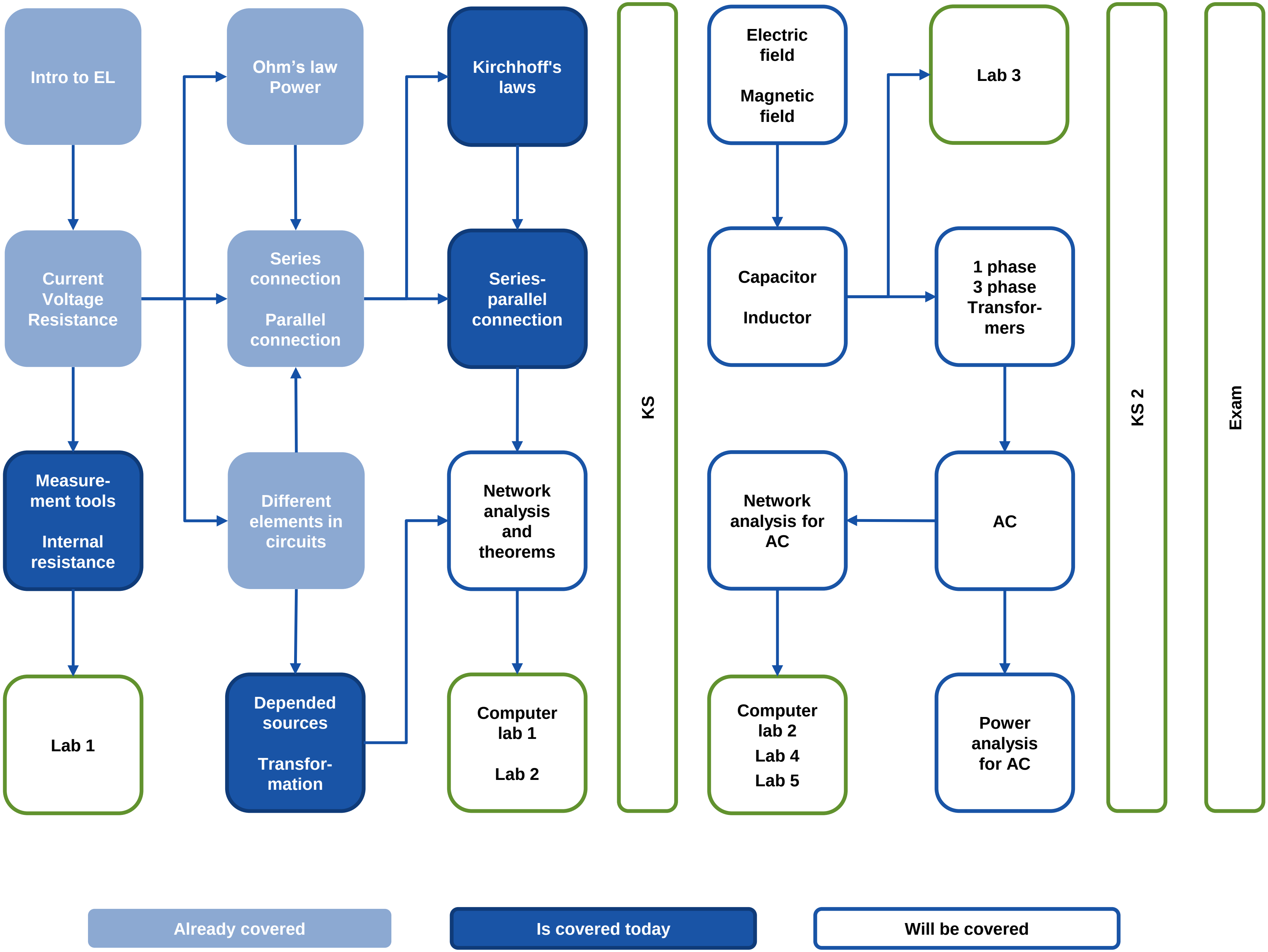
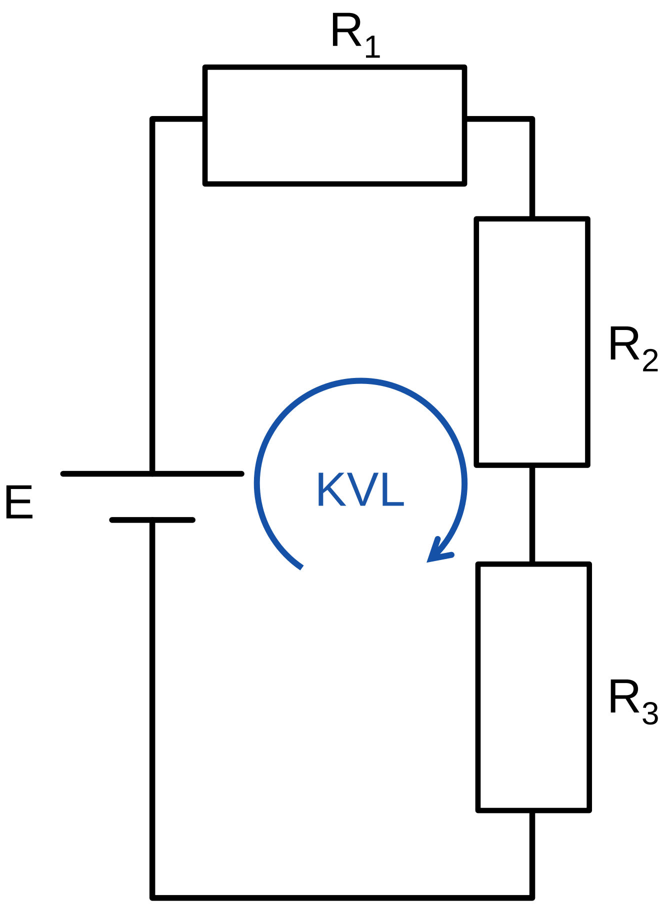
HE1027 Electrical Principals

Lecture 2: Series-Parallel Circuits Exercises


Intro to EL
Ohm's law
Power
Kirchhoff's laws
KS
Electric field
Magnetic field
Lab 3
KS 2
Exam
Current
Voltage
Resistance
Series connection
Parallel connection
Series-parallel connection
Capacitor
Inductor
1 phase
3 phase
Transfor-mers
Measure-ment tools
Internal resistance
Different elements in circuits
Network analysis and theorems
Network analysis for AC
AC
Lab 1
Depended sources
Transfor-mation
Computer lab 1
Lab 2
Computer lab 2
Lab 4
Lab 5
Power analysis for AC
Already covered
Is covered today
Will be covered

