Introduction to Mechatronics MEC100x – Lectures 2

Energy, Power and Intelligent Control

School of Electronics, Electrical Engineering and Computer Science

Ashby Building

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Aims

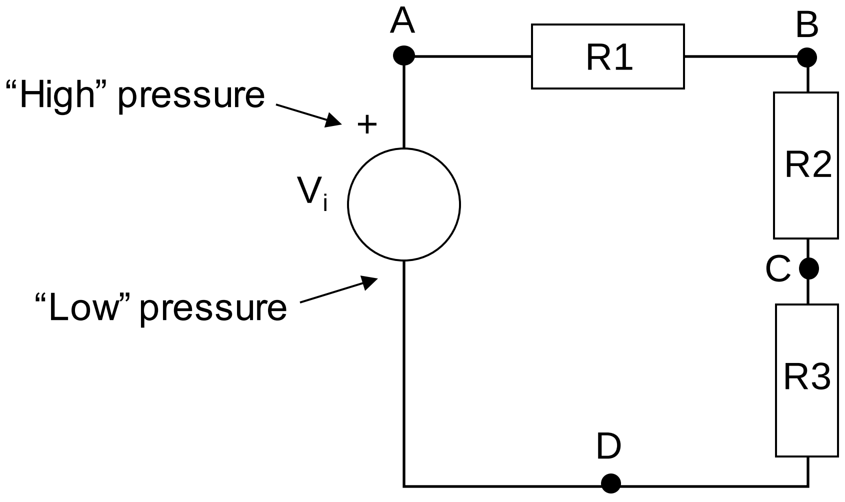
1. Basic electronics Review
2. Voltage- Current- Resistor, Capacitor, Inductor- Impedance- Power
3. Voltage division

Key Concepts

- Voltage
- Ground
- Current
- Resistor
- Capacitor
- Inductor
- Impedance
- Power

Basic Electronics Review - 1

- **Voltage**
  - **"Pressure"**
    - **<u>Pressure</u>** on electric charge (e^-)
    - Units are in Volts
    - Urges charge to 'flow'
    - Measured relative to a reference pressure level
      - An "across" quantity – we measure it <u>across</u> two points (Don't say 'the voltage through…')



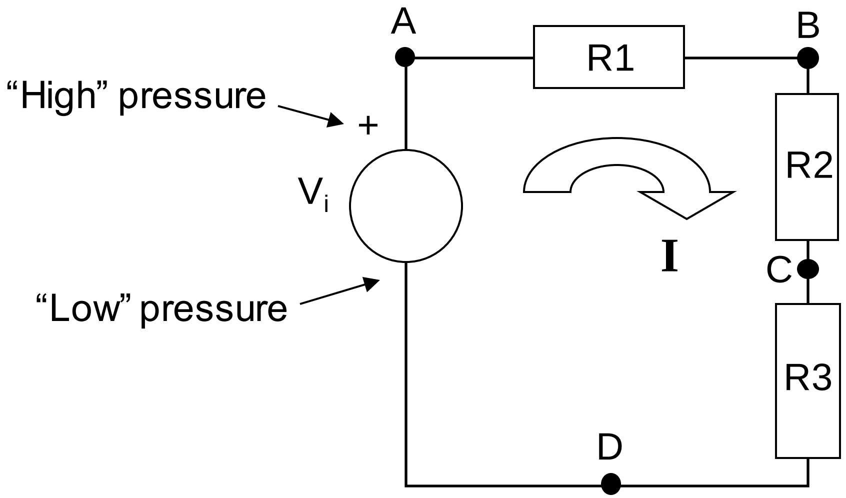
Voltage source acts like a pump

Ground is often taken as the low-pressure point, but any point could be taken as 'ground'

ex. $V_{AD} = V_i = -V_{DA}$

Basic Electronics Review - 2

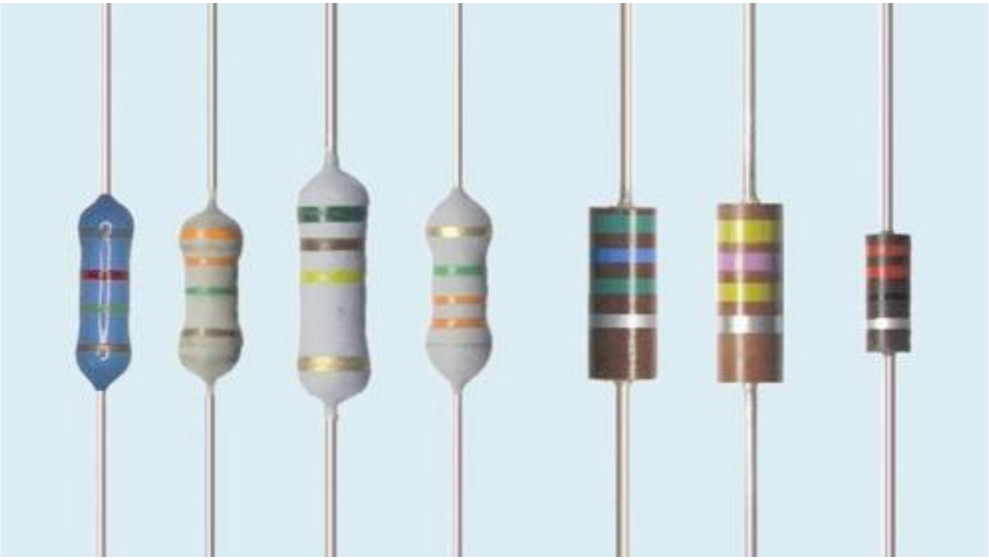
- **Current**
  - **"Flow"**
    - Flow of electric charge (e^-). Units are in Amps
    - The response of charge to applied voltage
    - Need a **complete** circuit for current to flow
      - A "through" quantity – we measure it ***through*** an element



