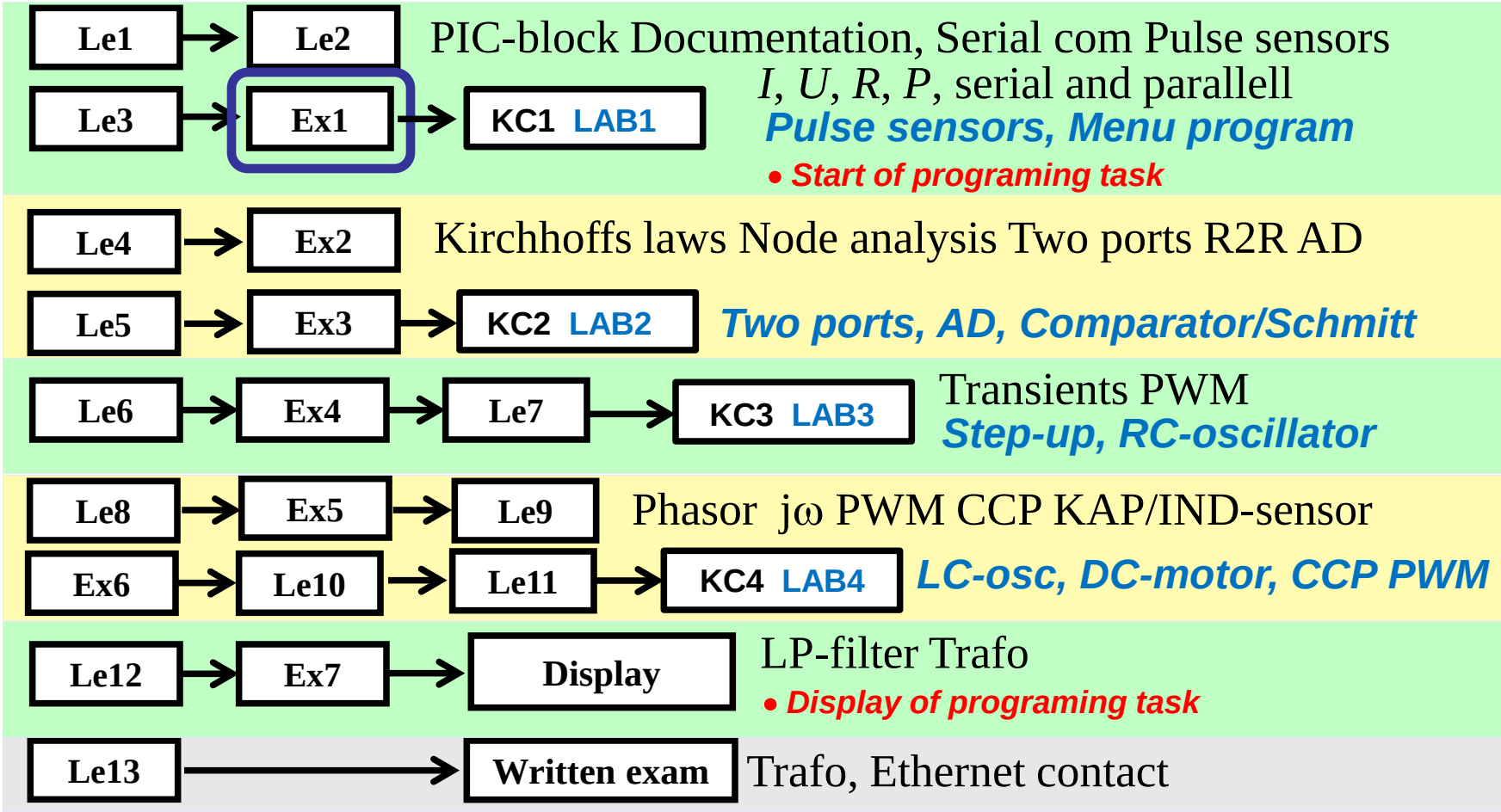
IE1206 Embedded Electronics

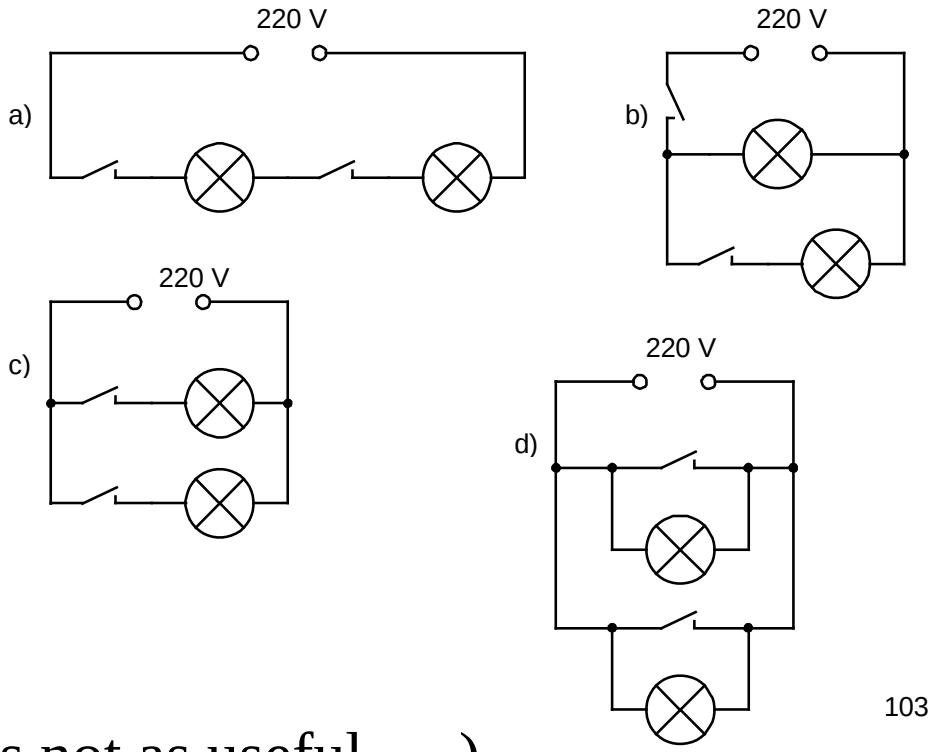


William Sandqvist william@kth.se

Closed circuit?

- ***discussion.***

Current can only flow through a circuit on condition there is a closed circuit.



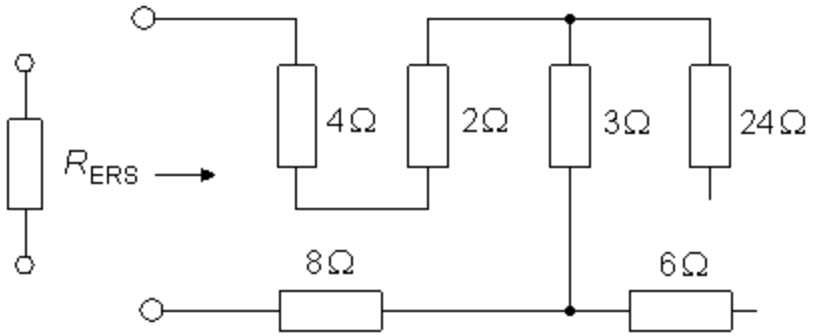
Describe in words the action of circuits a) … d) when when you operate the two switches.

(All the circuits are perhaps not as useful …)

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Series resistors



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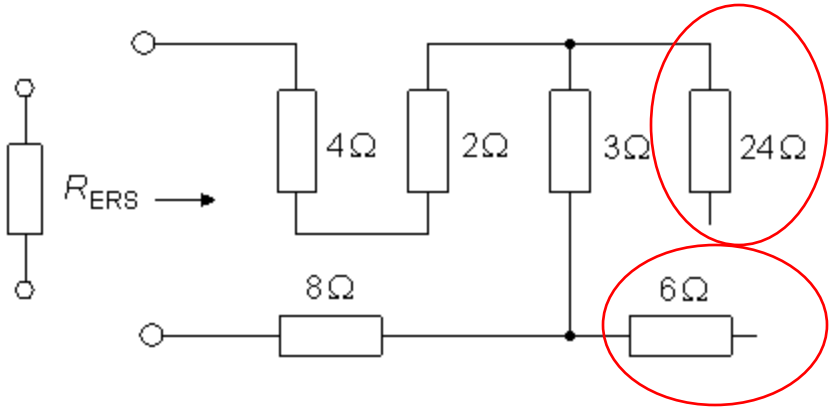
Series resistors



no current = not included in circuit!