Series Circuits – Kirchhoff's Voltage Law



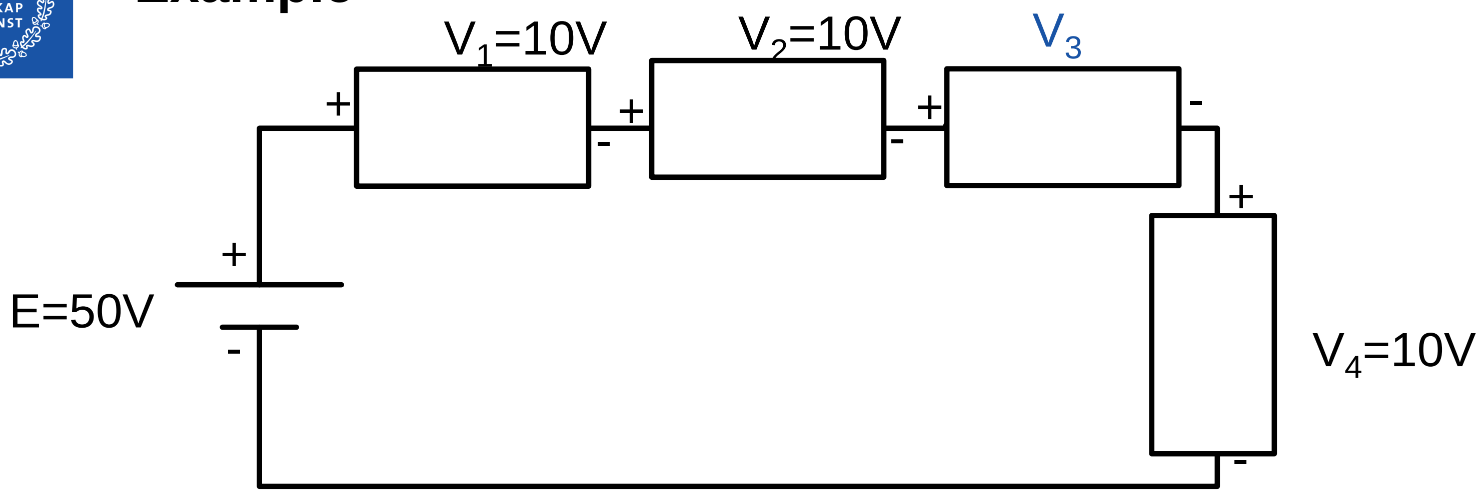
- The sum of all potential rises (sources) and drops (consumptions) around a closed path is zero

$E+V_1+V_2+V_3=0$ (V_1 V_2 V_3 has negative values)

$E=V_1+V_2+V_3$ (V_1 V_2 V_3 has positive values)

$\sum E = \sum V$

Example



What is V_3 voltage?

$E = V_1 + V_2 + V_3 + V_4$ or $E - V_1 - V_2 - V_3 - V_4 = 0$

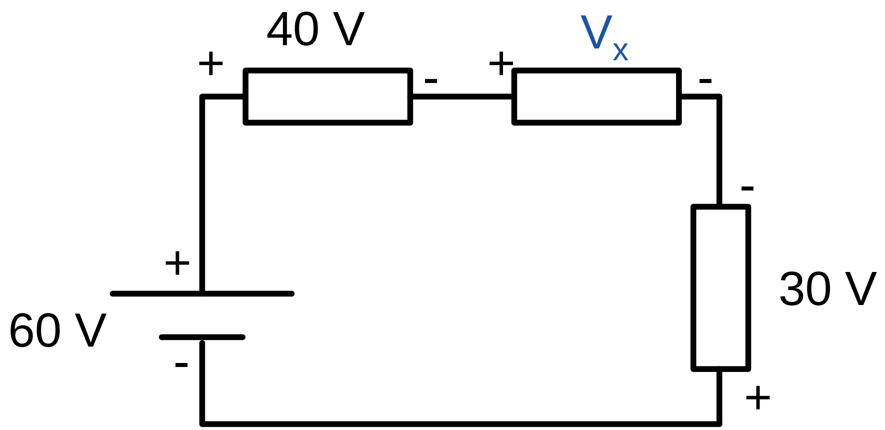
$$50 = 10 + 10 + V_3 + 10$$

$$V_3 = 50 - 10 - 10 - 10 = 20V$$

Determine a current if R_3 is 40Ω?

$$I = \frac{V_3}{R_3} = \frac{20}{40} = 0{,}5A$$

Example



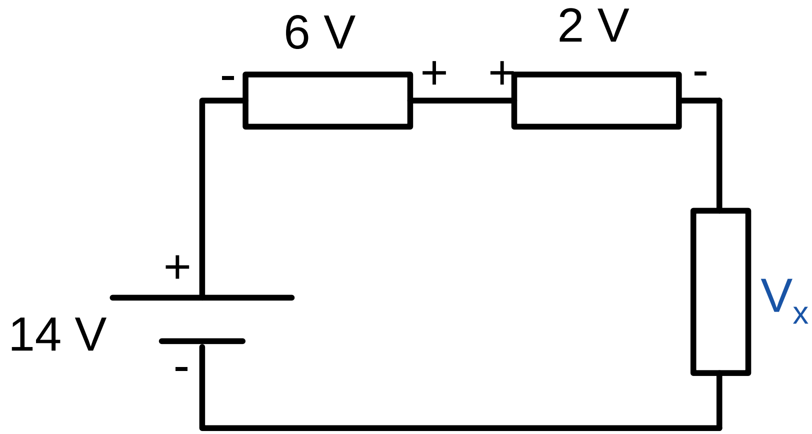
Blocks represent mixtures of components. Determine the unknown voltage

$$60 - 40 - V_x + 30 = 0$$

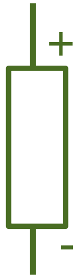
$$-V_x = -60 + 40 - 30 = -50$$

$$V_x = 50 \text{ V}$$

Example



Determine the unknown voltage and polarity

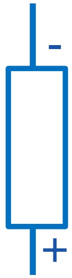


(randomly selected)

$$14 + 6 - 2 - V_x = 0$$

$$V_x = 18V$$

Polarity was selected correct



(randomly selected)

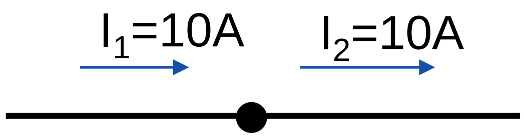
$$14 + 6 - 2 + V_x = 0$$

$$V_x = -18V$$

Polarity was selected incorrect and should be reversed

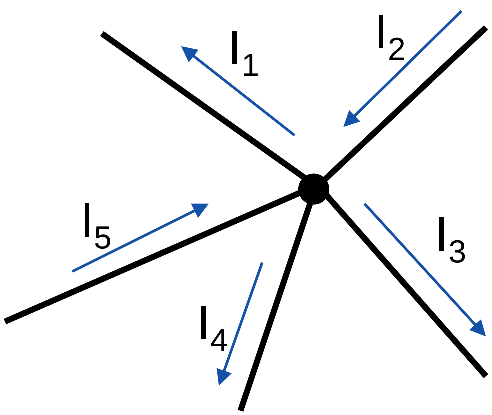
Kirchhoff's Current Law

- The sum of currents entering and leaving a junction or region of network is zero



