IE1206 Inbyggd Elektronik

F1 → F2 PIC-block Dokumentation, Seriecom Pulsgivare

F3 → Ö1 → KK1 LAB1 *I*, *U*, *R*, *P*, serie och parallell

Pulsgivare, Menyprogram

- ***Start för programmeringsgruppuppgift***

F4 → $\boxed{\text{Ö2}}$ Kirchhoffs lagar Nodanalys Tvåpolsatsen R2R AD

F5 → Ö3 → KK2 LAB2 ***Tvåpol, AD, Komparator/Schmitt***

F6 → Ö4 → F7 → KK3 LAB3 Transienter PWM

Step-up, RC-oscillator

F8 → Ö5 → F9 Visare jω PWM CCP KAP/IND-sensor

Ö6 → F10 → F11 → KK4 LAB4 ***LC-osc, DC-motor, CCP PWM***

F12 → Ö7 → redovisning LP-filter Trafo + Gästföreläsning

- ***Redovisning av programmeringsgruppuppgift***

F13 → tentamen Trafo, Ethernetkontakten

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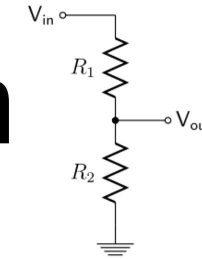
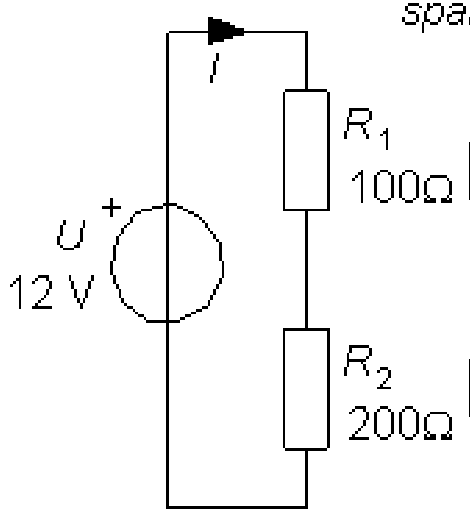
Spänningsdelningsformeln





Del-spänning | *Total-spänning* | *Spännings-delnings-faktor*

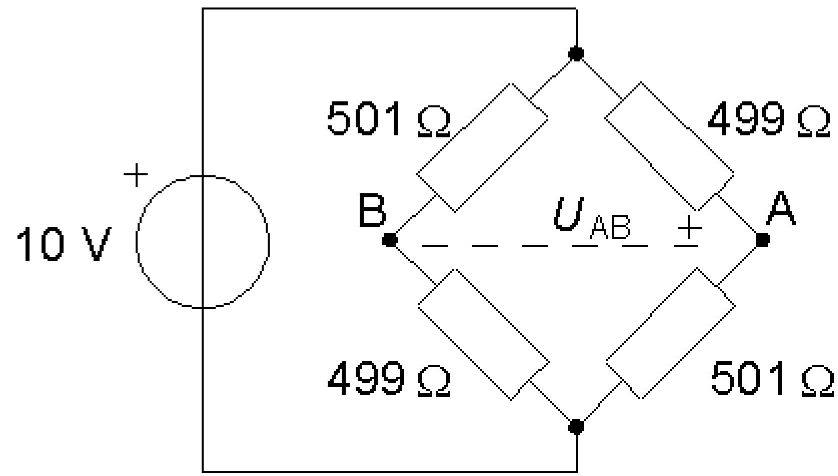
$$\boxed{U_1} = \boxed{U} \times \boxed{\frac{R_1}{R_1+R_2}} = 12\,\frac{100}{100+200} = 4\text{V}$$

$$\boxed{U_2} = \boxed{U} \times \boxed{\frac{R_2}{R_1+R_2}} = 12\,\frac{200}{100+200} = 8\text{V}$$

Enligt spänningsdelningsformeln får man en delspänning, tex. U_1 över resistorn R_1, genom att multiplicera den totala spänningen U med en spänningsdelningsfaktor. Spänningsdelningsfaktorn är resistansen R_1 delad med summan av *alla* resistanser som ingår i seriekopplingen.

Wheatstonebryggans obalansspänning

Punkterna A och B ligger på ungefär halva batterispänningen.
A ligger närmare ”+polen” och B närmare ”-polen”. Skillnaden U_{AB} kan mätas med en känslig millivolt-meter ansluten mellan A och B.



Wheatstonebryggans obalansspänning

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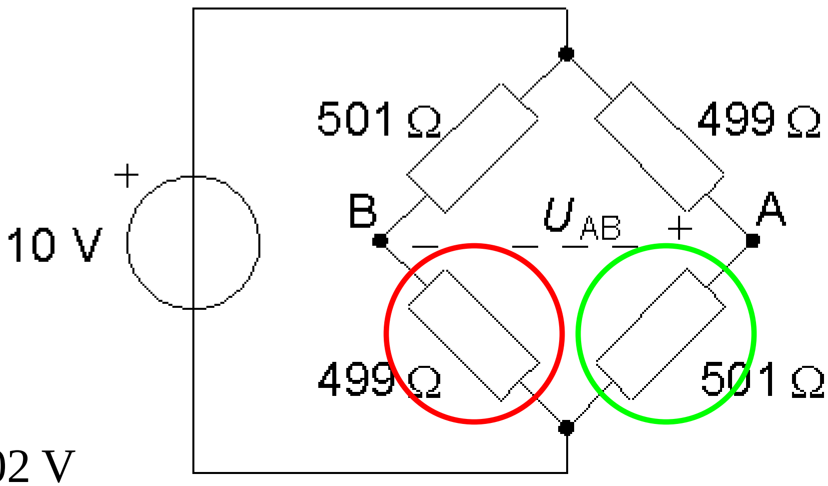
$$U_{AB} = 10\frac{501}{499+501} - 10\frac{499}{501+499} = 0{,}02\ \text{V}$$



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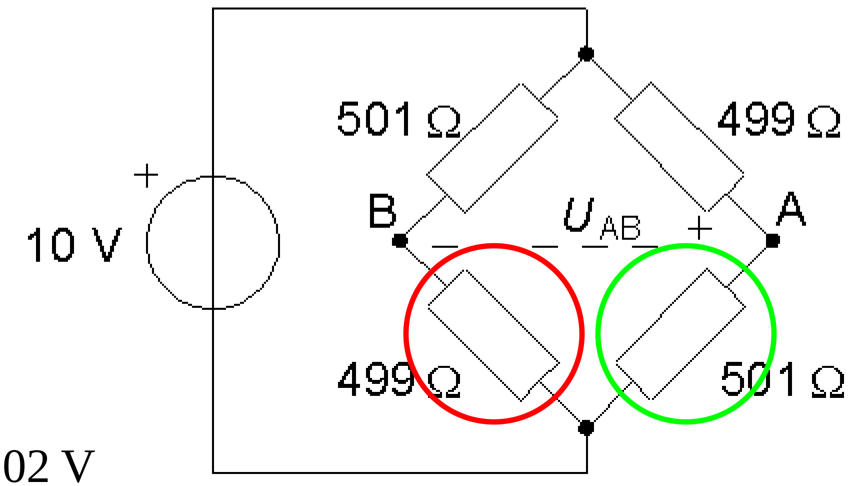
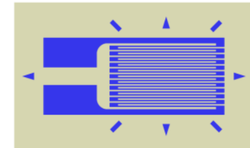


$$U_{AB} = 10\frac{501}{499+501} - 10\frac{499}{501+499} = 0{,}02 \text{ V}$$

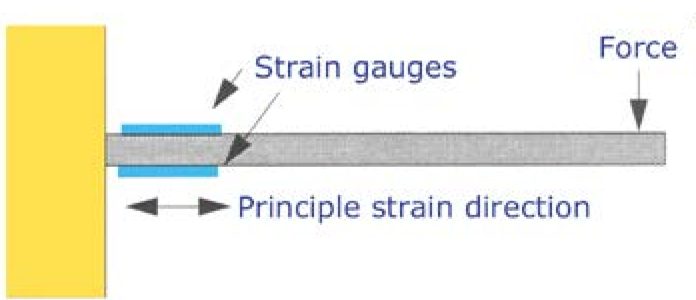
Varför har resistorerna värdena 501 respektive 499?

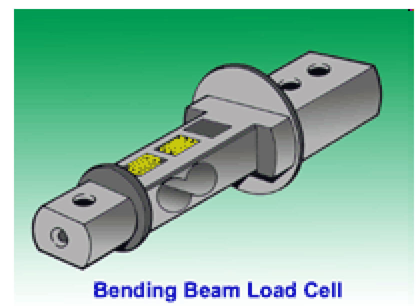
Lastcell

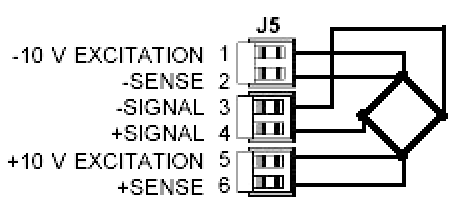


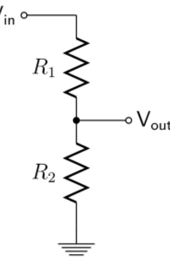
Industrivåg. Två trådtöjningsgivare på ovansidan av en balk ökar från 500 till 501. Två trådtöjningsgivare på undersidan av en balk minskar från 500 till 499.

Givarna är kopplade som en Wheatstonebrygga. Obalansspänningen ger ett direkt mått på kraften *F* (eller för en våg $F = mg$).



