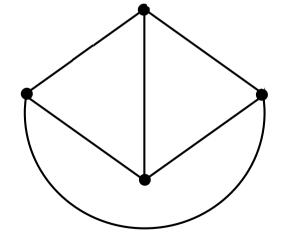




 $R_1$  +  $R_2i_{s2}$ 

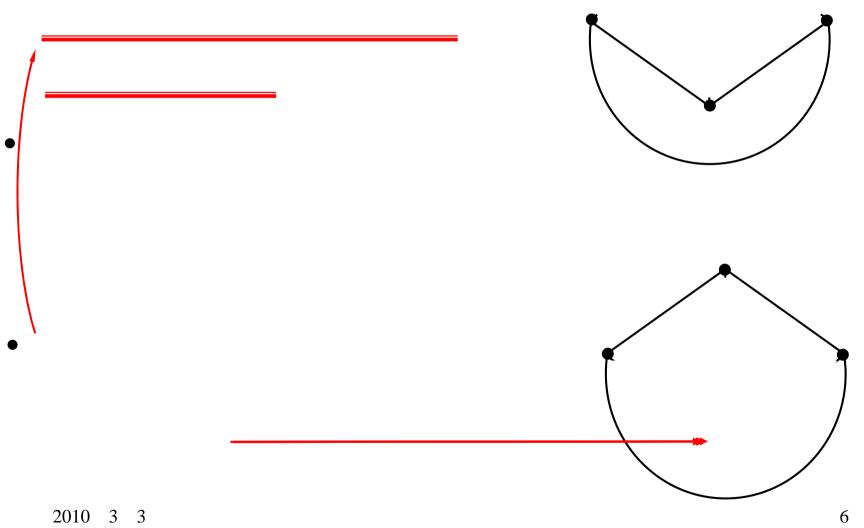
•

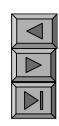
4 6

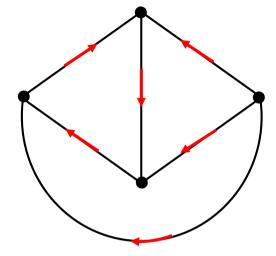


2010 3 3





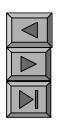




• ( )

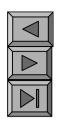
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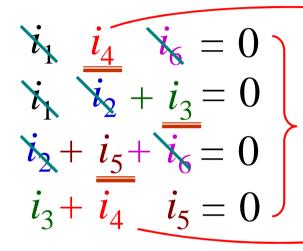
66 99

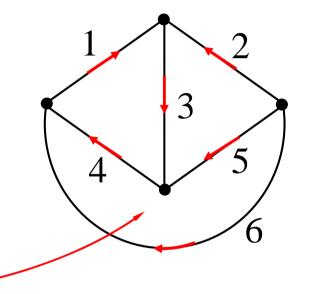
# 3 2 KCL KVL



## **KCL**

LVL





• 4

3

( )

( )