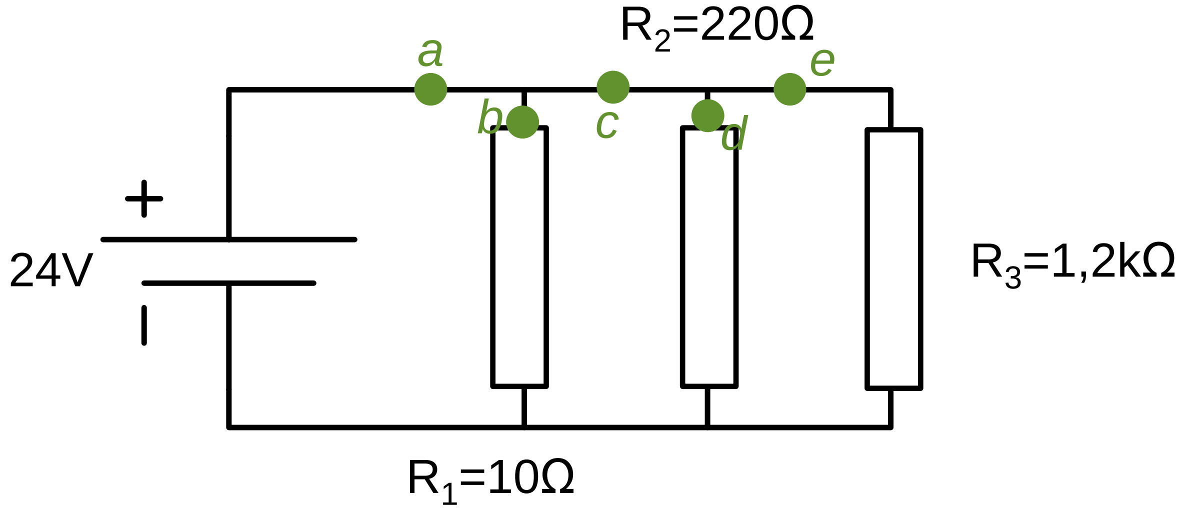
$I_1+I_2=0$ (if I_2 is negative)

$I_1-I_2=0$ (if I_2 is positive)



$-I_1+I_2-I_3-I_4+I_5=0$

Example



Determine the current in points a, b, c, d *and* e

Prom previous lecture we know that

I_a=2,53 A

I_b=2,4A

I_c=0,11A

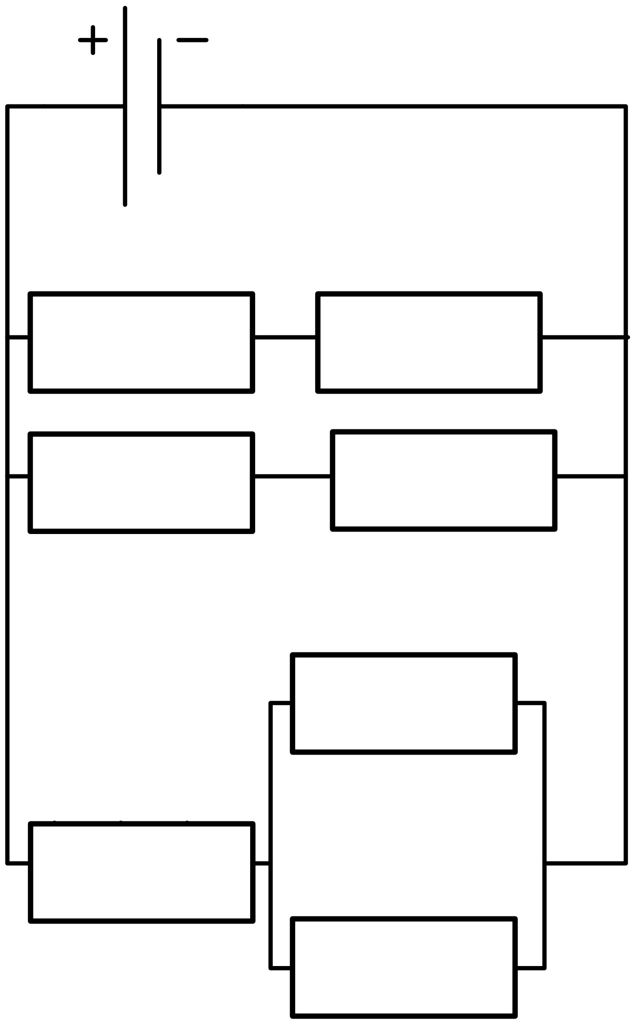
I_d=0,02A

I_c=I_a-I_b=0,13A

or

I_c=I_d+I_e=0,13A

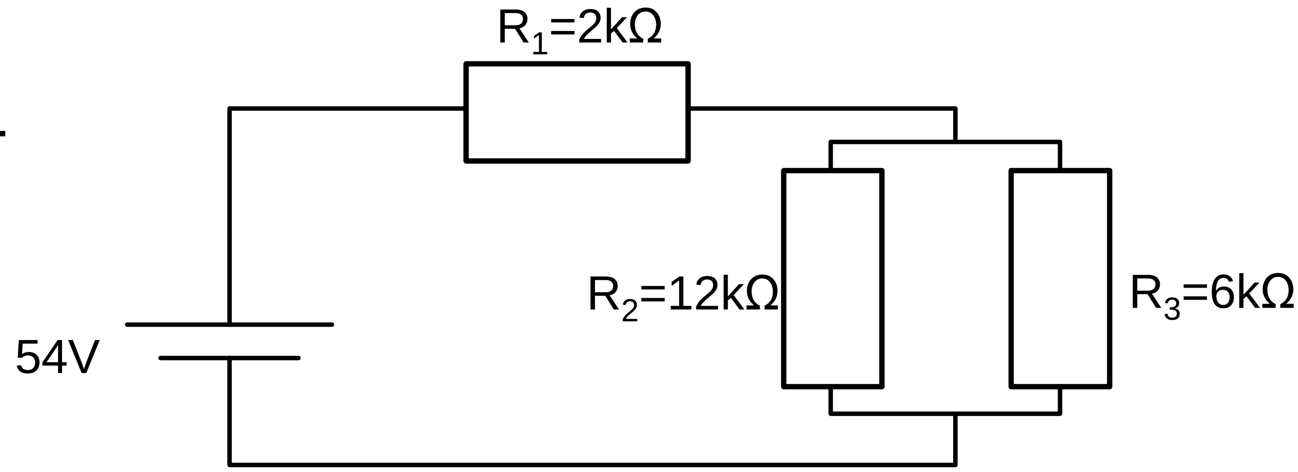
Series-Parallel Circuits



- Most of circuits are combination of series connections and parallel connections
- To solve it we can use reduce and return approach:
  - find and solve elements that are just series or just parallel
  - (mentally) redraw these elements as one
  - repeat until all is reduced to one element
  - now redraw circuit back to original based on found values

Example 1

$$R_{Total\ for\ parallel\ resitors} = \frac{R_x \cdot R_y}{R_x + R_y}$$



Find current I_3

$$R_T = R_1 + \frac{R_2 \cdot R_3}{R_2 + R_3} = 2 + \frac{12 \cdot 6}{12 + 6} = 2 + 4 = 6k\Omega$$