We will assume 'conventional' current flow – positive charges flow out of the + terminal and return to the - terminal

Resistors

Resistors are considered to be **the most used and the most important component** of all the electronic circuits.

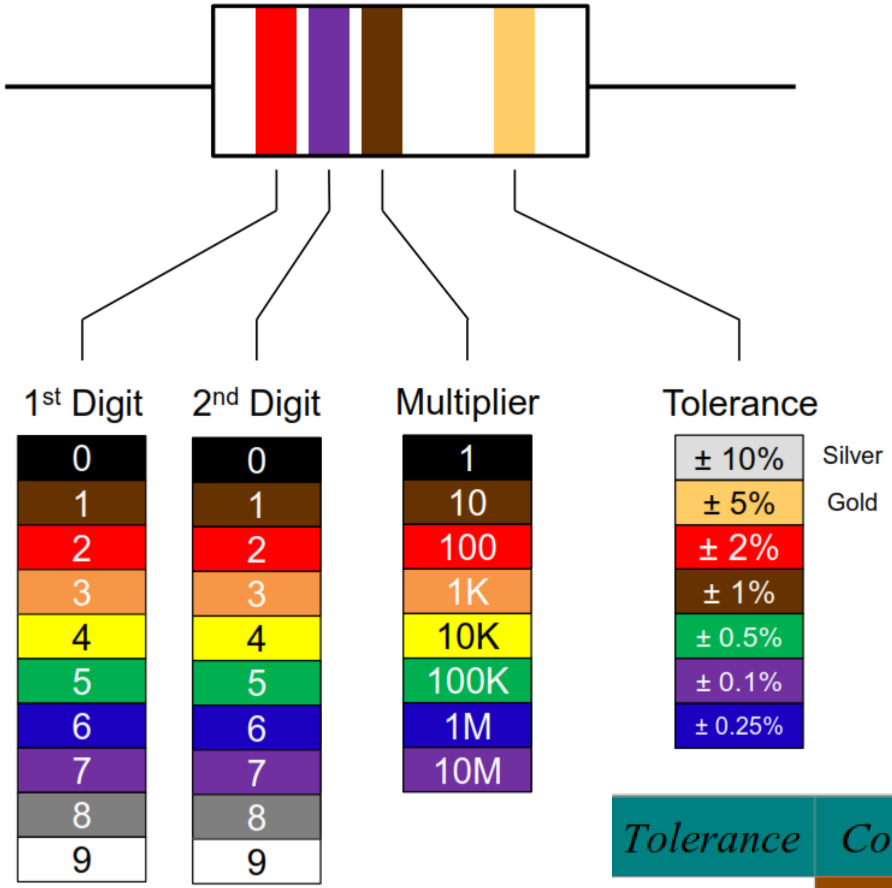


http://www.circuitstoday.com/working-of-resistors

Symbol of Resistor

Color Coding

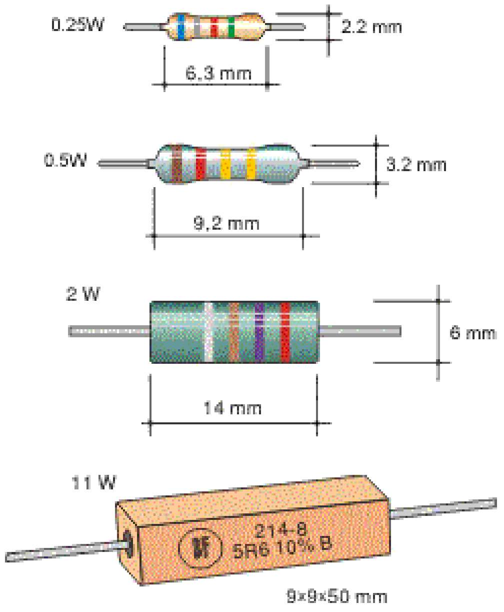
- The **value of the resistance** is found out **by color coding**. The resistors have a band of colors shown in their outer covering. Here are the steps to determine the value of the resistor.