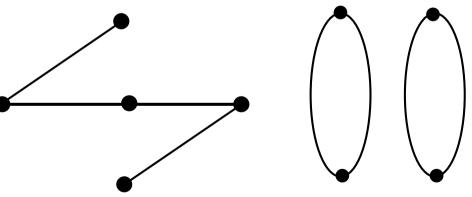


G

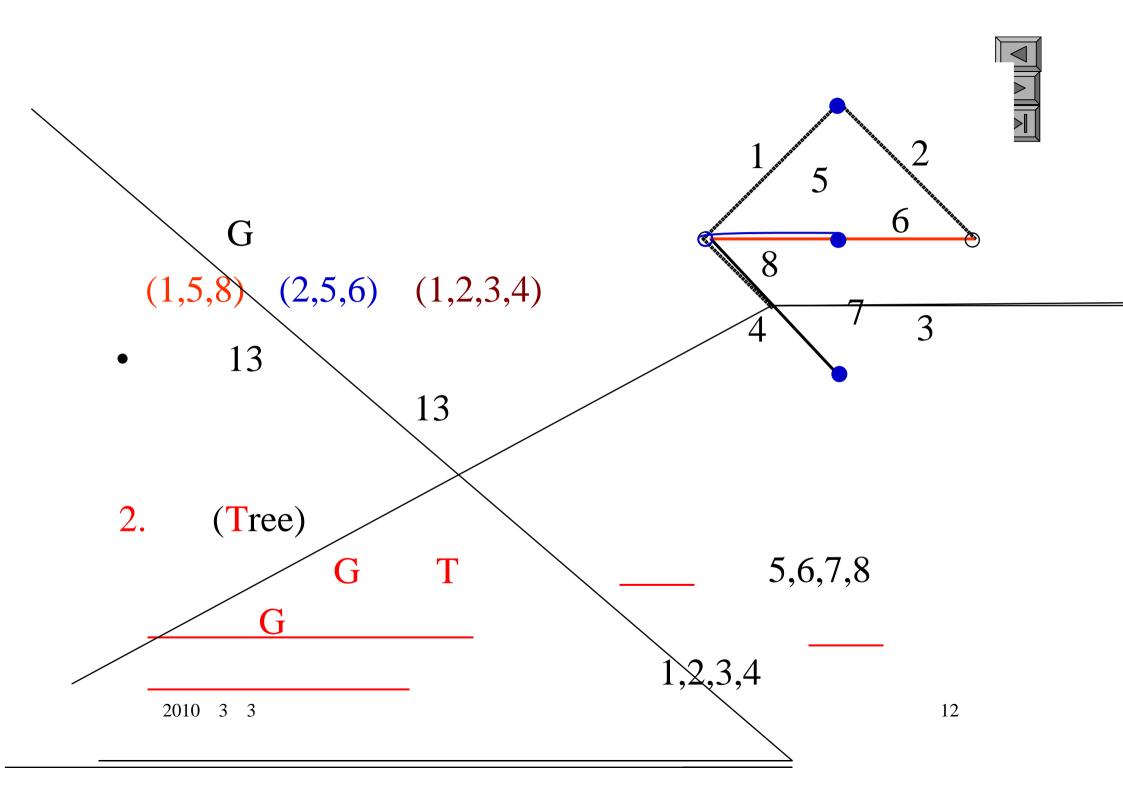
(

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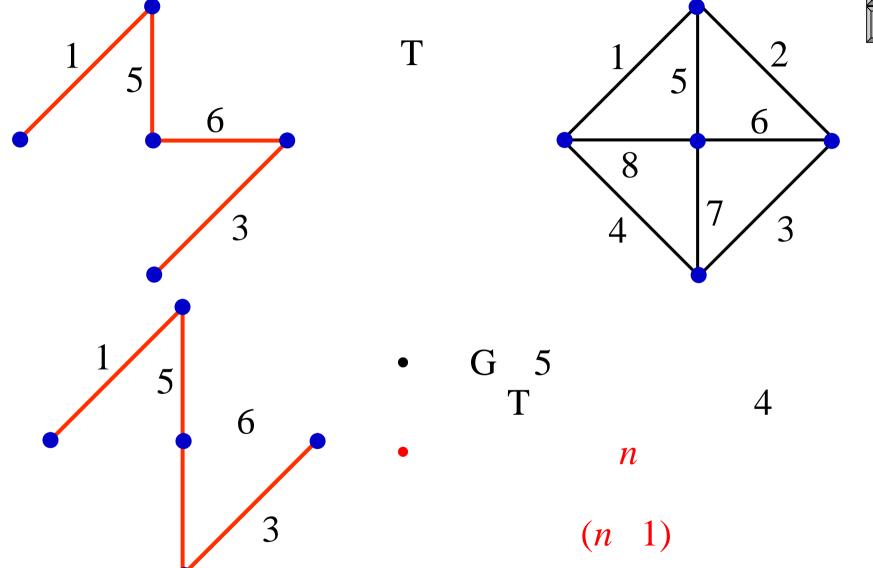
• G

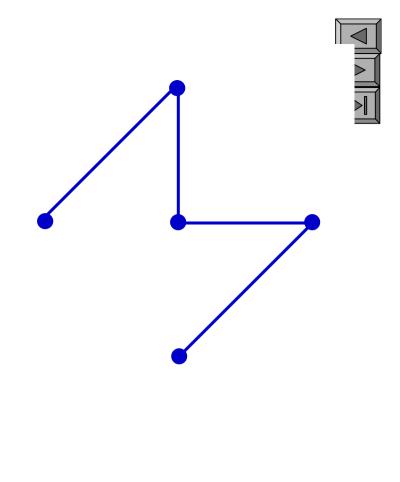


2010 3 3



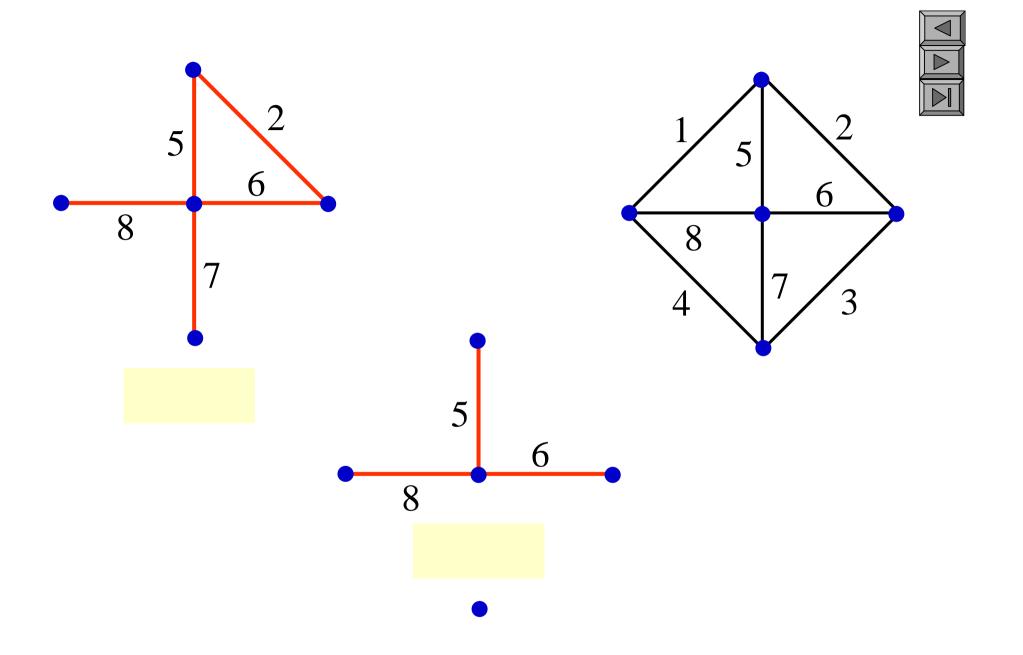




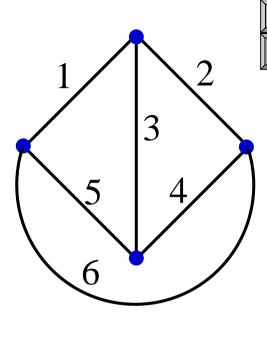


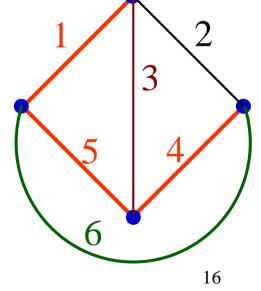
	G	
	n (=5)	
•	G	
1	2	
•		
	(	

n (=5) (n 1=4)





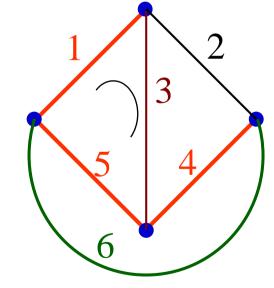




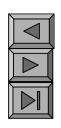
• G n b (n 1)

*b* (*n* 1)