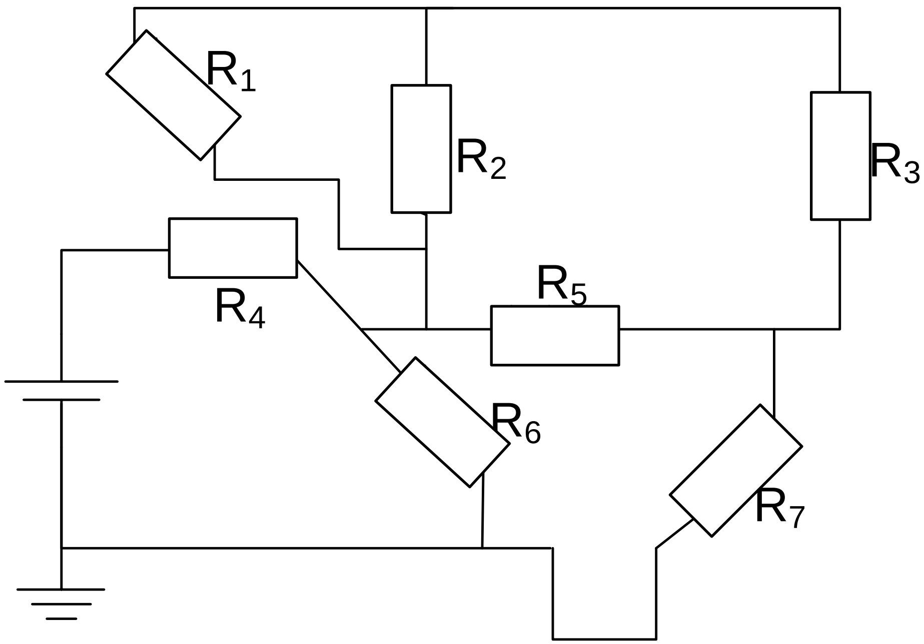
$$I_T = \frac{54}{6000} = 9mA$$

$$V_1 = I_T \cdot R_1 = 9mA \cdot 2k\Omega = 18V$$

$$V_3 = V_2 = E - V_1 = 54 - 18 = 36V$$

$$I_3 = \frac{V_3}{R_3} = 6mA$$

Example 2

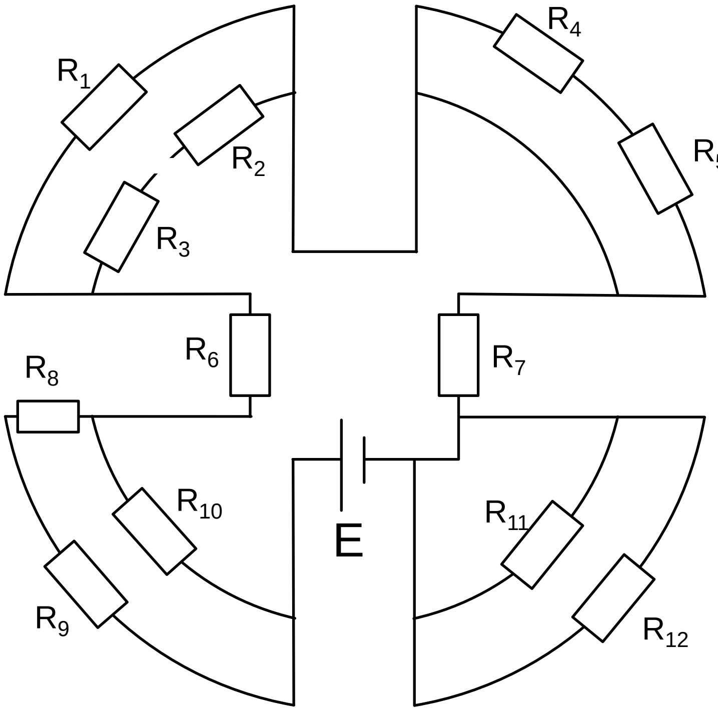


Find R_{total}

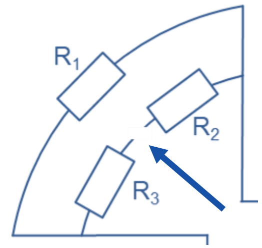
Parallel $R_a//R_b$
Serial R_a+R_b

$$R_T=(((R_1//R_2)+R_3)//R_5+R_7)//R_6+R_4$$

Example 3

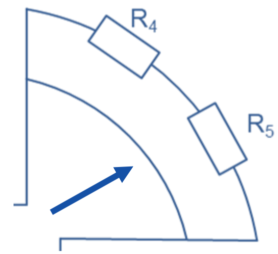


Find R_{total}



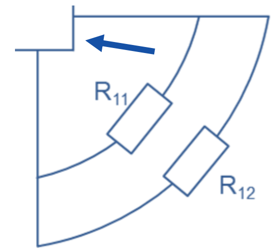
$R_T = R_1$

R_2 and R_3 are open circuit



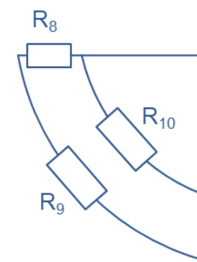
$R_T = 0$

R_4 and R_5 are closed circuit



$R_T = 0$

R_{11} and R_{12} are closed circuit

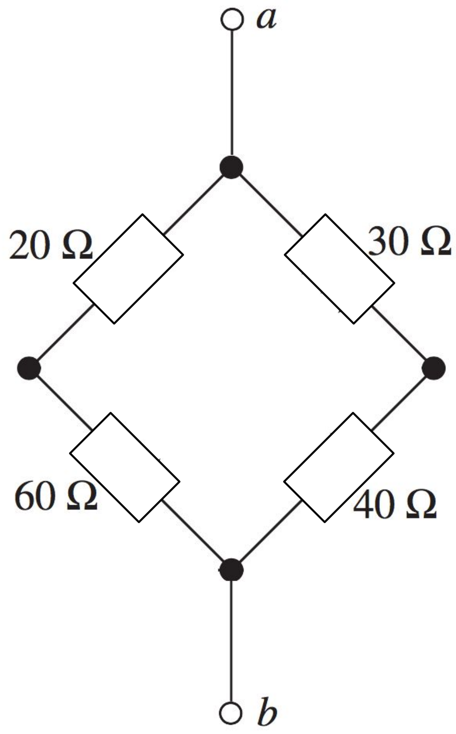


$R_T = (R_8 + R_9) // R_{10}$

$$R_T = R_1 + R_7 + (R_8 + R_9) // R_{10} + R_6$$

Example 4

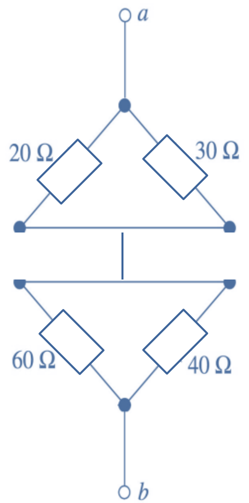
Find resistance between *a* and *b*



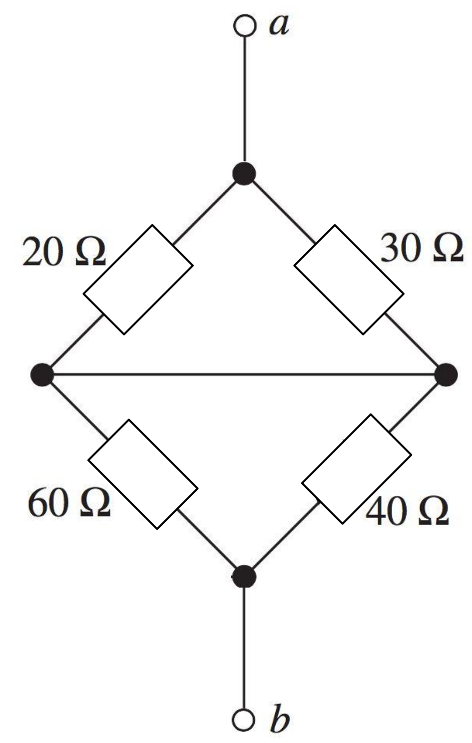
$R_T=(20+60)//(30+40)$

Example 5

Find resistance between *a* and *b*



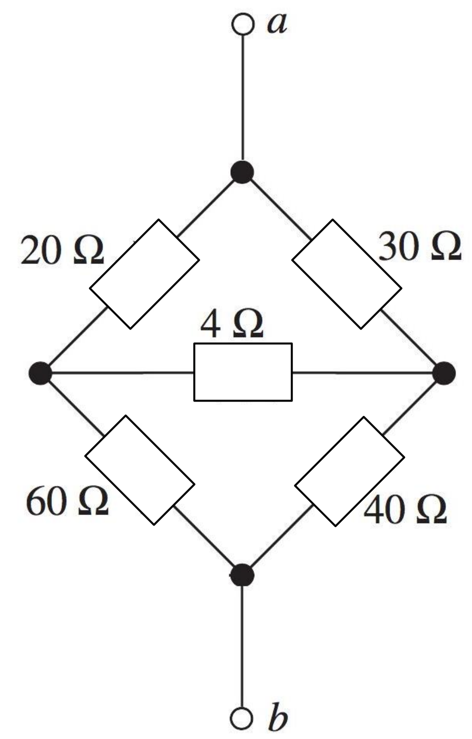