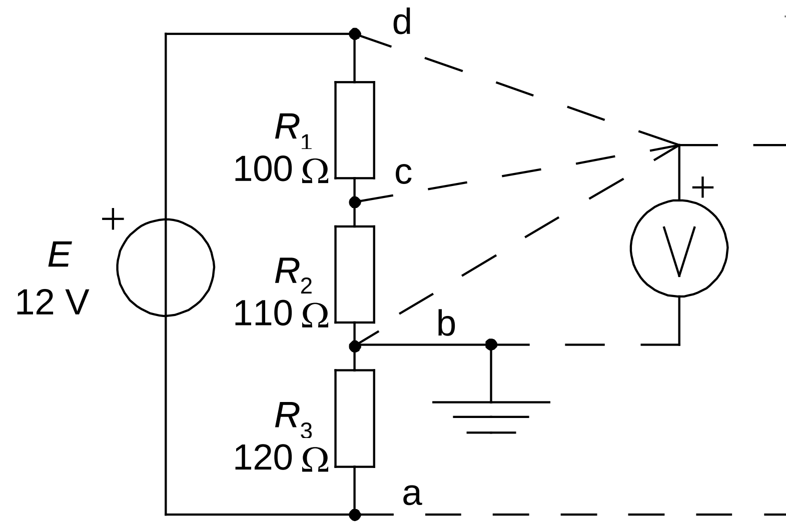






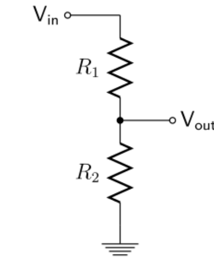
Potential (7.1)

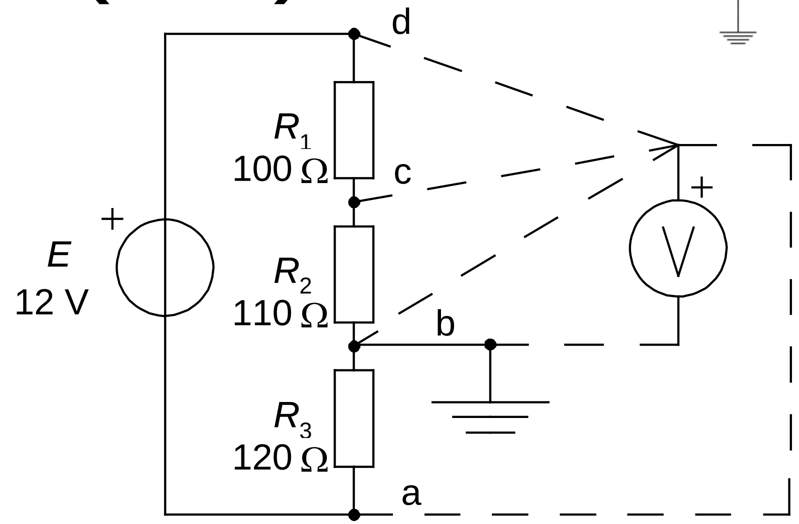
En spänningsdelare bestående av tre motstånd $R_1 = 100\ \Omega$, $R_2 = 110\ \Omega$, $R_3 = 120\ \Omega$, matas med en emk $E = 12$ V.



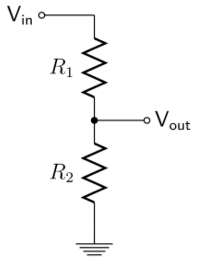
Man mäter potentialen (spänningen i förhållande till jord) vid olika uttag på spänningsdelaren.
Voltmeterns minuspol är hela tiden ansluten till uttag **b**, jord, medan voltmeterns pluspol i tur och ordning ansluts till uttagen **a**, **b**, **c**, och **d**. Vad visar voltmetern?

Potential (7.1)



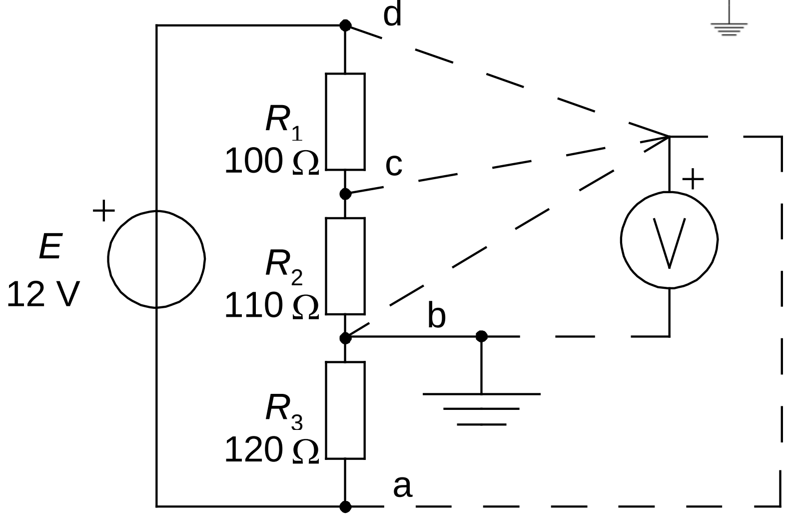


Uttag	a)	b)	c)	d)
Voltmeter [V]				

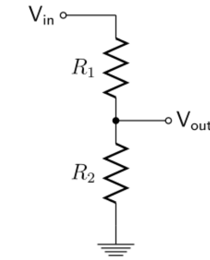


Potential (7.1)

$$U_{ab} = -U_{ba} = -12\frac{120}{100+110+120} = -4{,}37$$

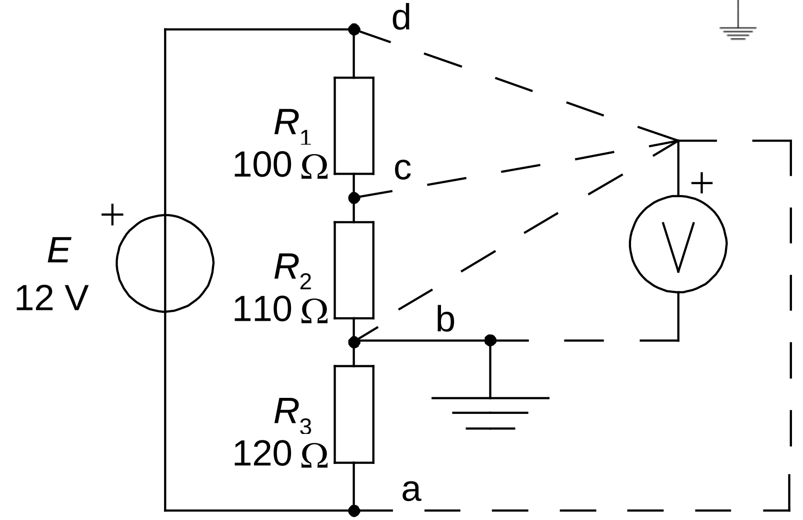


Uttag	a)	b)	c)	d)
Voltmeter [V]	-4,37			

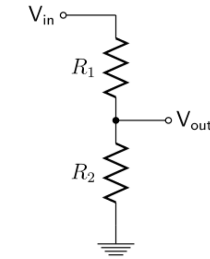


Potential (7.1)

$$U_{ab} = -U_{ba} = -12\frac{120}{100+110+120} = -4{,}37$$



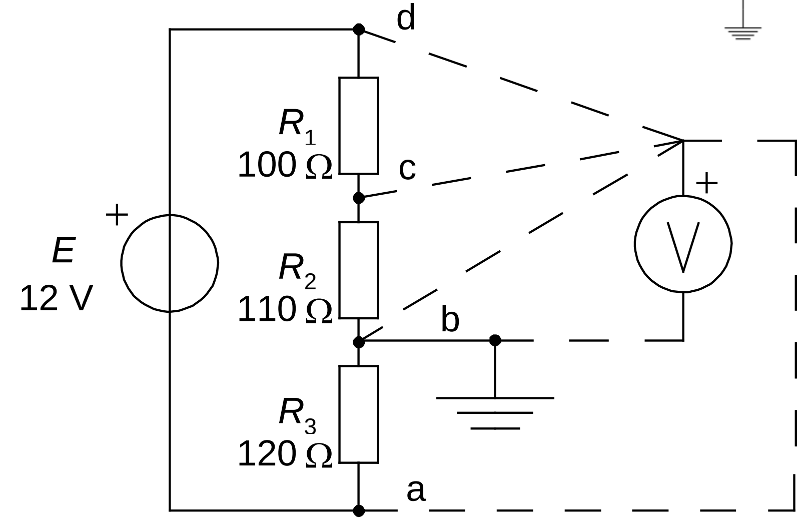
Uttag	a)	b)	c)	d)
Voltmeter [V]	-4,37	0		



Potential (7.1)

$$U_{ab} = -U_{ba} = -12\frac{120}{100+110+120} = -4{,}37$$

$$U_{cb} = 12\frac{110}{100+110+120} = 4$$



Uttag	a)	b)	c)	d)
Voltmeter [V]	-4,37	0	4	

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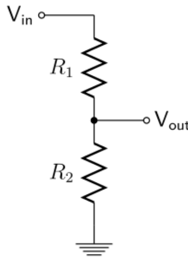
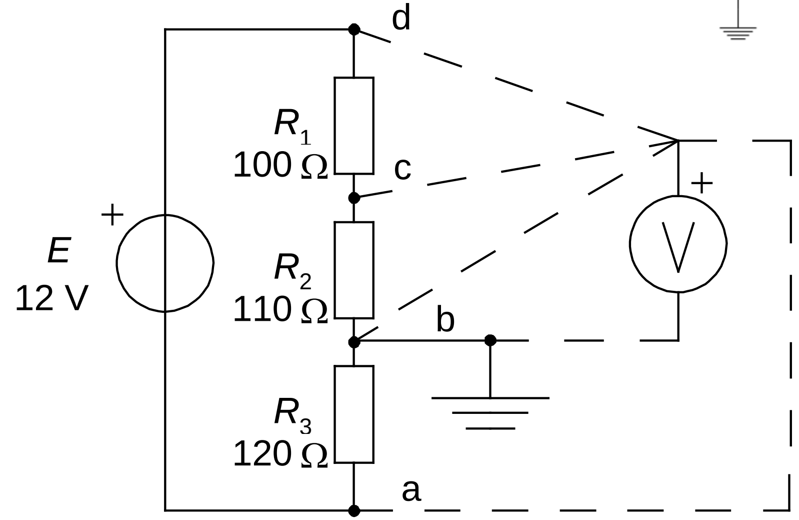
Potential (7.1)



$$U_{ab} = -U_{ba} = -12\frac{120}{100+110+120} = -4{,}37$$

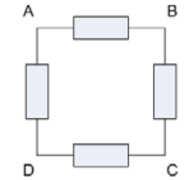
$$U_{cb} = 12\frac{110}{100+110+120} = 4$$