 $l = b \quad (n \quad 1)$ 

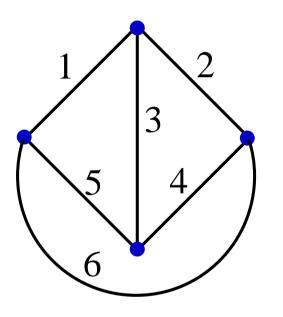


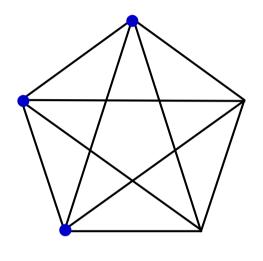
2010 3 3



•

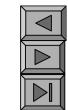
$$l = b \quad (n \quad 1)$$





> KV





3 3

n

b

 $\left. \begin{array}{l} KCL:(n-1) \\ KVL:(b-n+1) \end{array} \right\} b$ 

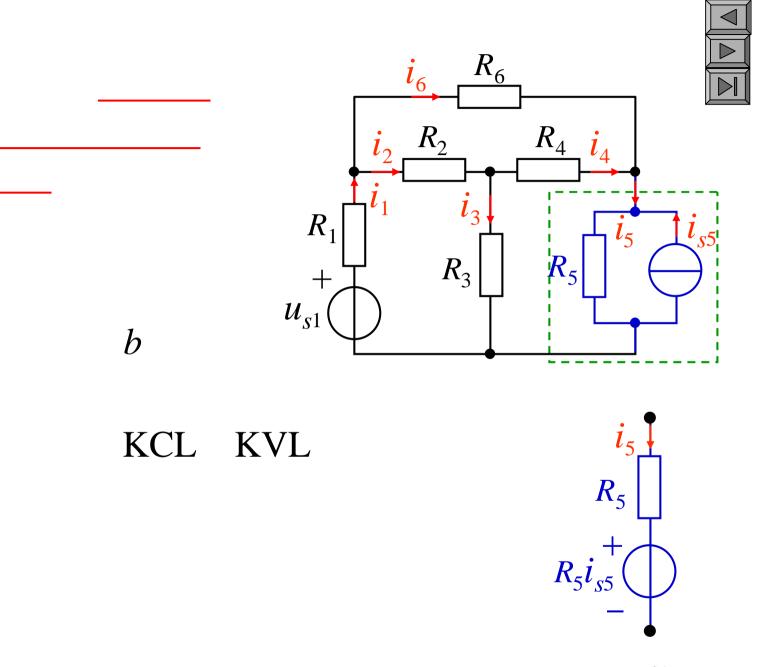
VCR: **b** 

*2b* 

2*b* 

2*b* 

*2b* 



(1)

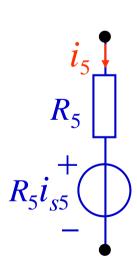
2*b* 

VAR



- :  $-i_1+i_2+i_6=0$
- :  $-i_2+i_3+i_4=0$
- $-i_4+i_5-i_6 \approx 0.45139 > J_+$

$$(3)$$
  $(b n+1)$ 



 $\begin{array}{c|c}
i_6 & R_6 \\
\hline
i_2 & R_2 & i_4 \\
\hline
i_1 & i_3 & i_5 & i_{s5} \\
\hline
u_{s1} & 0 & TcR_3 & Tw & R_5 & 27.96 & Tf
\end{array}$ 

2010 3 3

$$-i_{1} + i_{2} + i_{6} = 0$$

$$-i_{2} + i_{3} + i_{4} = 0$$

$$-i_{4} + i_{5} - i_{6} = 0$$

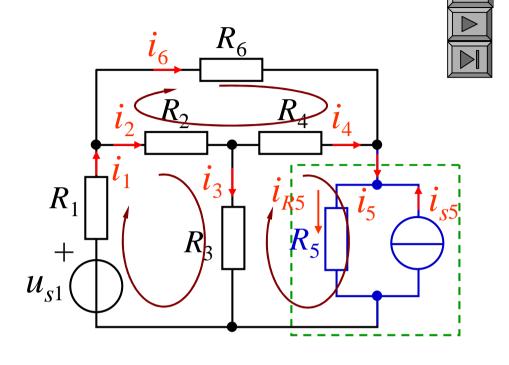
$$R_{1}i_{1} + R_{2}i_{2} + R_{3}i_{3} = u_{s1}$$

$$-R_{3}i_{3} + R_{4}i_{4} + R_{5}i_{5} = -R_{5}i_{s5}$$

$$-R_{2}i_{2} - R_{4}i_{4} + R_{6}i_{6} = 0$$

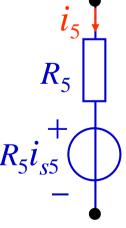
$$(4)$$

$$i_{1} \quad i_{6}$$





$$u_{14} = u_{s1} - R_1 i_1$$
 $R_{5}i_{R5} = i_{s5} + i_{5}$ 



$$R_1 i_1 + R_2 i_2 + R_3 i_3 = u_{s1}$$

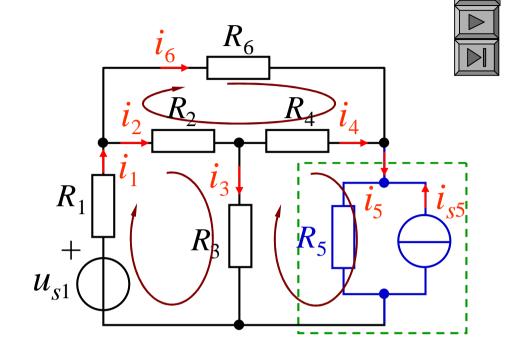
$$-R_3 i_3 + R_4 i_4 + R_5 i_5 = -R_5 i_{s5}$$

$$-R_2 i_2 - R_4 i_4 + R_6 i_6 = 0$$

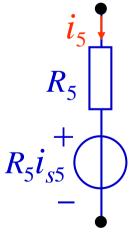
$$R_k i_k = u_{sk}$$

ullet  $i_k$ 

 $u_{sk}$ 

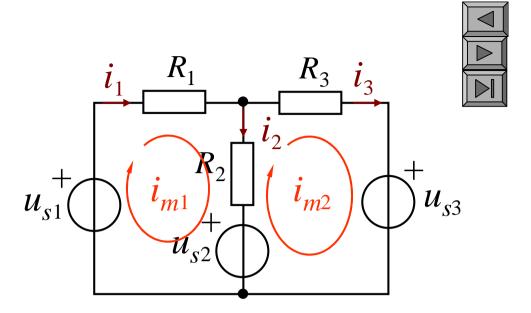


 $R_k i_k$   $u_{sk}$ 





2010 3 3



1.

