ISC0100 CYBERELECTRONICS

Fall 2018

The 2nd lecture

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Learning environment : http://isc.ttu.ee
Materials : http://isc.ttu.ee/martin

Topics

Direct current, electric measurenents

1. Voltage, potential, current, resistance, conducance
2. Kirchhoffs laws
3. directions, signs
4. Sources, meters
5. Dividers

Voltage

Voltage, electric potential difference, electric pressure or electric tension (formally denoted ΔV or ΔU, but more often simply as V or U, for instance in the context of Ohm's or Kirchhoff's laws) is the difference in electric potential energy between two points per unit electric charge. The voltage between two points is equal to the work done per unit of charge against a static electric field to move the test charge between two points and is measured in units of volts (a joule per coulomb).

The volt (symbol: V) is the derived unit for electric potential, electric potential difference (voltage), and electromotive force. The volt is named in honour of the Italian physicist Alessandro Volta (1745–1827), who invented the voltaic pile, possibly the first chemical battery.

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Kirchhoff's voltage law

The directed sum of the electrical potential differences (voltage) around any closed network is zero, or:

More simply, the sum of the emfs in any closed loop is equivalent to the sum of the potential drops in that loop, or:

The algebraic sum of the products of the resistances of the conductors and the currents in them in a closed loop is equal to the total emf available in that loop.

The sum of all the voltages around a loop is equal to zero. v1 + v2 + v3 - v4 = 0

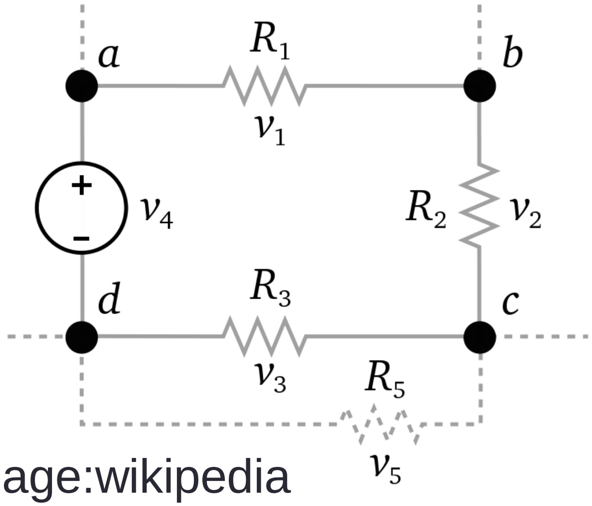

Image:wikipedia

How to find the voltages?

Voltage is difference of potentials !

1.We choose a node in circuit and say that it is 0 V. (usually this „ground“ node is set in cirtuit)

2. We find voltages related to this node.

How to find the voltages?

If we move from negative node to positive, the rise
Of voltage is positive.
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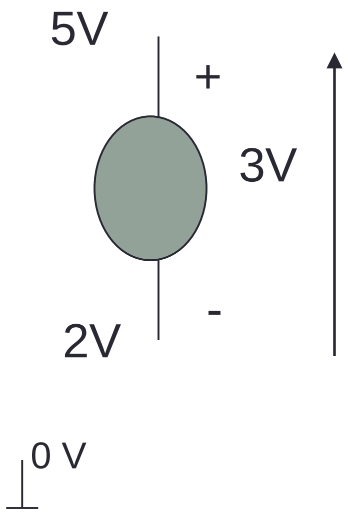

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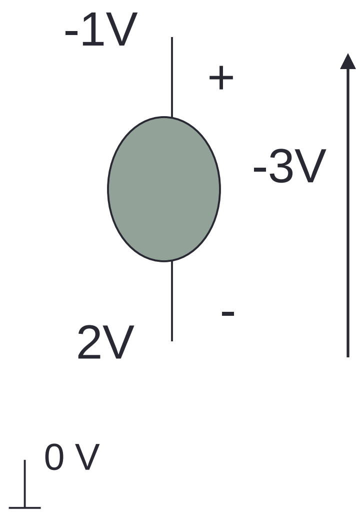

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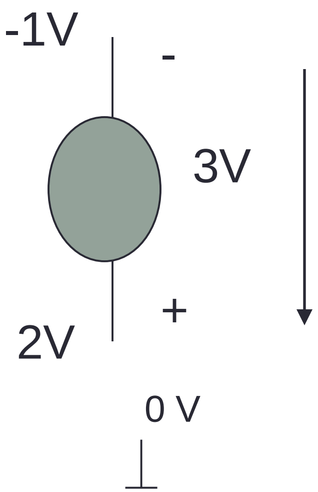


Current

An electric current is a flow of electric charge. In electric circuits this charge is often carried by moving electrons in a wire. It can also be carried by ions in an electrolyte, or by both ions and electrons such as in a plasma.

The SI unit for measuring an electric current is the ampere (A), which is the flow of electric charge across a surface at the rate of one coulomb per second.