$R_T = 20//30 + 60//40$



Example 6

Find resistance between *a* and *b*

?



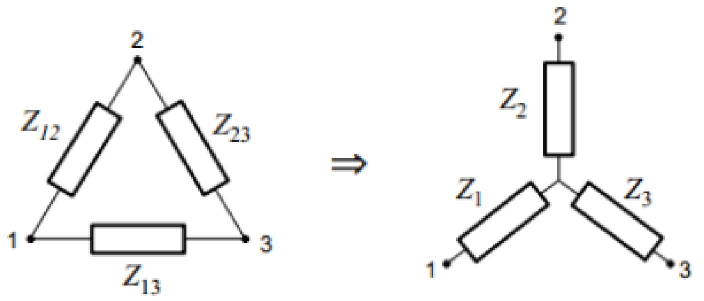
Delta-Wye transformation

$$Z_1 = \frac{Z_{12} \cdot Z_{13}}{Z_{12} + Z_{13} + Z_{23}}$$

$$Z_2 = \frac{Z_{12} \cdot Z_{23}}{Z_{12} + Z_{13} + Z_{23}}$$

$$Z_3 = \frac{Z_{13} \cdot Z_{23}}{Z_{12} + Z_{13} + Z_{23}}$$

Triangel – Stjärntransformation/ D - Y

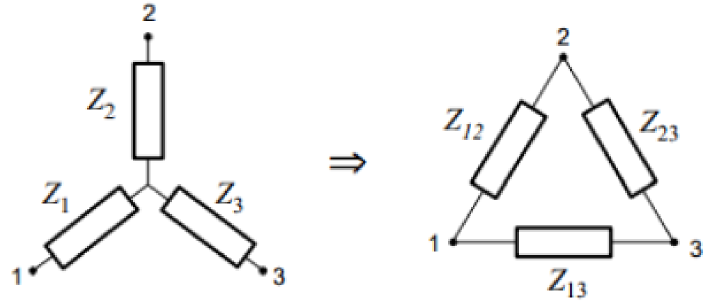


$$Z_{12} = Z_1 \cdot Z_2 \sum_{i=1}^{3} \frac{1}{Z_i}$$

$$Z_{13} = Z_1 \cdot Z_3 \sum_{i=1}^{3} \frac{1}{Z_i}$$

$$Z_{23} = Z_2 \cdot Z_3 \sum_{i=1}^{3} \frac{1}{Z_i}$$

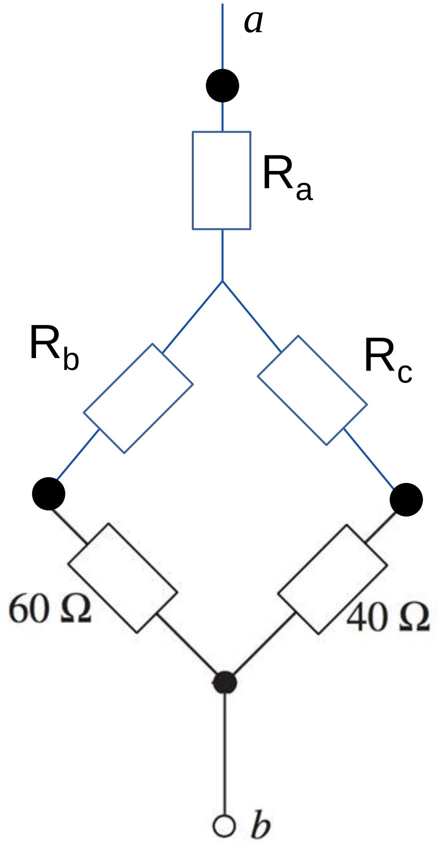
Stjärn – Triangeltransformation/ Y - D



Example 6

Find resistance between *a* and *b*

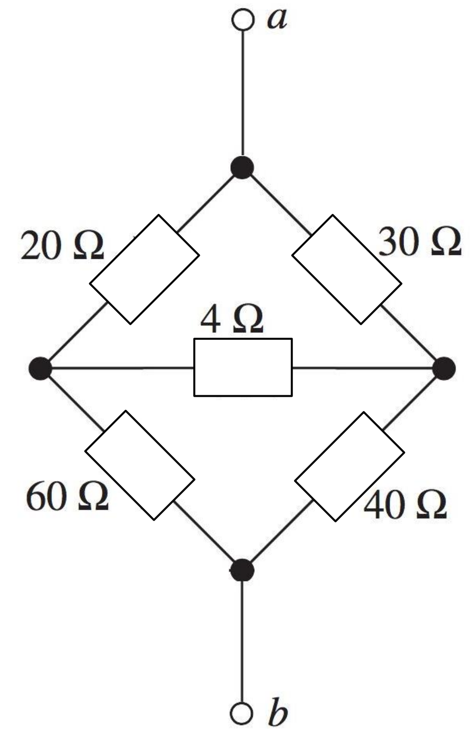
Transforming top triangle into star: $R_1 = \dfrac{R_{12} \cdot R_{13}}{R_{12} + R_{13} + R_{23}}$



$$R_a = \frac{20 \cdot 30}{20 + 30 + 4} = 11\Omega$$

$$R_b = \frac{20 \cdot 4}{20 + 30 + 4} = 1{,}482\Omega$$

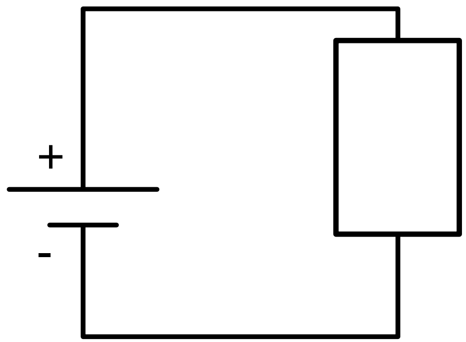
$$R_c = \frac{30 \cdot 4}{20 + 30 + 4} = 2{,}222\Omega$$

