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Ministry of Higher Education and Scientific Research

Mohamed Khider University of Biskra

Faculty of Sciences Exact

Department of Computer Science

1st year engineer

Module: Fundamental electronic

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Introduction

This pedagogical publication of the course "Fundamental electronics" is in accordance with the curriculum taught and it intended for 1st year engineer computer science students.

The objective of this educational document is studying the functioning of electronic components such as diodes, bipolar transistors and field-effect transistors as well as their applications.

Evaluation

The evaluation of the subject «Fundamental electronics» is calculated on final exam (100%) based on lectures only, and does not contain any continuous assessment or additional projects. A student's performance is evaluated based on their attendance and understanding of the content displayed during lectures. The subject belongs to the discovered teaching unit, its number of credits is 3 and the coefficient is 1.

Chapter 1: The basic concepts of electricity

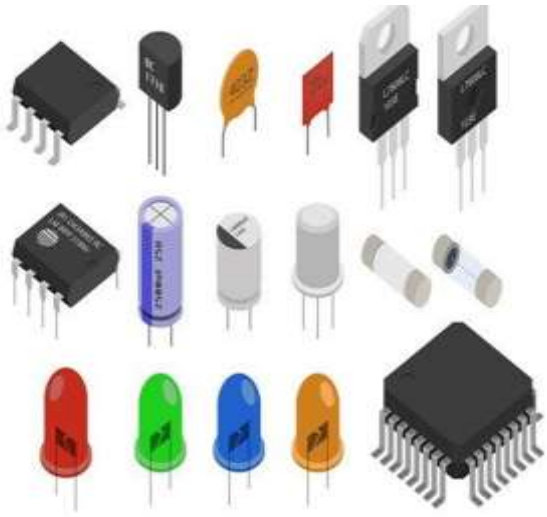
What is electronics?

Electronics: it is a technical or engineering science that studies and designs structures that process electrical signals, electrical currents or voltages, carrying information or energy.



Examples of electronic components:

- Resistances
- Capacitors
- Inductances
- Diodes
- Transistors



- Basic electronic components can be divided into two main families:

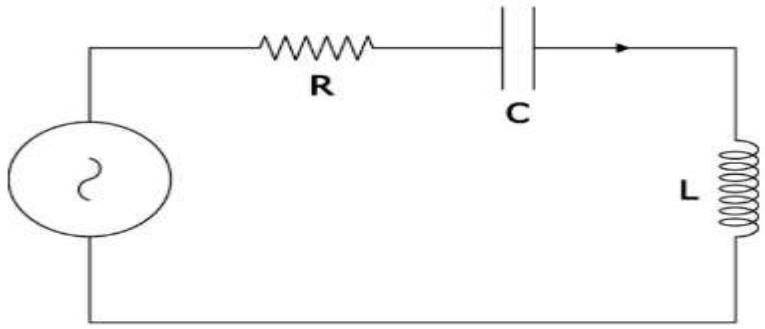
1) **The Passive components**: Components that do not increase the power of an electrical signal. This classification includes:

- Capacitors
- Resistors
- Inductors

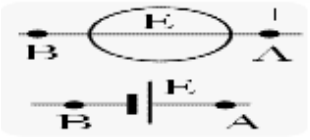
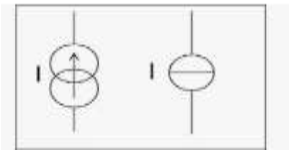
2) **The Active components:** An active component is a component that increases the power of a signal:

- Transistors
- Diodes
- Triacs

Electrical networks: a network is a circuit composed of various components interconnected by connectors.



Examples:

The Symboles	The name and Unit of the symbols
	Resistance (Ω)
	Inductance (H)
	Capacity (F)
	Direct voltage source (V)
	Direct current source (A)

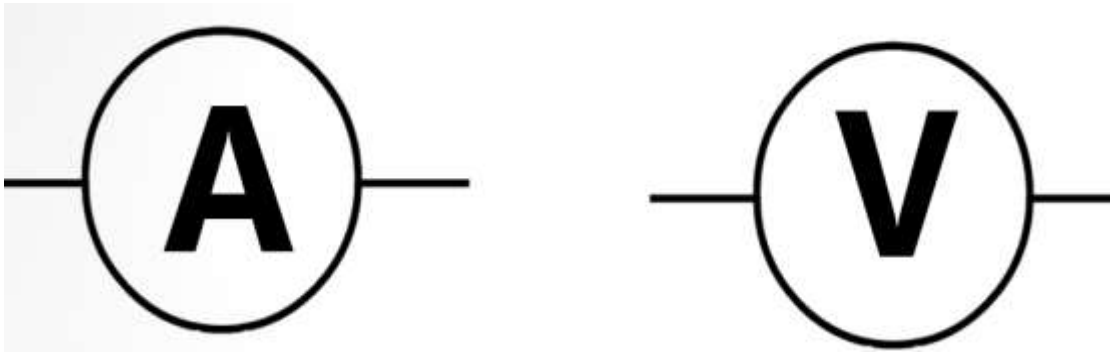
➢ Measuring instruments can be used to measure voltage and current in an electrical circuit:

To measure current, use the ammeter.

- **The ammeter:** it is the device used to measure current intensity.

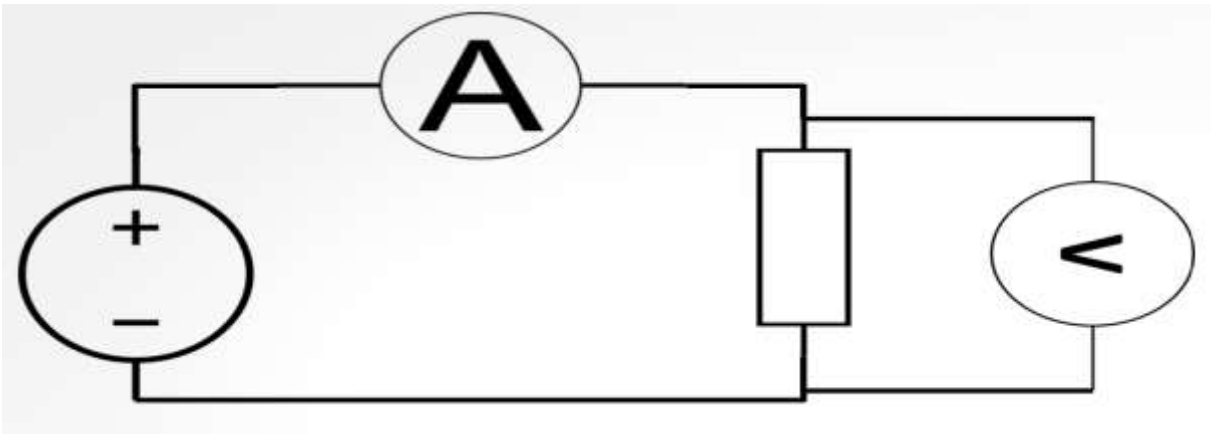
To measure voltage use voltmeter.

- **The voltmeter:** it is the device used to measure voltage.



Nb: The pinout of the voltmeter and the ammeter

- A voltmeter is always connected in parallel with the device whose voltage you wish to measure.
- An ammeter is always connected in series with the device whose current intensity is to be measured.



Ohm's law is a formula used to calculate the relationship between voltage, current and resistance in an electrical circuit.

- Ohm's law is given by the equation :

$$E = R * I$$

This formula means Voltage = Current x Resistance



The power dissipated by the resistance: it is supplied by the source. The power P (in W) dissipated by the resistance is then:

$$P = E * I = R * I^2$$

- When the feed voltage increases, I increases and the power dissipated by R increases.
- When the value of R increases, I decreases

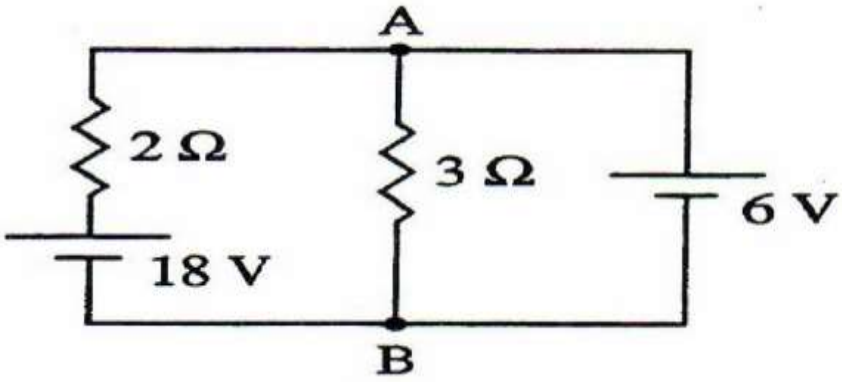
The Nodes: A node is a point in a circuit where three or more wires meet.