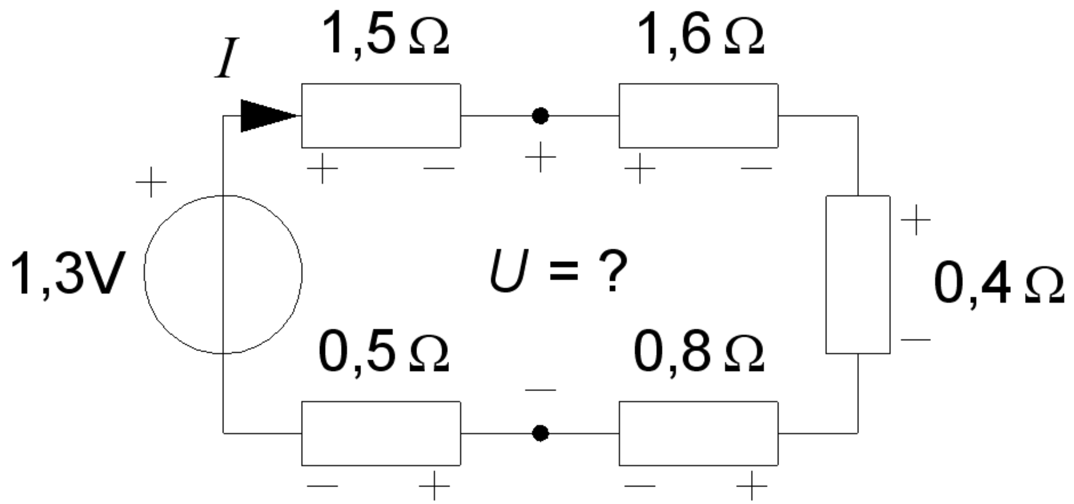
$$U_{db} = 12\frac{100+110}{100+110+120} = 7{,}64$$



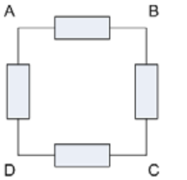
Uttag	a)	b)	c)	d)
Voltmeter [V]	-4,37	0	4	7,64

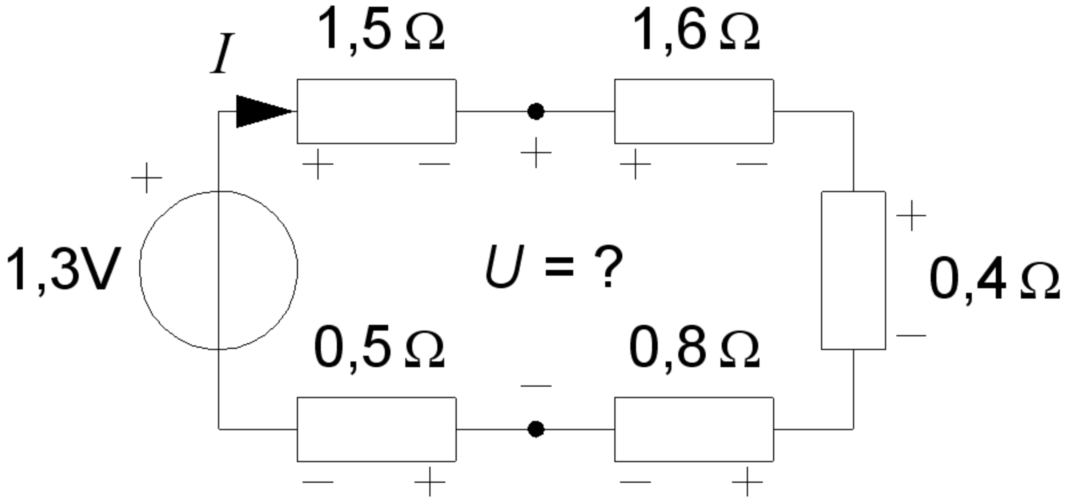
Kirchhoffs spänningslag (5.3)





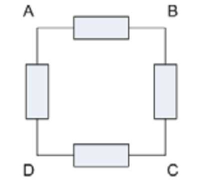
Kirchhoffs spänningslag (5.3)

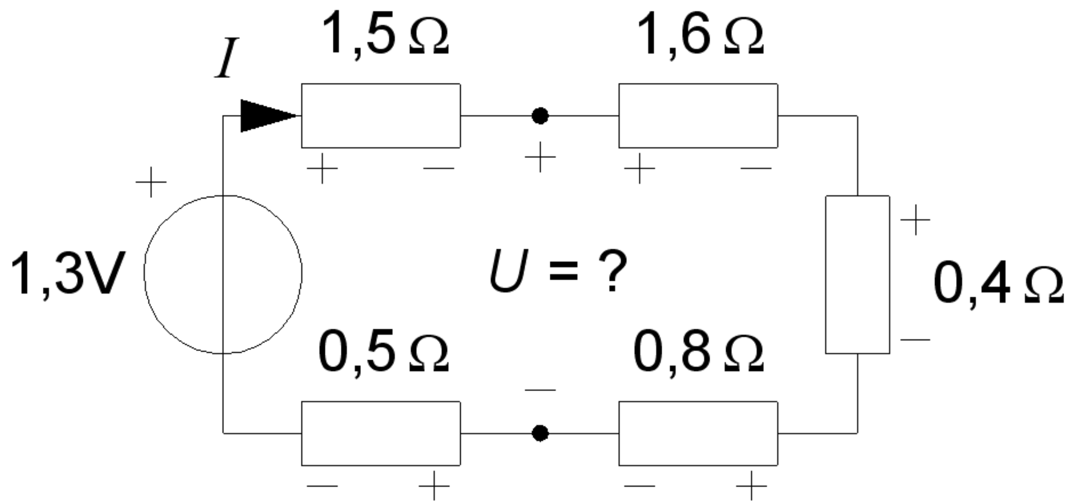




$$I = \frac{1{,}3}{1{,}5 + 1{,}6 + 0{,}4 + 0{,}8 + 0{,}5} = 0{,}27$$

Kirchhoffs spänningslag (5.3)



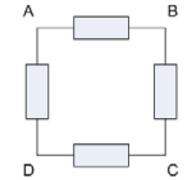


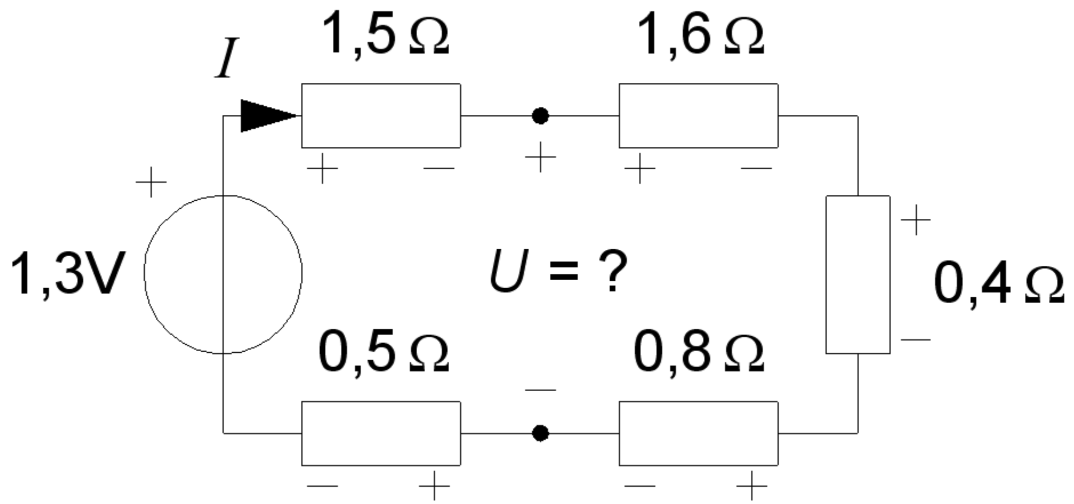
$$I = \frac{1{,}3}{1{,}5 + 1{,}6 + 0{,}4 + 0{,}8 + 0{,}5} = 0{,}27$$

$$U_{0,5} = 0{,}5 \cdot 0{,}27 = 0{,}14$$

$$U_{1,5} = 1{,}5 \cdot 0{,}27 = 0{,}41$$

Kirchhoffs spänningslag (5.3)





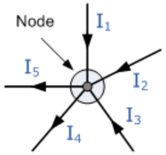
$$I = \frac{1,3}{1,5+1,6+0,4+0,8+0,5} = 0,27 \qquad U_{0,5} = 0,5 \cdot 0,27 = 0,14$$

$$U_{1,5} = 1,5 \cdot 0,27 = 0,41$$

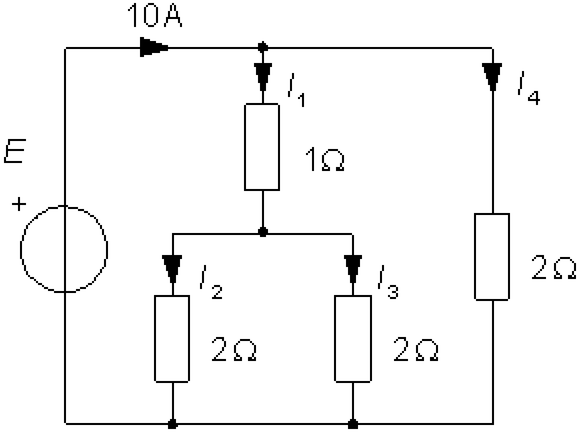
$$U = -\,0,14 + 1,3 - 0,41 = 0,76 \text{ V}$$

eller $U = 0,27 \cdot (0,8+0,4+1,6) = 0,76$ V

Kirchoffs strömlag (5.1)



Kan Du gissa strömmarna?



