Exp1 :- Resistors and DC circuits.

(*) Resistors :

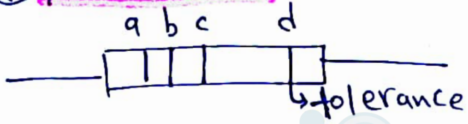
Symbol R 

→ the value of a Resistor can be known :

1. from the Color Code on the Resistor
2. By mesuring the value of it using an ohmmeter.

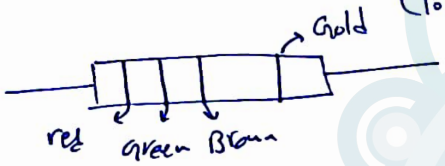
Black → 0	Blue → 6
Brown → 1	Violet → 7
red → 2	gray → 8
orange → 3	white → 9
Yellow → 4	Tolerance:
Green → 5	Gold → 5%
	selvir → 10%

Ex: (A) 4-color Codes



$$R = ab \times 10^{c} \pm d$$

$$\left(\frac{d}{100}\right) \times (ab \times 10^{c})$$

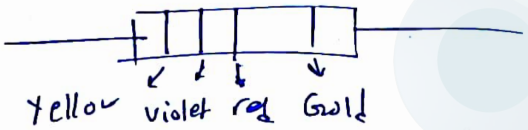
① 

$R = 250 \pm 5\%$ Ω → $\left(\frac{5}{100}\right) \times 250 = 12.5$

$250 + 12.5$, $250 - 12.5$

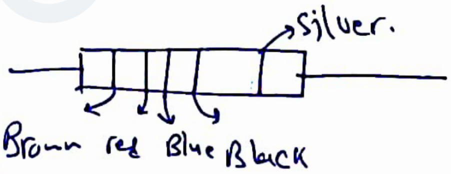
237.5

when reading the Resistor let the tolerance to the right and the other colors to the left. (start reading from the left to the right)

② 

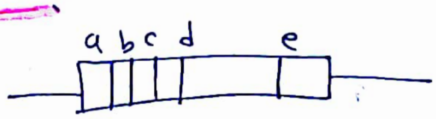
$R = 4700 \pm 0.05$ Ω.

Ex:



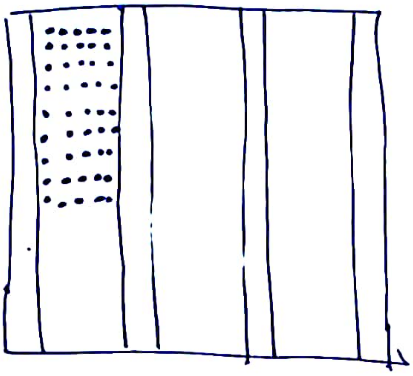
$R = 126 \pm 0.1$ Ω

(B) 5-Color Codes.



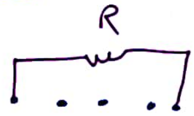
$$R = abc \times 10^{d} \pm e$$

Bread Board:

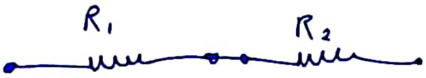


each 5 series dots represents a node

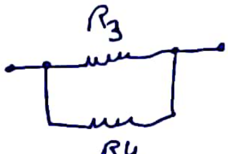
*if the resistor is connected on the same node, it creats a short circuit.

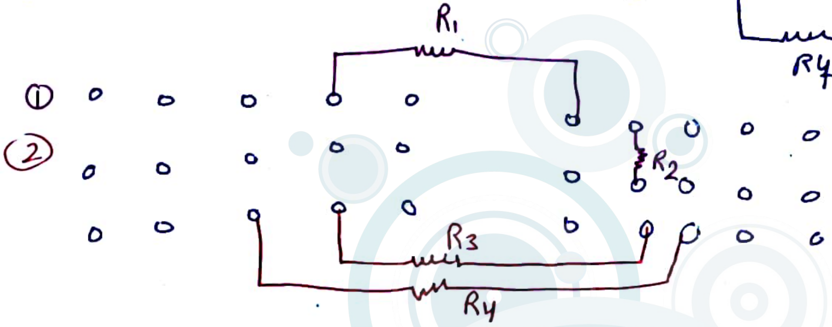


Ex: ①



②

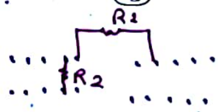




① R1: one end is connected on node ① and the other end at node ②

R2: is connected where R1 ended (at node ②) and the other end is on node ③

(*) node ③ can be the vertical node or the horizontal



Both are correct.