Number	*Color*
0	black
1	brown
2	red
3	orange
4	yellow
5	green
6	blue
7	violet
8	grey
9	white

Tolerance	*Color*
±1%	brown
±2%	red
±5%	gold
±10%	silver

Resistors despite energy as heat

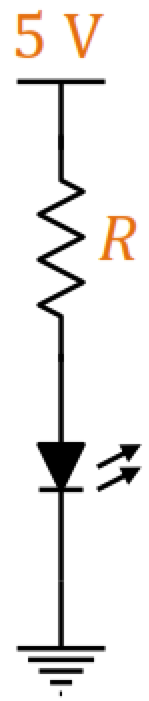


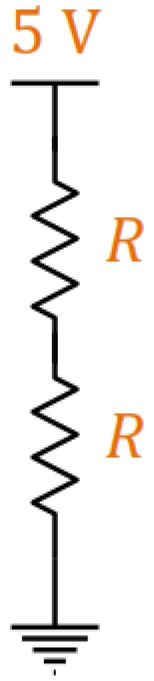
- **Standard power ratings for resistors:**

1/8 W (~3.0 mm long x 1.8 mm dia.)
1/4 W (~6.3 mm long x 2.2 mm dia.)
1/2 W (~9.2 mm long x 3.2 mm dia.)
1 W (~11 mm long x 5 mm dia.)
2 W (~14 mm long x 6 mm dia.)

Why do we need resistors?

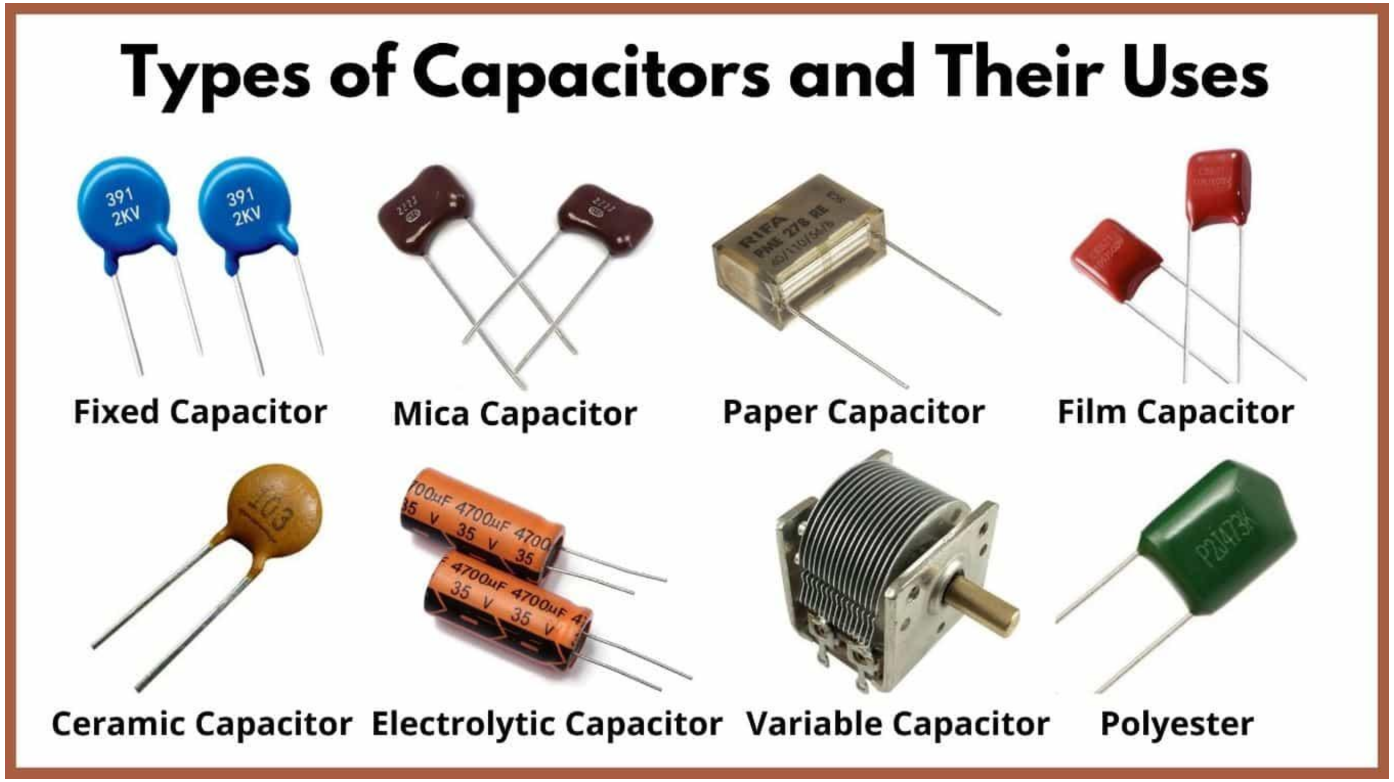
1. Limit current flow
2. Divide voltage





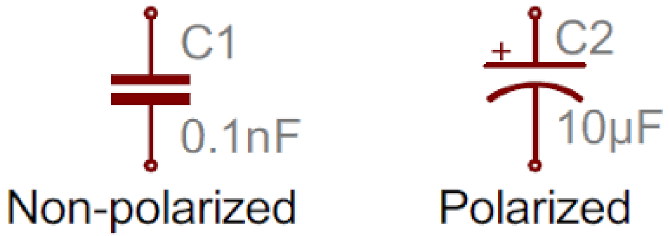
Capacitors

Capacitors store energy as an electric field.