$I_1 =$ 5 A
$I_2 =$ 2,5 A
$I_3 =$ 2,5 A
$I_4 =$ 5 A

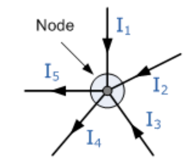
$I_1 + I_4 = 10$

$I_1 = I_2 + I_3 \quad I_2 = I_3$

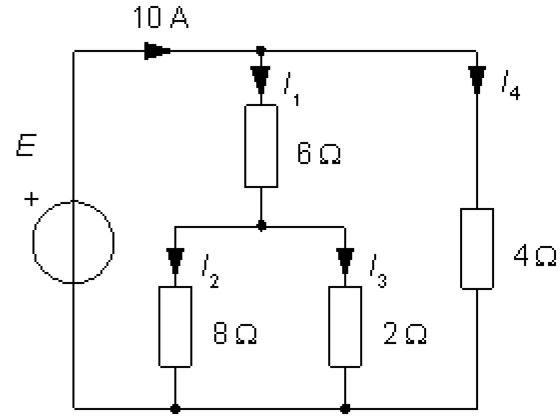
Parallellkrets, OHM's lag: $I_4 \cdot 2 = I_1 \cdot (1+2//2) \Rightarrow I_4 = I_1 = 10/2 = 5$

$I_1 = I_2 + I_3 \Rightarrow \quad I_2 = I_3 = 5/2 = 2,5$

Kirchoffs strömlag (5.2)



Nu måste man räkna!

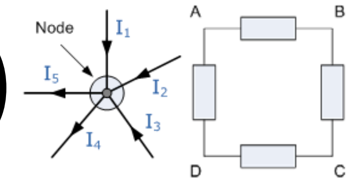


$$R_{ERS} = \frac{\left(6+\frac{8\cdot 2}{8+2}\right)\cdot 4}{\left(6+\frac{8\cdot 2}{8+2}\right)+4} = 2.62\ \Omega \quad E = R_{ERS}\cdot I = 2{,}62\cdot 10 = 26{,}2\ \mathrm{V}$$

$$I_4 = \frac{E}{4} = \frac{26{,}2}{4} = 6{,}55\ \mathrm{A} \qquad I_1 = I - I_4 = 10 - 6{,}55 = 3{,}45\ \mathrm{A}$$

$$I_2 = \frac{E - 6\cdot I_1}{8} = \frac{26{,}2 - 3{,}45\cdot 6}{8} = \frac{5{,}5}{8} = 0{,}69\ \mathrm{A} \qquad I_3 = \frac{5{,}5}{2} = 2{,}75\ \mathrm{A}$$

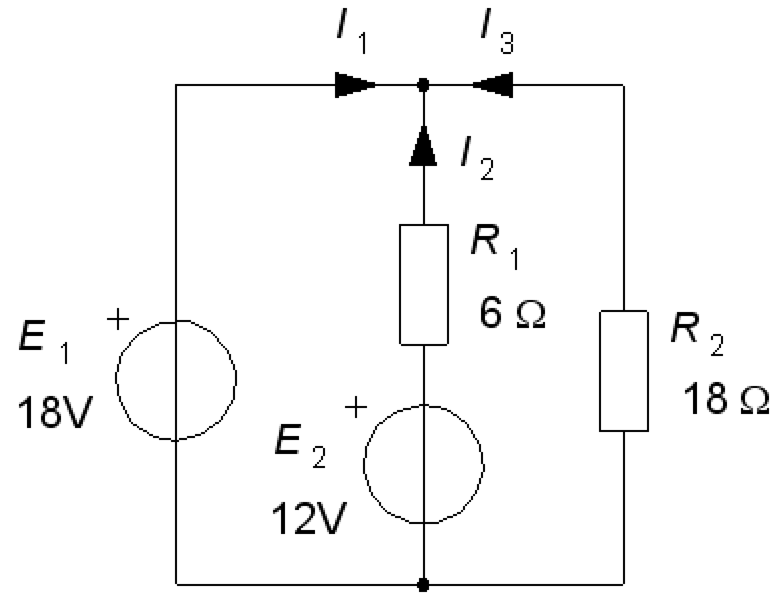
Kirchhoffs lagar? (6.3)



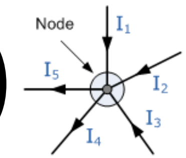
a) $U_{R2} = ?$

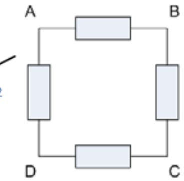
b) $I_2 = ?$

c) $I_1 = ?$



Kirchhoffs lagar? (6.3)



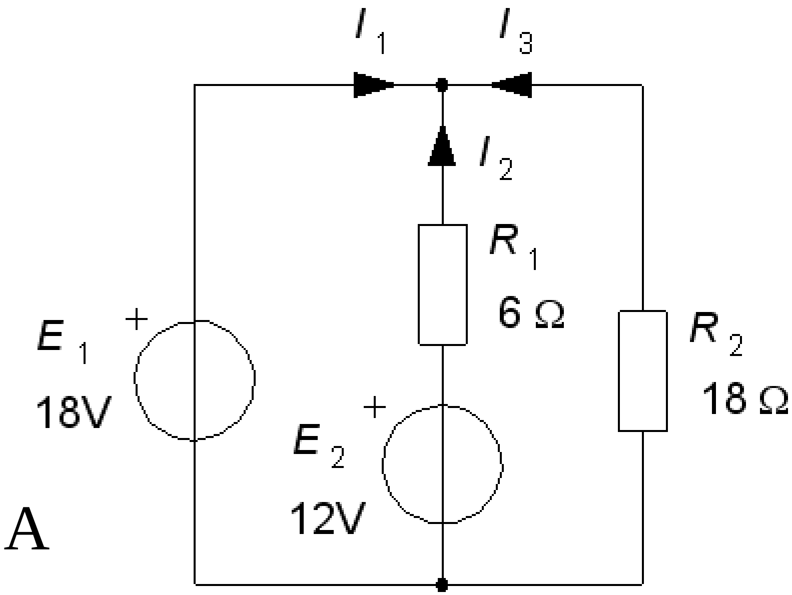


a) U_{R2} = ? = 18 V (E_1)

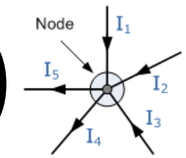
b) I_2 = ?

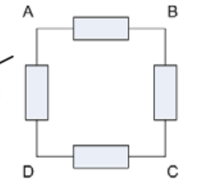
c) I_1 = ?

$18 + I_3 18 = 0 \quad I_3 = -18/18 = -\ 1\text{ A}$



Kirchhoffs lagar? (6.3)



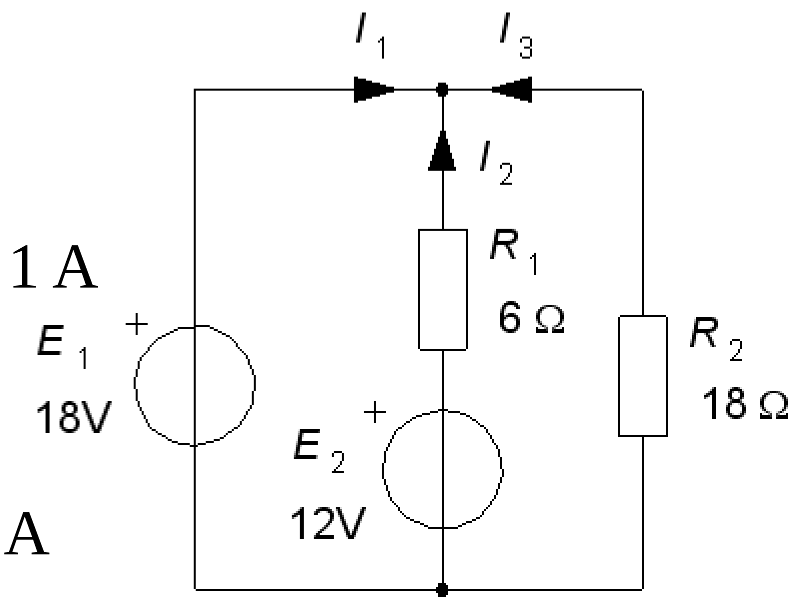


a) $U_{R2} = ?$ $= 18$ V (E_1)

b) $I_2 = ?$ $18 + 6I_2 - 12 = 0$

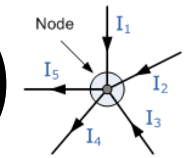
$I_2 = (12 - 18)/6 = -1$ A

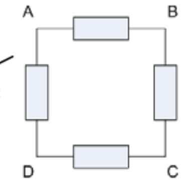
c) $I_1 = ?$



$18 + I_3 18 = 0$ $I_3 = -18/18 = -1$ A

Kirchhoffs lagar? (6.3)