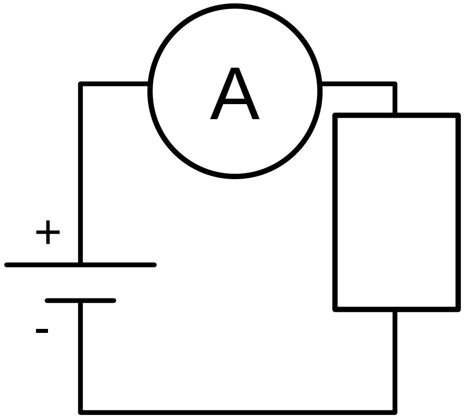


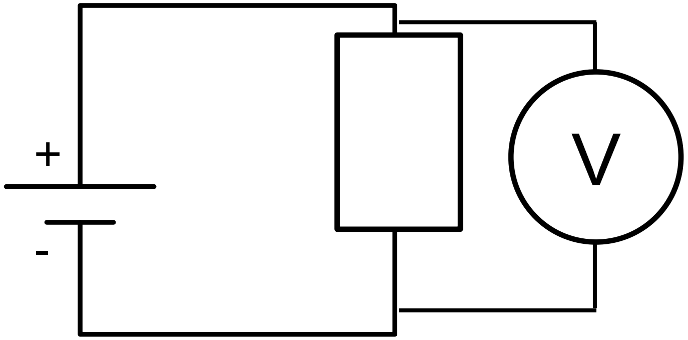
R_T=11+(1,482+60)//(2,222+40)

Measuring tools

- Based on series or parallel – how should measuring tools be connected?





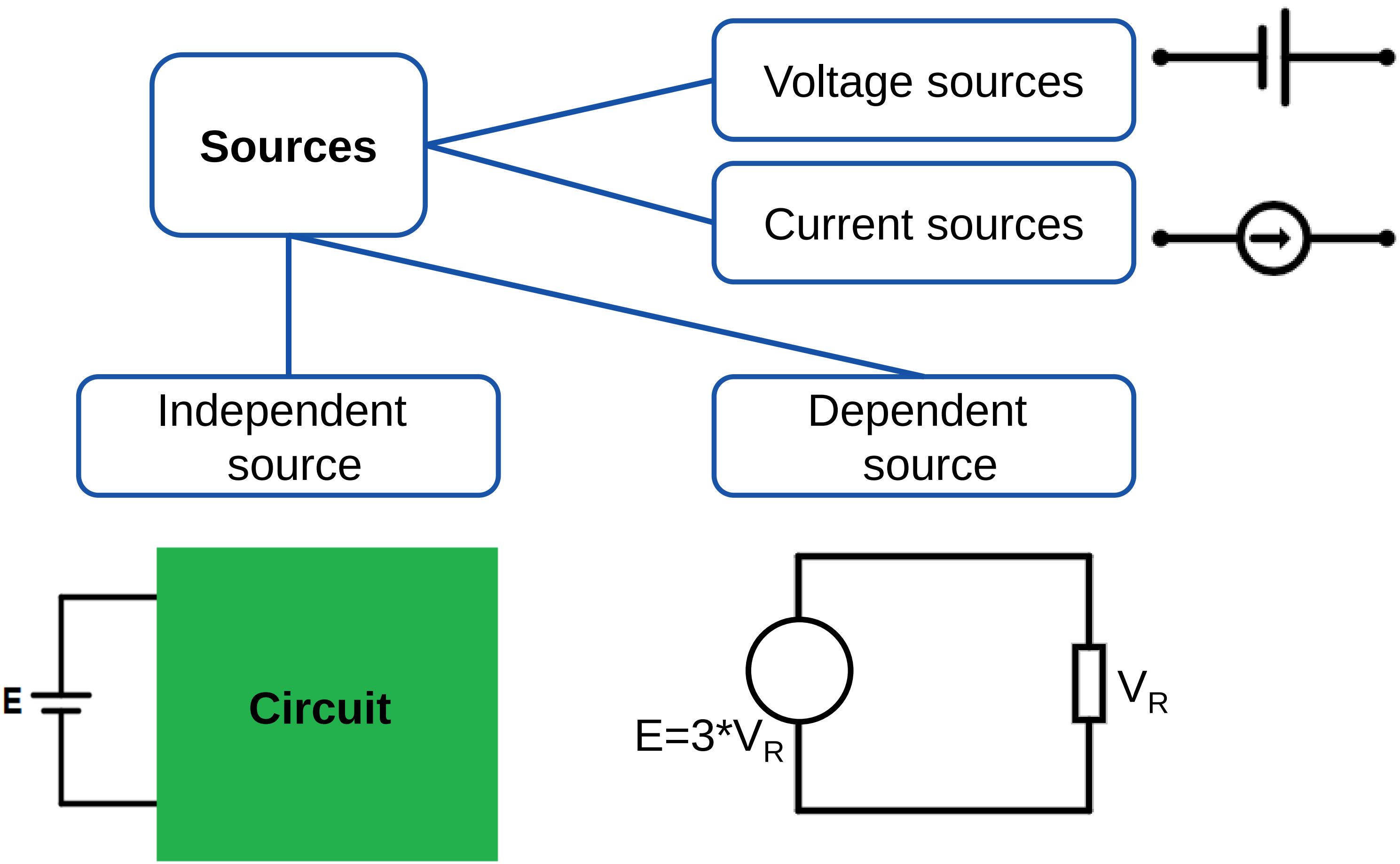


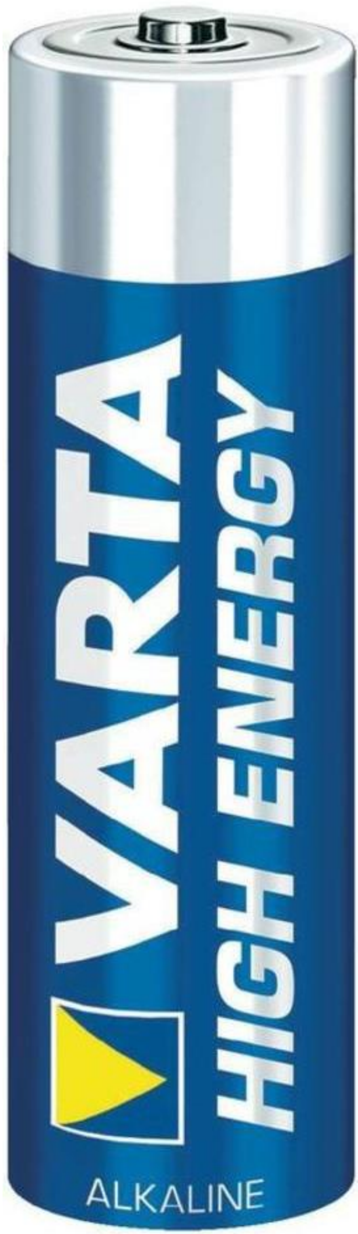
Internal resistance

- A voltmeter needs some current to flow to measure
- It should not change the amount of current going through the element between those two points
- The less current is better to avoid affecting the circuit
- Digital voltmeters today have an input resistance of 10 Megohms or more
- Wrong readings in circuits with high resistance