https://www.theengineerspost.com/capacitors-types/

Symbol of capacitor



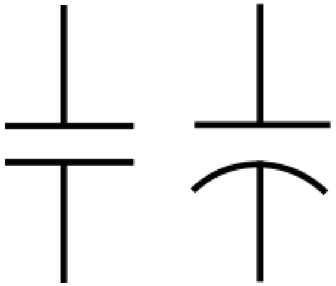
https://learn.sparkfun.com/tutorials/how-to-read-a-schematic/schematic-symbols-part-1

Unit of Capacitance

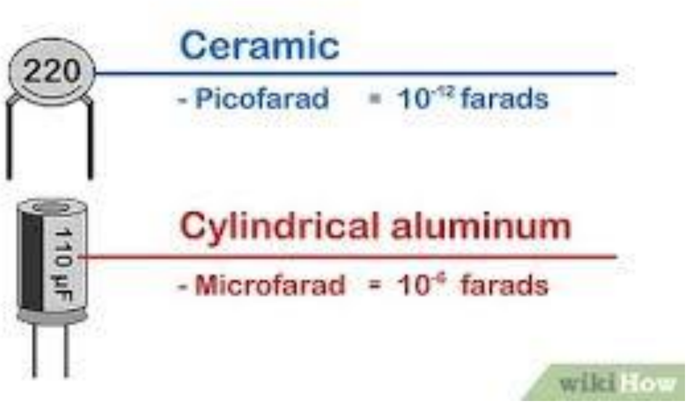
$$1\ F = 10^3\ mF$$
$$= 10^6\ \mu F$$
$$= 10^9\ nF$$
$$= 10^{12}\ pF$$

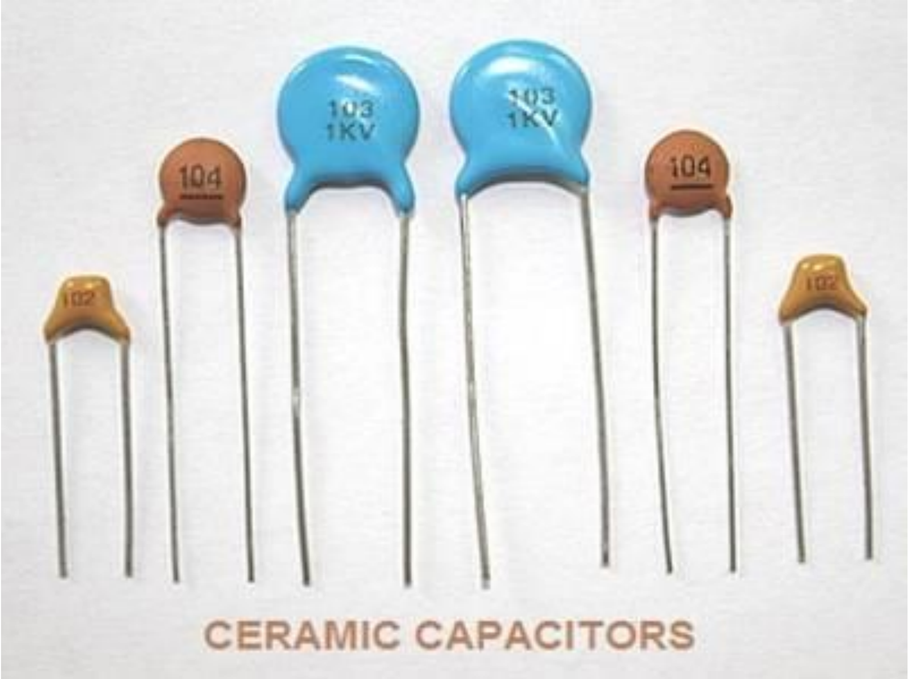
- **Capacitance is normally given in uF or PF.**

Non-Polarized



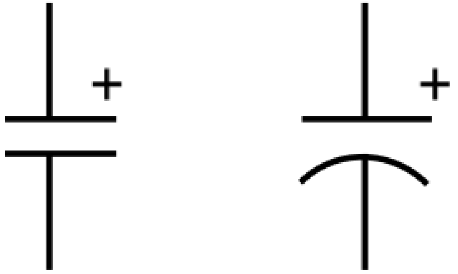
- Ceramic (1 pF- 10 uF) and Film (10 pF- 100uF).
- Low- leakage current ; long life
- Can be temperature sensitive
- Useful at high frequencies