② R3, R4 start at the same node and ends at the same node.

(*) DC Supply

⇒ when measuring the resistance (Ω)
remove all supplies in the circuit
لازم اقيس المقاومة لحالها بشيلها من الدارة بكون بقيس
ال thevinin R

→ Power device: DC Power supply

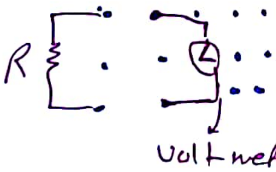
it provides a steady direct current (DC) voltage to power electronic circuits.

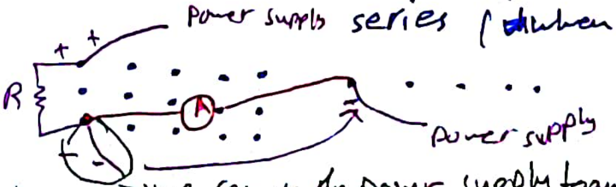
→ Mesuring devices:

- digital multimeter : Mesures : diaod, ohom, volt, capacitor, current

  ↳ digital multimeter is always connected parallel (when volt meter)

  series (when Ameter.)





→ we remove the power supply to another node ②

then connect the resistor with it using the (A)

EP2: Resistors and DC circuits.

Ex: Find the color code for each resistor (4 Band resistors)

$R = ab \times 10^{c} \pm d$

[1] $R = 1600\ \Omega$ — Brown, Blue, red

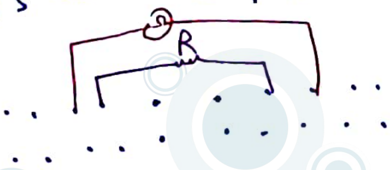
[2] $R = 1200\ \Omega$ — Brown, red, red

[3] $R = 10000\ \Omega$ — Brown, Black, orange.

ohmmeter.

→ using the digital multimeter as (ohmmeter) to find the resistance.

(the ohmmeter is connected parallel with the resistors).



connecting Resistors in parallel and series and finding the resistance.

⇒ series:

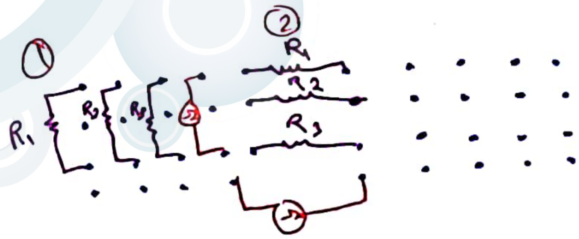
$\Sigma R = R_{series} = R_1 + R_2 + R_3$

the ohmmeter is connected in parallel with the circuit.

(positive wire on the Beginning of it and the negative wire on the end of it)

⇒ Parallel:

$$\Sigma R_{parallel} = \frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_2}$$



voltage and current division.

⇒ voltage division

* in series: the total voltage is divided among the Resistors

$V_{tot} = V_1 + V_2 + V_3 + \dots + V_n$

⇒ if you have n resistors $R_1, R_2, \dots, R_n$ in series with a total voltage V_{tot}, the voltage across resistor R_i is:

$$\boxed{V_i = \frac{R_i}{R_{total}} \times V_{tot}}$$

⊛ in parallel : the voltage across all Resistors is the same.

$$\boxed{V_{parallel} = V_{tot}}$$

⇒ this is because all the Branches in a parallel circuit share the same two nodes.