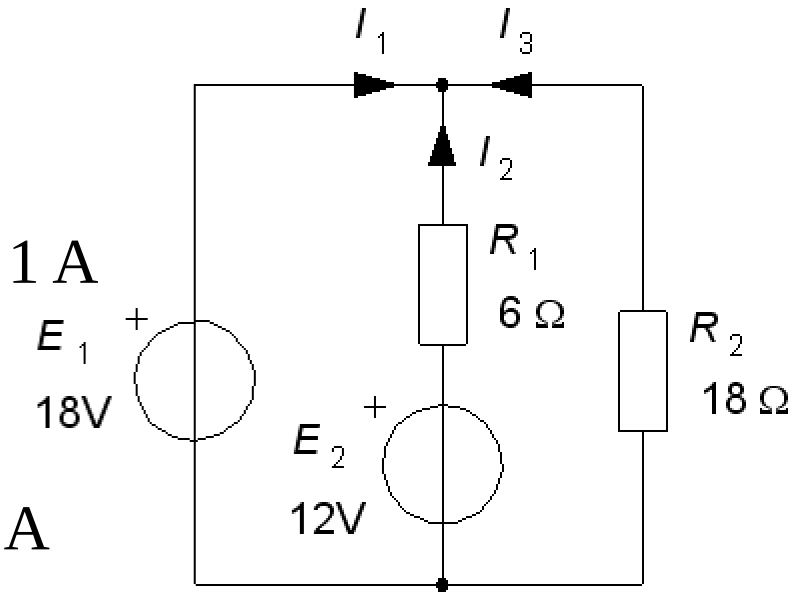


a) $U_{R2} = ?$ $= 18\ \mathrm{V}\ (E_1)$

b) $I_2 = ?$ $18 + 6I_2 - 12 = 0$

$I_2 = (12 - 18)/6 = -1\ \mathrm{A}$

c) $I_1 = ?$

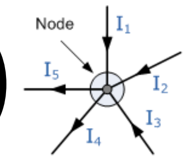


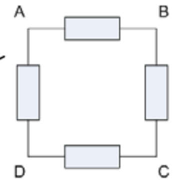
$18 + I_3 18 = 0 \quad I_3 = -18/18 = -1\ \mathrm{A}$

$I_1 + I_2 + I_3 = 0$

$I_1 = -I_2 - I_3 = -(-1) - (-1) = 2\ \mathrm{A}$

Kirchhoffs lagar? (6.3)

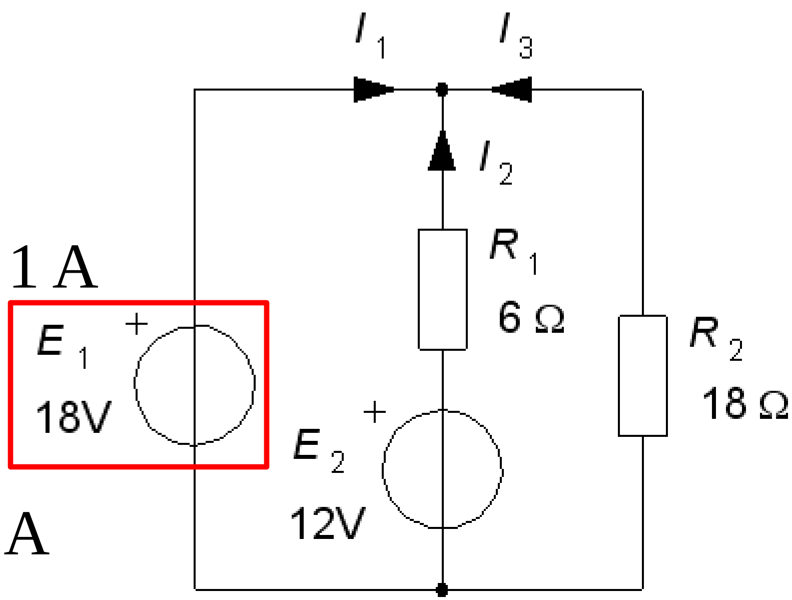




a) $U_{R2} = ?$ $\quad = 18\text{ V } (E_1)$

b) $I_2 = ?$ $\quad 18 + 6I_2 - 12 = 0$

$I_2 = (12 - 18)/6 = -1\text{ A}$



c) $I_1 = ?$

$18 + I_3 18 = 0 \quad I_3 = -18/18 = -1\text{ A}$

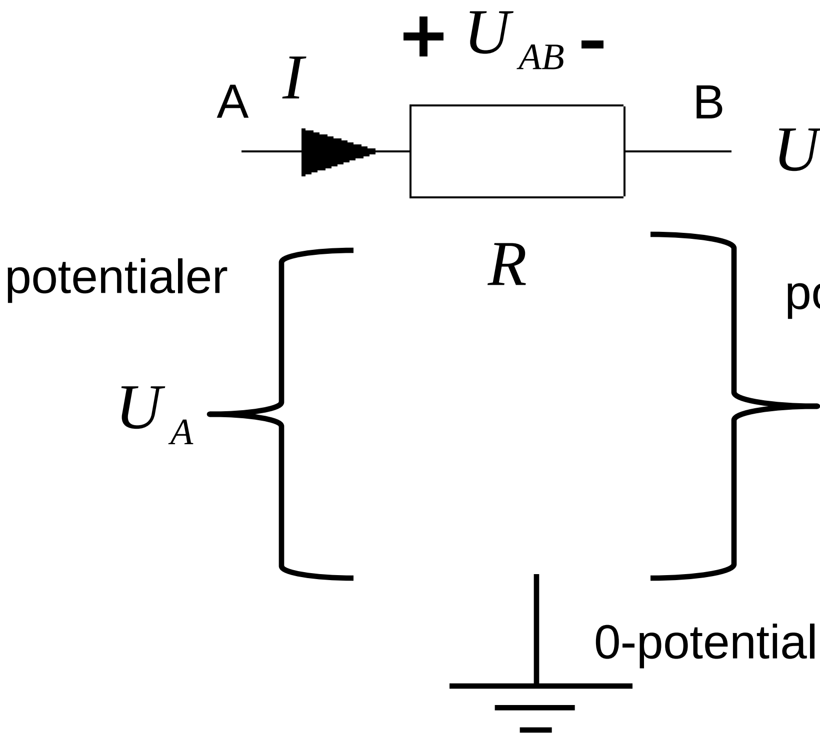
$I_1 + I_2 + I_3 = 0$

$I_1 = -I_2 - I_3 = -(-1) - (-1) = 2\text{ A}$

Att E_1 är en *ideal* emk är det som förenklar beräkningarna!

Nodanalys

$$U_{AB} = U_A - U_B$$



$$U_{AB} = I \cdot R$$

$$\boxed{I = \frac{U_{AB}}{R} = \frac{U_A - U_B}{R}}$$

eller med Nodanalys (7.3)

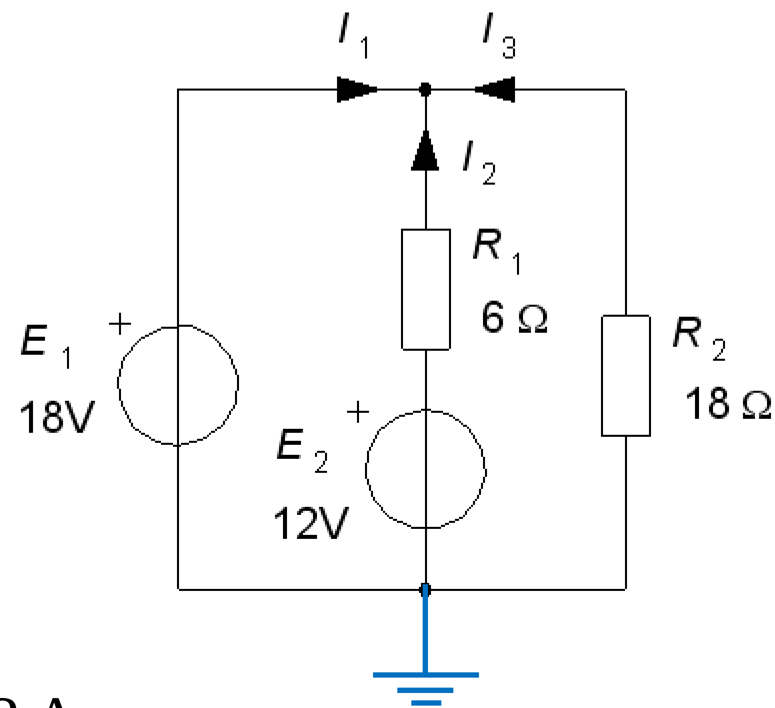
$I_1 + I_2 + I_3 = 0 \quad I_1 = -I_2 - I_3$

$E_1 = 18$ V

$I_3 = -(E_1 - 0)/R_2 = -18/18$
$= -1$ A

$I_2 = -(E_1 - E_2)/R_1 = -(18 - 12)/6 =$
$= -1$A

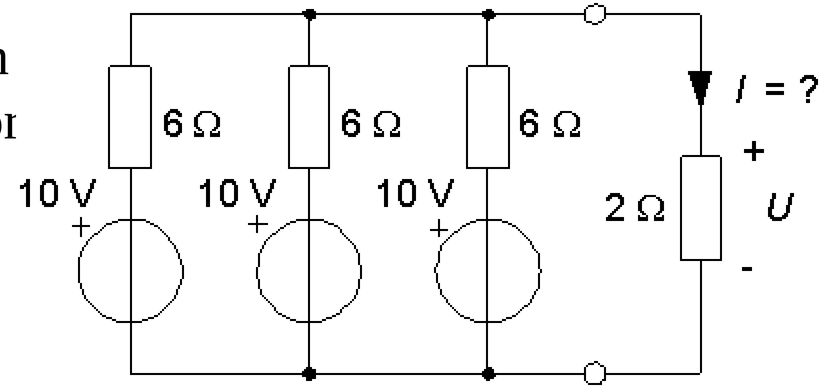
$I_1 = -I_2 - I_3 = -(-1) - (-1) = 2$ A



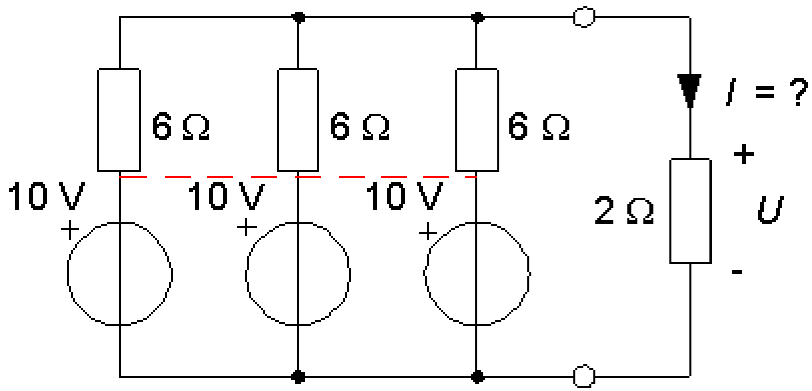
Parallellkopplade batterier (4.4)