(1)

(2)

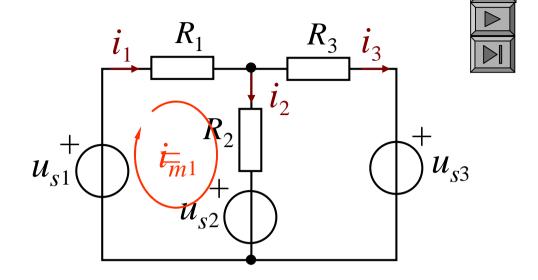
**KVL** 

$$i_{m1}$$
  $i_{m2}$   $R$ 

1 
$$R_1 i_{m1} + R_2 i_{m1} R_2 i_{m2} = u_{s1} - u_{s2}$$

2 
$$R_2 i_{m1} + R_2 i_{m2} + R_3 i_{m2} = u_{s2} - u_{s3}$$

$$R_{11}i_{m1} + R_{12}i_{m2} = u_{s11}$$
  
 $R_{21}i_{m1} + R_{22}i_{m2} = u_{s22}$ 

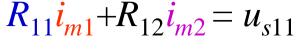


$$R_{1} i_{m1} + R_{2} i_{m1} R_{2} i_{m2} = u_{s1} - u_{s2}$$

$$R_{2} i_{m1} + R_{2} i_{m2} + R_{3} i_{m2} = u_{s2} - u_{s3}$$

$$(R_{1} + R_{2}) i_{m1} R_{2} i_{m2} = u_{s1} - u_{s2}$$

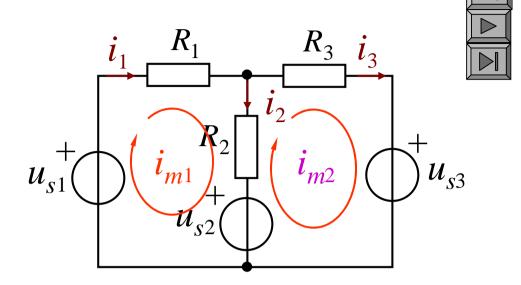
$$R_{2} i_{m1} + (R_{2} + R_{3}) i_{m2} = u_{s2} - u_{s3}$$



$$R_{21}i_{m1} + R_{22}i_{m2} = u_{s22}$$

$$R_{12}i_{m2}$$
  $i_{m2}$ 

$$R_{21}i_{m1}$$
  $i_{m1}$  2



$$R_{12}$$
  $R_{21}$ 

$$i_{m2}$$
  $(i_{m1})$ 

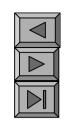
$$R_{12} = R_{21} = R_2$$

#### 1(2)

$$(R_1 + R_2) i_{m1} R_2 i_{m2} = u_{s1} - u_{s2}$$

$$R_2 i_{m1} + (R_2 + R_3) i_{m2} = u_{s2} - u_{s3}$$

2010 3 3



$$R_{11}i_{m1} + R_{12}i_{m2} + R_{13}i_{m3} + \cdots + R_{1m}i_{mm} = u_{s11}$$

$$R_{21}i_{m1} + R_{22}i_{m2} + R_{23}i_{m3} + \cdots + R_{2m}i_{mm} = u_{s22}$$

$$R_{31}i_{m1} + R_{32}i_{m2} + R_{33}i_{m3} + \cdots + R_{3m}i_{mm} = u_{s33}$$

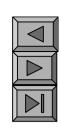
$$R_{m1}i_{m1}+R_{m2}i_{m2}+R_{m3}i_{m3}+\cdots+R_{mm}i_{mm}=u_{smm}$$

ullet  $R_{11}$   $R_{mm}$  \_\_\_\_\_

 $\bullet \qquad \qquad R_{12} \quad R_{1m} \quad R_{21} \quad R_{m1}$ 

(1)

(2)



(3)

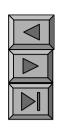
**(4)** 

 $R_{ik} = R_{ki}$ 

m•  $u_{s11}$   $u_{smm}$ 

66 99

3–1 ( P60)



1. (T)

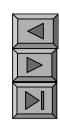
(1) (2) G

(3)

2. (L) G

(1) (2)

2010 3 3



*3. KCL* 

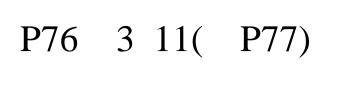
n-1

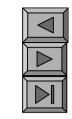
KVL

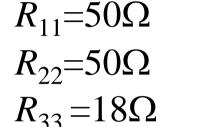
b (n 1)

4.

5.

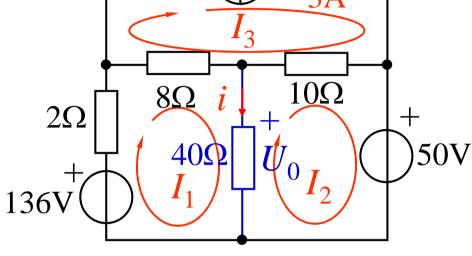








 $U_0$ 



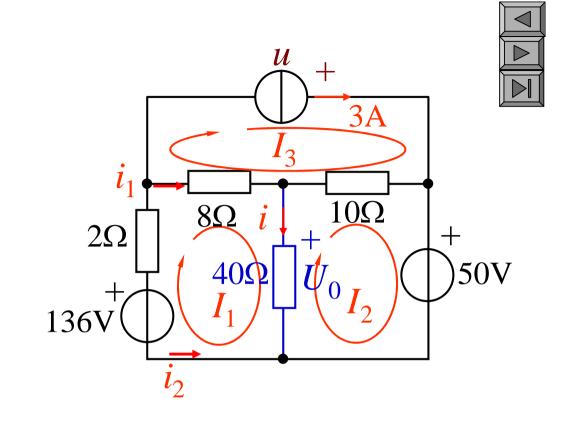
$$R_{12} = R_{21} = 40\Omega$$
  
 $R_{13} = R_{31} = 8\Omega$   
 $R_{23} = R_{32} = 10\Omega$ 

$$\begin{cases} 50 I_{1} - 40I_{2} - 8 I_{3} = 136 \\ -40 I_{1} + 50 I_{2} - 10 I_{3} = -50 \\ -8 I_{1} - 10 I_{2} + 18 I_{3} = u \end{cases}$$