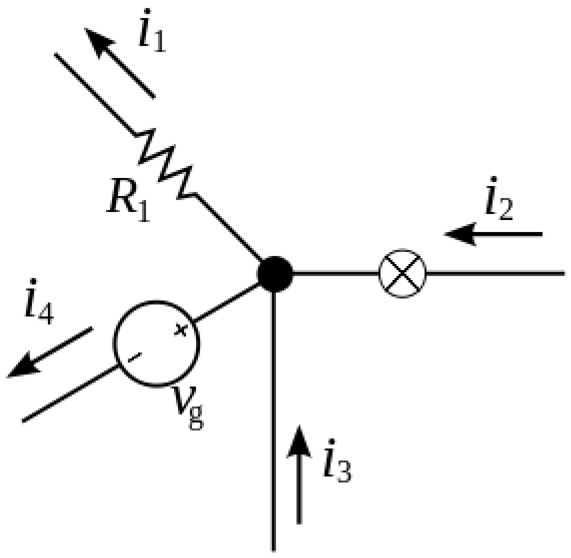
Kirchhoff’s current law

At any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node

or equivalently

The algebraic sum of currents in a network of conductors meeting at a point is zero.

The current entering any junction is equal to the current leaving that junction. i2 + i3 = i1 + i4



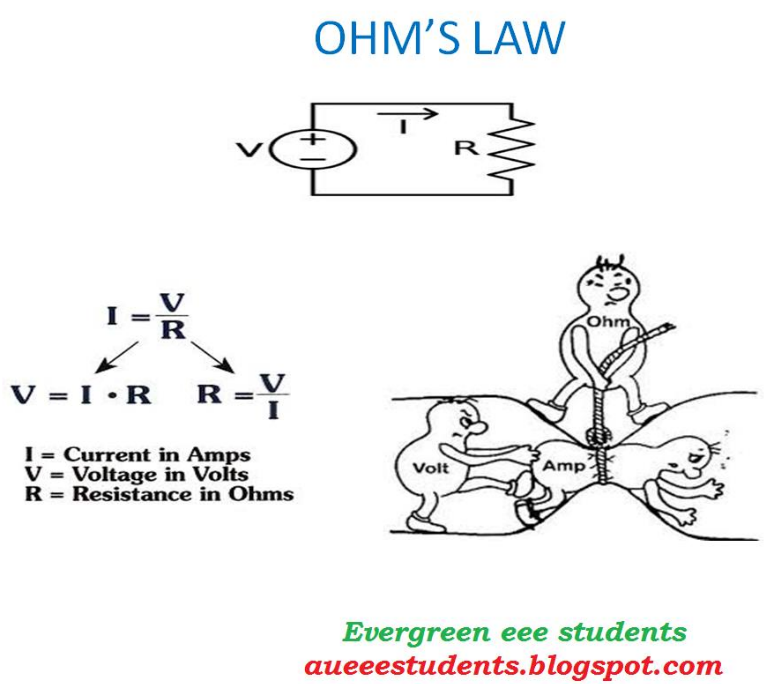
Electrical resistance and conductance

The electrical resistance of an electrical conductor is a measure of the difficulty to pass an electric current through that conductor. The inverse quantity is electrical conductance, and is the ease with which an electric current passes. Electrical resistance shares some conceptual parallels with the notion of mechanical friction. The SI unit of electrical resistance is the ohm (Ω), while electrical conductance is measured in siemens (S).

An object of uniform cross section has a resistance proportional to its resistivity and length and inversely proportional to its cross-sectional area. All materials show some resistance, except for superconductors, which have a resistance of zero.

Ohm's law

- Ohm's law states that the current through a conductor between two points is directly proportional to the voltage across the two points. Introducing the constant of proportionality, the resistance, one arrives at the usual mathematical equation that describes this relationship:



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Series connection

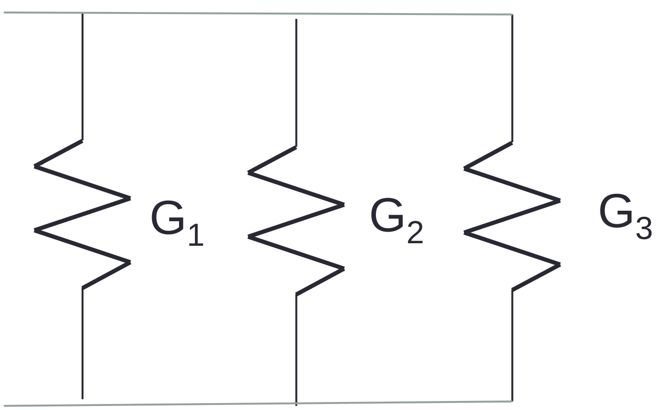
Two elements are in series if they have one common node..
Components connected in series are connected along a single path, so the same current flows through all of the components.

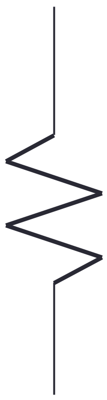
$$R=R_1+R_2+R_3$$

It appies only to twopoles!
It applies also to reacive components (Z)

Parallel connection

Components are in parallel when they have two common nodes.
If two or more components are connected in parallel they have the same potential difference (voltage) across their ends.





$G=G_1+G_2+G_3 \dots$

$1/R=1/R_1+1/R_2+1/R_3 \dots$

Only 2 components !