⇒ Current division.

⊛ in seires : the current is the same through all components because there is only one path for the current to flow.

$$\boxed{I_{series} = I_{total}}$$

⇒ this means the current does not divide, it remains constant throughout the circuit...

⊛ in parallel : the current divides between the branches in inverse proportion to their resistances. (Branches with lower resistance will carry more current, while those with higher resistance will carry less)

⇒ For two resistors R_1, R_2 connected in parallel, and total current I_{tot}:

$$\boxed{I_1 = \frac{R_2}{R_1+R_2} \times I_{tot}} \quad , \quad \boxed{I_2 = \frac{R_1}{R_1+R_2}}$$

⇒ For n resistors $R_1, R_2, \ldots R_n$ the current through any branch i is:

$$\boxed{I_i = \frac{R_{eq}}{R_i} \times I_{tot}} \qquad R_{eq} \rightarrow \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

Capacitors and inductors

Capacitor

$\boxed{I = 0}$

$$\boxed{C = \frac{Q}{V}}$$

C: Capacitance (farad)
Q: charge (in coulombs)
V: voltage (in volts)

- A capacitor blocks direct current (DC) once it is fully charged.
- initially, current flows as the capacitor charges.
- over time, the current decreases and eventually stops when the capacitor is fully charged.
- The branch behaves like an open circuit after charging.

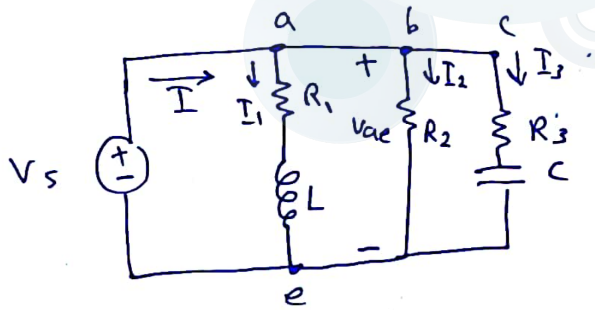
inductor

- The branch behaves like an short circuit, allowing the DC current to flow freely.

$$\boxed{L = \tau R}$$

L: inductance (in Henries)
τ: time constant (in sec)
R: Resistance in series with the inductor (in ohm)

⇒ the current might decrease just a little due to the inner resistance of the inductor



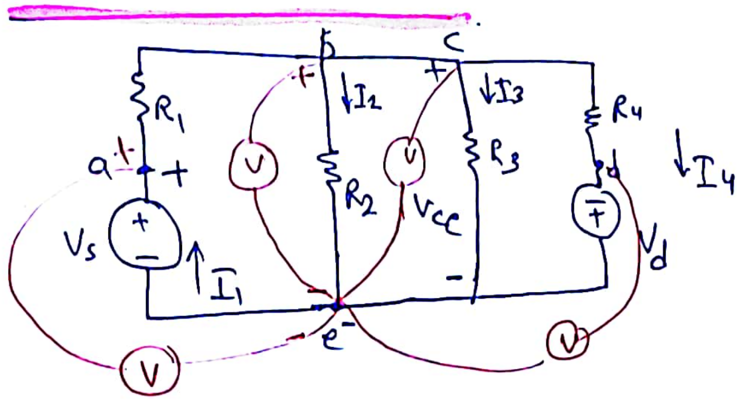
$I_3 = 0$

I_1 → stays the same value

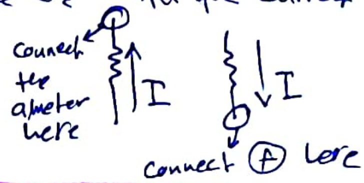
when finding the current in any Branch just connect the Ameter in parallel from the end where the I is flowing

Connect from here

Nodal and mesh analysis



Note: when connecting an (A) always connect it from the end with the current flow



Nodal Analysis

Steps for nodal:

1- identify all nodes in the circuit

2- choose a reference node

3- for each node apply Kirchhoff's current law (KCL)

$$\sum I_{in} = \sum I_{out}$$

4- express the currents in terms of node voltages using ohm's law $\boxed{I = \frac{V}{R}}$

5- solve the system of equations for the unknown node voltages.