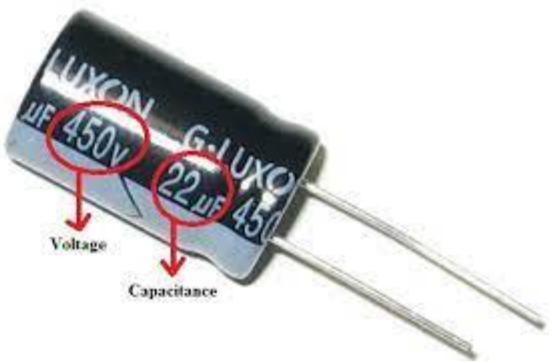


https://www.linquip.com/blog/what-is-ceramic-capacitor-2/

Polarized Capacitors



- ❑ Aluminium and Tantalum Electrolytic
- ❑ Typically 1 uF- 0.1 F
- ❑ No AC without DC Bias(May burst)
- ❑ High- leakage current ; short life
- ➢ Large capacitors can hold a significant charge for a long time.



https://en.wikipedia.org/wiki/Electrolytic_capacitor

SMART EDU 4.0

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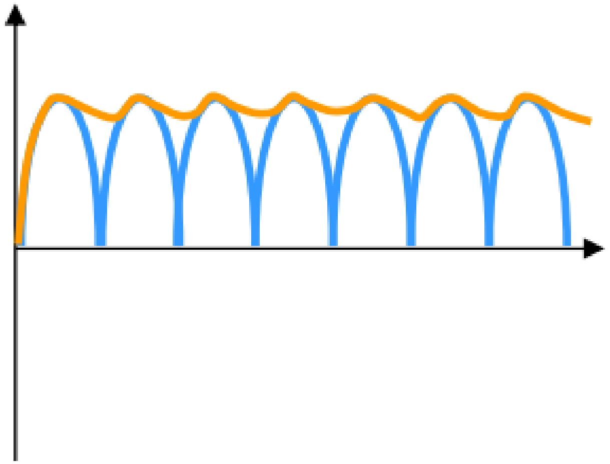
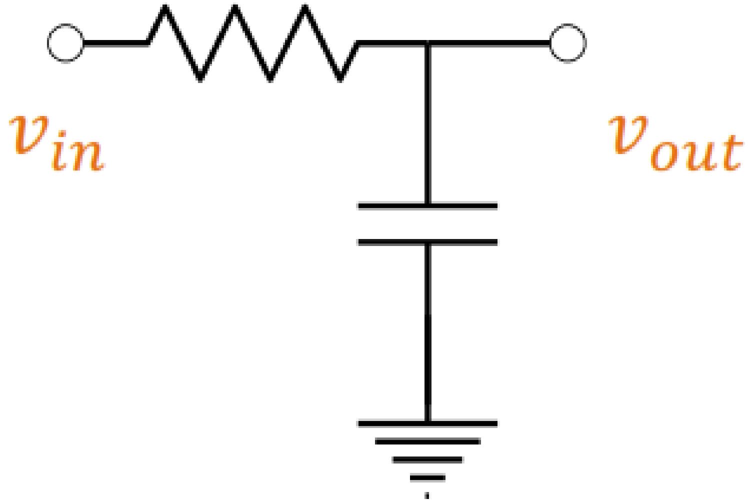
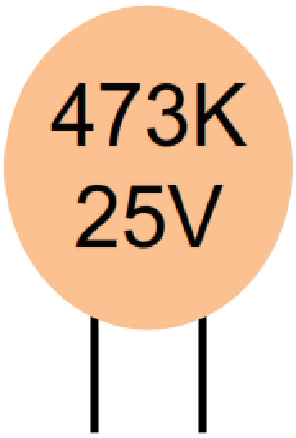
Why do we need capacitors?

- Energy storage
- Signal coupling/ decoupling
- Noise filters
- Power conditioning





Capacitors



Letter Code	Tolerance Value
B	±0.1 pF
C	±0.25 pF
D	±0.5 pF
F	±1 %
G	±2 %
J	±5 %
K	±10 %
M	±20 %
Z	+ 80 %, - 20%

https://electricalfundablog.com/decode-capacitor-number-marking/

- ❑ Capacitance values for smaller capacitors are usually given in picofarad (pF).
- ❑ If there are two numbers, read value in pF.
- ❑ If there are three numbers, use first two to establish a value in pF, then multiply by 10^x.

x is third number.

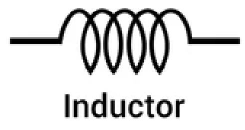
❖ Letter code normally indicates capacitor tolerance, as in the provided table.

Inductors

Inductors store energy as an magnetic field.