$$I_{3} = 3A$$

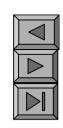
$$I_1 = 8A$$
  $I_2 = 6A$ 

$$U_0 = 40i = 40(I_1 \ I_2) = 80V$$



$$i = I_1 - I_2$$
 $i_1 = I_1 - I_3$ 
 $i_2 = -I_1$ 





lacktriangle

KVL

lacktriangle

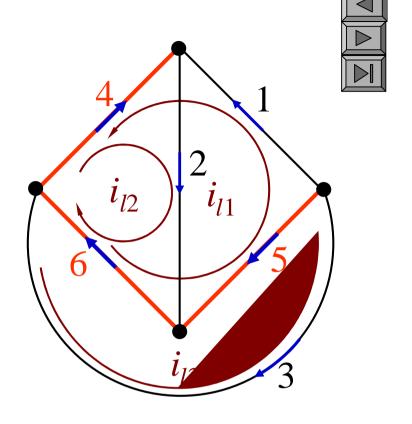
$$i_1$$
  $i_2$   $i_3$ 

$$i_{l1}$$
  $i_{l2}$   $i_{l3}$   $i_{1} = i_{l1}$   $i_{2} = i_{l2}$   $i_{3} = i_{l3}$ 

$$i_{4} = -i_{l1} + i_{l2}$$

$$i_{5} = -i_{l1} - i_{l3}$$

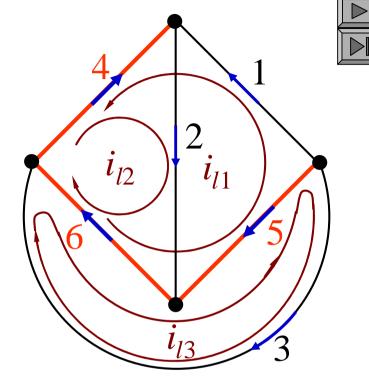
$$i_{6} = -i_{l1} + i_{l2} - i_{l3}$$





$$\begin{aligned} & i_4 = -i_1 + i_2 = -i_{l1} + i_{l2} \\ & i_5 = -i_1 - i_3 = -i_{l1} - i_{l3} \\ & i_6 = -i_1 + i_2 - i_3 = -i_{l1} + i_{l2} - i_{l3} \end{aligned}$$

KCL



66 99

•



$$b$$
  $n$   $($   $)$   $l=b$   $(n 1)$   $KVL$ 

$$R_{11}i_{l1} + R_{12}i_{l2} + R_{13}i_{l3} + \cdots + R_{1l}i_{ll} = u_{s11}$$

$$R_{21}i_{l1} + R_{22}i_{l2} + R_{23}i_{l3} + \cdots + R_{2l}i_{ll} = u_{s22}$$

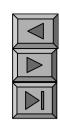
$$R_{31}i_{l1} + R_{32}i_{l2} + R_{33}i_{l3} + \cdots + R_{3l}i_{ll} = u_{s33}$$

$$\vdots$$

$$R_{l1}i_{l1} + R_{l2}i_{l2} + R_{l3}i_{l3} + \cdots + R_{ll}i_{ll} = u_{sll}$$

$$R_{12}$$
  $R_{13}$   $R_{23}$   $R_{l1}$   $R_{1l}$ 

66 99



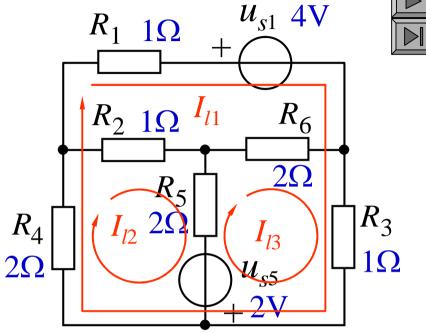
39

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} & \cdots & R_{1l} \\ R_{21} & R_{22} & R_{23} & \cdots & R_{2l} \\ R_{31} & R_{32} & R_{33} & \cdots & R_{3l} \\ & & & & & \vdots \\ R_{l1} & R_{l2} & R_{l3} & \cdots & R_{ll} \end{bmatrix} \begin{bmatrix} i_{l1} \\ i_{l2} \\ i_{l3} \\ \vdots \\ i_{li} \end{bmatrix} = \begin{bmatrix} u_{s11} \\ u_{s22} \\ u_{s33} \\ \vdots \\ u_{sll} \end{bmatrix}$$

 $\mathbf{0}$ 

$$u_{s11}$$
  $u_{sll}$  1  $l$ 

P65 3 2



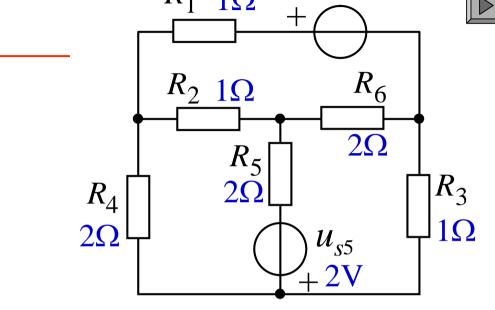
L1 
$$4I_{l1} + 2I_{l2} + 1I_{l3} = -4$$
  