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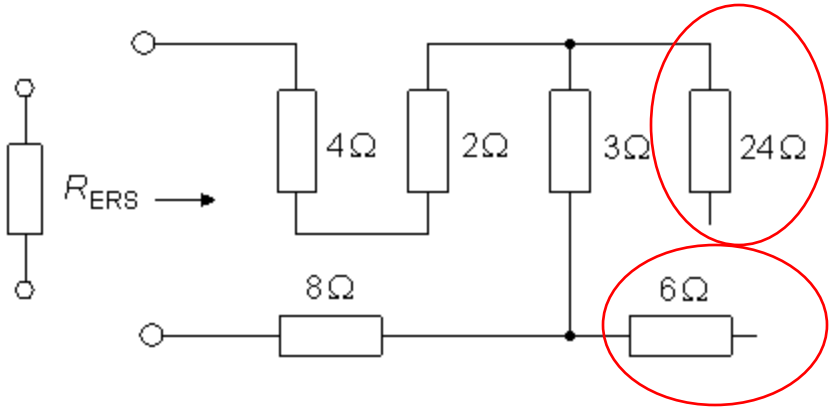
Series resistors



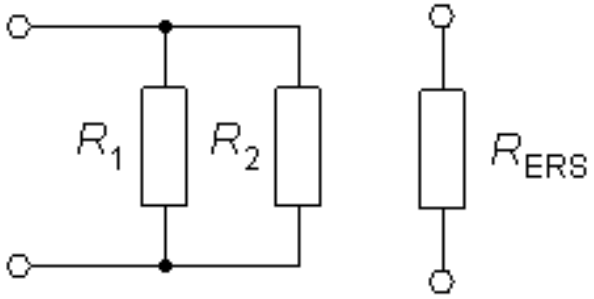
no current = not included in circuit!

$$R_{ERS} = 4 + 2 + 3 + 8 = 17$$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Two resistors in Parallell



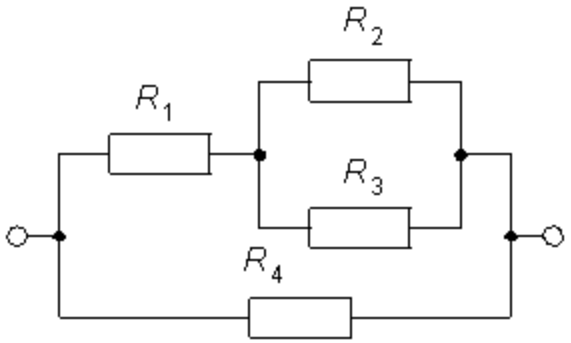
$$\frac{1}{R_{ERS}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2}{R_2} \cdot \frac{1}{R_1} + \frac{R_1}{R_1} \cdot \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 \cdot R_2}$$

$$R_{ERS} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

William Sandqvist william@kth.se

Equivalent resistance (1.2)

$R_1 = 1\ \Omega$
$R_2 = 21\ \Omega$
$R_3 = 42\ \Omega$
$R_4 = 30\ \Omega$



$$R_{\text{ERS}} = 30//(1+21//42)$$

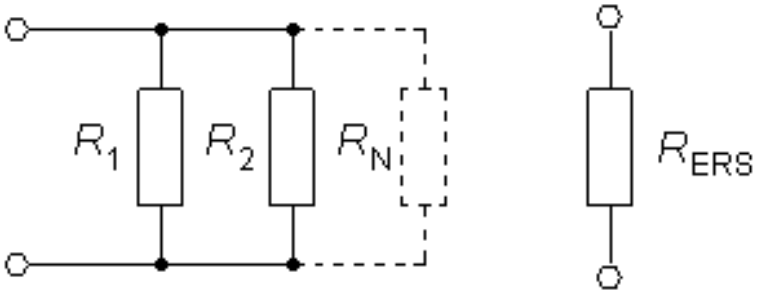
$$21//42 = \frac{21\cdot 42}{21+42} = 14 \quad \Rightarrow \quad (1+21//42) = 15$$

$$30//15 = \frac{30\cdot 15}{30+15} = 10 \quad \Rightarrow \quad R_{ERS} = 10\ \Omega$$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

N *same value* in parallell



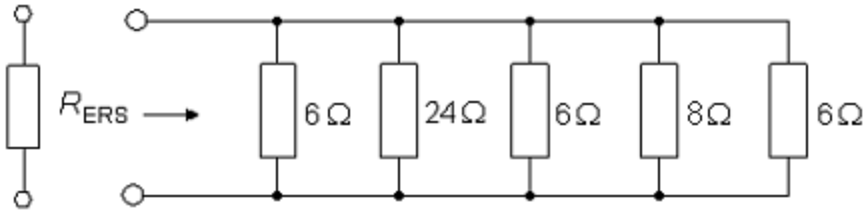
$$R_1 = R_2 = \cdots = R_N = R$$

$$\frac{1}{R_{ERS}} = \frac{1}{R} + \frac{1}{R} + \cdots = \frac{N}{R}$$

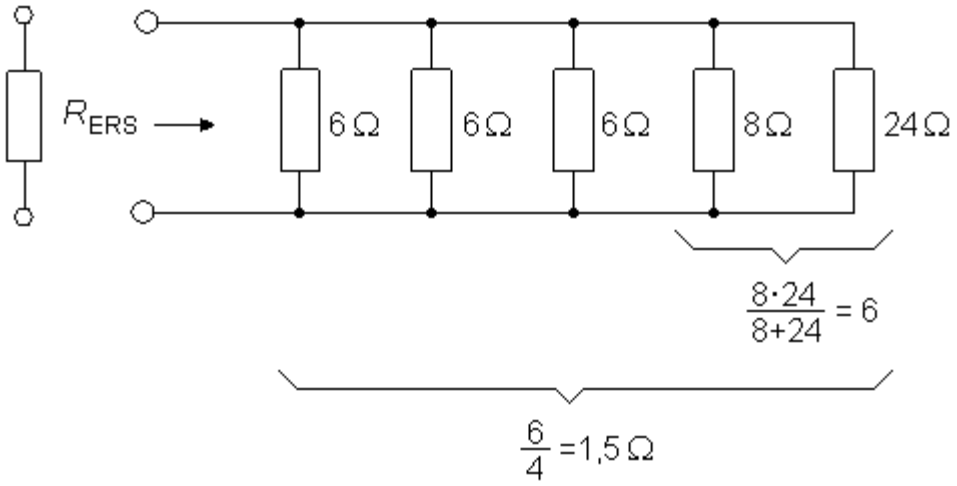
$$R_{ERS}(N) = \frac{R}{N}$$

William Sandqvist william@kth.se

OK to move …



Redrawn:



William Sandqvist william@kth.se

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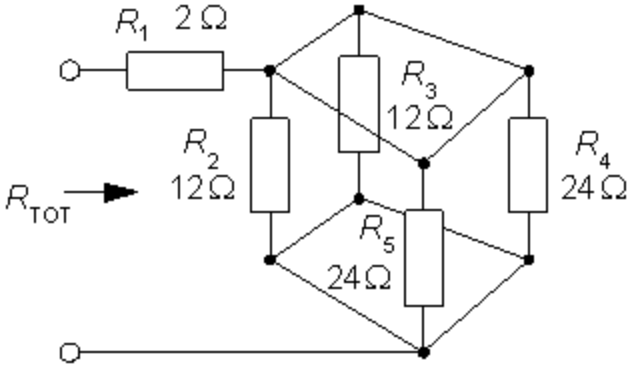
Equivalent resistance (1.6)

$R_{TOT} = 2+(12//12)//(24//24)$

// means parallell connection



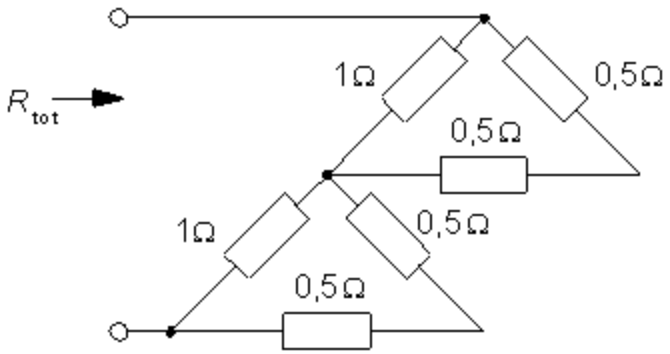
$$12//12 = 6 \quad 24//24 = 12$$

$$(12//12)//(24//24) = \frac{6 \cdot 12}{6+12} = 4$$

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

William Sandqvist william@kth.se

Equivalent resistance (1.1)