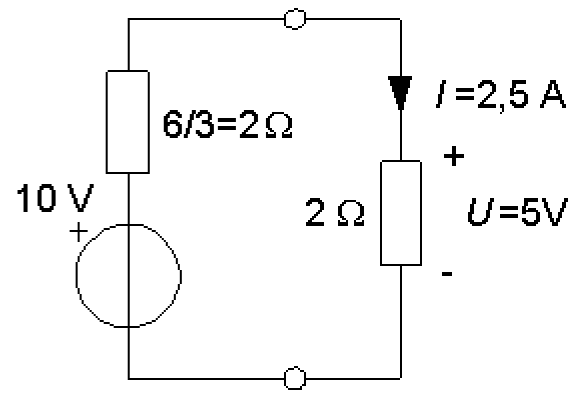
Tre likadana batterier med *E* = 10 V och inre resistansen 6 Ω parallell-kopplas för att leverera ström till en resistor med resistansen 2 Ω.

a) Hur stor blir strömmen *I* och kläm-spänningen *U* ?

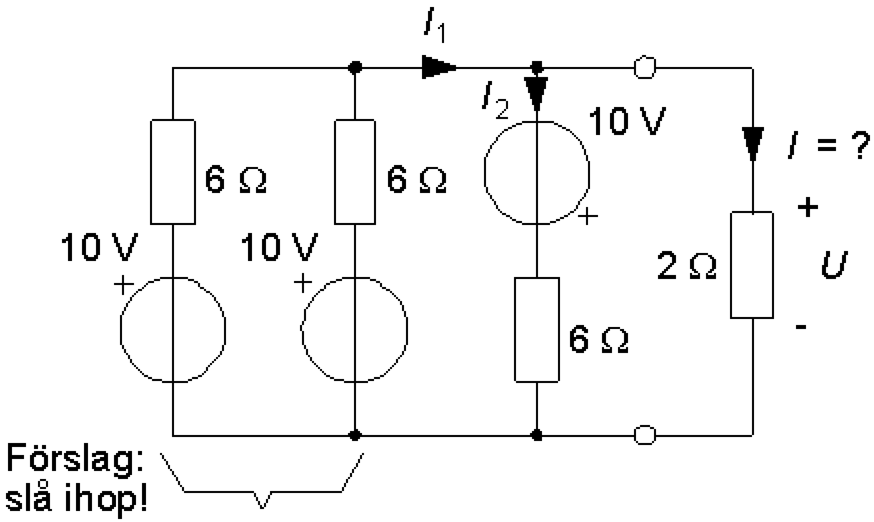


De tre inre resistanserna 6Ω har gemensam spänning i båda ändar, och är därigenom i praktiken parallellkopplade. R_I = 6/3 = 2Ω. *I* = 2,5 A och *U* = 5V.

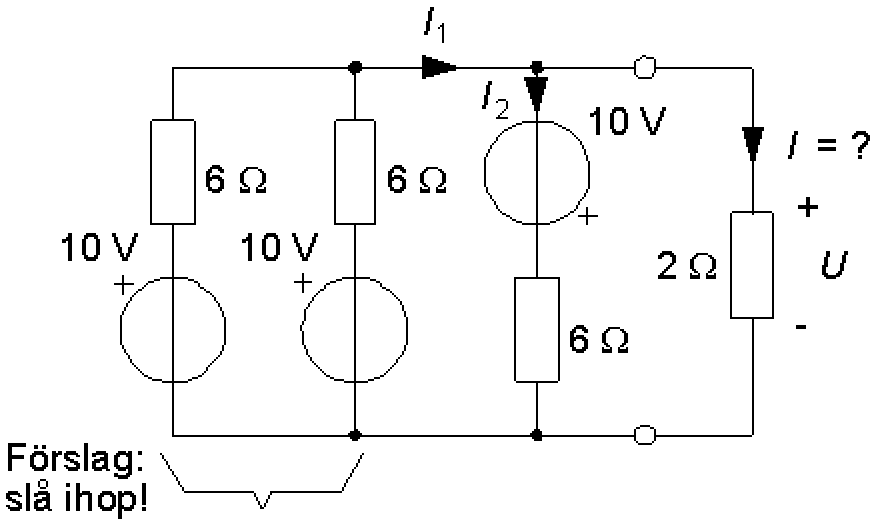


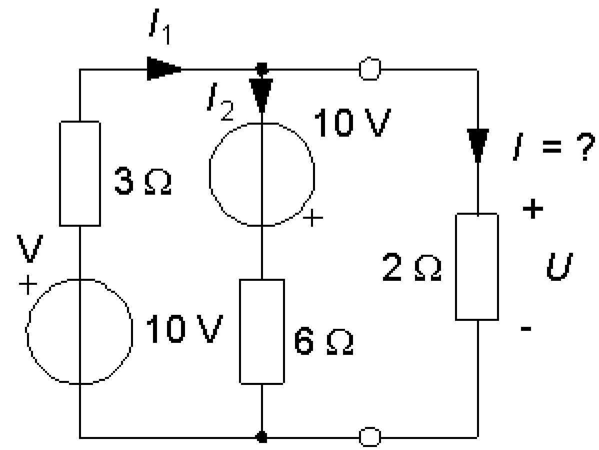


Ett batteri felvänt !

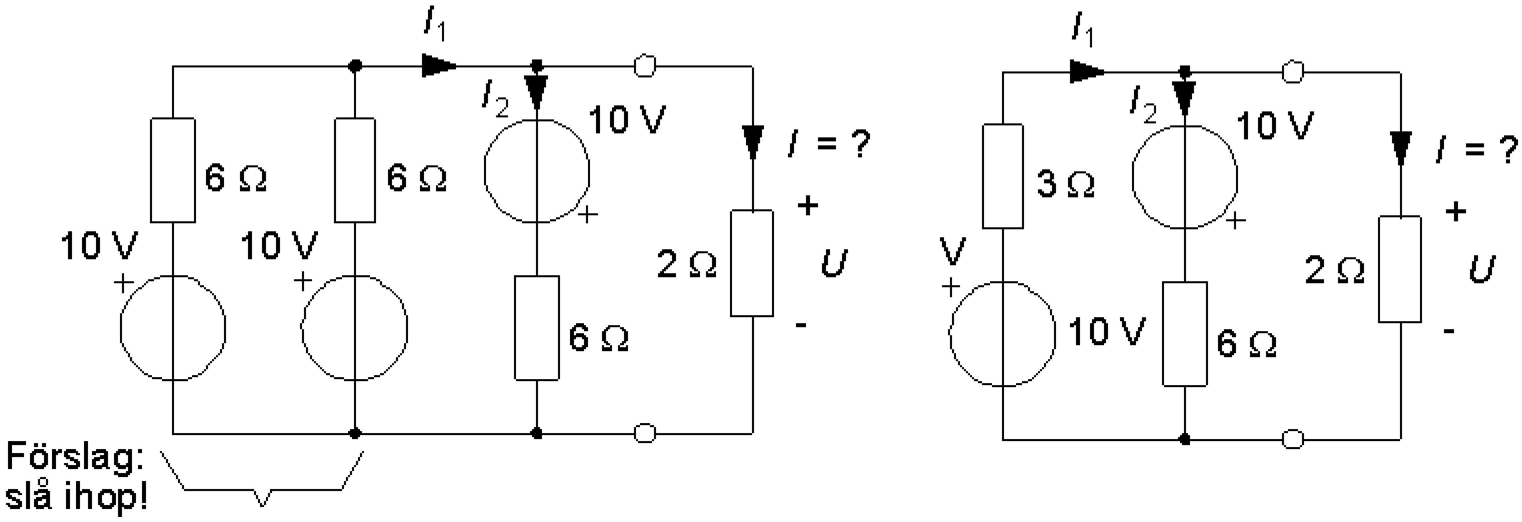


Ett batteri felvänt !