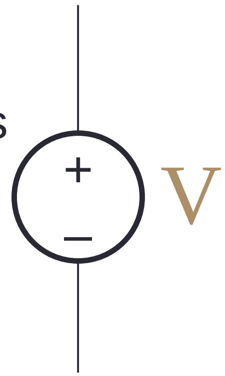
$$R = \frac{R1 * R2}{R1 + R2}$$

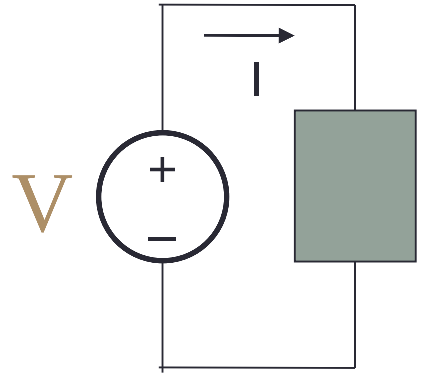
It appies only to twopoles!
It applies also to reacive components (Z)

Voltage source

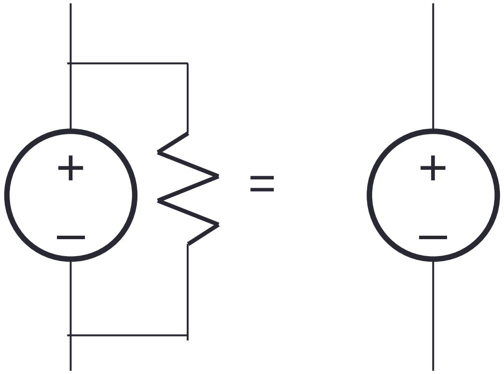
The goal of voltage source
To keep voltage between nodes

Internal resistance is 0.

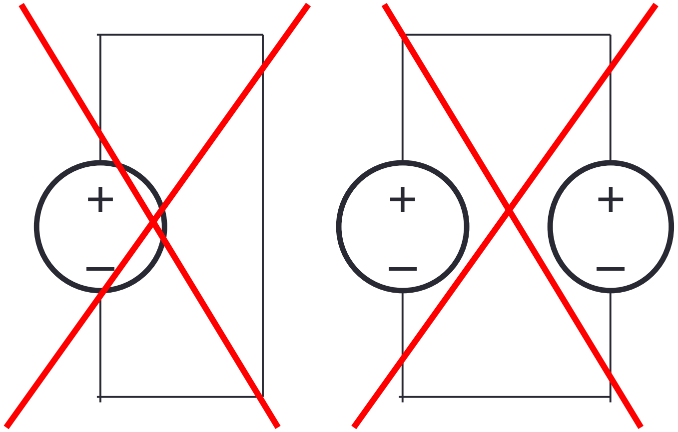




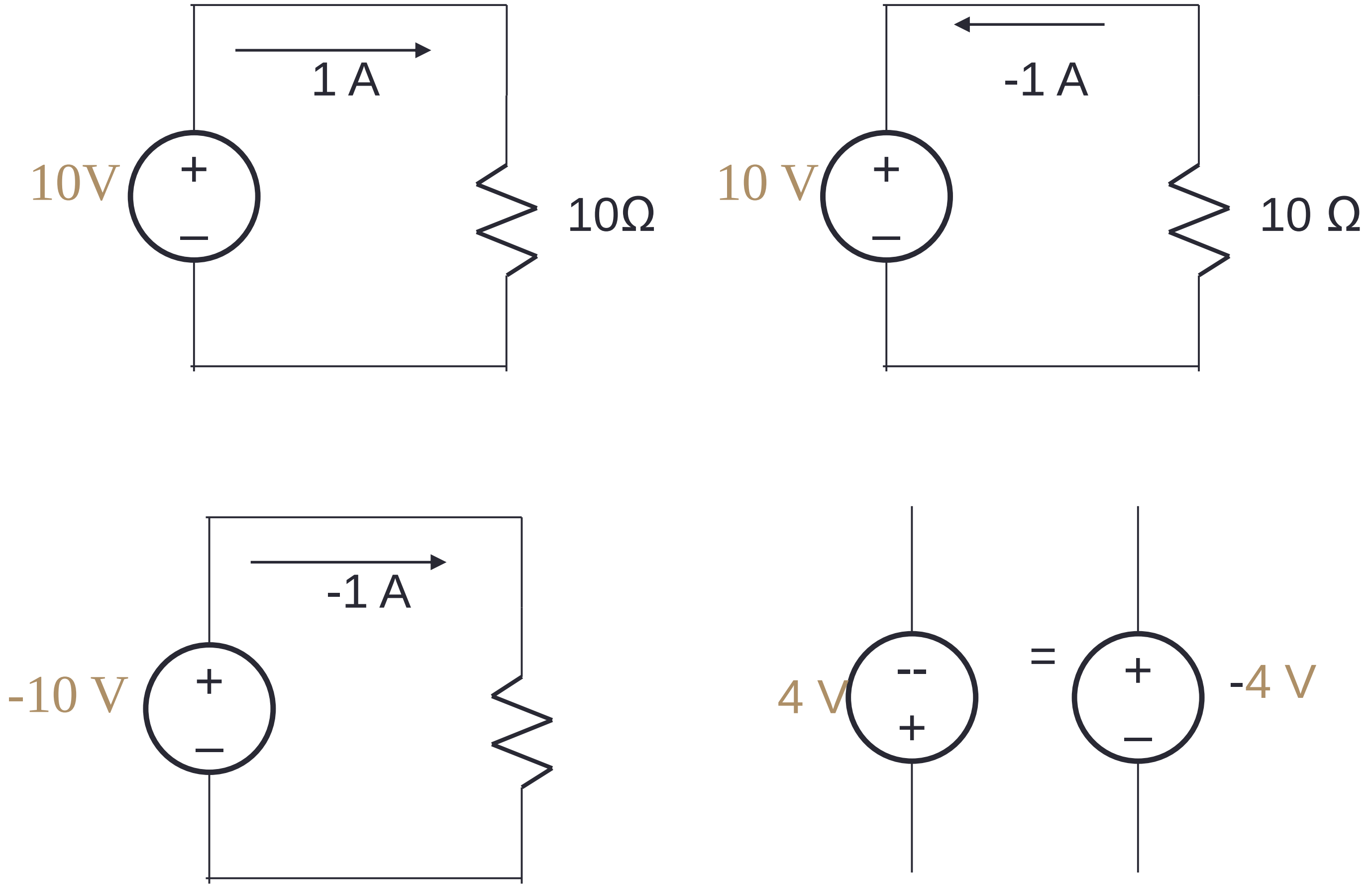
The voltage does not depend on current or connected components.