It is not a node | Node (3 wires) | Node (4 wires)

Example:

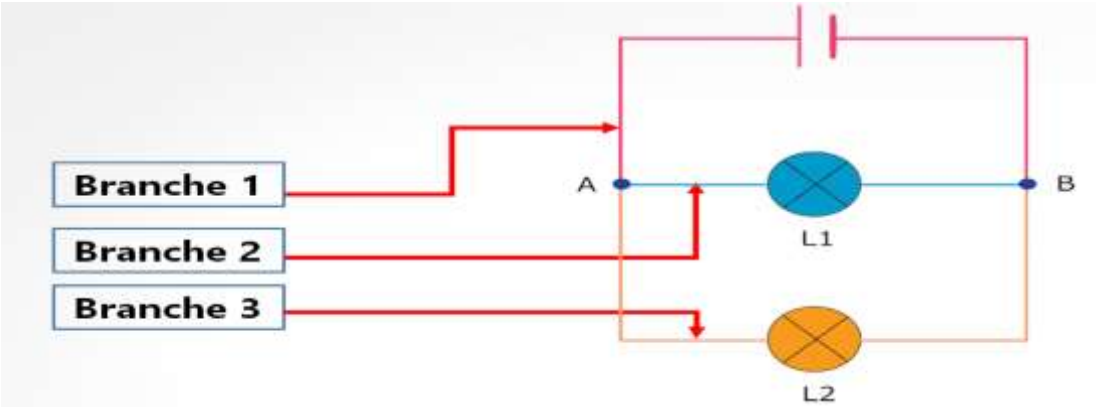
Consider the above circuit:



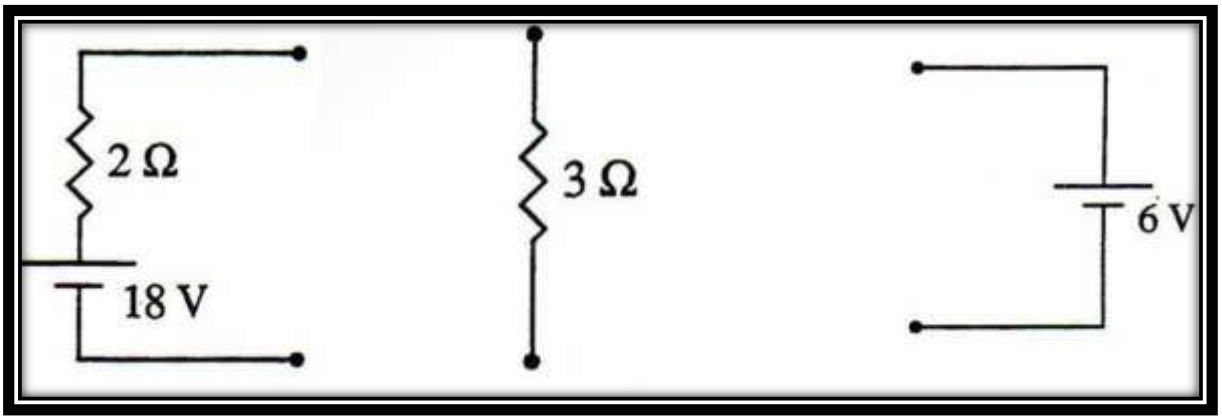
The circuit comprises:

- Two nodes (A and B)

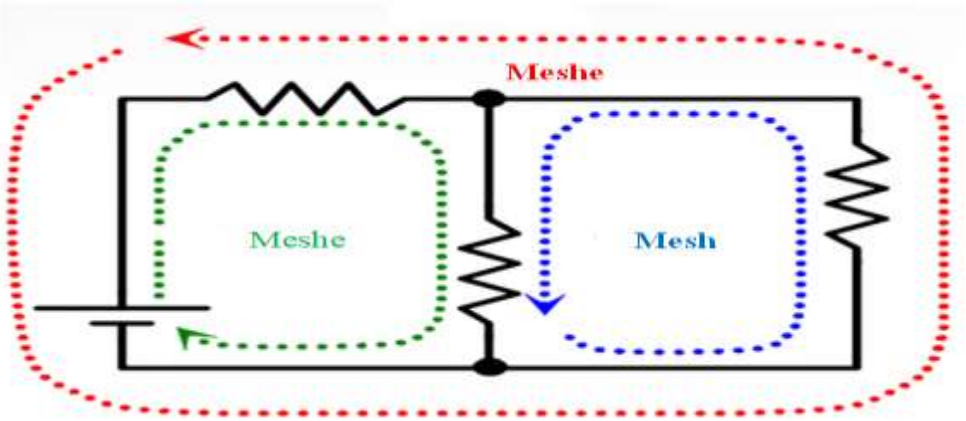
The Branches: it is a set of elements between two consecutive nodes.



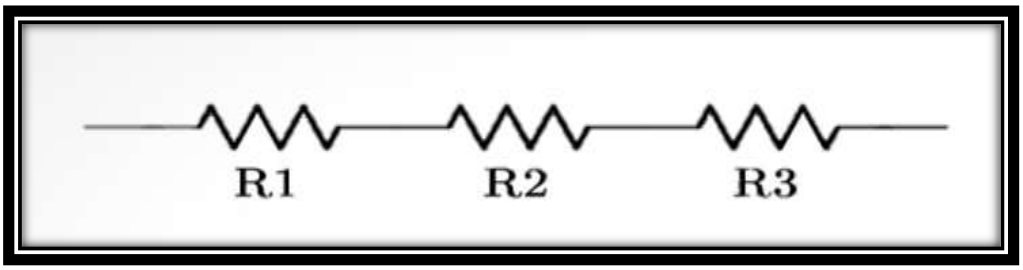
- Three branches :



The Meshes: a mesh is any closed path in a circuit that allows you to return to the starting point.



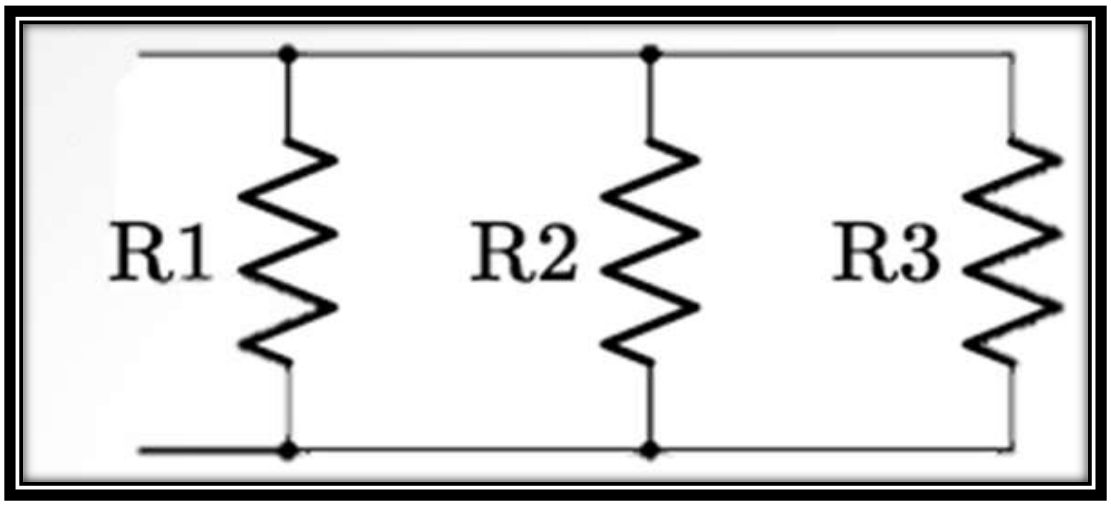
- **Series resistances**: Resistances on the same branch. Resistances in series carry the same current I, but do not produce the same potential difference.



$$R_{eq} = R_1 + R_2 + R_3 + \ldots\ldots\ldots R_n$$

- Resistances connected by the same pair of knots.

Parallel resistance produce the same potential difference, but do not carry the same current.