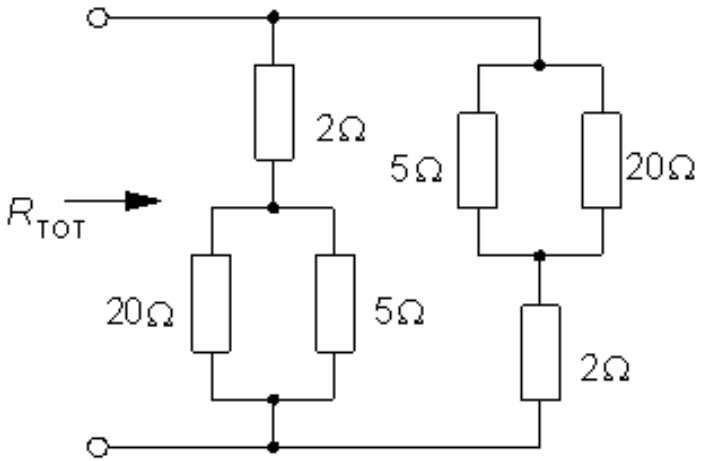


$R_{TOT} = 1//(0,5+0,5) + 1//(0,5+0,5) = 1//1+1//1 = 0,5+0,5 = 1$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Equivalent resistance (1.8)



$R_{\mathrm{TOT}} = (2+20//5)//(20//5+2)$

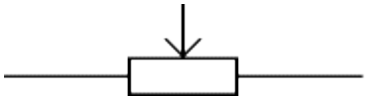
$$(2+20//5) = 2+\frac{20\cdot 5}{20+5} = 2+4 = 6 \qquad 6//6 = 3$$

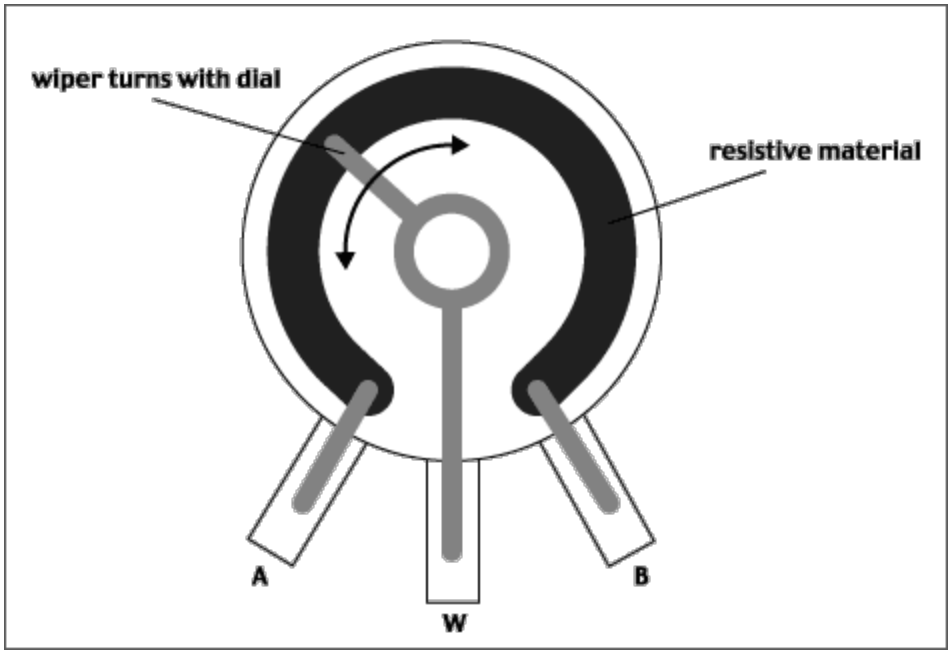
$$R_{TOT} = 3\,\Omega$$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Potentiometer

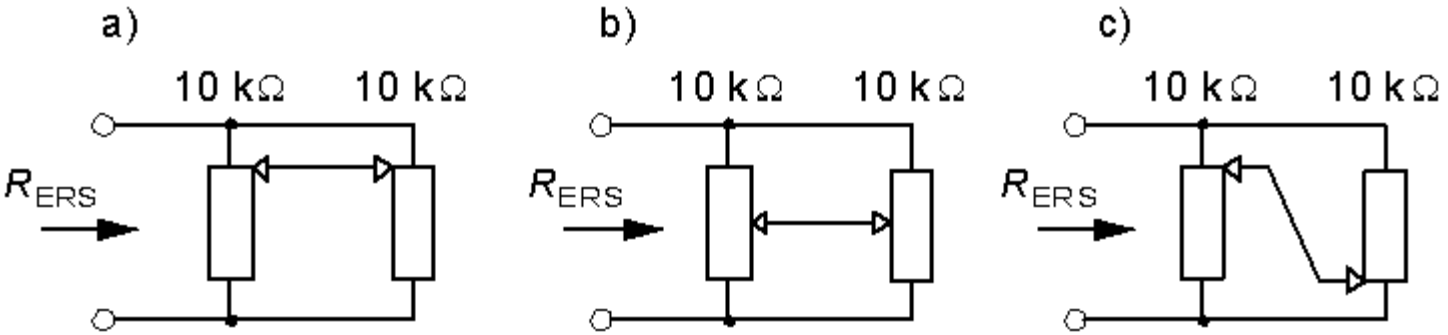




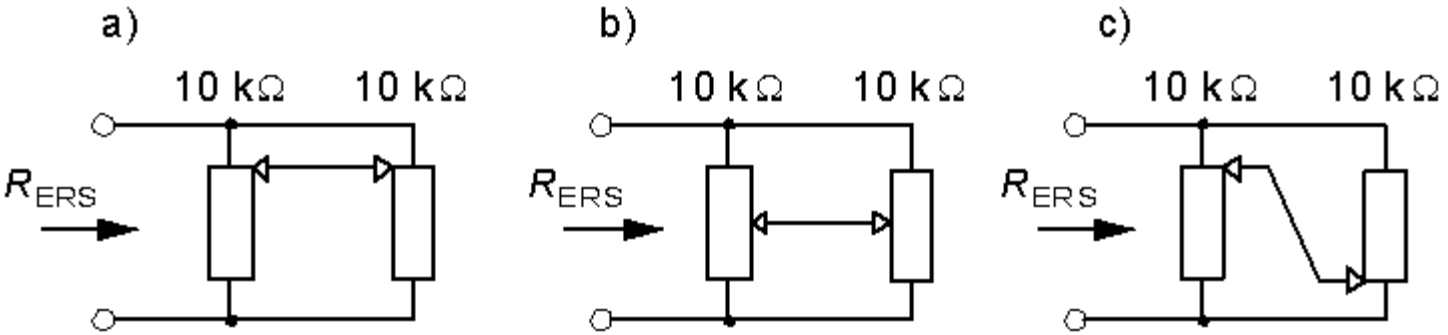
Appearance at our labs.

William Sandqvist william@kth.se

Equivalent resistance (1.10)



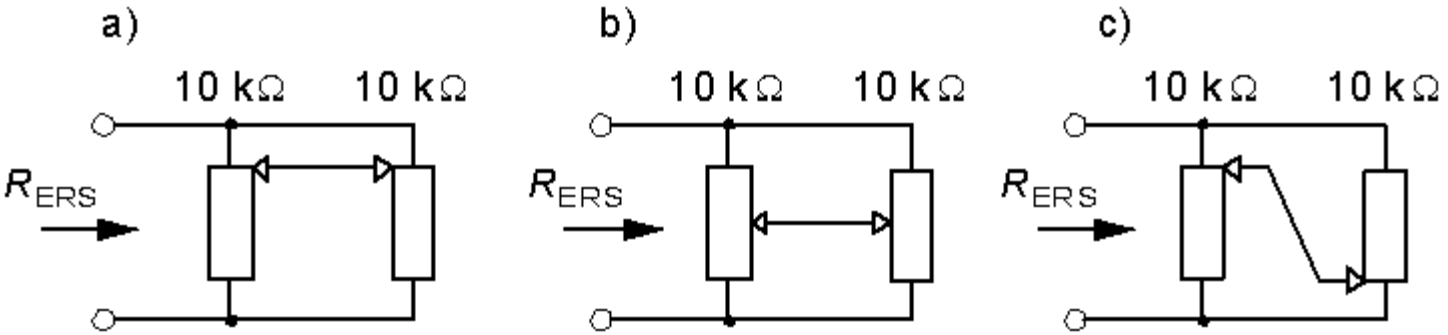
Equivalent resistance (1.10)



a) R_{ERS} = 10/2 = 5 kΩ

William Sandqvist william@kth.se

Equivalent resistance (1.10)