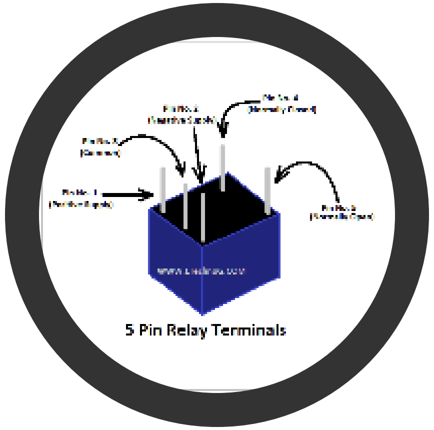
https://www.coilws.com/index.php?main_page=index&cPath=208_212

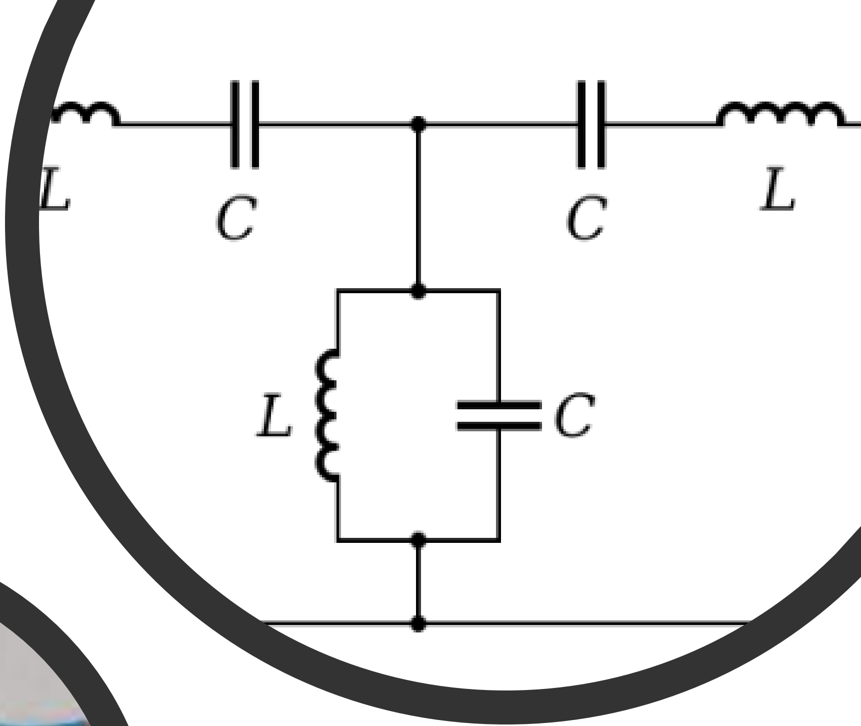
Symbol of inductor



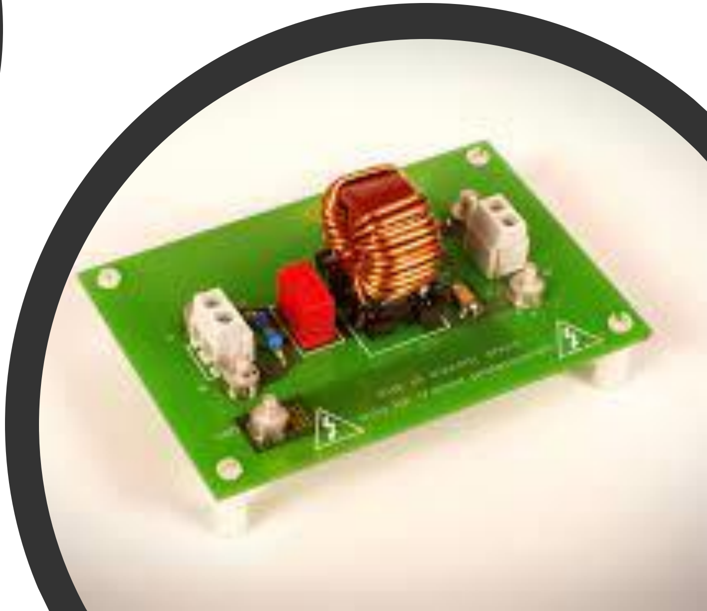
Inductance normally given in mH.

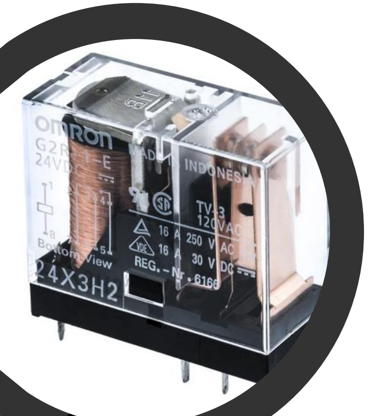
Why do we need inductors?