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\frac{1}{R_n}$$

- Calculate the equivalent resistance :

1) Resistance in series



$R_{eq}=R_1+R_2$

$R_{eq}=220+480$

$R_{eq}=700\Omega$

$R_{eq}=700\Omega$

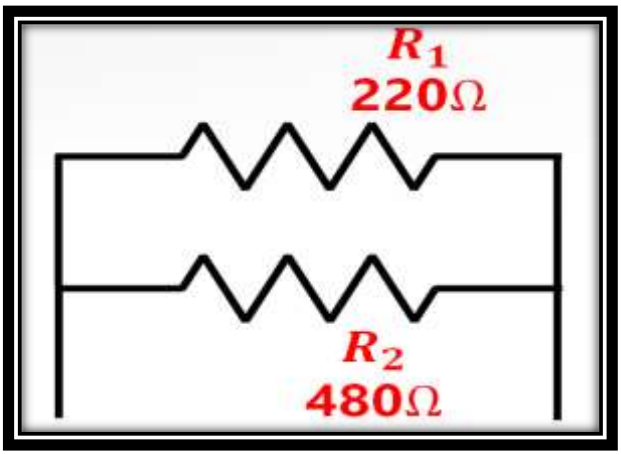


2) Resistance in Parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{220} + \frac{1}{480}$$

$$R_{eq} = 150.86\ \Omega$$



$R_{eq} = 150.86\ \Omega$



The laws of Gustavo Robert Kirchhoff

- In 1845, German physicist Gustav Robert Kirchhoff applied conservation of charge and conservation of energy to an electrical circuit. He derived two fundamental laws of electrical circuit analysis, known as Kirchhoff's law of nodes and Kirchhoff's law of meshes.

$$\sum \boldsymbol{I} = \mathbf{0} \qquad\qquad \sum \Delta \boldsymbol{V} = \mathbf{0}$$



Gustav Robert Kirchhoff (1824-1887)

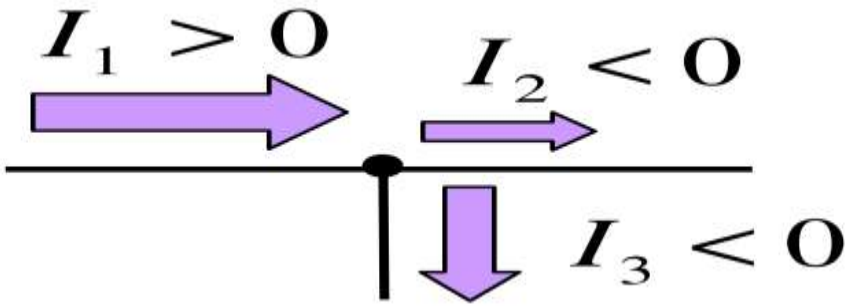
- ***I*:** Current entering or leaving a node in a circuit.
- **ΔV:** Potential variation produced by an electrical component of a circuit.

➢ Conventions on current :

-A current entering a node is a positive current (I > 0).

- A current leaving a node is a negative current (I <0).

- The current is constant on a branch and changes when a node is encountred.



$$\sum I = 0$$

$$I_1 - I_2 - I_3 = 0$$

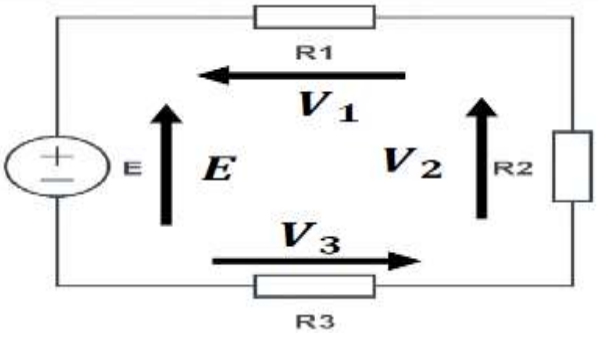
$$I_1 = I_2 + I_3$$

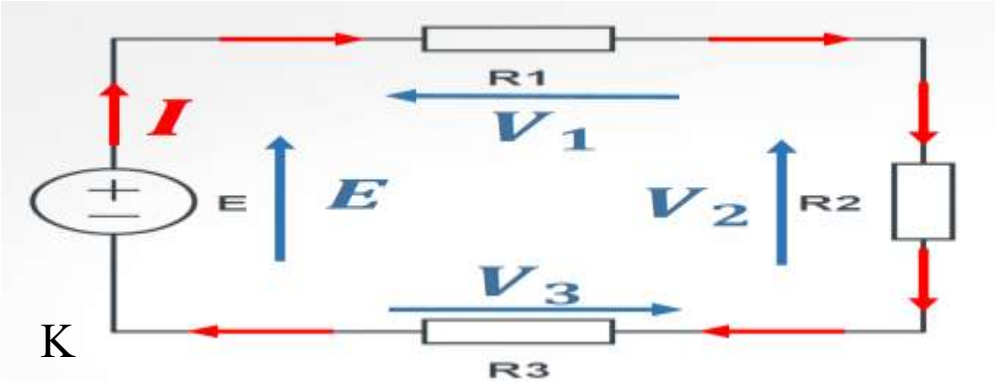
➢ The law of loops says that in an electric circuit loop, the voltage (E) across the power source is equal to the sum of the voltages across each of the other components.

$$\sum \Delta V = 0$$

$$E - V_1 - V_2 - V_3 = 0$$

$$E = V_1 + V_2 + V_3$$





$$V_1 = R_1 * I \quad , \quad V_2 = R_2 * I \quad , \quad V_3 = R_3 * I$$

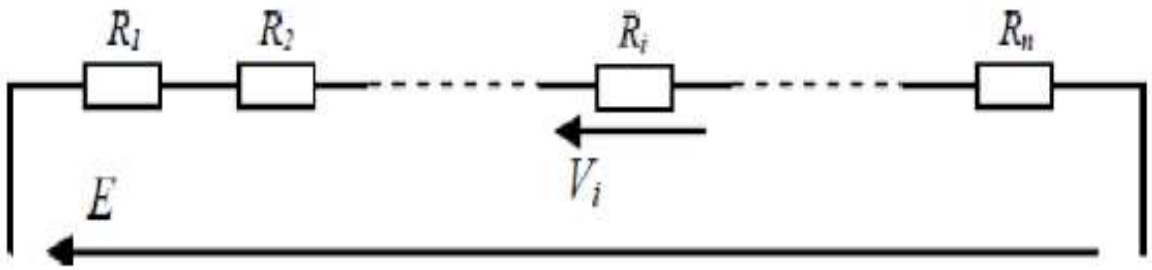
$$E = R_1 * I + R_2 * I + R_3 * I$$

$$E = (R_1 + R_2 + R_3) * I$$

$$\Rightarrow I = \frac{E}{(R_1 + R_2 + R_3)}$$

Voltage Divider Bridge

This theorem is used to calculate voltages at the good points of impedances placed in series. Let n resistors be placed in series and supplied with a voltage *E*.

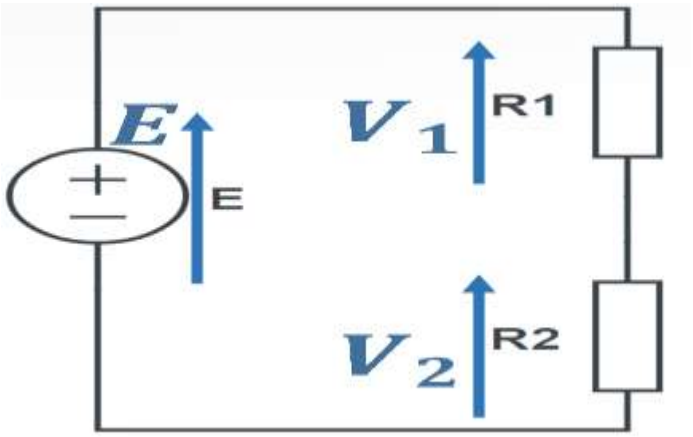


Application of the voltage divider bridge on series resistors.

The voltage across the R_i resistor is written:

$$V_i = \frac{R_i}{\sum_{j=1}^{n} R_j} \mathrm{E}$$

Example 1 :

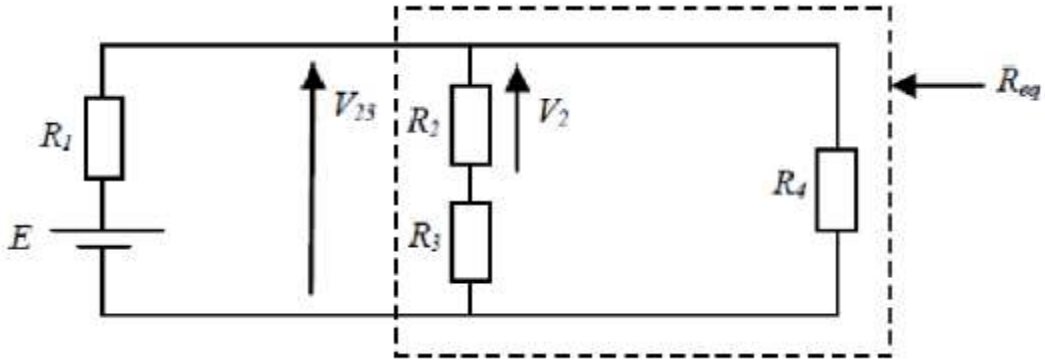


$$V_1 = \frac{R_1}{R_{1+R_2}} E$$

$$V_2 = \frac{R_2}{R_{1+R_2}} E$$

Example 2 :

Determine the voltage across resistor R2 .