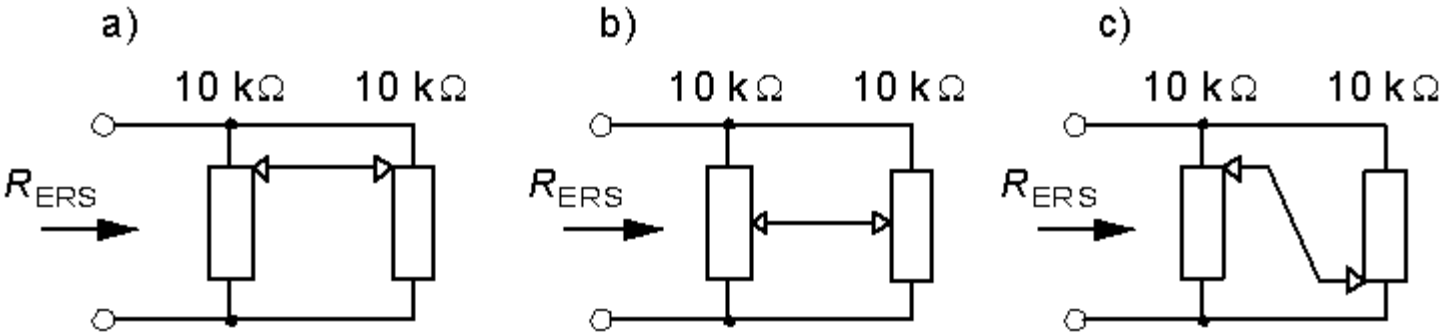


a) $R_{ERS} = 10/2 = 5\ k\Omega$

b) $R_{ERS} = 5/2 + 5/2 = 5\ k\Omega$

William Sandqvist william@kth.se

Equivalent resistance (1.10)



a) $R_{ERS} = 10/2 = 5\ k\Omega$

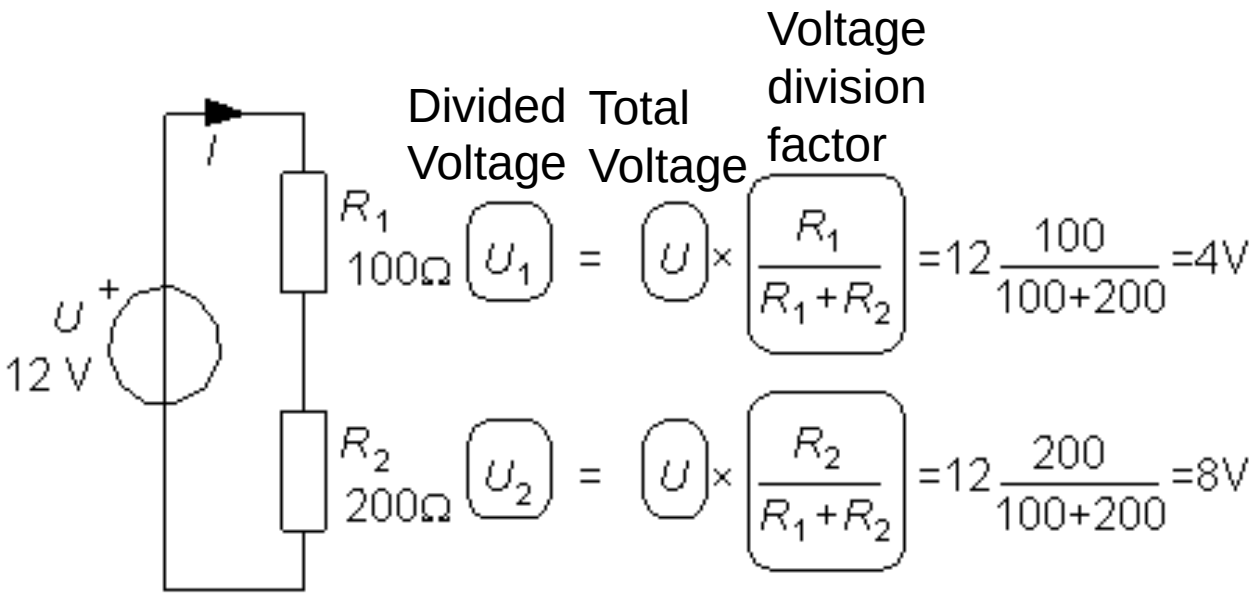
b) $R_{ERS} = 5/2 + 5/2 = 5\ k\Omega$

c) $R_{ERS} = 0\ \Omega$!

William Sandqvist william@kth.se

William Sandqvist william@kth.se

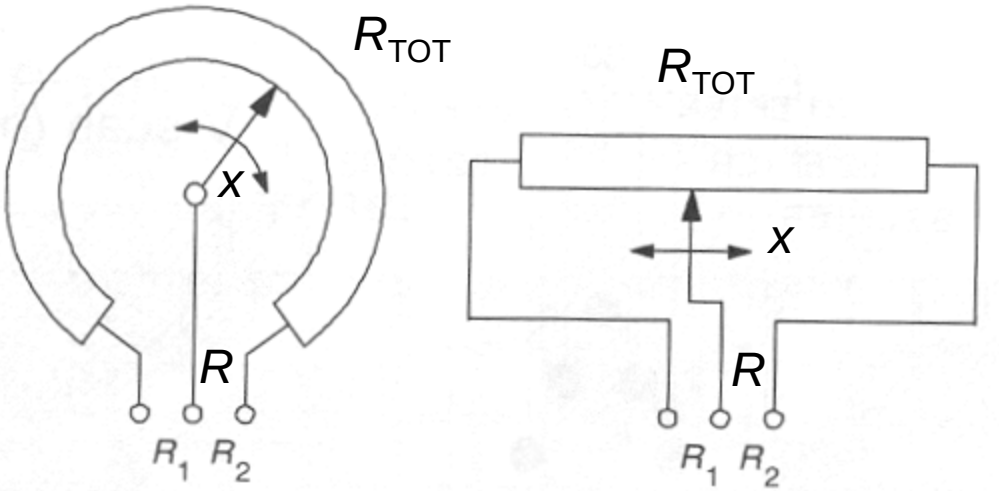
Voltage divider



According to the voltage divider formula tyou get a divided voltage, for example U_1 across the resistor $R_{1,}$ by multiplying the total voltage U with a voltage division factor. This voltage division factor is the resistance R_1 divided by the sum of all the resistorss that are in the series connection.

William Sandqvist william@kth.se

Resistive sensors, rotate and slide resistances

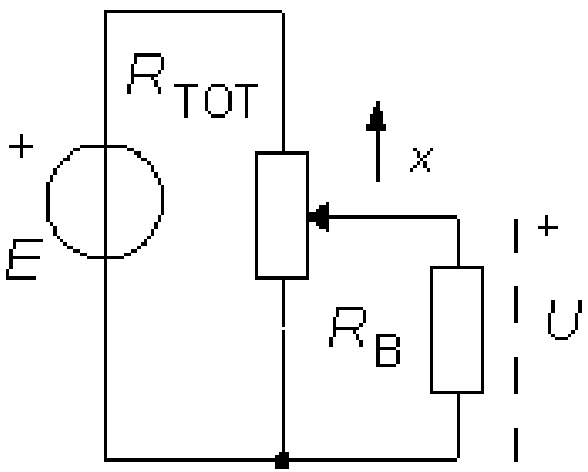


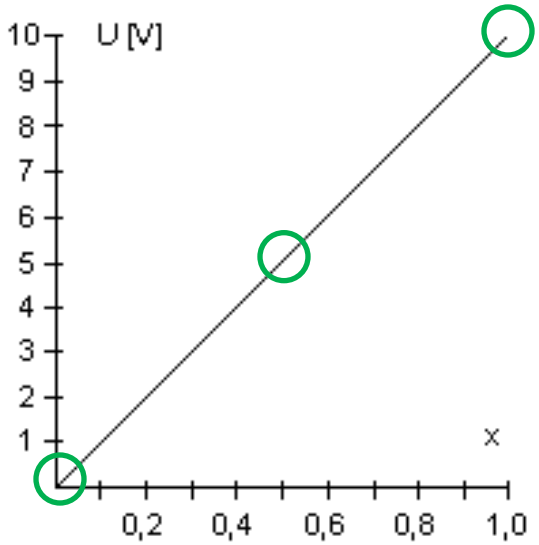
$$R = R_{TOT} \cdot x$$

x relative movement/rotation $0 < x < 1$

William Sandqvist william@kth.se

Potentiometer with load (1.11)