Mesh analysis

1- Identify all meshs in the circuit (a mesh is a loop that does not contain any other loops inside it)

3-meshes.

2- define a mesh current for each mesh (generally, clockwise or counterclockwise

3- For each mesh, apply kirchhoff's voltage law (KVL).

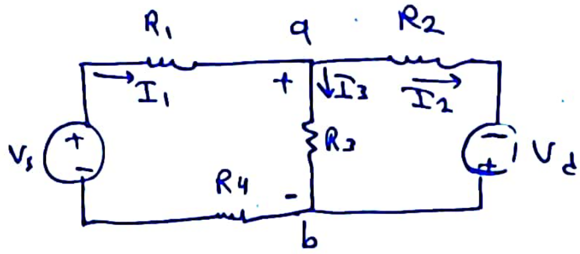
$$\boxed{\sum V = 0}$$

4- express each voltage in terms of the mesh currents using ohm's law $\boxed{V = IR}$

5- solve the system of equations for the unknown mesh currents.

EXP 3: Network theorem

* Super position theorem



Steps for applying superposition:

1- identify all independent sources in the circuit. These can be voltage source or current source

2- turn off all but one independent source:

- For voltage source: Replace it with a short circuit (a wire).
- for current source: Replace it with an open circuit (a break in the circuit)

3- Solve the circuit with the remaining active source using any of the usual circuit analysis methods (e.g: Ohm's law, Kirchhoff's laws, mesh or nodal analysis)

4- Repeat steps 2 and 3 for each independent source in the circuit.

5- Sum the individual contributions from each active source to find the total voltage or current at each point in the circuit.

* Thevenin and Norton.

=> thevenin: states that any linear two terminal circuit can be replaced with an equivalent circuit consisting of:

1- a single voltage source V_{th} 2- in series with a single resistor R_{th}

steps to find thevenin equivalent:

1- remove the load resistor (if present)

2- find V_{th}: Determine the open-circuit voltage across the terminals (where the load resistor was connected).

3- find R_{th}: • Turn off any sources (replace voltage source with short circuits and current sources with open circuits) • find the equivalent resistance seen across the terminals.

4- Replace the original circuit with the Thevenin equivalent circuit.

⇒ **Norton**: States that any linear 2-terminal circuit can be replaced with an equivalent circuit consisting of:

1- A single current source I_N 2- in parallel with a single resistor R_N

Steps to find Norton equivalent:

1- Remove the load resistor (if present)

2- Find I_N : Determine the short circuit current across the terminals

3- Find R_N : • R_N is the same as R_{th} in thevenin's equivalent circuit.

• Turn off all ~~indep~~ independent sources and find the equivalent resistance seen across the terminals.

4- Replace the original circuit with the Norton equivalent circuit.

* $\boxed{R_{th} = R_N}$
* $\boxed{I_N = \frac{V_{th}}{R_{th}}}$
* $\boxed{V_{th} = I_N R_N}$

* V_{th} can be found by using any circuit analysis (ohm's law, voltage Division, Nodal Analysis, mesh Analysis)

$V_{th} = V_{ab}$

↳ the potential difference between 2 terminals (a, b)

Imp Note:

- use open-circuit voltage to find V_{th}.
- for R_{th}:
  - combine resistors based on their series or parallel configuration after deactivating sources.
  - if the Resistor is on an open circuit branch take it.

(*) Maximum Power Transfer theorem

A load resistor (R_L) will receive the maximum power from a circuit when its resistance is equal to the Thevenin resistance (R_{th}) of the circuit as seen from the loads terminals. $R_L = R_{th}$.

Key points:

1- The source circuit must first be simplified to its Thevenin equivalent, wich consists of:
- Thevenin voltage (V_{th})
- " Resistance (R_{th})

2- once R_{th} is known, the load resistance (R_L) should be set to match R_{th} for max power transfer.