Example of the voltage divider bridge on resistors

Resistors R_2 and R_3 are in series, so: $V_2 = \frac{R_2}{R_{2+R_3}} V_{23}$

Note that resistors R_2 and R_3 are in parallel with resistor R_4, so

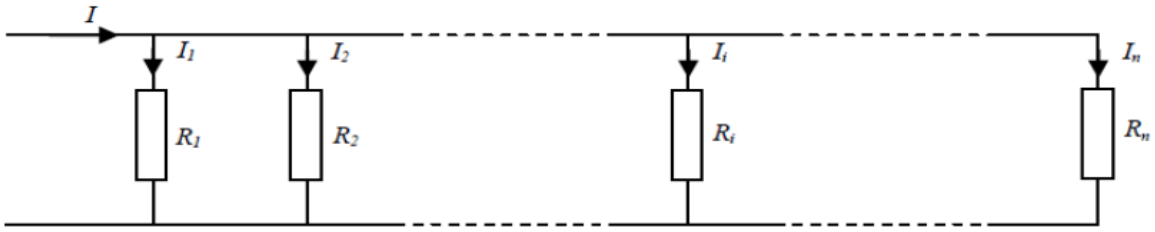
$R_{eq} = (R_2 + R_3) // R_4$

Resistors R_{eq} and R_1 are in series, so: $V_{23} = \frac{R_{eq}}{R_{eq+R_1}} E$

Replacing V_{23}, we obtain: $V_2 = \frac{R_2}{R_{2+R_3}} \frac{R_{eq}}{R_{eq+R_1}} E$

Current Divider Bridge:

This theorem applies to branches containing resistors and/or impedances in parallel, as shown in Figure.



Applying the current divider bridge to resistors in parallel.

The current I_i, flowing through resistor R_i, placed in parallel with resistors R_1, R_2, ... and R_n, is given by:

$$I_i = \frac{\frac{1}{R_i}}{\sum_{j=1}^{n}\frac{1}{R_j}} \mathrm{I}$$

Where I is the current feeding the parallel circuit formed by the n resistors.

Example 1:

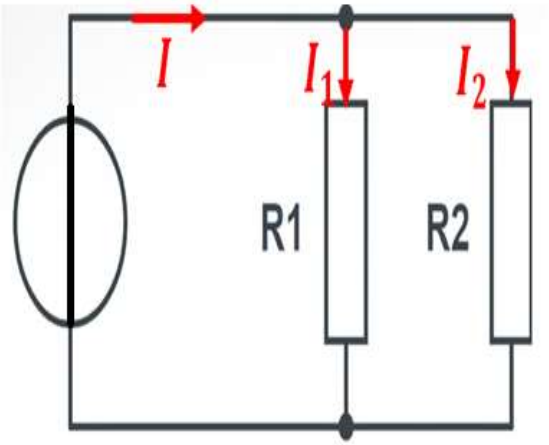
Calculate currents I_1 *and* I_2

$$I_1 = \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}} \mathrm{I}$$

$$I_1 = \frac{R_2}{R_1+R_2} \mathrm{I}$$

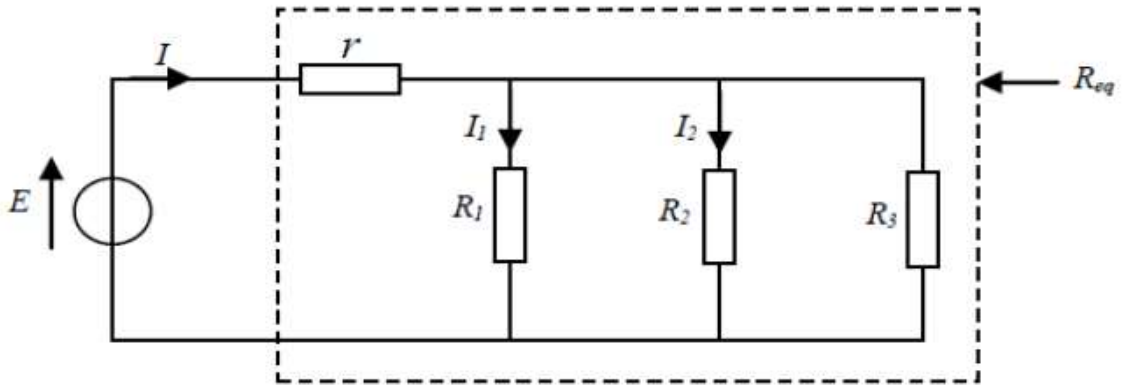
$$I_2 = \frac{\frac{1}{R_2}}{\frac{1}{R_1}+\frac{1}{R_2}} \mathrm{I}$$

$$I_2 = \frac{R_1}{R_1+R_2} \mathrm{I}$$



Example 2:

Describe the currents I_1 as a function of the continuous voltage E and the resistances r, R_1, R_2 and R_3



Example of the current divider bridge on parallel resistors.

Calculate I_1 :

Since resistors R_1 , R_2 and R_3 are in parallel, so we obtain after applying the current divider bridge theorem:

$$I_1 = \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} \text{ I}$$

Calculate I :

R_{eq} is the resistance equivalent to the enclosed circuit such that: R_{eq} =r +$(R_1//R_2//R_3)$

Applying Ohm's law, the current I is written as:

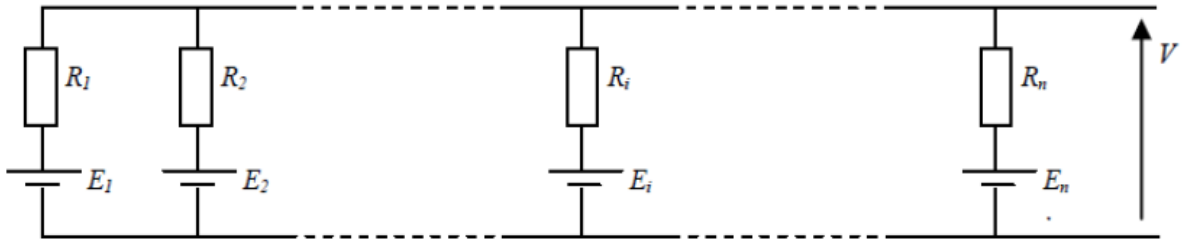
$$\text{I}= \frac{E}{R_{eq}}$$

by replacing the current I in the expression of I_1, we obtain :

$$I_1 = \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} \frac{E}{R_{eq}}$$

Millman théorème

The Millman’s theorem is an electrical circuit analysis technique that allows you to simplify complex circuit .It’s used to find the voltage across and current through a particular branch of circuit with multiple parallel voltage source.Millman’s theorem applies only to circuits with parallel voltage sources, and not to circuits with series voltage sources.



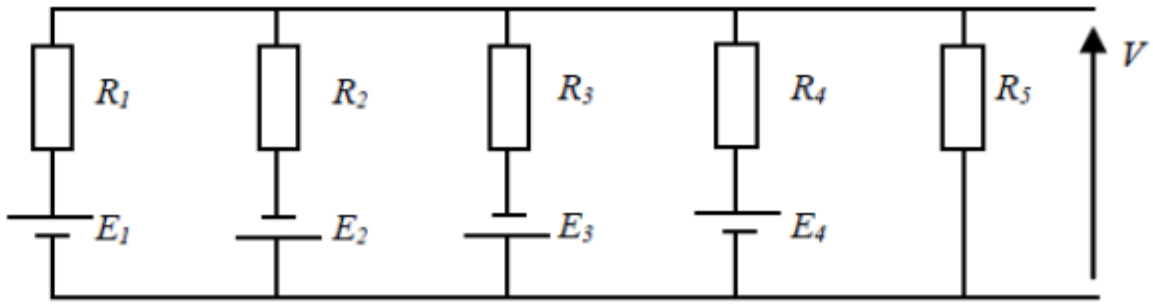
Application of Millman's theorem to parallel branches each comprising a voltage source and a resistor

The voltage V is written:

$$V=\frac{\sum_{i=1}^{n}\frac{E_i}{R_i}}{\sum_{j=1}^{n}\frac{1}{R_j}}$$

Example:

Consider the electrical circuit shown in figure. Calculate the voltage across resistor R_5.



Application of Millmnn's theorem.