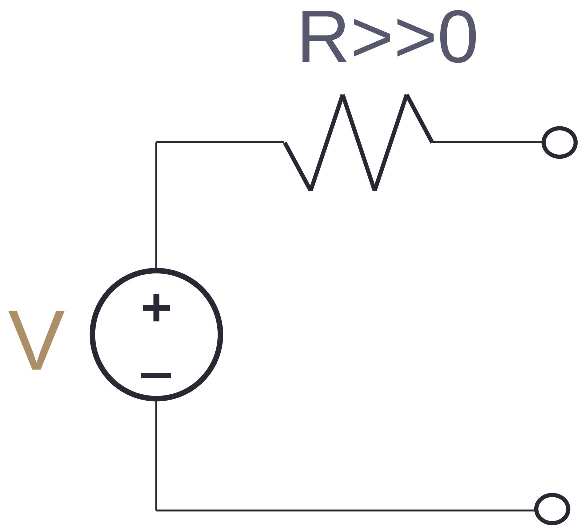
You most not short or connect in parallel with other voltage source!

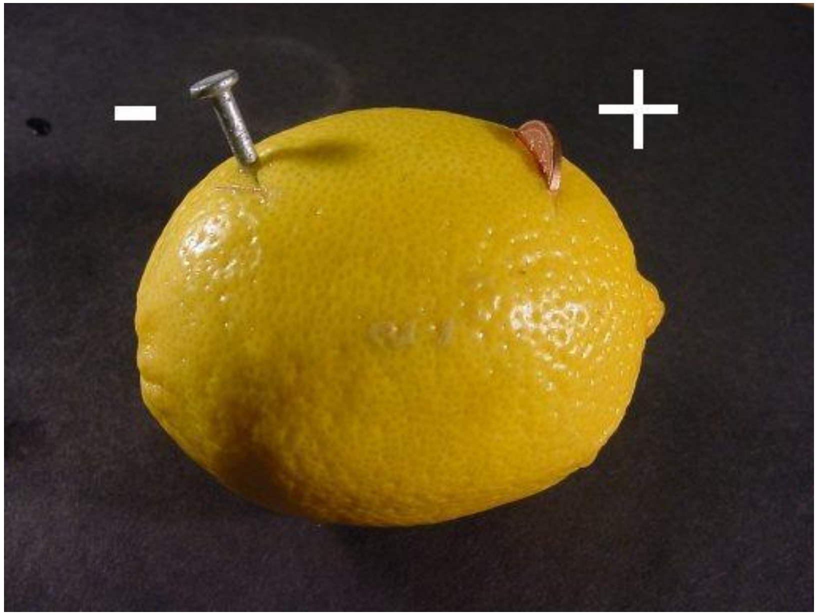


Voltage source



Real voltage source

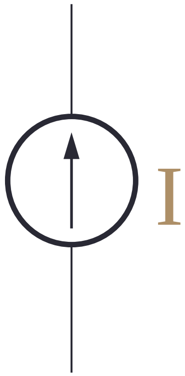


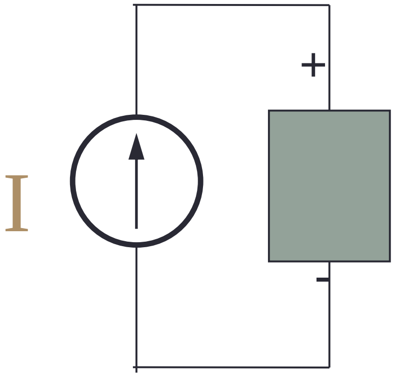


Current source

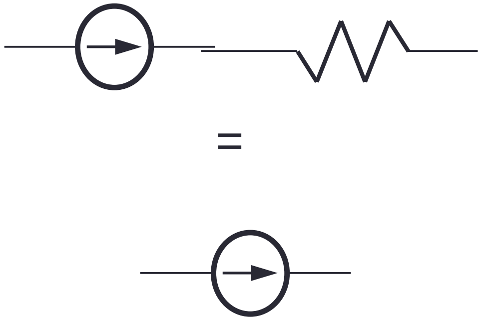
The goal of current source is to
Keep current flowing.

The internal conductancse of
Current source is 0.