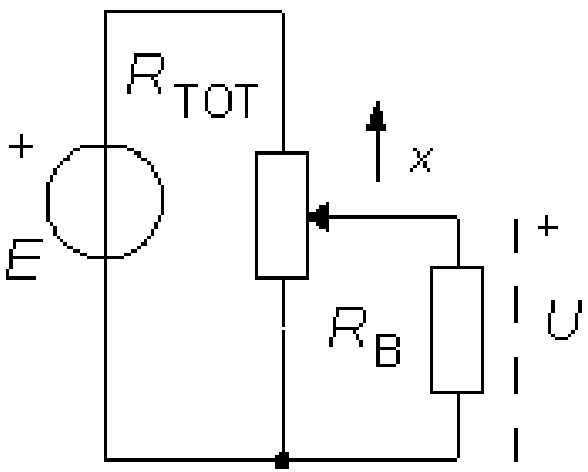


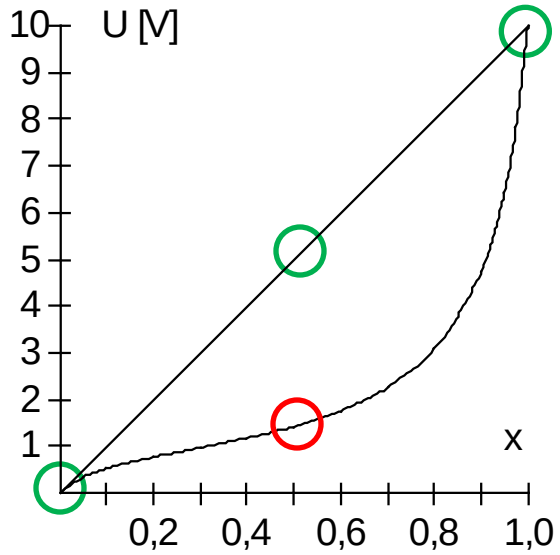


Without R_B $\quad U = E \cdot x \quad \{0 \ldots x \ldots 1\}$

William Sandqvist william@kth.se

Potentiometer with load (1.11)



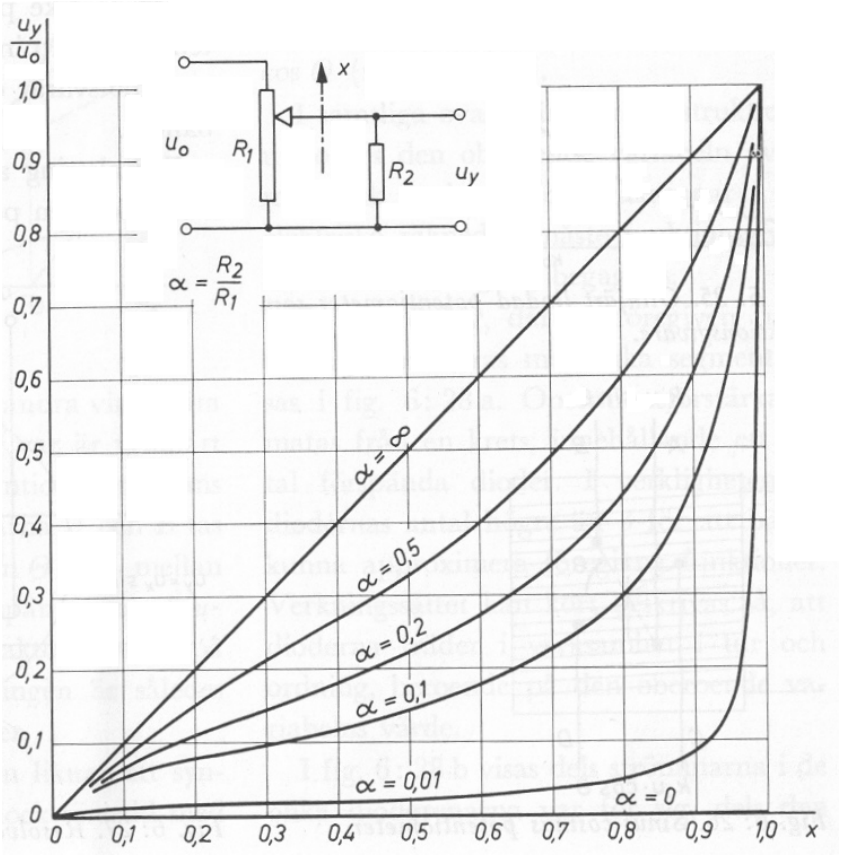


At $x = 0$ and $x = 1$ then $U = 0$ and $U = 10$V.
At $x = 0{,}5$ the load R_B draws current from the voltage divider and this ” reduce” U.

William Sandqvist william@kth.se

Potentiometer with load ?

Would you happen to wish for any of the non-linear relationship that exists in the figure, it costs apparently just an extra resistor R_2!



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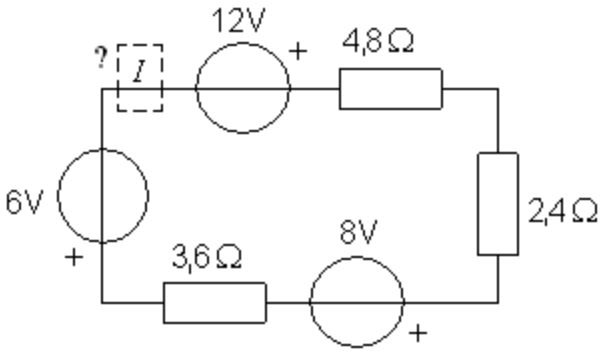
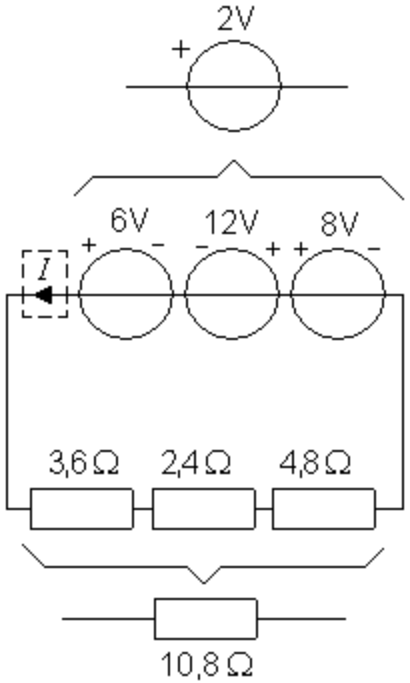
William Sandqvist william@kth.se

Seriel circuit (3.1)

Determine the current I, its magnitude and direction.





$$8+6-12=2 \quad 3{,}6+2{,}4+4{,}8=10{,}8$$

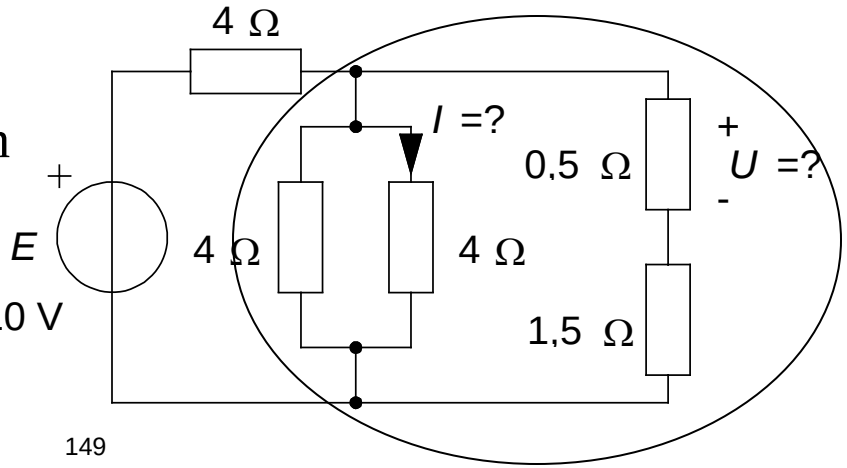
$$I=\frac{2}{10{,}8}=0{,}19\ \text{A}$$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Serial – parallel circuits (3.4)

Calculate current I = ? And voltage U = ? for the serial-parallel circuit in the figure.