Applying Millinan's theorem directly, we obtain:

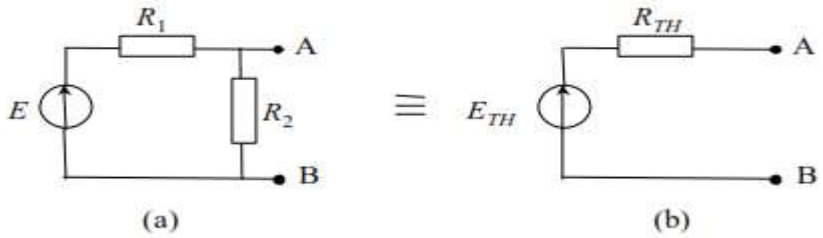
$$V=\frac{\frac{E_1}{R_1}-\frac{E_2}{R_2}-\frac{E_3}{R_3}+\frac{E_4}{R_4}+\frac{0}{R_5}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}+\frac{1}{R_5}}$$

Thévenin's theorem

Consider a linear electric circuit placed between two points A and B. With respect to points A and B (seen from an element placed between A and B), the previous circuit can be replaced by a Thévenin equivalent generator E_{TH} and internal resistance R_{TH}.

- The E_{TH} value is equal to the measured voltage between A and B at no-load.
- The internal resistance R_{TH} corresponds to the value of the resistance seen between A and B when the independent sources are passivated.

Let's take for example the assembly of the figure 1



Example of Thévenin's theorem application.

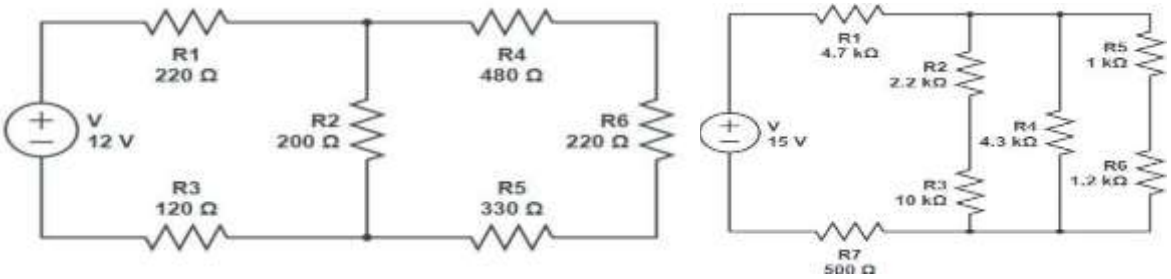
- The Thévenin voltage E_{TH} is the voltage obtained at no load between A and B. This voltage obtained across R_2 is calculated by applying the divider bridge theorem.
- The R_{TH} resistance is obtained by passivating the voltage source E. All you have to do is replace the E source with a short circuit.

$$E_{TH} = \frac{R_2}{R_1 + R_2} E \qquad \text{and} \qquad R_{TH} = \frac{R_1 R_2}{R_1 + R_2}$$

Exercises related to the first chaptre

Exercise 1:

The following electronic circuits are produced:

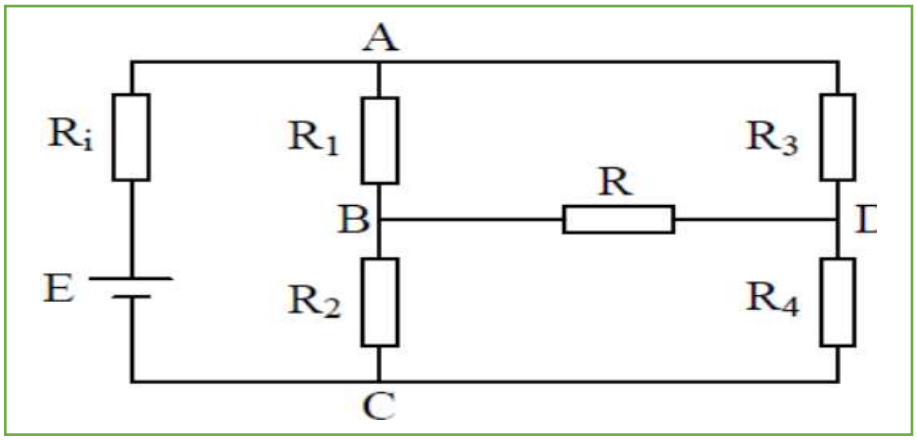


For each circuit:

- Determine the direction of the current I flowing through each resistor.
- Calculate the resistance Req, and then calculate the current I.
- Calculate the power dissipated by resistor Req.

Exercise 2:

In the following circuit, indicate the number of nodes, the number of branches and the number of meshes.

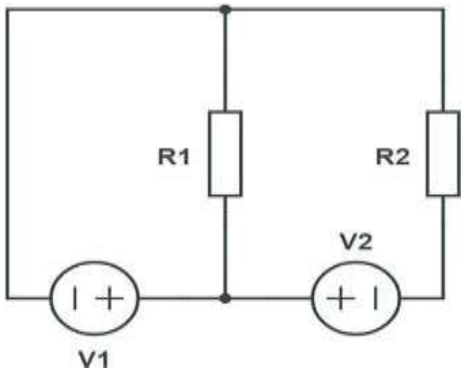


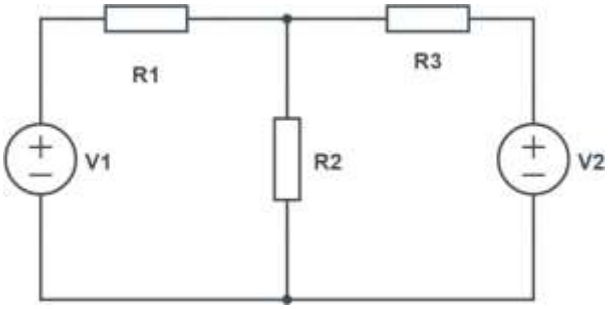
Exercise 3:

Find the currents flowing through each of the resistors in the two circuits below using Kirchhoff's laws:

$R_1=R_2=10\Omega$ and $V_1=10, V_2=15V$ (Schematic1)

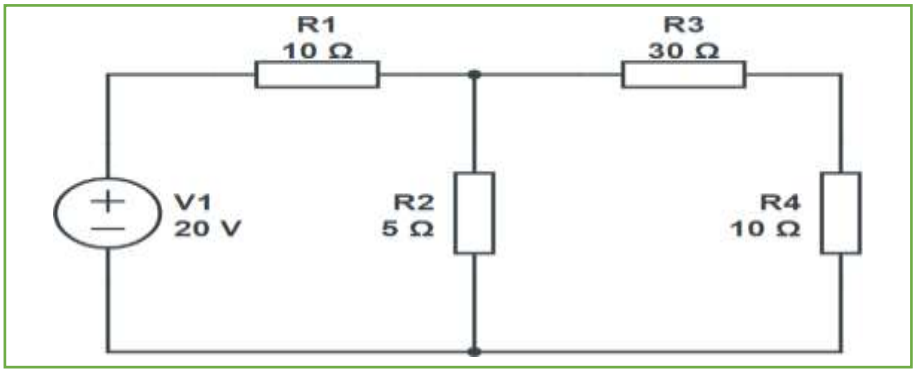
$R_1=10\Omega, R_1=20\Omega, R_1=40\Omega, V_1=10V, V_2=20V$ (Schematic2)





Exercise 4:

Determine the voltage across: R2 and R4 using the voltage division rule and then determine the current flowing through R3 and R4 using the current division rule.