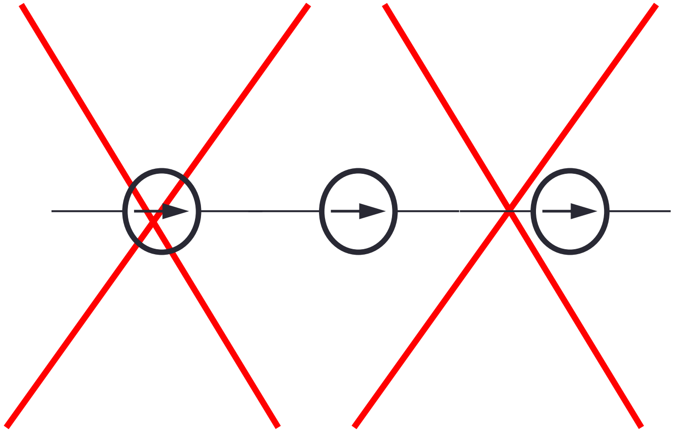




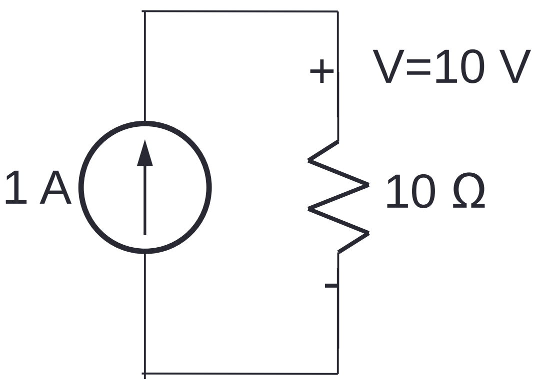
The current does not depend on
voltage or connected components.

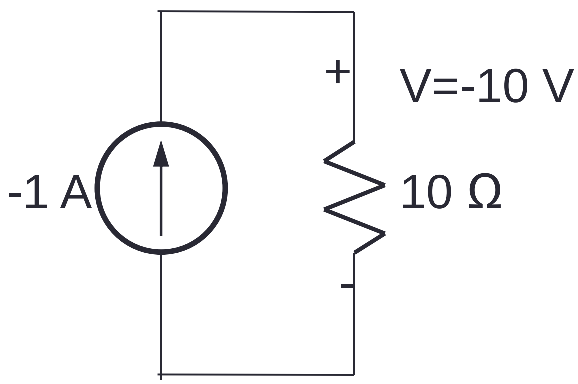


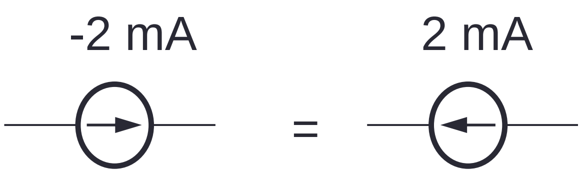
You must not leave current source
in open circuit or connect them in series.



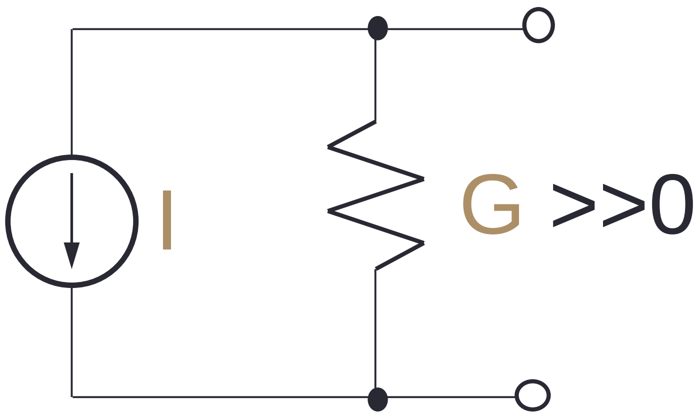
Current source

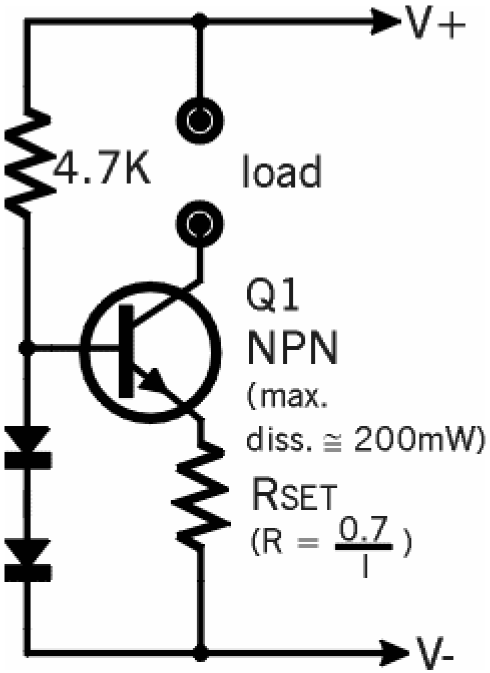




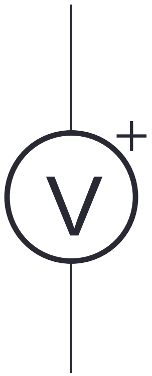


Real current source



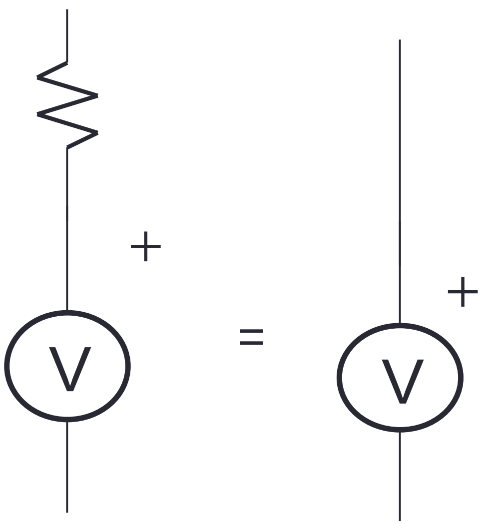


Ideal voltmeter



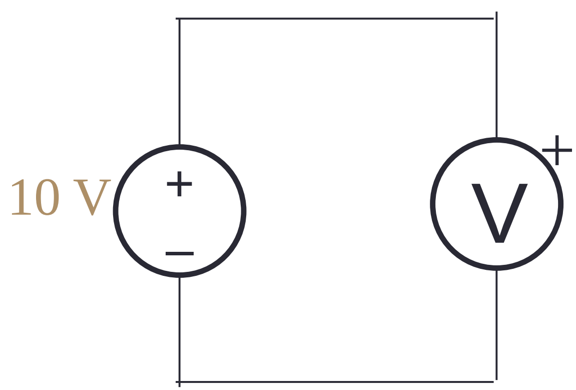
The voltmeter is used to measure vopltage.