L2  $2I_{l1} + 5I_{l2} - 2I_{l3} = 2$   
L3  $1I_{l1} - 2I_{l2} + 5I_{l3} = -2$ 

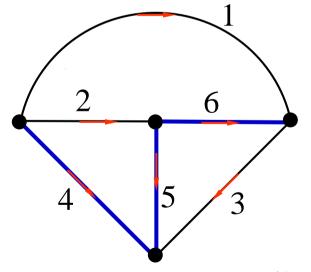
P65 3 2

 $R_1 \quad 1\Omega \quad \mu_{s1} \quad 4V$ 

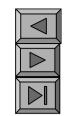
•

•





P67 3 3



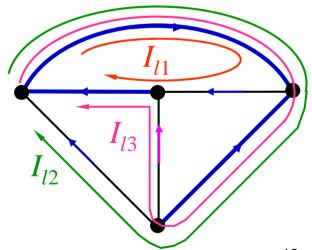
20V

(1)

(2)

 $\frac{10\Omega}{I_{l2}}$  U  $\frac{30\Omega}{I_{l2}}$ 

 $45I_{l1} + 20I_{l2} + 30I_{l3} = 0$   $20I_{l1} + 90I_{l2} + 60I_{l3} = 30$   $30I_{l1} + 60I_{l2} + 70I_{l3} = U - 20$   $I_{l3} = 1$ 



 $20\Omega$ 

1**A** 

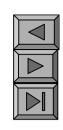
 $15\Omega$ 

 $I_{l3}$ 

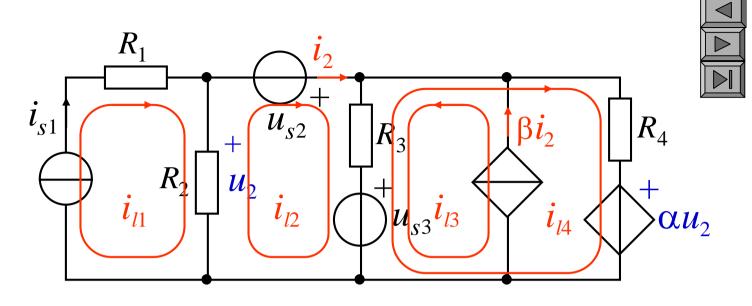
 $40\Omega$ 

2010 3 3

42



P67-68 3 4



L2 
$$-R_{2}i_{l1} + (R_{2} + R_{3})i_{l2} + R_{3}i_{l3} - R_{3}i_{l4} = u_{s2} - u_{s3}$$
  
L4  $-R_{3}i_{l2} - R_{3}i_{l3} + (R_{3} + R_{4})i_{l4} = u_{s3} - \alpha u_{2}$   
 $i_{l1} = i_{s1}$   $i_{l3} = |\beta i_{l2}|$ 

$$\alpha u_2 = \alpha R_2(i_{11} - i_{12}) = \alpha R_2 i_{11} - \alpha R_2 i_{12}$$

$$\alpha R_2 i_{l1} - (\alpha R_2 + R_3) i_{l2} - R_3 i_{l3} + (R_3 + R_4) i_{l4} = u_{s3}$$

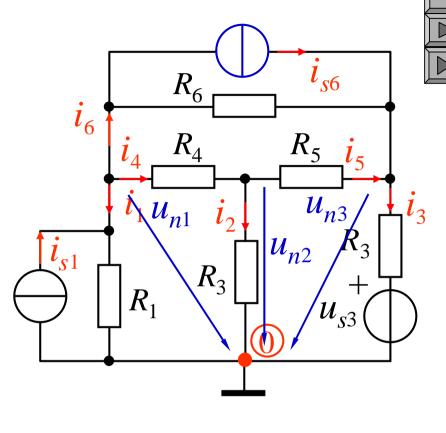
1 3 KVL



•

•

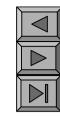
n



45

(n 1)





•

•  $u_{n1}=u_1$   $u_{n2}=u_2$   $u_{n3}=u_3$ 

•

$$KVL u_{1} + u_{4} + u_{2} = 0$$

$$u_{4} = u_{1} u_{2} = u_{n1} u_{n2}$$

$$u_{5} = u_{n2} u_{n3}$$

$$u_{6} = u_{n1} u_{n3}$$

$$u_{1} u_{n3}$$

$$u_{1} u_{n3}$$

• KCL!

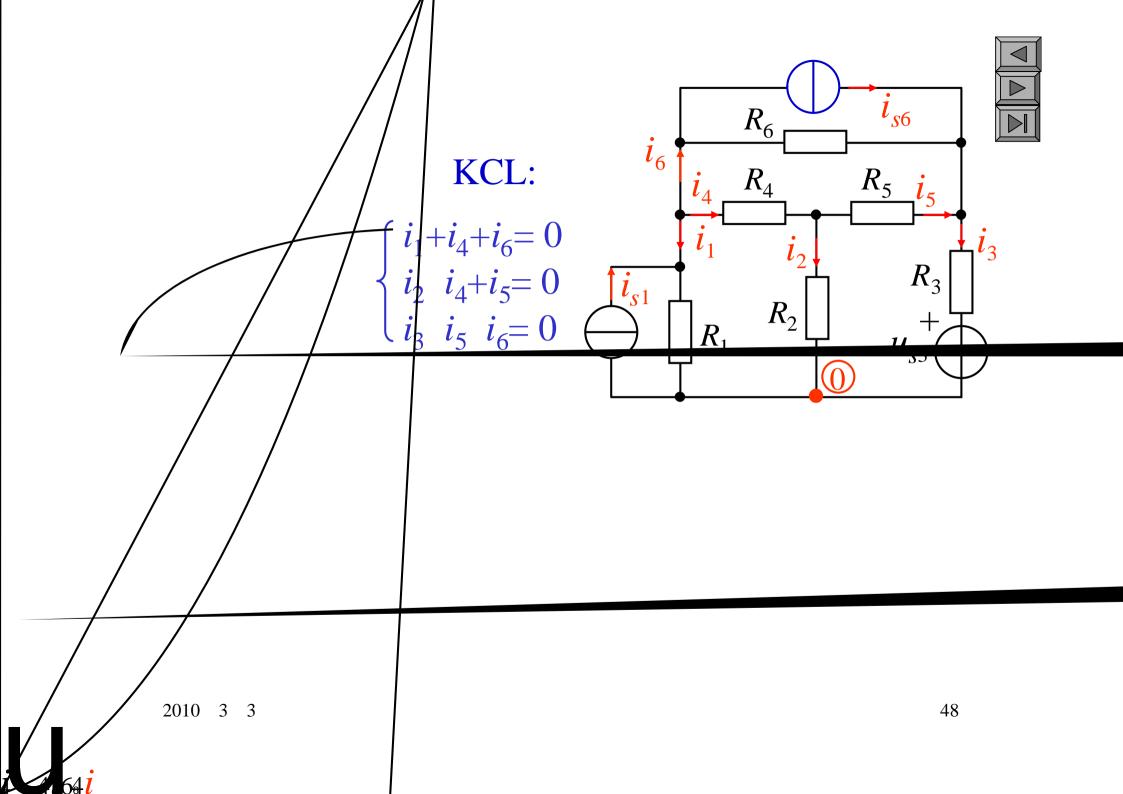
 $i_6$   $i_{4}$   $R_{4}$   $R_{5}$   $i_{5}$   $R_{1}$   $R_{2}$   $R_{2}$   $R_{3}$   $R_{3}$   $R_{4}$   $R_{5}$   $R_{5}$   $R_{6}$   $R_{1}$   $R_{2}$   $R_{3}$   $R_{4}$   $R_{5}$   $R_{5}$ 