Solve exercises related to the first chaptre

Exercice1 :

1) R_{eq1}=R_4+R_5+R_6 ⟶ R_{eq1}=1030 Ω

$R_{eq2} = \frac{R_2 * R_{eq1}}{R_2 + R_{eq1}}$ ⟶ R_{eq2} =181 .28 Ω

R_{eq3}=R_1+R_{eq2}+R_3 ⟶ R_{eq3} =521.28 Ω

2) I = $\frac{V}{R_{eq3}}$ ⟶ I=0.023A

3) P= $R_{eq3} * I^2$ ⟶ P=0.27 W

Exercice 2 :

We have :

Node :4 Branches :6 Meshes :7

Exercice 3 :

Schematic1

1) V_1-V_{R_1}=0

V_1=V_{R_1}

V_1=R_1*I_1 ⟶ I_1=1A

2) V_2 - V_{R_1} − V_{R_2} =0

V_2 = V_{R_1} + V_{R_2} ⟶ I_2=0 .5A

Exercice 4 :

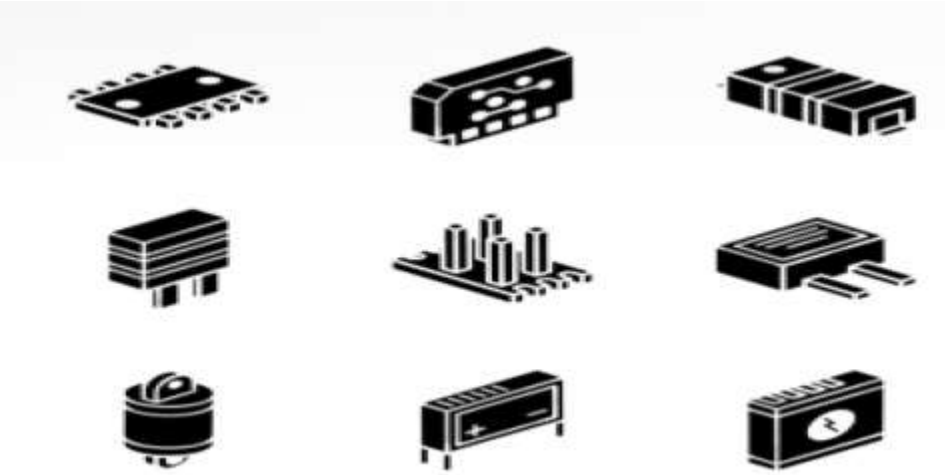
R_{eq1}=R_3+R_4 and $R_{eq2} = \frac{R_2 * R_{eq1}}{R_2 + R_{eq1}}$

$V_2 = \frac{R_{eq2}}{R_{eq1}+R_1}$ *V ⟶ V_2 =6 .14V

Chapter 2: Semiconductors Diodes

Semi-Conductors

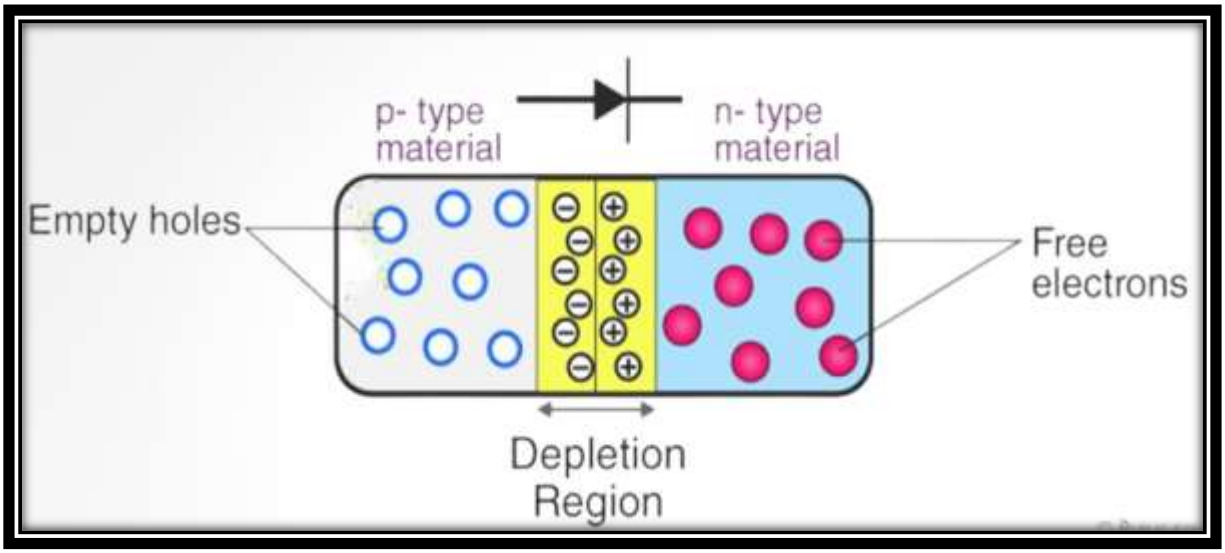
- Semiconductors are solid chemical compounds that can conduct electricity under certain conditions, while under others they cannot, which makes them a good way of controlling an electric current.



- Silicon is the most widely used semiconductor material commercially, due to its good properties and natural abundance; there are also dozens of other semiconductors in use, such as germanium, gallium arsenide and silicon carbide.

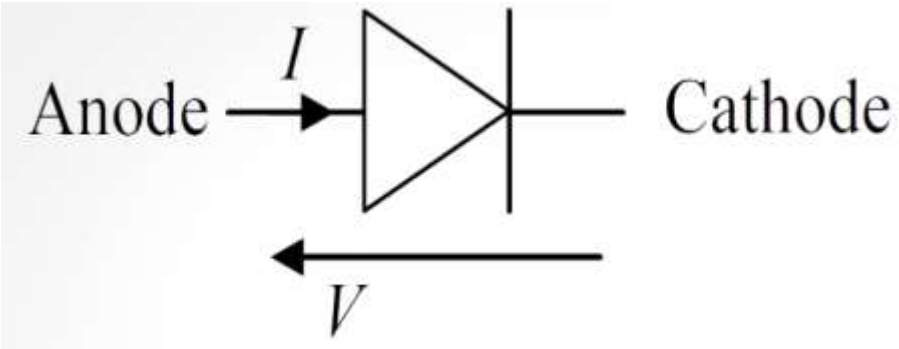


- The doping technique increases the carrier density within the semiconductor material. If the electron density is increased, this is called N-type doping. If it increases the density of holes, it's called P-type doping.



The junction diode

The diode is a non-linear component (the relationship between current and voltage is given by a non-linear equation). The symbolic representation of the diode is given in the figure below



Symbolic representation of the diode

Applications field of Diode :

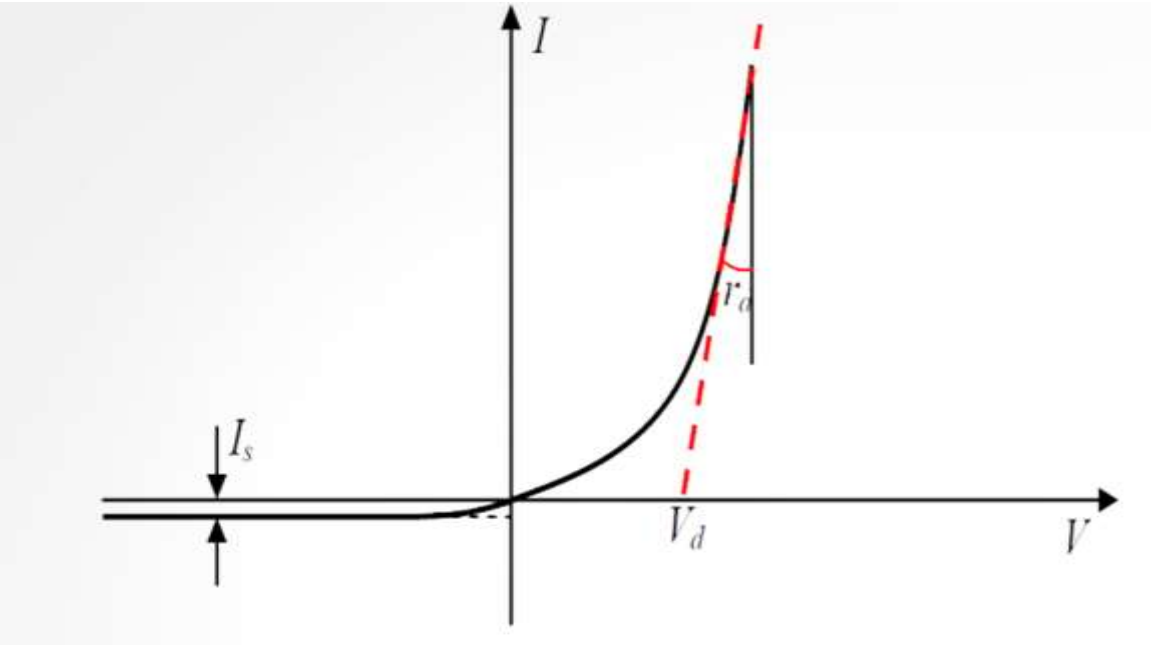
- Reverse current protection circuits
- Rectifier circuits
- In logic gates

The current-voltage (I-V) characteristic of the diode is given by :

$$I = I_s \left(e^{\frac{V}{nV_T}} - 1 \right)$$

With:

- Is : Saturation current of the diode
- n: Diode ideality coefficient ($1 \leq n \leq 2$)
- V_T: Thermal voltage, $\frac{KT}{q}$
- k: Boltzmann constant, $k=1.38\times10^{-23}$ J.K-1
- T: Temperature
- q: Electron charge, $q=1.60219\times10^{-19}$ C



I-V characteristic of a diode

In **reverse polarization** (V<0), the current flowing through the diode from cathode to anode is negligible (Is≈0).