Calculate the equivalent resistance:

$R_{ERS} = 2//(4//4) = 2//2 = 1\Omega$

Calculate voltage over the equivalent resistor U_{RERS}

$$U_{RERS} = 10\frac{1}{4+1} = 2$$

Current $I = U_{RERS}/4 = 2/4 = 0{,}5$ A

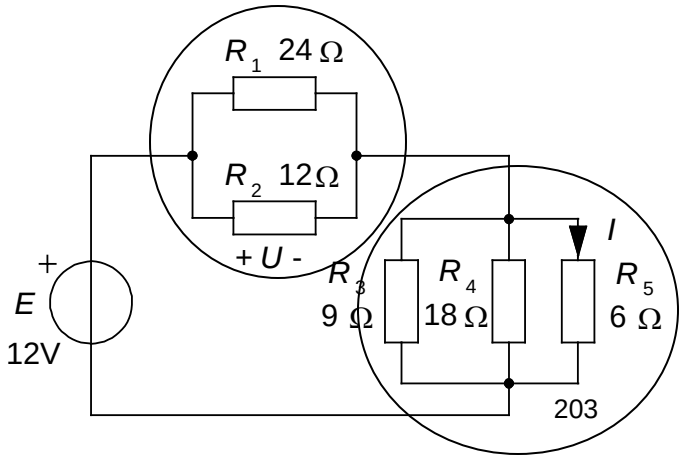
Voltage $$U = 2\frac{0{,}5}{1{,}5+0{,}5} = 0{,}5 \text{ V}$$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Serial – parallel circuits (3.3)

Calculate current I = ? And voltage U = ? for the serial-parallel circuit in the figure.



We start by calculating two equivalent resistances:

$$R_{1//2} = \frac{24 \cdot 12}{24 + 12} = 8 \qquad \frac{1}{R_{3//4//5}} = \frac{1}{9} + \frac{1}{18} + \frac{1}{6} = \frac{2+1+3}{18} = \frac{6}{18} \quad \Rightarrow \quad R_{3//4//5} = \frac{18}{6} = 3$$

Voltage divider:

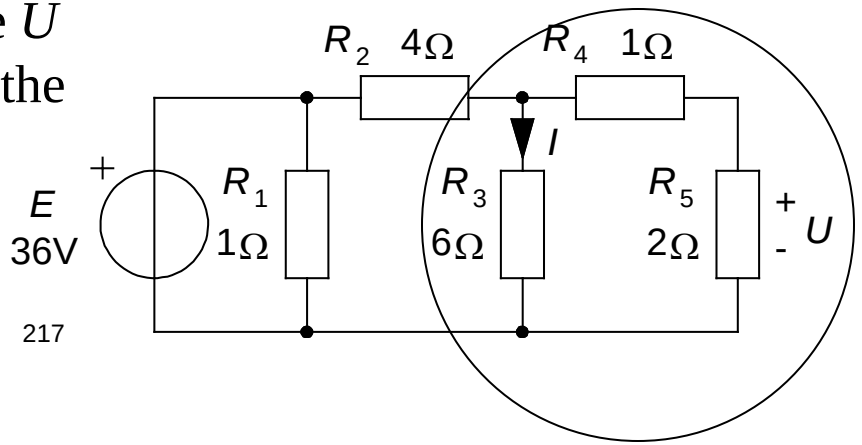
$$U = 12\frac{8}{8+3} = 8{,}73 \quad \Rightarrow \quad U_{3//4//5} = E - U \quad \Rightarrow \quad I = \frac{U_{3//4//5}}{R_5} = \frac{12 - 8{,}73}{6} = 0{,}55 \text{ A}$$

William Sandqvist william@kth.se

William Sandqvist william@kth.se

Serial – parallel circuits (3.5)

Calculate current I = ? And voltage U = ? for the serial-parallel circuit in the figure.



We calculates a equivalent resistance:

$$R_{3//4,5} = \frac{6 \cdot (1+2)}{6+1+2} = 2$$

$U_{R1} = 36$ V. $U_{R3} = U_{R3//4,5}$ can be calculated by voltage division:

$$U_{R3} = E\frac{R_{3//4,5}}{R_{3//4,5}+R_2} = 36\frac{2}{2+4} = 12 \quad \Rightarrow \quad I = \frac{U_{R3}}{R_3} = \frac{12}{6} = 2 \text{ A}$$

U can be calculated by voltage division:

$$U = U_{R3//4,5}\frac{R_5}{R_4+R_5} = 12\frac{2}{1+2} = 8 \text{ V}$$

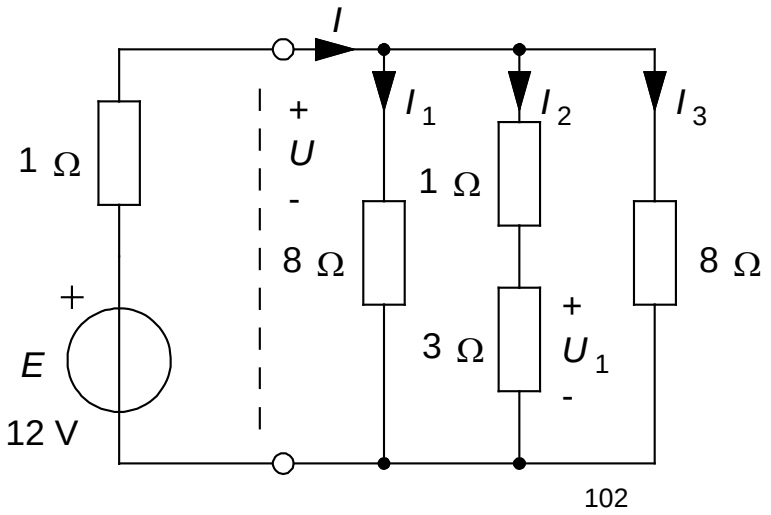
William Sandqvist william@kth.se

William Sandqvist william@kth.se

(3.2) OHM's law are often enough!

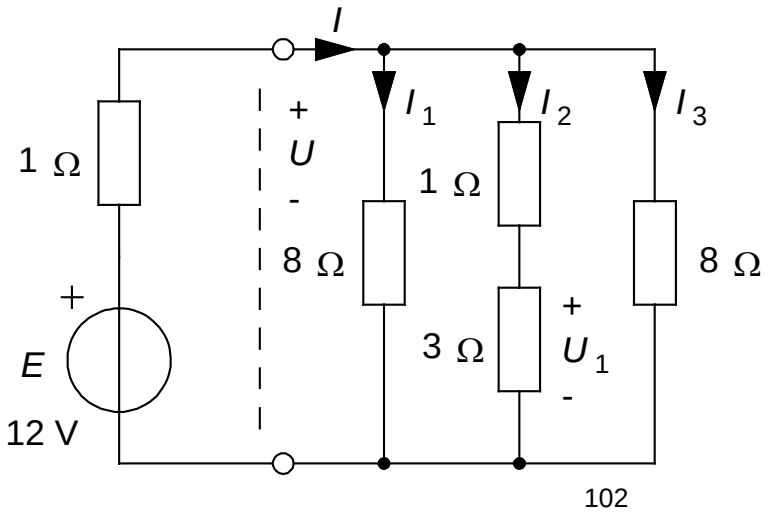
a) Calculate the resultant resistance R_{ERS} for the three parallel connected branches.

b) Culculate current I and voltage U.



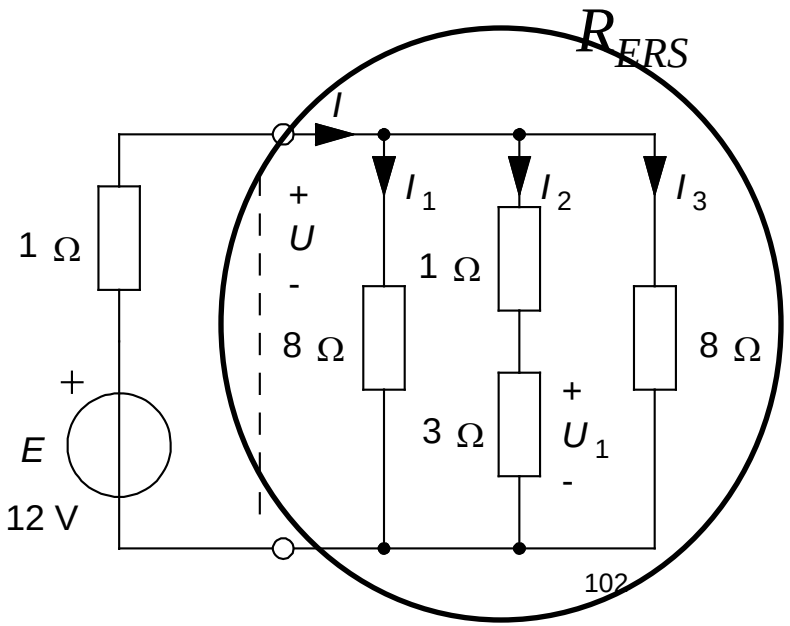
c) Calculate the three currents I_1 I_2 and I_3 together with the voltage U_1 over 3 Ω-resistor.