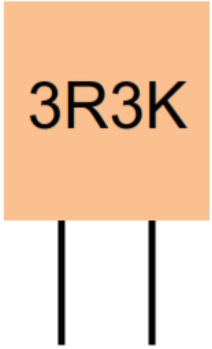


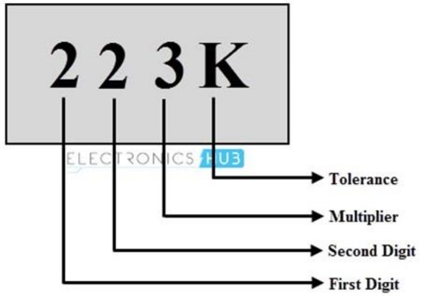
- **Actuators (Motors, electromagnets, mechanical switches,…)**
- **Analog filters**
- **''Chock'' off input ripple.**





Inductors



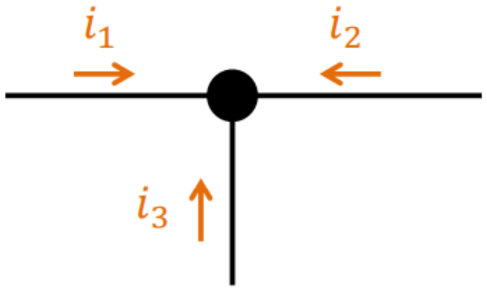


Letter Code	Tolerance
F	1%
G	2%
H	3%
J	5%
K	10%
M	20%
Z	+80%, -20%

- inductor values for smaller inductors are usually given in Micro-Henries (uH).
- If there are two numbers, read value in uF.
- If there are three numbers, use first two to establish a value in uH, then multiply by 10^x.
- x is third number.
- Letter code normally indicates inductor tolerance, as in the provided table.

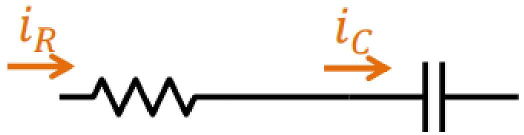
KRICHHOFF'S Current LAW (KCL)

- $\sum_{k=1}^{n} I_k = 0$ at any node



$i_1 + i_2 + i_3 = 0$

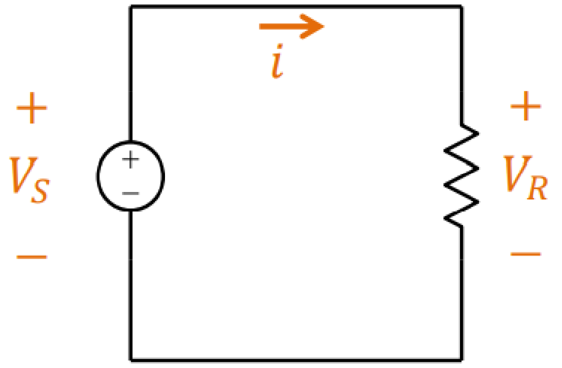
- ❑ Elements in series experience the same current



$i_R = i_C$

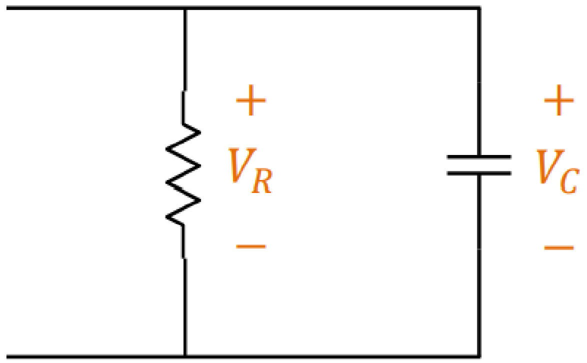
KRICHHOFF'S Voltage LAW (KVL)