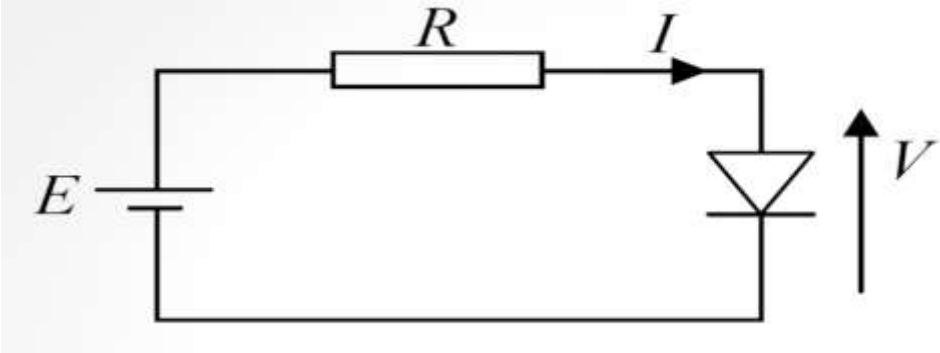
In **direct polarization** (V>0), current increases rapidly with voltage, as shown in figure 1.

V_d :The diode's threshold voltage. It's usually less than 1 V.

r_d :The diode's dynamic resistance

Example:

Consider the following diode circuit. Determine the voltage V across the diode



By applying the law of meshes: $\boldsymbol{E - RI - V = 0}$

The current I is given by: $I = I_s\,(e^{n\frac{V}{V_T}} - 1)$

So: $E - R\,I_s\,(e^{n\frac{V}{V_T}} - 1) - V = 0$

The above equation is a non-linear equation that cannot be solved analytically.

Linear electrical diode models:

The diode is a non-linear element, and analyzing a circuit with non-linear behavior is quite difficult. We therefore replace the diode with linear models.

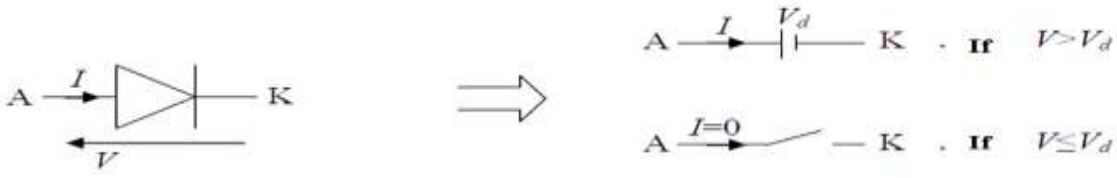
1. Ideal model (r_d=0 and V_d =0):

It is a closed switch in forward polarization, V>0, and open in reverse polarization, V≤0.



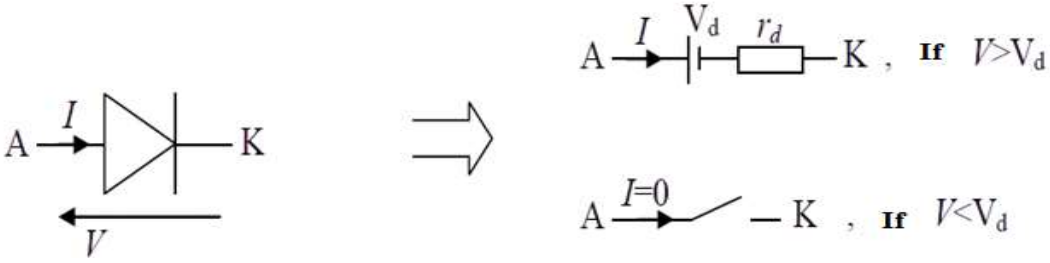
2. Perfect diode model

In this model, the current is zero for voltages below the threshold voltage V_d (V<V_d). At this value, the diode conducts and the voltage across its terminals remains constant, whatever the current flowing through it.



3. Real diode model

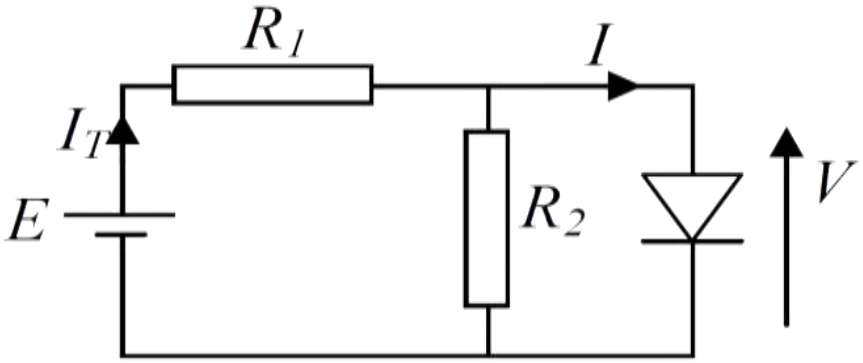
In this model, the dynamic resistance r_d is included.



Example:

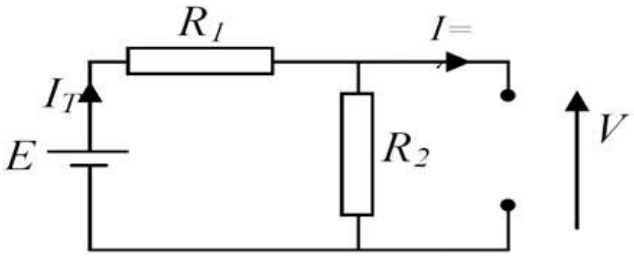
Analyze the following circuit:

Given E = 9V, R1 = 220Ω, R2 = 480Ω



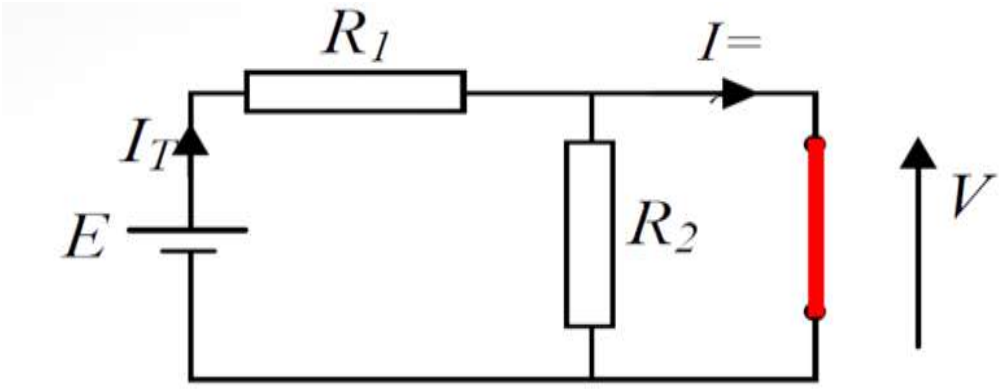
Determine the voltage V and current I_T?

V is determined when the diode is removed from the circuit (*I=0*).



V= $\frac{R_2}{R_1+R_2}$

V> 0 ⟹The diode is on



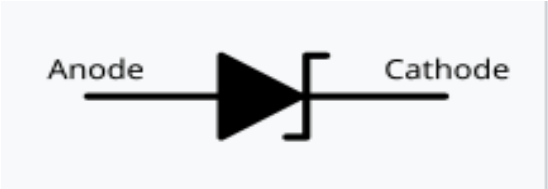
=> V=0

=> E - $R_1 I_T$ - V=0 ⟹ $I_T = \frac{E}{R_1}$

The zener diode

A Zener diode is a type of diode designed to allow current to flow not only in the forward direction, like a regular diode, but also in the reverse direction when a specific reverse voltage (known as the *Z*ener breakdown voltage) is reached. This breakdown voltage is precisely controlled and makes the Zener diode useful for regulating voltage in circuits.