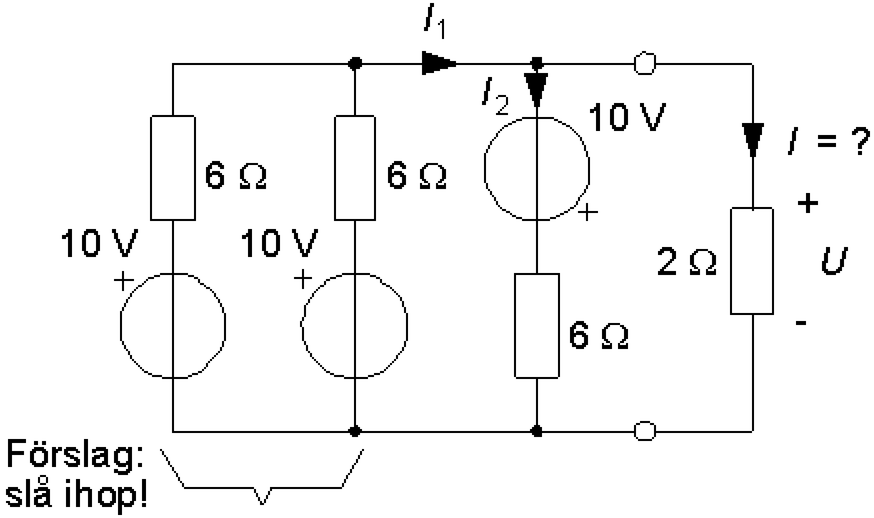


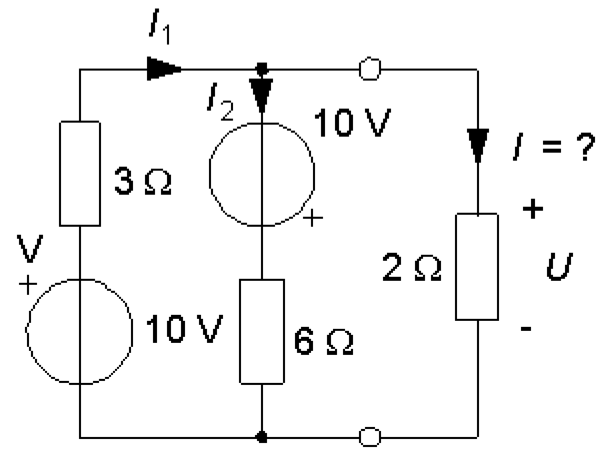
Ett batteri felvänt !



Detta är en mer komplicerad krets som kräver Kirchhoffs lagar för att lösas …

Ett batteri felvänt !





Detta är en mer komplicerad krets som kräver Kirchhoffs lagar för att lösas …

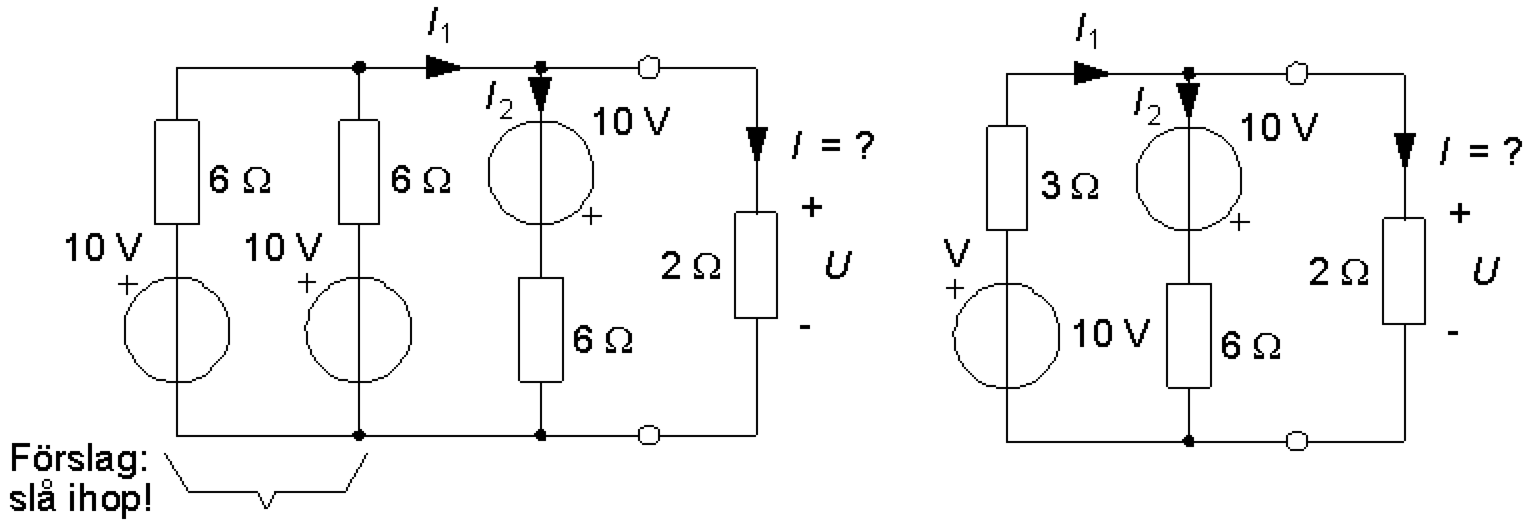
$$I_1 - I_2 - I = 0$$

$$10 - 3I_1 + 10 - 6I_2 = 0 \quad \Leftrightarrow \quad -3I_1 - 6I_2 + 0I = -20$$

$$6I_2 - 10 - 2I = 0 \quad \Leftrightarrow \quad 0I_1 + 6I_2 - 2I = 10$$

$$\begin{pmatrix} 1 & -1 & -1 \\ -3 & -6 & 0 \\ 0 & 6 & -2 \end{pmatrix} \cdot \begin{pmatrix} I_1 \\ I_2 \\ I \end{pmatrix} = \begin{pmatrix} 0 \\ -20 \\ 10 \end{pmatrix}$$

Ett batteri felvänt !



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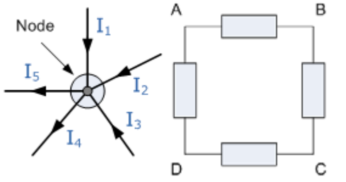
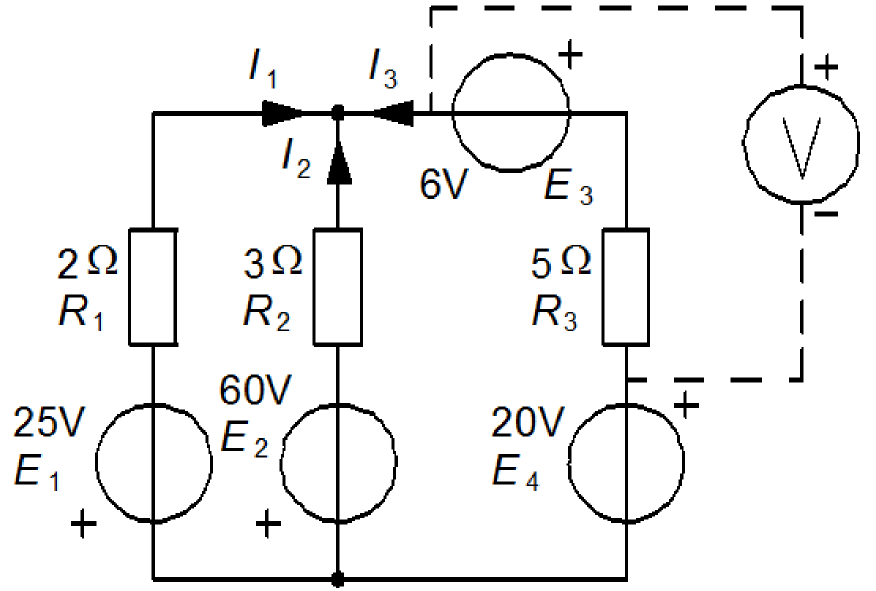
$$\begin{pmatrix} 1 & -1 & -1 \\ -3 & -6 & 0 \\ 0 & 6 & -2 \end{pmatrix} \cdot \begin{pmatrix} I_1 \\ I_2 \\ I \end{pmatrix} = \begin{pmatrix} 0 \\ -20 \\ 10 \end{pmatrix}$$

I_1 = 2,78 A
I_2 = 1,94 A
I = 0,83 A

$$U = I \cdot 2 = 0{,}83 \cdot 2 = \boxed{1{,}67\text{ V}}$$

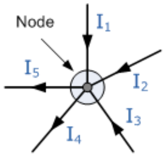
Kirchhoffs lagar (6.5)

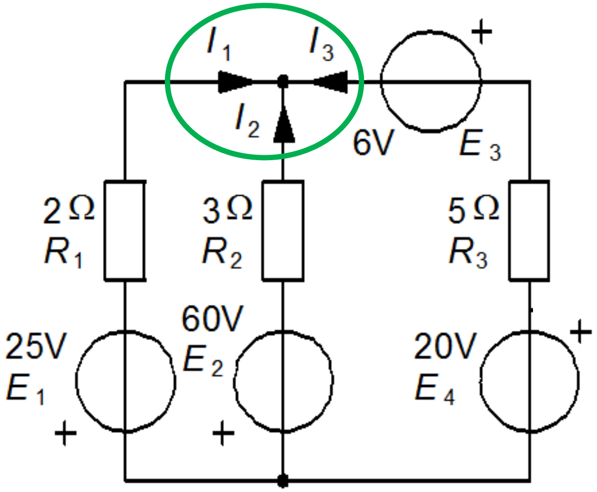




a) Ställ med hjälp av Kirchhoffs två lagar upp ett ekvationssystem med vars hjälp de tre strömmarna I_1 I_2 och I_3 kan beräknas. Hyfsa ekvationerna. (Du behöver således *inte* lösa ekvationssystemet)

Kirchhoffs lagar (6.5)

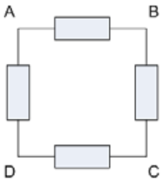


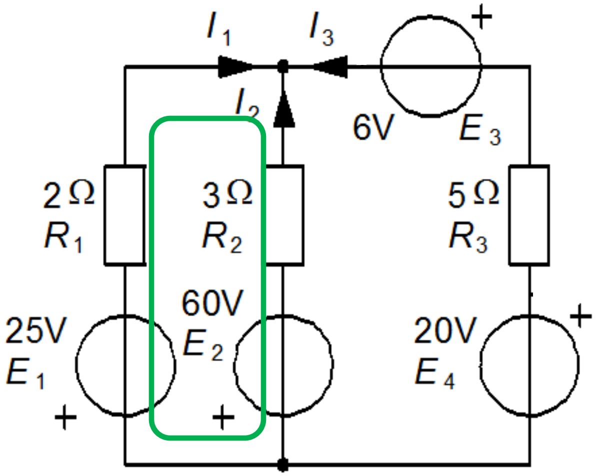


Kirchhoffs strömlag:

$$I_1 + I_2 + I_3 = 0$$

Kirchhoffs lagar (6.5)