(*) $$\boxed{P_{max} = \frac{V_{th}^2}{4R_{th}}}$$

For exp4:

(*) lead / lag

Exp 4: Sinusoidal signals. AC

Function Generator Device

Key features:

- wave form Types: Sine wave, Square wave, triangular wave, Sawtooth wave
- Frequency Range: Adjustable from a few Hz to several MHZ
- Amplitude control: Allows adjustment to the output signal's voltage.

oscilloscope Device

Key features:

- Axes: Y-axis → voltage / X-axis → time.
- Triggering: Allows stable display of repetitive wave form.
- Probes: used to connect the oscilloscope to the circuit.
- Measurements: voltage, frequency, phase, rise time.

measures took from a sinusoidal signal.

1- Vpeak: - Count the number of vertical divisions of the signal to the highest point
- Find the vertical scale (2V/div)
- Multiply # of div. by the # of squares.

$$\boxed{V_p = \#\text{ of squares} \times \text{Volt/div.}}$$

* Time / div
  Horizontal

* Volt / div
  vertical

2- $\boxed{V_{pp} = 2V_p}$

3- $\boxed{V_{RMS} = \frac{V_p}{\sqrt{2}}}$ or $V_{RMS} = \frac{V_{pp}}{2\sqrt{2}}$

4- frequency $\boxed{f = \frac{1}{T}}$ T → period

5- period $\boxed{T = \#\text{ of Horizontal squares} \times \text{time/div.}}$

6- phase shift $\emptyset$ or $\boxed{\phi = \frac{\Delta t}{T} \times 360}$

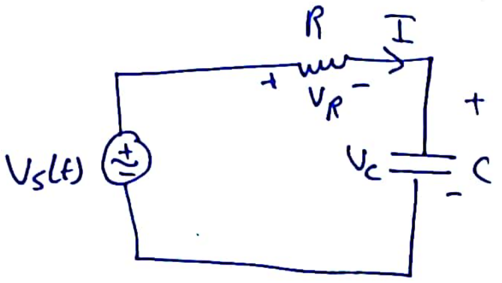
Δt = time difference between the two signals.

7- Amplitude (A) $\boxed{A = V_p}$

Exp 5: Capacitive reactance

A) RC circuit: (phasor diagram)

+ in series: Resistor in series with capacitor

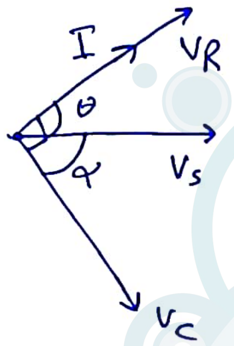


* always assume that the supply is the reference.

$\Rightarrow \phi_{v_s} = \text{Zero}$

* the current passes in the circuit befor the V_c is on the capacitor

I leads V_c with $\measuredangle = 90°$

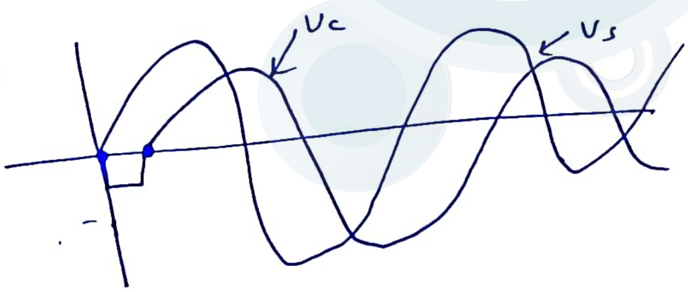


* on a resistor the current passing through the resistor is in phase with the V on the resistor