OHM’s law …



OHM’s law …

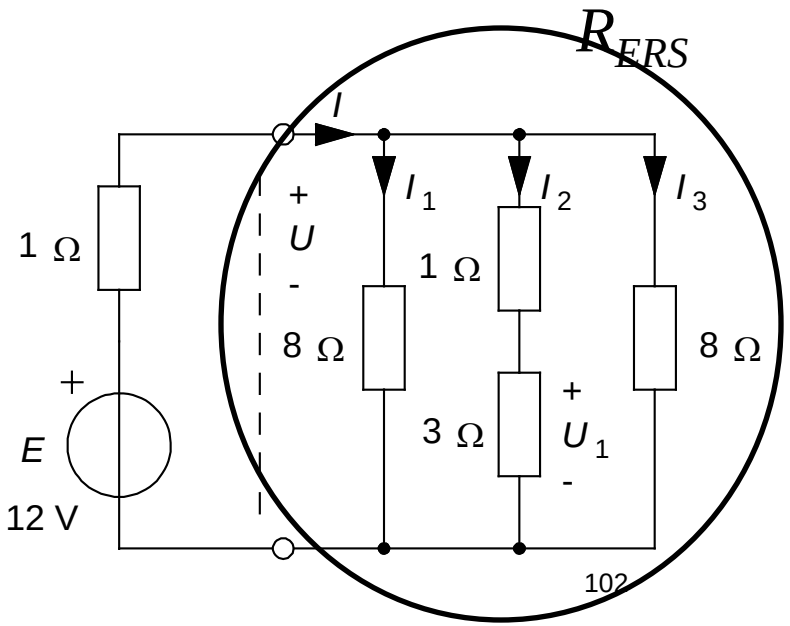
$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$



OHM's law …

$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$

$$I = \frac{E}{1+R_{ERS}} = \frac{12}{1+2} = 4$$

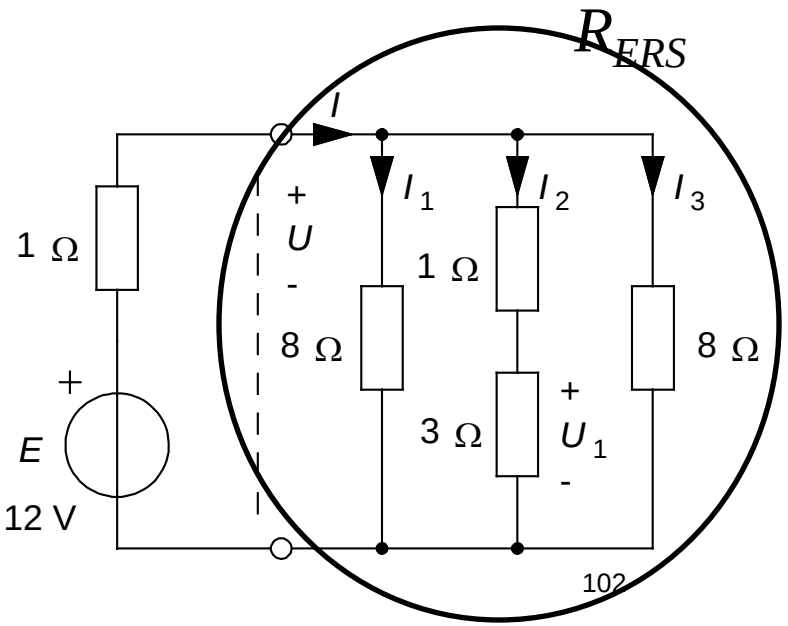


OHM's law …

$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$

$$I = \frac{E}{1+R_{ERS}} = \frac{12}{1+2} = 4$$

$$U = I \cdot R_{ERS} = 4 \cdot 2 = 8$$



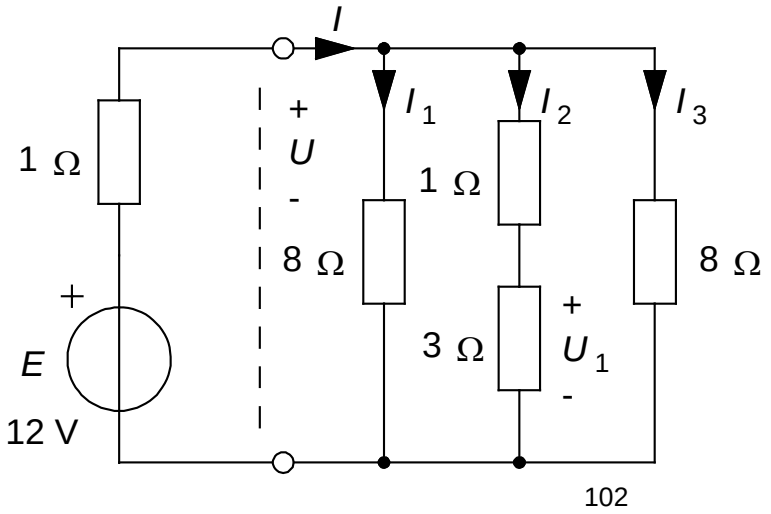
OHM's law …

$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$

$$I = \frac{E}{1+R_{ERS}} = \frac{12}{1+2} = 4$$

$$U = I \cdot R_{ERS} = 4 \cdot 2 = 8$$

$$I_1 = \frac{U}{8} = \frac{8}{8} = 1$$



William Sandqvist william@kth.se

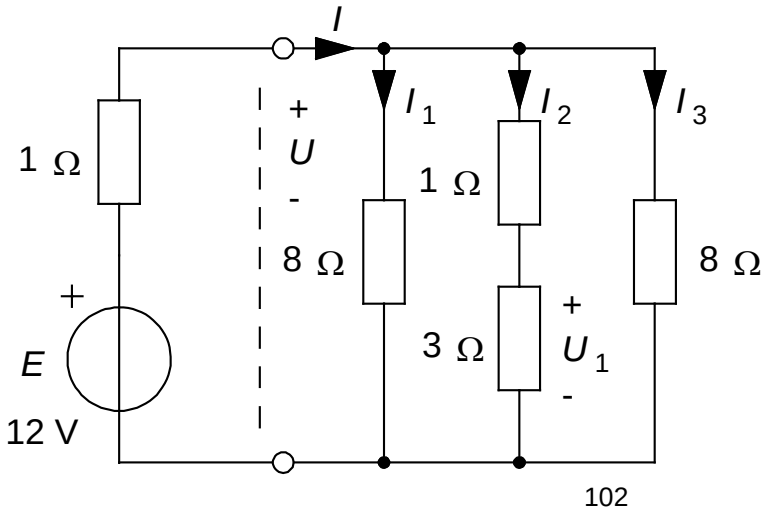
OHM's law …

$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$

$$I = \frac{E}{1+R_{ERS}} = \frac{12}{1+2} = 4$$

$$U = I \cdot R_{ERS} = 4 \cdot 2 = 8$$

$$I_1 = \frac{U}{8} = \frac{8}{8} = 1 \qquad I_2 = \frac{U}{1+3} = \frac{8}{1+3} = 2$$



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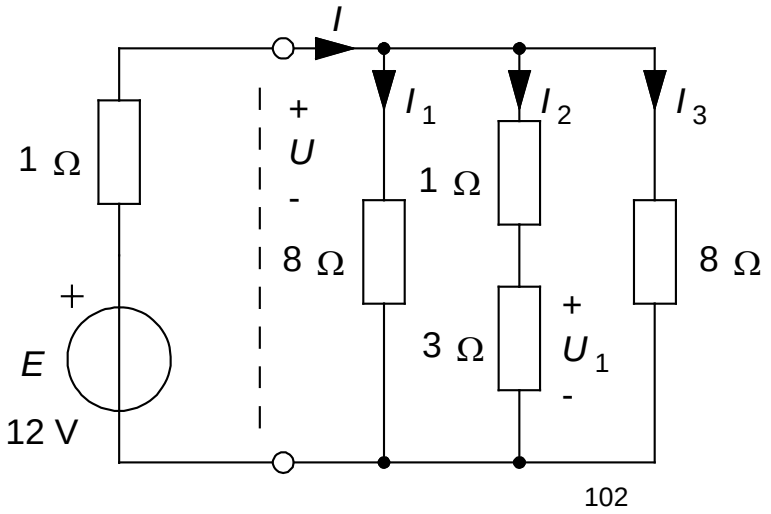
OHM's law …