$\sum_{k=1}^{n} V_k$ = 0 around any closed circuit



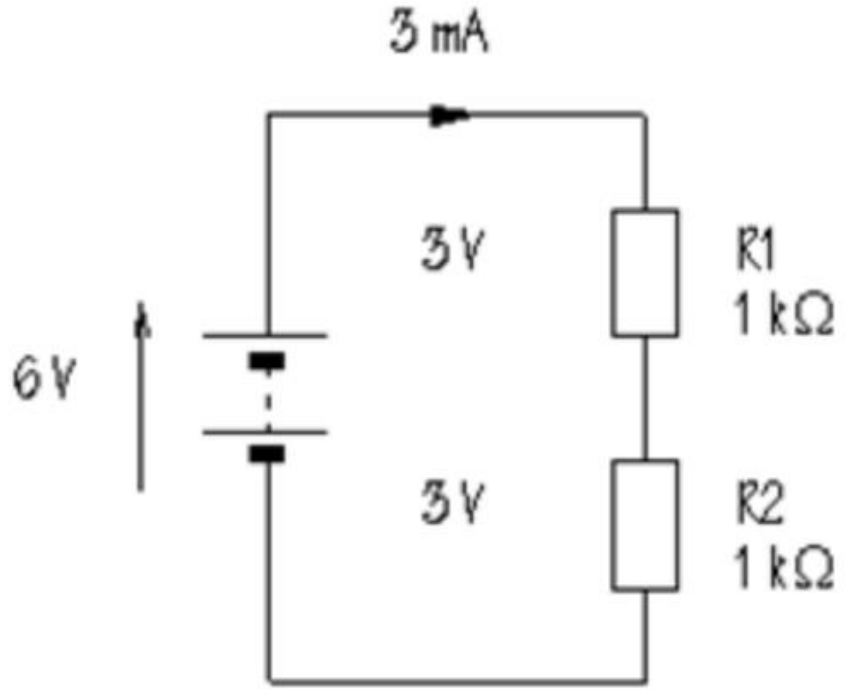
$$-V_S + V_R = 0$$

- Elements in parallel circuit experience the same voltage drop



$$V_R = V_C$$

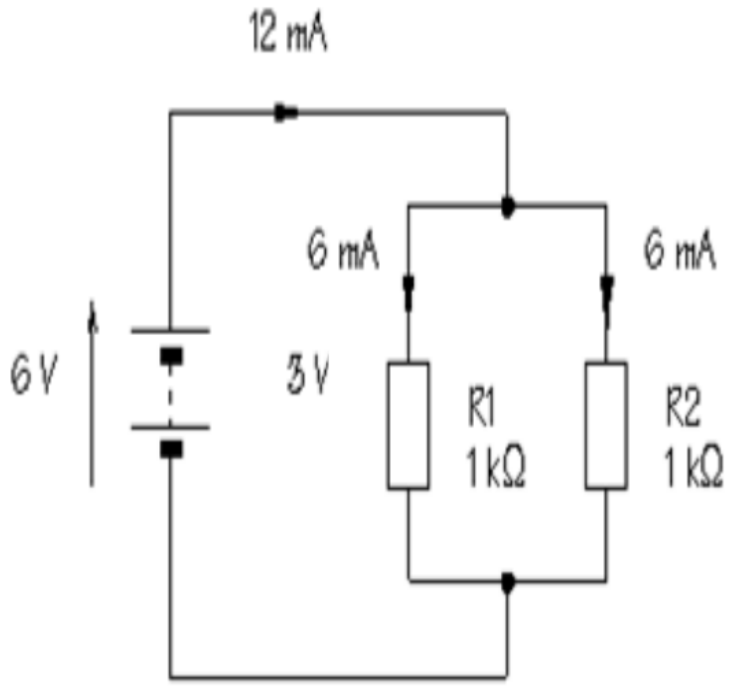
Resistors in Series



$$R_{total}=R_1+R_2$$

$$R_{total}=1+1=2k\Omega$$

Resistors in Parallel

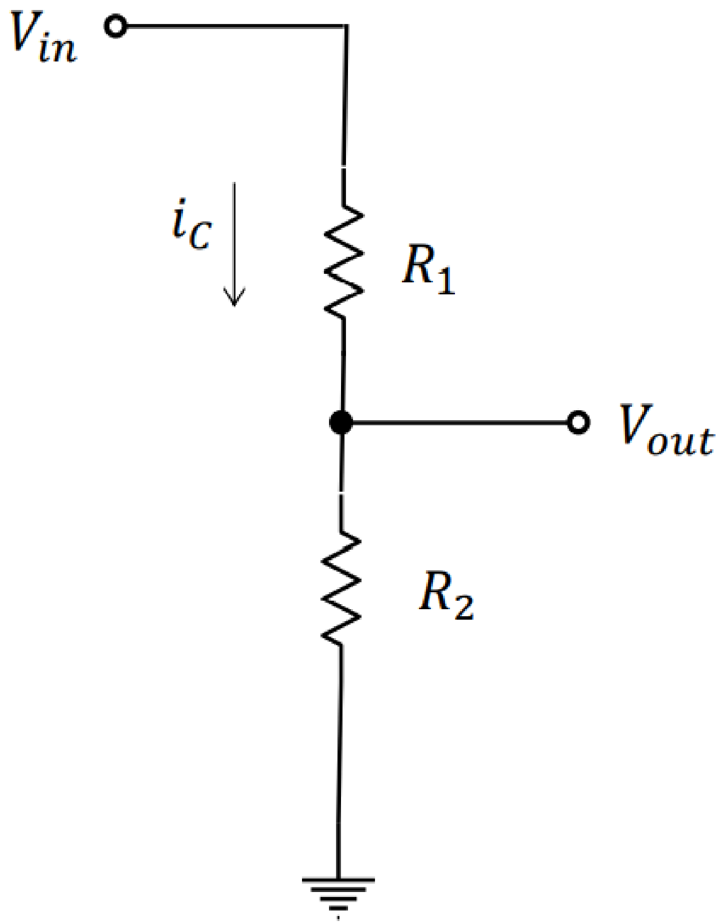


$$R_{total} = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_{total} = \frac{1 \times 1}{1+1} = \frac{1}{2} = 0.5k\Omega$$

Circuit Analysis

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



Thank You For Your Attention!

Any Question?