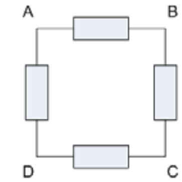
Kirchhoffs strömlag:

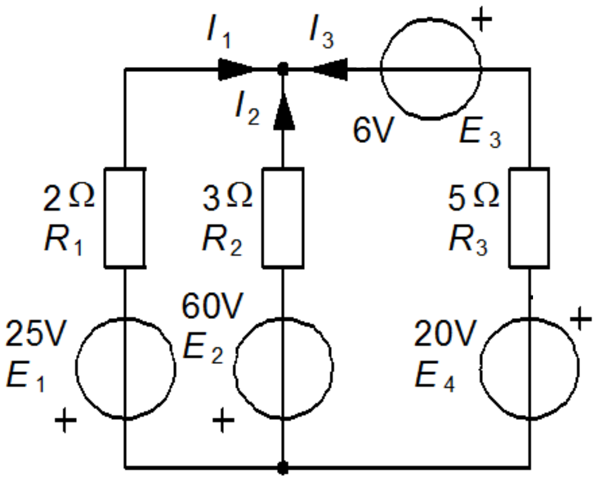
$$I_1 + I_2 + I_3 = 0$$

Kirchhoffs spänningslag (vänstra slingan):

$$-25 - 2 \cdot I_1 + 3 \cdot I_2 + 60 = 0$$

Kirchhoffs lagar (6.5)





Kirchhoffs strömlag:

$$I_1 + I_2 + I_3 = 0$$

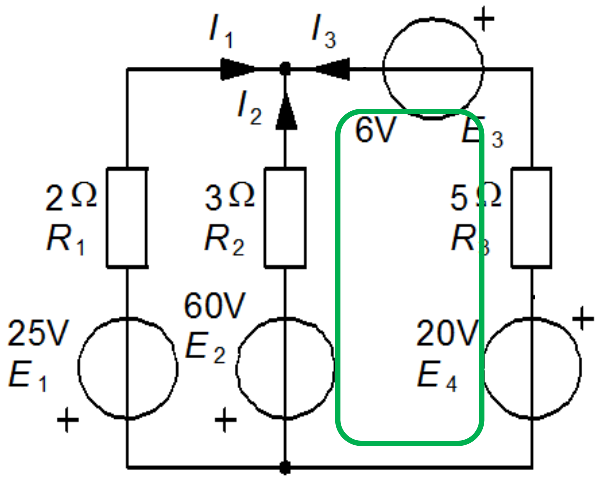
Kirchhoffs spänningslag (vänstra slingan):

$$-25 - 2 \cdot I_1 + 3 \cdot I_2 + 60 = 0$$

hyfsa:

$$-2 \cdot I_1 + 3 \cdot I_2 + 0 \cdot I_3 = -35$$

Kirchhoffs lagar (6.5)



Kirchhoffs strömlag:

$$I_1 + I_2 + I_3 = 0$$

Kirchhoffs spänningslag (vänstra slingan):

$$-25 - 2 \cdot I_1 + 3 \cdot I_2 + 60 = 0$$

hyfsa:

$$-2 \cdot I_1 + 3 \cdot I_2 + 0 \cdot I_3 = -35$$

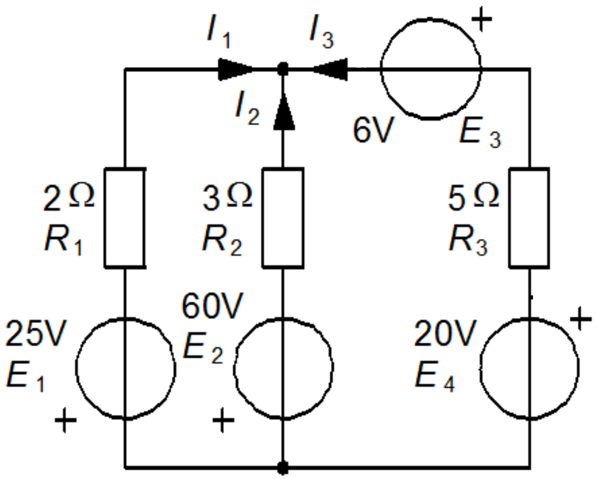
Kirchhoffs spänningslag (högra slingan):

$$-60 - 3 \cdot I_2 + 6 + 5 \cdot I_3 - 20 = 0$$

hyfsa:

$$0 \cdot I_1 - 3 \cdot I_2 + 5 \cdot I_3 = 74$$

Kirchhoffs lagar (6.5)



$$I_1 + I_2 + I_3 = 0$$

$$-2 \cdot I_1 + 3 \cdot I_2 + 0 \cdot I_3 = -35$$

$$0 \cdot I_1 - 3 \cdot I_2 + 5 \cdot I_3 = 74$$

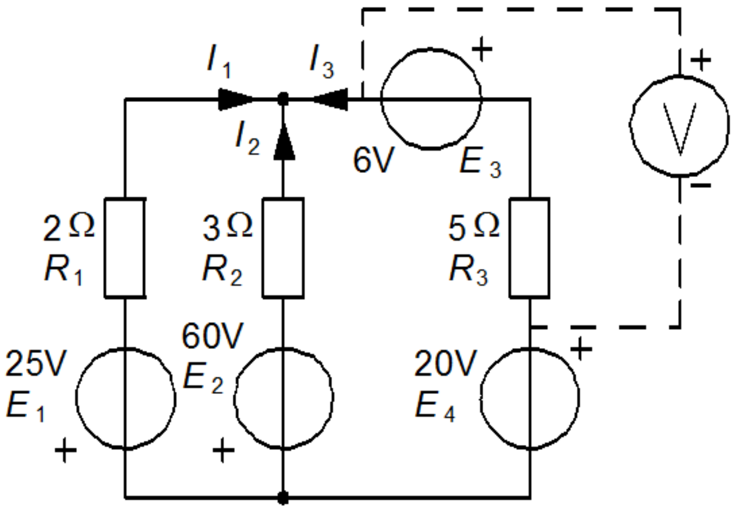
$$R \quad \cdot \quad I \; = \; U$$

$$\begin{pmatrix} 1 & 1 & 1 \\ -2 & 3 & 0 \\ 0 & -3 & 5 \end{pmatrix} \bullet \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 0 \\ -35 \\ 74 \end{pmatrix}$$

$$\Rightarrow \quad \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 1{,}87 \\ -10{,}4 \\ 8{,}55 \end{pmatrix}$$

William Sandqvist william@kth.se

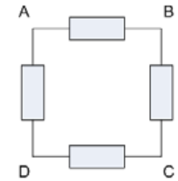
Kirchhoffs lagar (6.5)



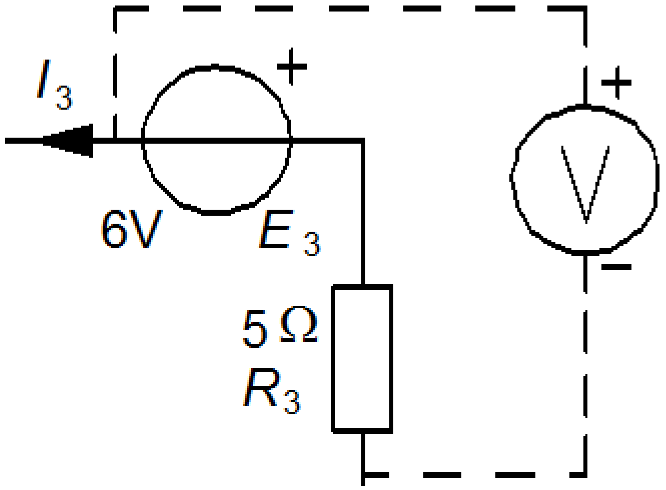
Om ekvationssystemet löses får man:
I_1 = 1,87 I_2 = -10,4 I_3 = 8,55 [A].

b) Vad visar voltmetern längst till höger i figuren (ange både spänningens belopp och tecken) [V]?

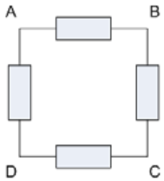
Kirchhoffs lagar (6.5)



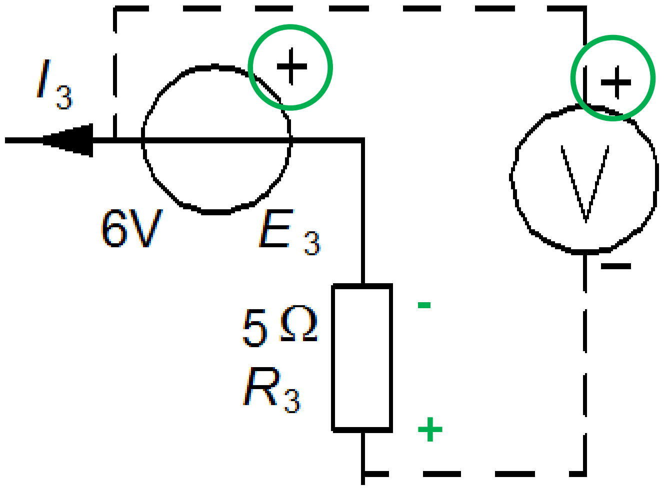
$I_3 = 8{,}55$ [A]



Kirchhoffs lagar (6.5)



$I_3 = 8{,}55$ [A]



Spänningen över voltmetern (U)

$$U + E_3 + R_3 \cdot I_3 = 0 \Rightarrow U = -6 - 5 \cdot 8{,}55 = -48{,}75 \text{ V}$$