$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$

$$I = \frac{E}{1+R_{ERS}} = \frac{12}{1+2} = 4$$

$$U = I \cdot R_{ERS} = 4 \cdot 2 = 8$$



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$$I_1 = \frac{U}{8} = \frac{8}{8} = 1 \qquad I_2 = \frac{U}{1+3} = \frac{8}{1+3} = 2 \qquad I_3 = \frac{U}{8} = \frac{8}{8} = 1$$

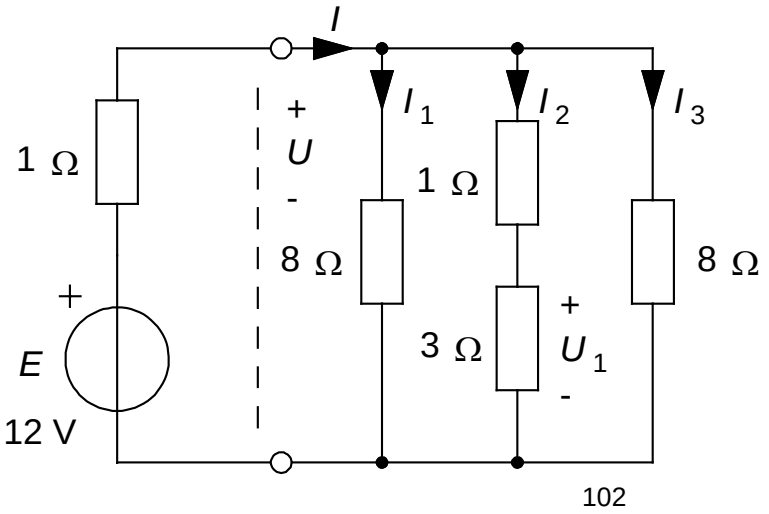
William Sandqvist william@kth.se

OHM's law …

$$\frac{1}{R_{ERS}} = \frac{1}{8} + \frac{1}{1+3} + \frac{1}{8} = \frac{4}{8} \quad \Rightarrow \quad R_{ERS} = \frac{8}{4} = 2$$

$$I = \frac{E}{1+R_{ERS}} = \frac{12}{1+2} = 4$$

$$U = I \cdot R_{ERS} = 4 \cdot 2 = 8$$



$$I_1 = \frac{U}{8} = \frac{8}{8} = 1 \qquad I_2 = \frac{U}{1+3} = \frac{8}{1+3} = 2 \qquad I_3 = \frac{U}{8} = \frac{8}{8} = 1$$

$$U_1 = I_2 \cdot 3 = 2 \cdot 3 = 6$$

William Sandqvist william@kth.se

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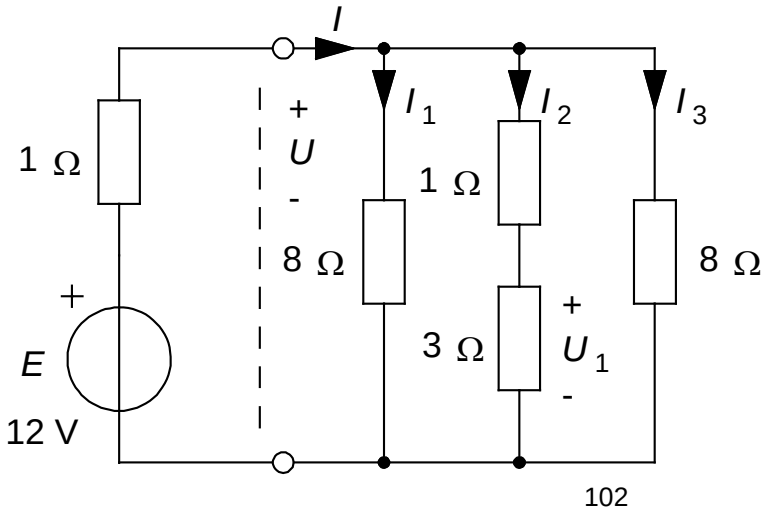


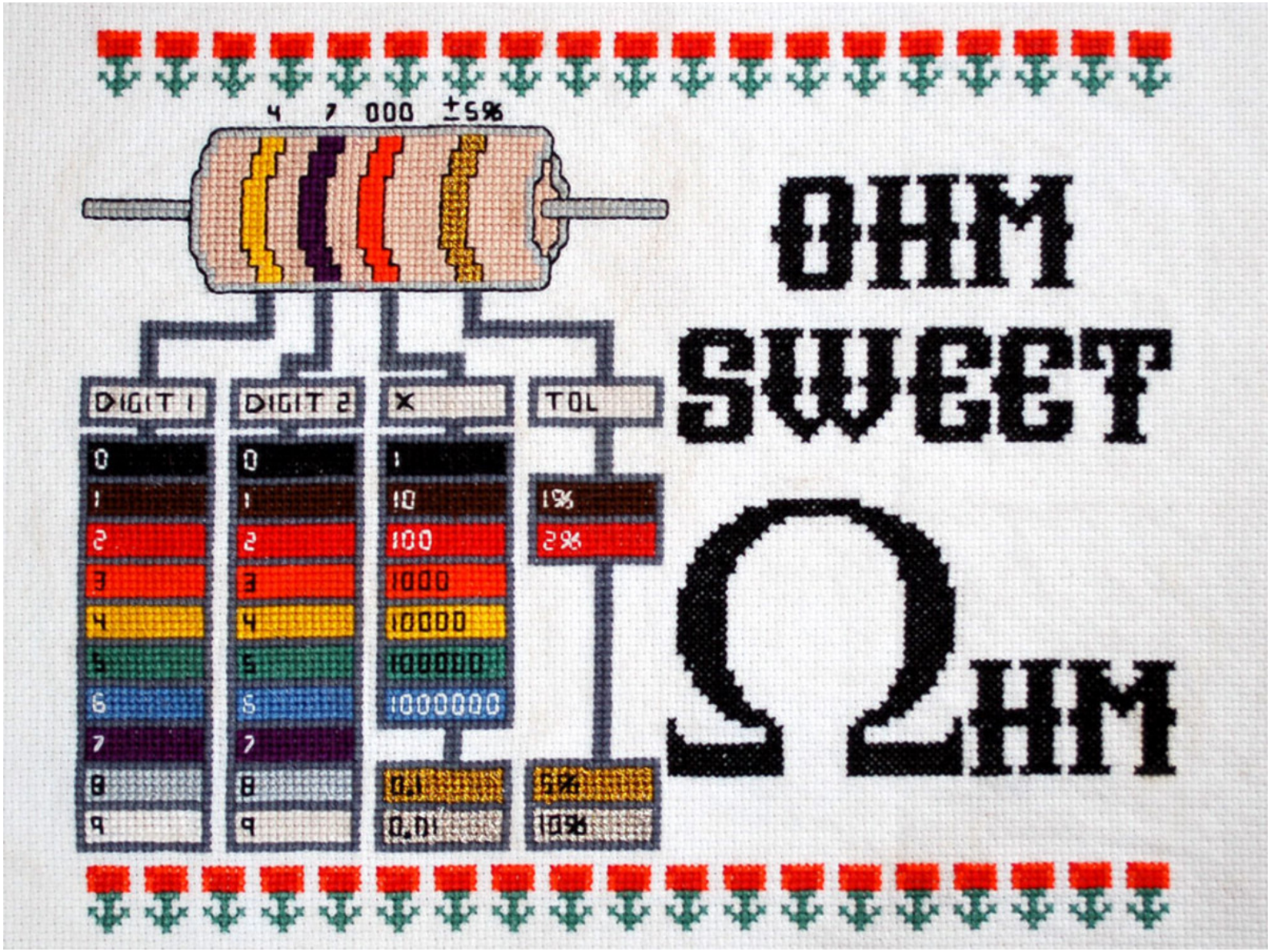
102

$$I_1 = \frac{U}{8} = \frac{8}{8} = 1 \qquad I_2 = \frac{U}{1+3} = \frac{8}{1+3} = 2 \qquad I_3 = \frac{U}{8} = \frac{8}{8} = 1$$

$$U_1 = I_2 \cdot 3 = 2 \cdot 3 = 6$$

OHM's law was enough!

William Sandqvist william@kth.se



William Sandqvist william@kth.se