The internal conductivity of voltmeter is 0
Polarity is important !

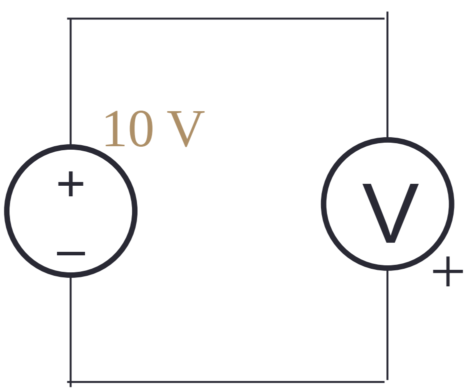


examples

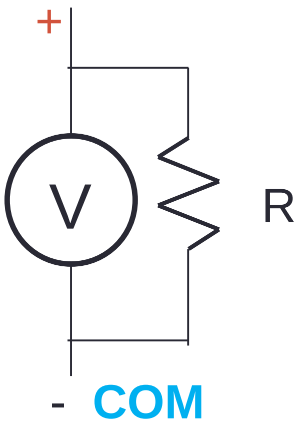
(shows +10 V)



(shows -10 V)



Real voltmeter



The real voltmeters have internal resistance ! The current flows through voltmeter.

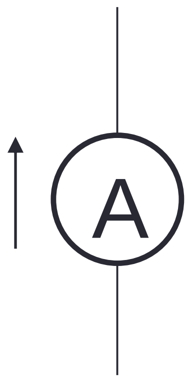
In digital voltmeters R>1MΩ , In analogue voltmeters R is between 10-1000kΩ .

Internal resistance depends on range.

In percisious measurements it must be accepted.

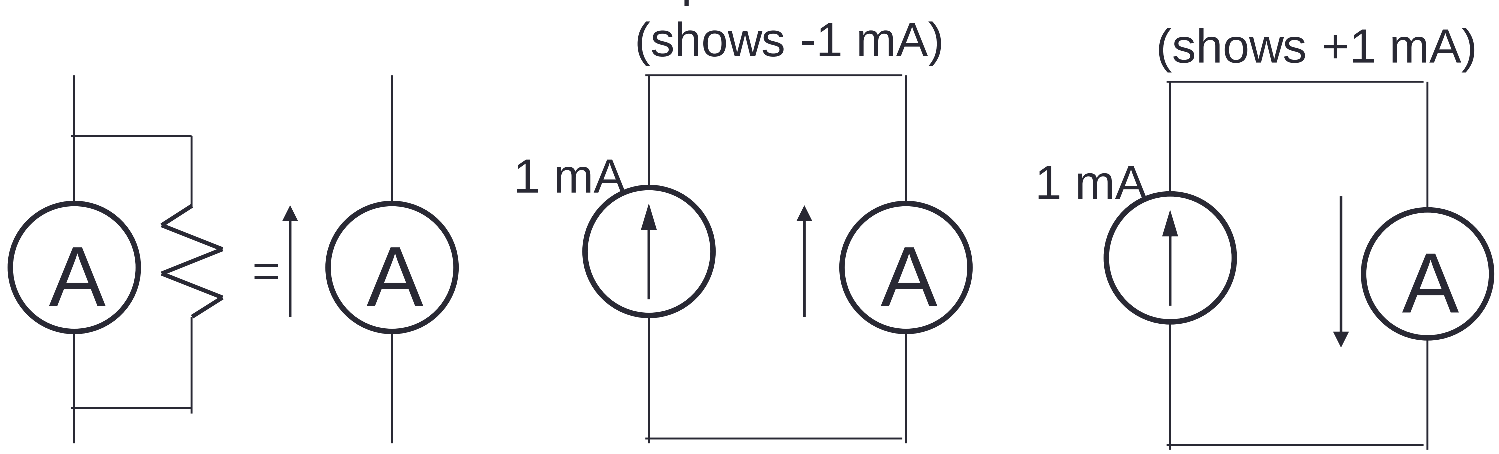
Never try to measure current using voltmeter !!!

Ideal ammeter

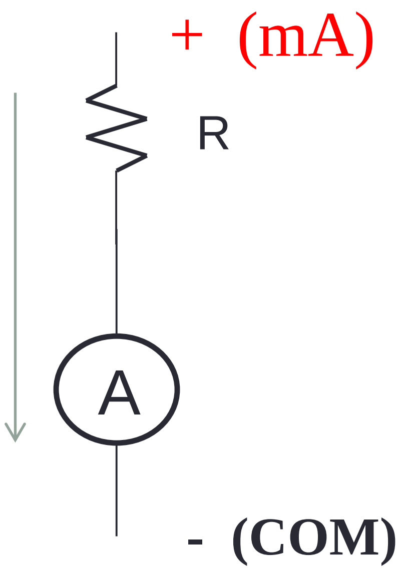


The ammeter is used to measure the current.
The internal resistance of ideal ammeter is 0.
Polarity is important !