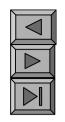
$$i_{1} = \frac{u_{n1}}{R_{1}} - i_{s1} \qquad i_{2} = \frac{u_{n2}}{R_{2}}$$

$$i_{4} = \frac{u_{n1} - u_{n2}}{R_{4}} \qquad i_{5} = \frac{u_{n2} - u_{n3}}{R_{5}}$$

$$i_3 = \frac{u_{n3} - u_{s3}}{R_3}$$

$$i_6 = \frac{u_{n1} - u_{n3}}{R_6} + i_{s6}$$





$$\left[\frac{1}{R_1} + \frac{1}{R_4} + \frac{1}{R_6}\right] u_{n1} - \frac{1}{R_4} u_{n2} - \frac{1}{R_6} u_{n3} = i_{s1} - i_{s6}$$

$$-\frac{1}{R_4}u_{n1} + \left[\frac{1}{R_2} + \frac{1}{R_4} + \frac{1}{R_5}\right]u_{n2} - \frac{1}{R_6}u_{n3} = 0$$

$$-\frac{1}{R_6}u_{n1} - \frac{1}{R_5}u_{n2} + \left[\frac{1}{R_3} + \frac{1}{R_5} + \frac{1}{R_6}\right]u_{n3} = i_{s6} + \frac{u_{s3}}{R_3}$$

$$\frac{1}{R_1} \frac{1}{R_6} G_1 G_6$$

$$(G_1 + G_4 + G_6)u_{n1} G_4 u_{n2} G_6 u_{n3} = i_{s1} i_{s6}$$

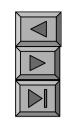
$$G_4 u_{n1} + (G_2 + G_4 + G_5)u_{n2} G_5 u_{n3} = 0$$

$$G_6 u_{n1} G_5 u_{n2} + (G_3 + G_5 + G_6)u_{n3} = i_{s6} + G_3 u_{s3}$$

$$(G_1+G_4+G_6)u_{n1} G_4u_{n2} G_6u_{n3}=i_{s1} i_{s6}$$

$$G_4u_{n1}+(G_2+G_4+G_5)u_{n2} G_5u_{n3}=0$$

$$G_6u_{n1} G_5u_{n2}+(G_3+G_5+G_6)u_{n3}=i_{s6}+G_3u_{s3}$$



$$G_{11}u_{n1}+G_{12}u_{n2}+G_{13}u_{n3}=i_{s11}$$

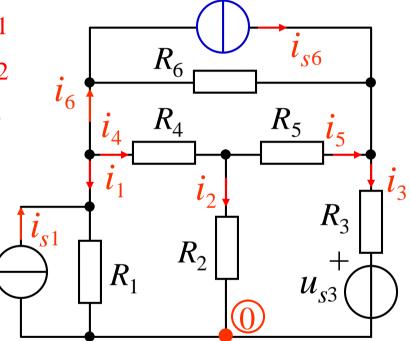
$$G_{21}u_{n1}+G_{22}u_{n2}+G_{23}u_{n3}=i_{s22}$$

$$G_{31}u_{n1}+G_{32}u_{n2}+G_{33}u_{n3}=i_{s33}$$

3

• 
$$G_{11} = (G_1 + G_4 + G_6)$$

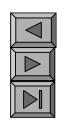
$$G_{22} = (G_2 + G_4 + G_5)$$
  
 $G_{33} = (G_3 + G_5 + G_6)$ 



$$(G_1+G_4+G_6)u_{n1} G_4u_{n2} G_6u_{n3}=i_{s1} i_{s6}$$

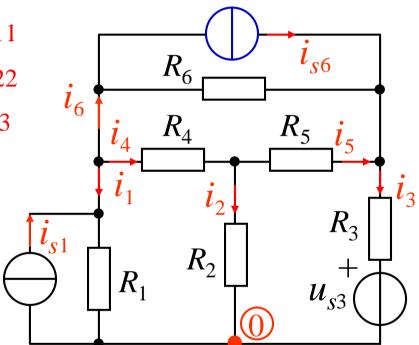
$$G_4u_{n1}+(G_2+G_4+G_5)u_{n2} G_5u_{n3}=0$$

$$G_6u_{n1} G_5u_{n2}+(G_3+G_5+G_6)u_{n3}=i_{s6}+G_3u_{s3}$$



 $G_{11}u_{n1}+G_{12}u_{n2}+G_{13}u_{n3}=i_{s11}$   $G_{21}u_{n1}+G_{22}u_{n2}+G_{23}u_{n3}=i_{s22}$   $G_{31}u_{n1}+G_{32}u_{n2}+G_{33}u_{n3}=i_{s33}$ 