- Ammeters tend to influence the amount of current in the circuits they're connected to
- The ideal ammeter has zero internal resistance, so as to drop as little voltage as possible
- Wrong readings in circuits with low resistance

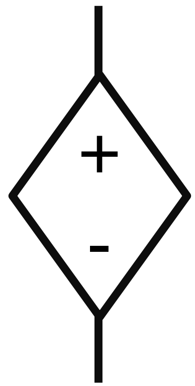
Electricity Sources in Circuits



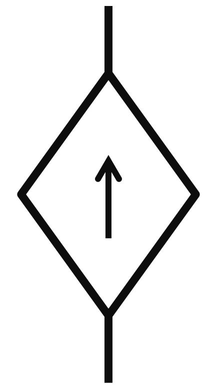


Dependent Source

The source output value depends upon the voltage or current at some other part of the circuit



Dependent voltage source

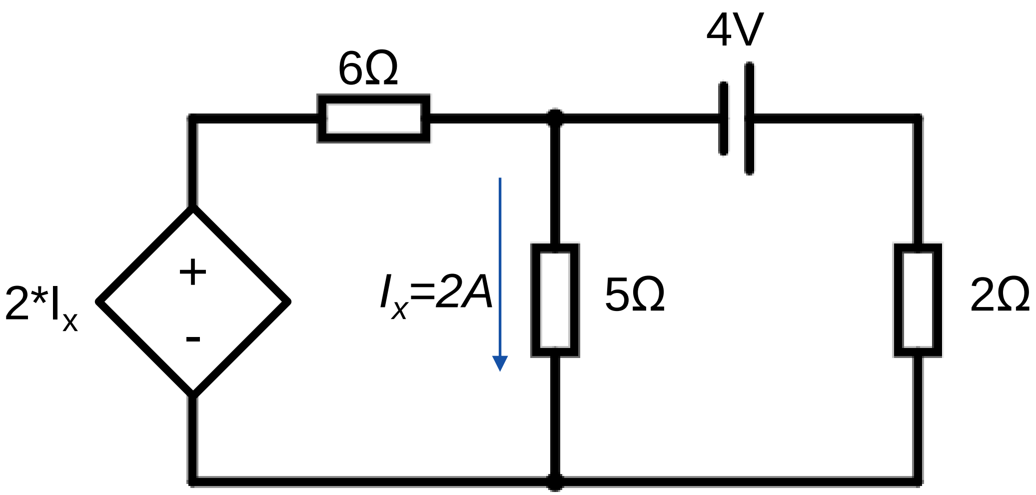


Dependent current source

Voltage Controlled Voltage Source	Current Controlled Voltage Source	Current Controlled Current Source	Voltage Controlled Current Source
$V=a*V_b$	$V=a*I_b$	$I=a*I_b$	$I=a*V_b$

Example

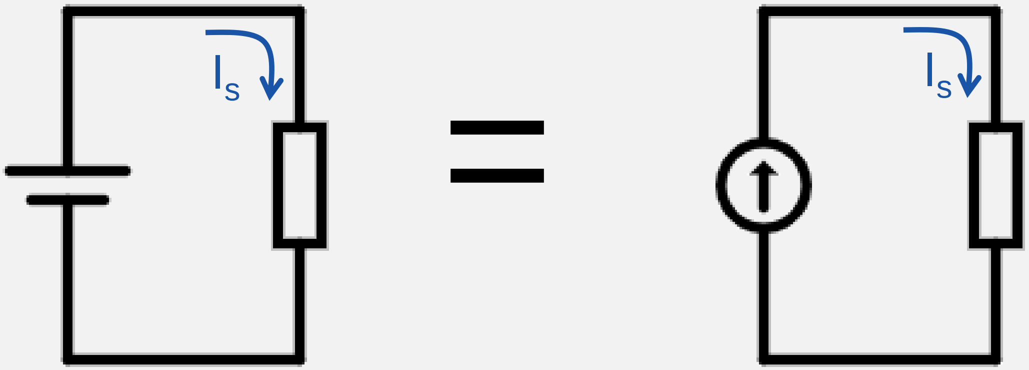
Determine type and voltage of the dependent source



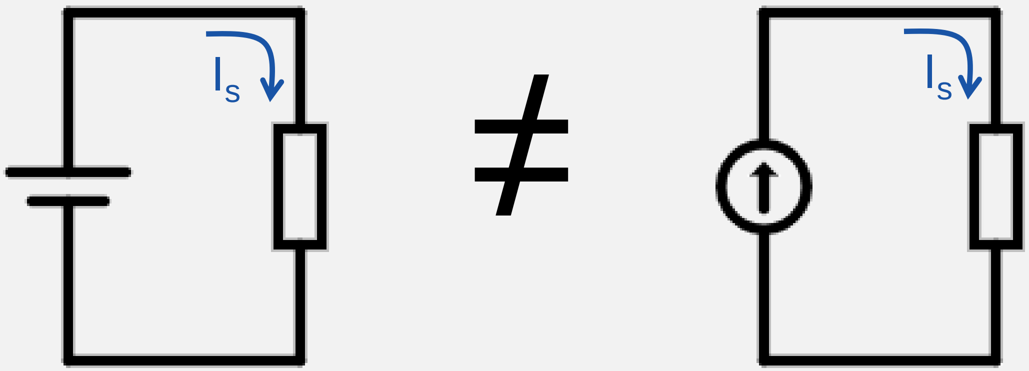
Current Controlled Voltage Source (CCVS)