Examples



Real ammeter



Real ammeters have internal resistance ! . It depends on range and is between 0.01-100Ω . The internal resistance of digital ammeter can be higher than in analogue one .

Do not measure voltage with ammeter !!!
(**It can be very dangerous**)

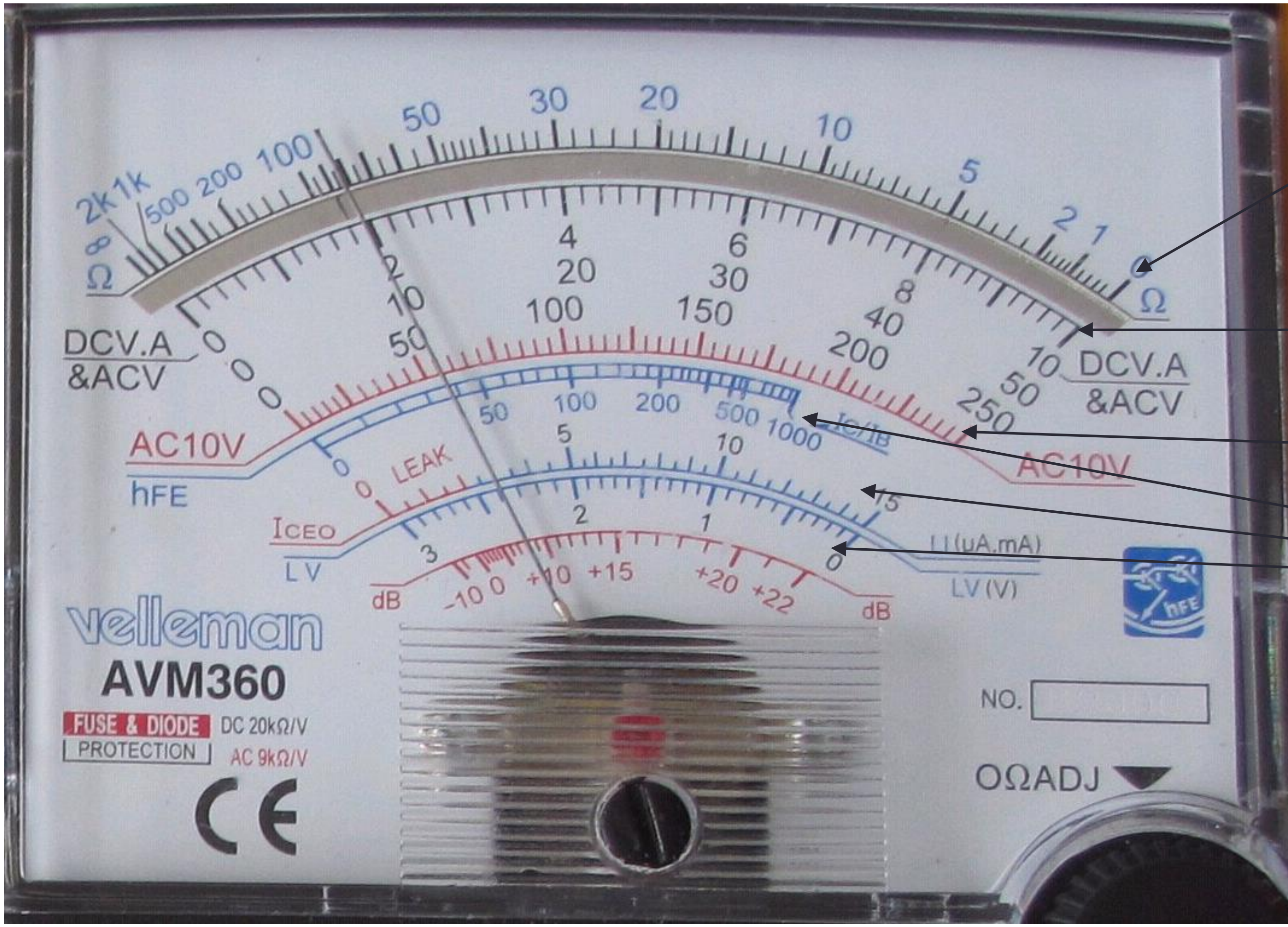
About analogue meters

- Digital meters are more percise and comfortable
- You can follow result instantly and notify changes
- You get faster an estimated result
- The probability to get totally incorrect result is lower.
- The last numbes on digital meters are usually „flashing“
- Are used nowadays in operative and less percise measurements
- If needed, analogue display is simulated on digital screen.
- Usually analogue meters are designed that the optimal value is in the middle of scale (planes).

AVM360

- Expencive than cheaper digital multimeters (mechanial parts)
- Basic electric measurements
- Relative accuracy is 3 % (in most ranges)
- In the HomeLabKit
- Manual range selection.

AVM360



Ohmmeter

Linear scale for Voltages and currents

ONLY 10V AC!!!

For additional Functions.