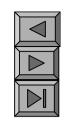
 $G_{12}=G_{21}=-G_4$   $G_{23}=G_{32}=-G_5$  $G_{13}=G_{31}=-G_6$ 



$$(G_1+G_4+G_6)u_{n1} G_4u_{n2} G_6u_{n3}=i_{s1} i_{s6}$$

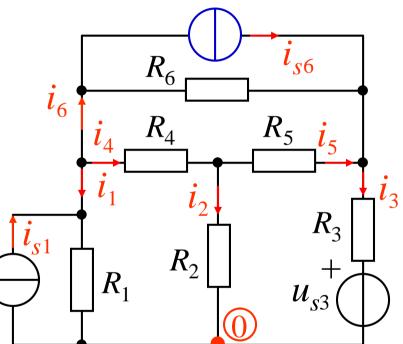
$$G_4u_{n1}+(G_2+G_4+G_5)u_{n2} G_5u_{n3}=0$$

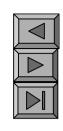
$$G_6u_{n1} G_5u_{n2}+(G_3+G_5+G_6)u_{n3}=i_{s6}+G_3u_{s3}$$



 $\begin{aligned} G_{11}u_{n1} + G_{12}u_{n2} + G_{13}u_{n3} &= i_{s11} \\ G_{21}u_{n1} + G_{22}u_{n2} + G_{23}u_{n3} &= i_{s22} \\ G_{31}u_{n1} + G_{32}u_{n2} + G_{33}u_{n3} &= i_{s33} \end{aligned}$ 

 $i_{s11} = i_{s1} - i_{s6}$   $i_{s22} = 0$  $i_{s33} = i_{s6} - G_3 u_{s3}$ 





## n

$$G_{11}u_{n1}+G_{12}u_{n2}+G_{13}u_{n3}+\cdots+G_{1(n-1)}u_{n(n-1)}=i_{s11}$$

$$G_{21}u_{n1}+G_{22}u_{n2} G_{23}u_{n3}+\cdots+G_{2(n-1)}u_{n(n-1)}=i_{s22}$$

$$G_{31}u_{n1}+G_{32}u_{n2}+G_{33}u_{n3}+\cdots+G_{3(n-1)}u_{n(n-1)}=i_{s33}$$

$$G_{(n\ 1)1}u_{n1}+G_{(n\ 1)2}u_{n2}+G_{(n\ 1)3}u_{n3}+\cdots+G_{(n\ 1)(n\ 1)}u_{(n\ 1)(n\ 1)}=\mathbf{i}_{s(n\ 1)(n\ 1)}$$

$$oldsymbol{G}_{ij}\!\!=\!\!G_{ji}$$

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0

$$: (G_1 + G_4 + G_8)u_{n1}$$

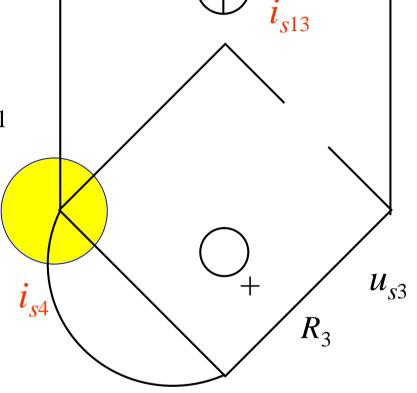
$$-G_1 u_{n2} - G_4 u_{n4} = i_{s4} - i_{s13}$$

: 
$$(G_1 + G_2 + G_5)u_{n2}$$

$$-G_1 u_{n1} - G_2 u_{n3} = 0$$

$$: (G_2 + G_3 + G_6)u_{n3}$$

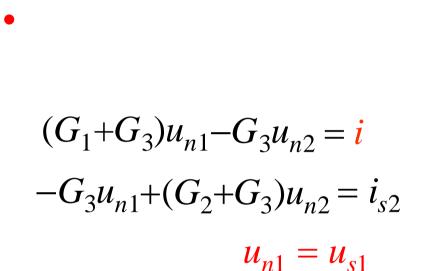
$$-G_2 u_{n2} - G_3 u_{n4} = i_{s13} - G_3 u_{s3}$$



:  $(G_3 + G_4 + G_7)u_{n4} - G_4 u_{n1} - G_3 u_{n3}$ =  $G_3 u_{s3} + G_7 u_{s7} - i_{s4}$ 

3 6 ( )

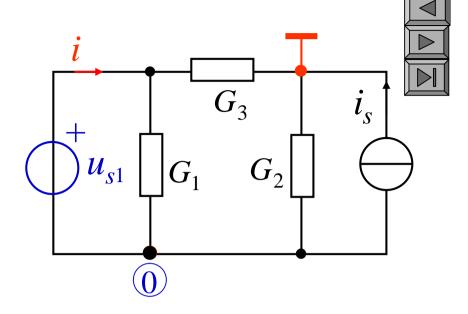
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$$u_{s1}$$

$$u_{n1} = u_{s1}$$

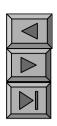
$$u_{n2}$$



$$(G_1+G_3)u_{n1}-G_1u_{n0} = i$$

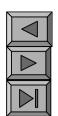
$$-G_1u_{n1} + (G_1+G_2)u_{n0} = -i_{s2}-i$$

$$u_{n1}-u_{n0} = u_{s1}$$



3 7

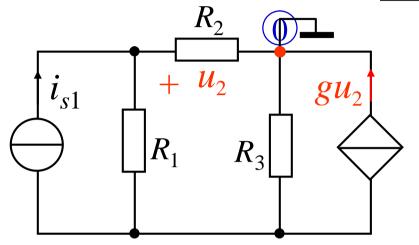
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**(1)** 

$$u_{n1} = u_2$$

(2)

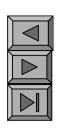


$$\left( \frac{1}{R_1} + \frac{1}{R_2} \right) u_{n1} - \frac{1}{R_1} u_{n2} = i_{s1}$$

$$+ \left( \frac{1}{R_2} + \frac{1}{R_3} \right) u_{n2} = -i_{s1} - g u_{n1}$$

$$(3)$$

$$\left(-\frac{1}{R_1} + g\right) u_{n1}$$



1. ("-")

2.

3.

4.