I, V_R in phase

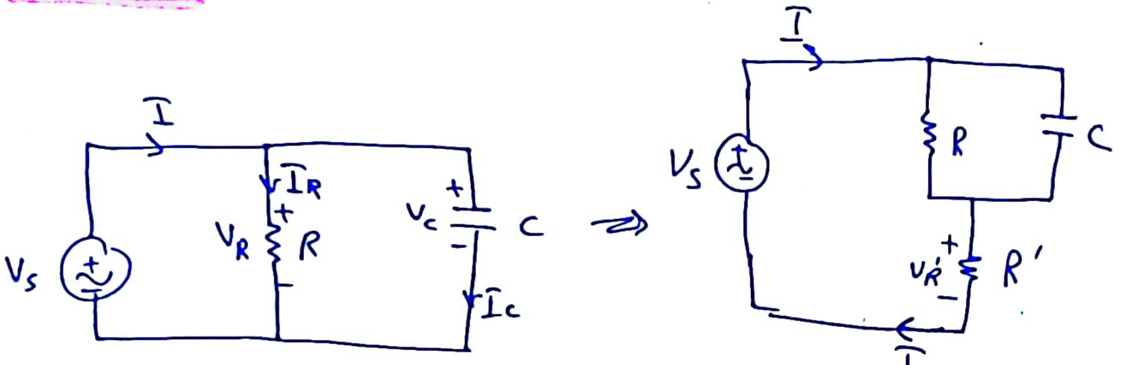
* The current and voltage at the capacitor I leads V_c $\measuredangle = 90°$ because the current goes through the capacitor first to charge it then voltage accurs.

$\Rightarrow$ therefore



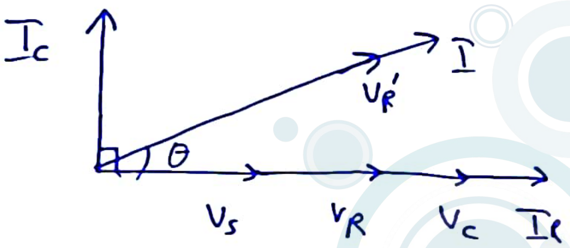
V_s leads V_c

In parallel

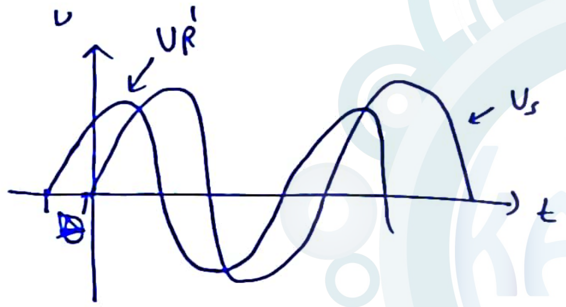


→ the total current pass through R'

* $V_s = V_R = V_c$ because connected in parallel



* I_R, V_R in phase
* I_c, V_c I_c leads V_c $\phi = 90°$
* $I = I_c + I_R$
  ↓
  Resultant of I_c and I_R



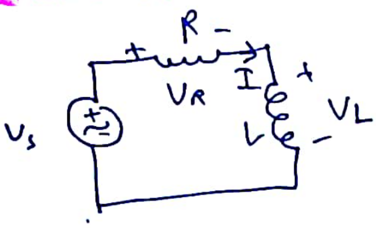
* I, V_R' in phase $\phi = 0$

⇒ V_R' lead V_s

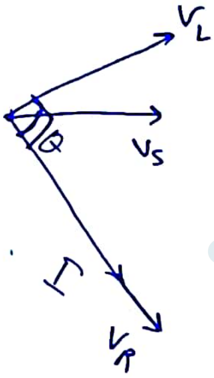
Exp6: Inductive reactance

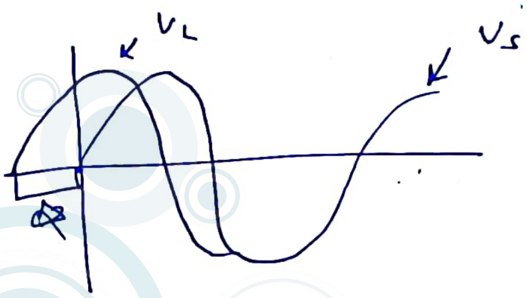
* phasor diagram

* in series.