E = 2*2=4V

Source Conversion

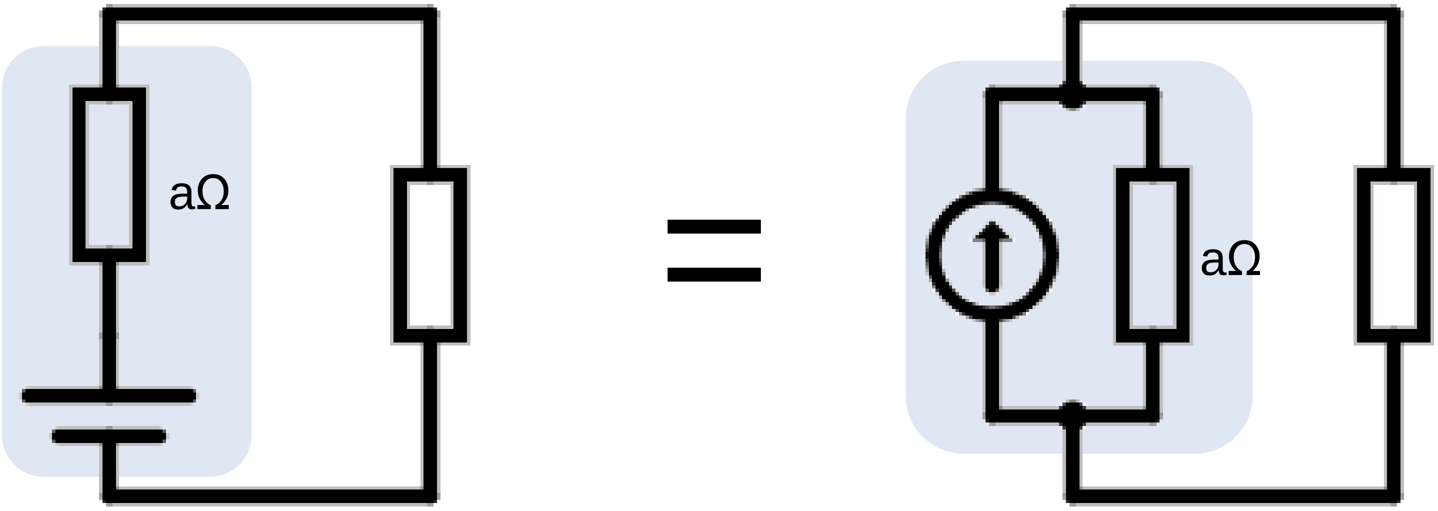


perfect world



reality (due internal resistance)

Source Conversion

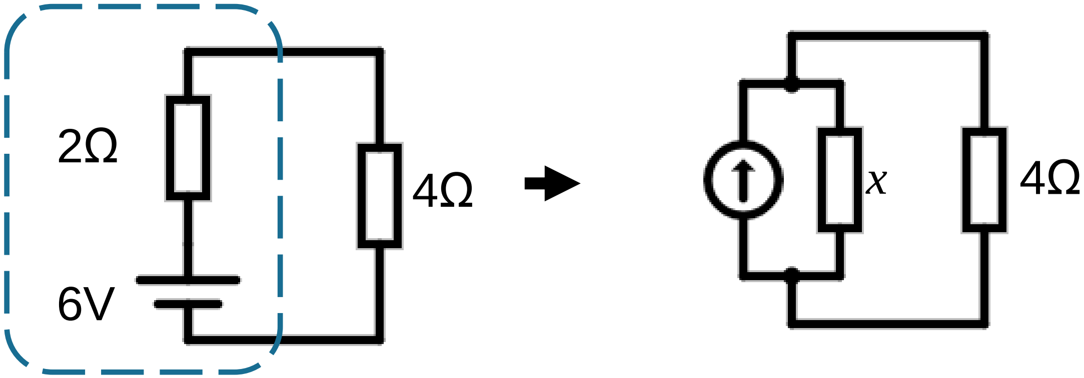


$$I = \frac{V}{a\Omega}$$

$$V = I \cdot a\Omega$$

Example

Convert to current source



Internal resistance is the same for both circuit, so x=2Ω

Current is equal to voltage source divided by internal resistance, so I=6/2=3A

Polarity of current source matches the polarity of voltage source

Suggested reading

Introductory Circuit Analysis

- Kap 5: **5.6 - 5.7**, 5.8 - 5.12, 5.14
- Kap 6: **6.5 - 6.7**, 6.8 - 6.9, 6.12
- Kap 7: **7.2 - 7.8**
- Kap 8: 8:9

The book does not have a good material about depended sources 😞

- Kretsanalysis by Bill Karlström p.19-20 (see last page of the slides)

*suggestions in bold are more important

Suggested exercises

- Kap 5: 25, 27
- Kap 6: 27, 31
- Kap 7: 3, 9, 11, 13, 23
- Kap 8: 65, 69

Beroende energikällor

I beroende energikällor är källströmmen eller källspänningen beroende av andra storheter i kretsen.
Beroende energikällor används för att modellera transistorer och förstärkare.

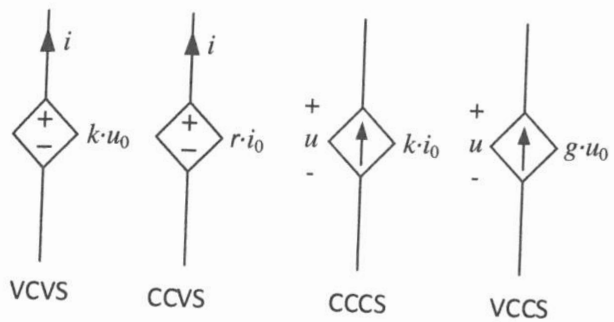


Fig 2.10 Beroende energikällor

VCVS Spänningsberoende spänningskälla. Dess källspänning beror av en spänning u_0 någon annanstans i kretsen oberoende av strömmen i.
Konstanten k är enhetslös.

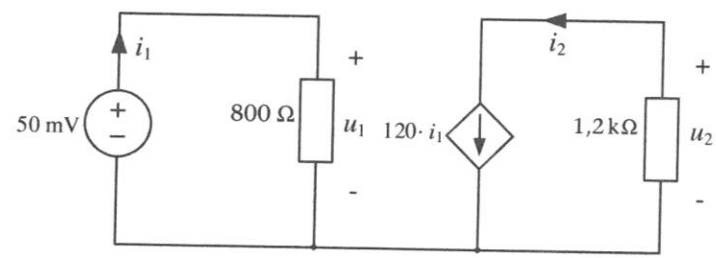
CCVS Strömberoende spänningskälla. Dess källspänning beror av en ström i_0 någon annanstans i kretsen oberoende av strömmen i.
Konstanten r har enheten Ω.

CCCS Strömberoende strömkälla. Dess källström beror av en ström i_0 någon annanstans i kretsen oberoende av spänningen u.
Konstanten k är enhetslös.

VCCS Spänningsberoende strömkälla. Dess källström beror av en spänning u_0 någon annanstans i kretsen oberoende av spänningen u.
Konstanten g har enheten $S = \text{siemens} = \Omega^{-1}$.

Exempel 2.7

Bestäm spänningen u_2 i kretsen nedan (enkel transistormodell).



Lösning

Spänningen u_1 över 800Ω-resistorn är 50mV. Detta ger

$$i_1 = \frac{50 \cdot 10^{-3}}{800} = 62{,}5\mu A \quad (2.34) \qquad \text{(strömmen } i_1 \text{ in vid plus).}$$

Detta ger

$$i_2 = 120 \cdot i_1 = 120 \cdot 62{,}5 \cdot 10^{-6} = 7{,}5mA \qquad (2.35)$$

så att

$$u_2 = -1{,}2 \cdot 10^3 \cdot i_2 = -1{,}2 \cdot 10^3 \cdot 7{,}5 \cdot 10^{-3} = \underline{\underline{-9V}} \qquad (2.36)$$

Observera minustecknet! Detta kommer av att strömmens referensriktning är in mot minustecknet!!