AVM360 – how to get result

How to get result

$$\text{Result}=\text{range}*\frac{\text{reading}}{\text{max value}}$$

Example

$$\text{Result}=2{,}5\ \text{mA}*\frac{2}{10}=0{,}5\ \text{mA}$$

Reading 2

Maximum 10

(Switch in position 2,5 mA)

M830 (and clones)

- Very cheap
- Suitable for simple measurements
- In HomeLabKit
- Manual range selection

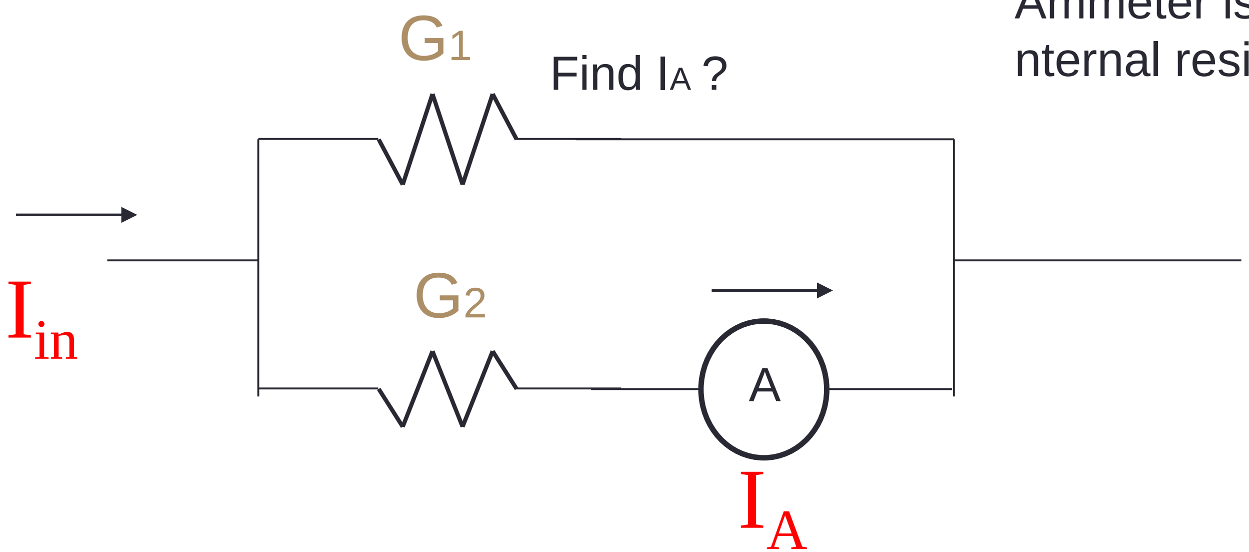
- Result is directly readable on screen.

- Accuracy ± % from reading + n digits
(depends on range – need to use manual)

Current divider

Find I_A ?

Ammeter is ideal. I
nternal resistance is 0.



Current I_{in} flows throw G_1 and G_2 produces voltage (Ohm's Law):

$$V_{G_1}=V_{G_2}=\frac{I_{in}}{G_1+G_2}$$

Currenr , flowing through G2

:

$$I_{G_2}=I_A=V_{G_2}*G_2 .$$

$$I_A=G_2*\frac{I_{in}}{G_1+G_2}$$

Transfer is : $\boxed{K=\frac{I_A}{I_{in}}=\frac{G_2}{G_1+G_2}}$

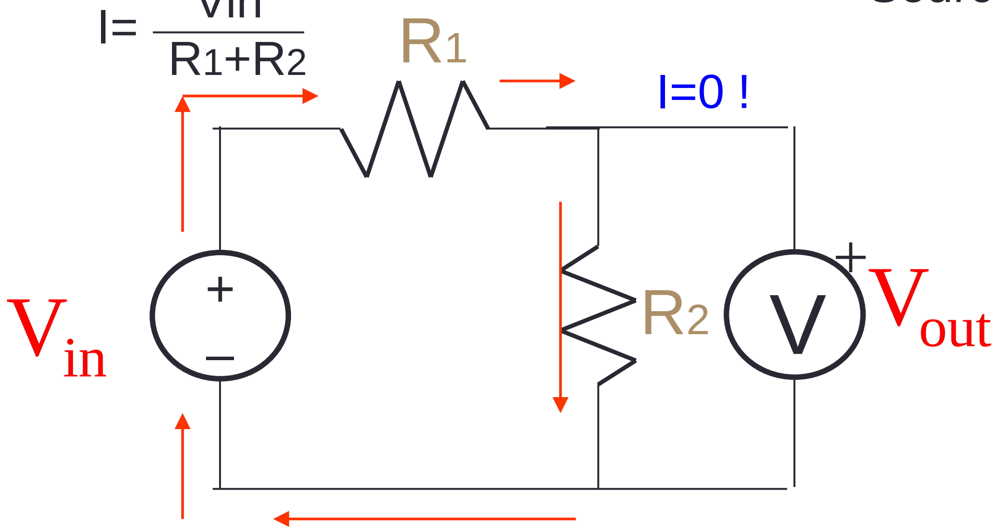
Since G=1/R, : $\boxed{K=\frac{I_A}{I_{in}}=\frac{R_1}{R_1+R_2}}$

Voltage divider

Find V_{out} ?

Source and voltmeter are ideal .

$$I = \frac{V_{in}}{R_1 + R_2}$$



Current flows through both resistors and equals: $I = \dfrac{V_{in}}{R_1 + R_2}$

In resistor R2 we get V_{out} : $V_{R_2} = V_{out} = I * R_2$

$$V_{R_2} = V_{out} = R_2 * \frac{V_{in}}{R_1 + R_2}$$

Transfer ratio: $\boxed{K = \dfrac{V_{out}}{V_{in}} = \dfrac{R_2}{R_1 + R_2}}$