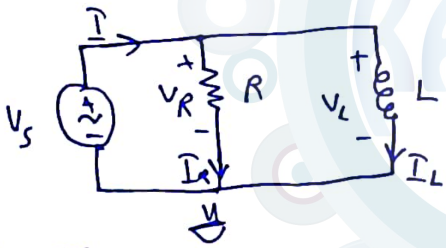
- I lag V_s $\measuredangle = \theta$
- I, V_R in phase $\measuredangle = 0$
- I, V_L V_L leads I $\measuredangle = 90^\circ$



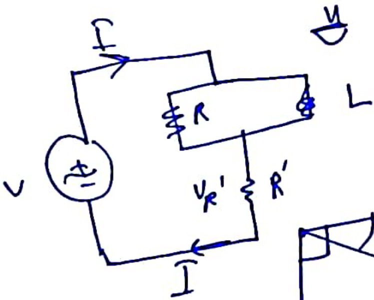


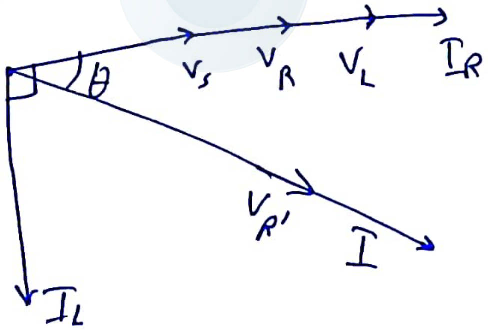
V_L leads V_s

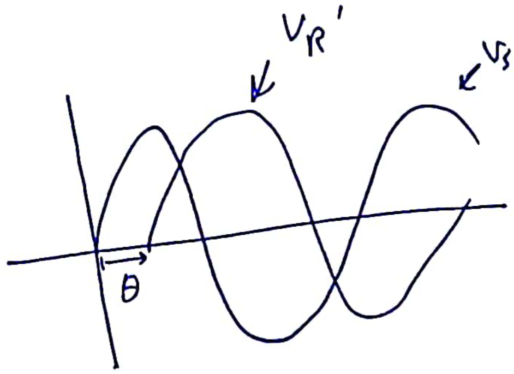
* in parallel



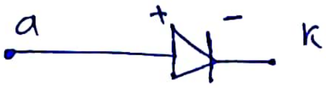
- $V_s = V_R = V_L$ → in phase
- I_R, V_R in phase
- I_L, V_L I_L lag V_L $\measuredangle = 90^\circ$
- $I = I_L + I_R$ → $\measuredangle = \theta$







Exp 7: DioDe characteristics.



a: ANode , K: Kathod

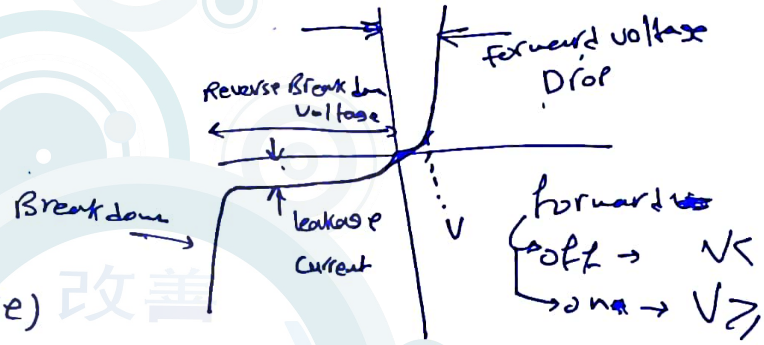
* the Diode starts working at specific V

Germanium → V ≈ 0.3V
Silicon → V = 0.7V
} → if it didn't reach or exeed the V, then it's an open circuit

* if the diode was connected in opposit direction I=0, Reverse Breakdown Voltage called the off ~~region~~ region.

3 regions:

1- Forward region
2- off region (Reverse)
3- Break down



diode is connected parallel with digital multimeter.

Exp 8: Diode applications