The following figures show the schematic symbols of a zener diode

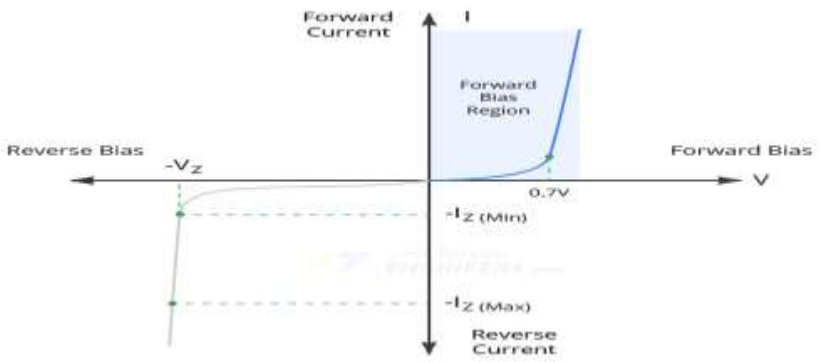


Zener diode

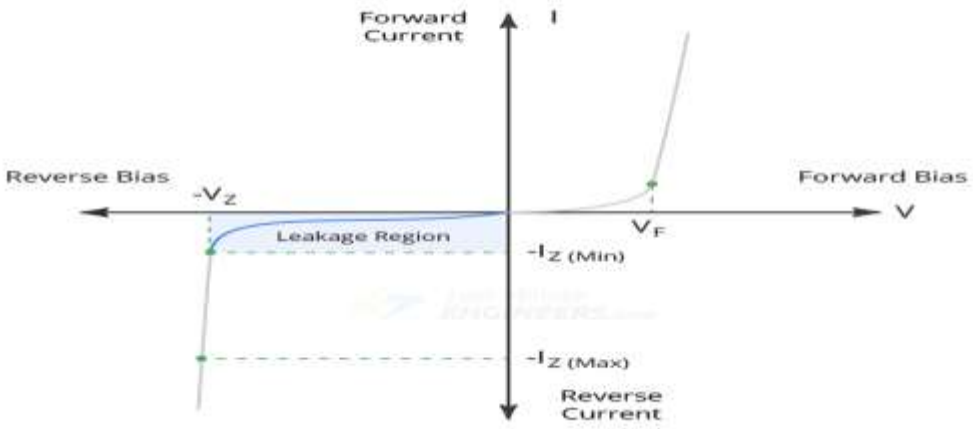
Current-Voltage (I-V) Characteristic of a Zener Diode

The I-V characteristic curve of a Zener diode has distinct regions:

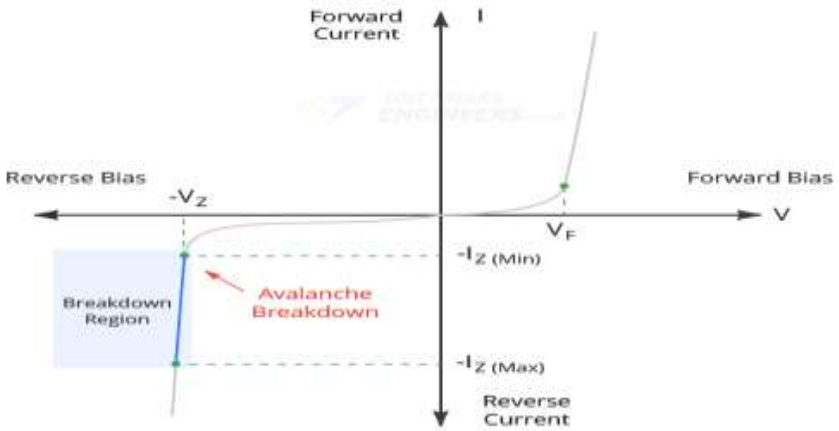
1. **Forward Region**: In the forward bias, the diode behaves similarly to a regular diode, conducting once the forward voltage threshold (approximately 0.7V for silicon diodes) is surpassed.



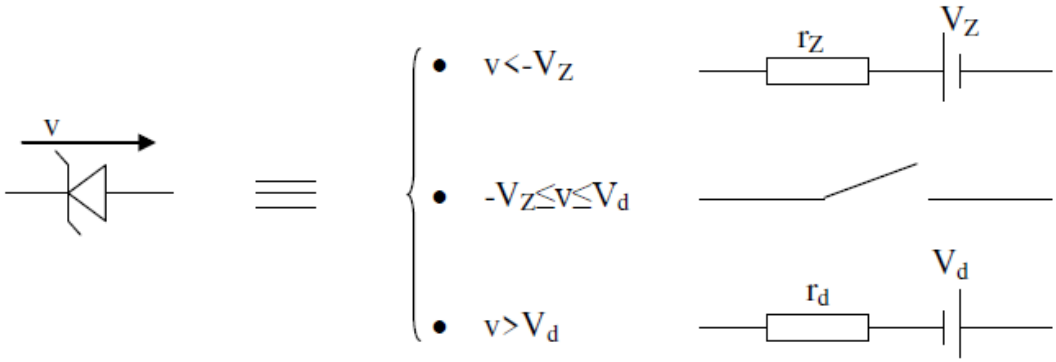
2. **Reverse Region**: In reverse bias, very little current flows until the reverse voltage reaches the Zener breakdown voltage (Vz). At this point, the diode starts to conduct in reverse, allowing current flow and keeping the voltage across it approximately constant at Vz, which makes it useful for voltage regulation.



3. **Breakdown Region**: When the reverse voltage is greater than the Zener voltage, the Zener diode conducts a large amount of reverse current while maintaining a stable voltage at the breakdown point (Vz). This is the characteristic that makes Zener diodes suitable for voltage regulation applications, as they can "clamp" the voltage to a set value.

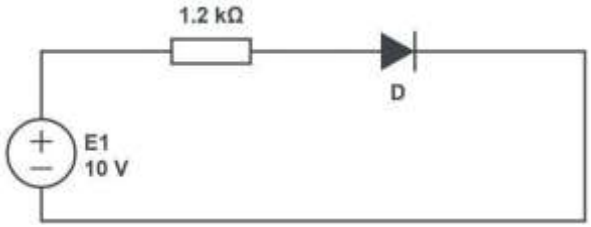


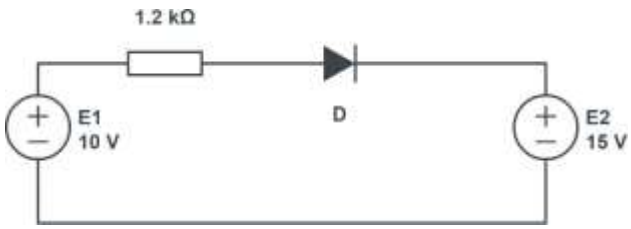
The Zener diode in 3rd approximation is presented by the linear model below

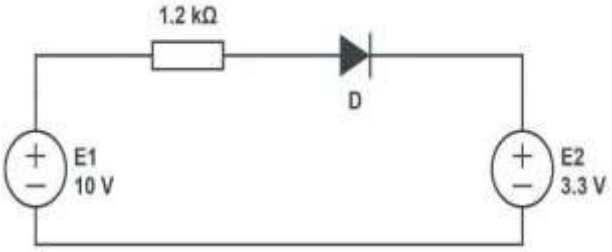


Exercises related to the second chaptre

Exercice 1 : Calculate the current through the 1.2kΩ in 3 following cases (Vd=0.6V,rd=0Ω)

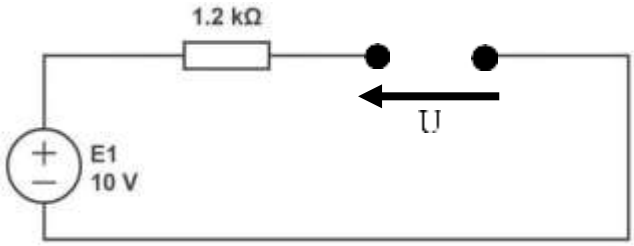






Solve exercises related to the second chaptre

Exercice 1



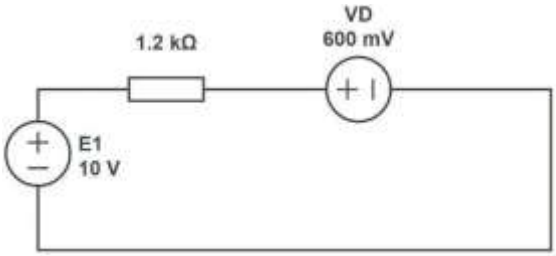
1) $E_1 - RI - U = 0$

$I = 0$ (au vide)

$E_1 = U = 10V$, $U > V_d$

In this case,the diode is conductive.

Then we replace the diode with its linear model and calculate the current I

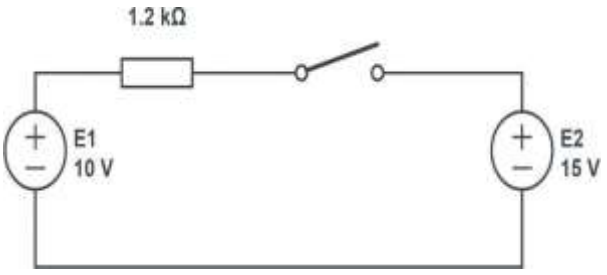


$E_1 - RI - V_d = 0$ ⟶ I=7.83 mA

2) The same applies to the second case:

$E_1 - U - E_2 = 0$

$U = E_1 - E_2 = -5V$, $U < V_d$

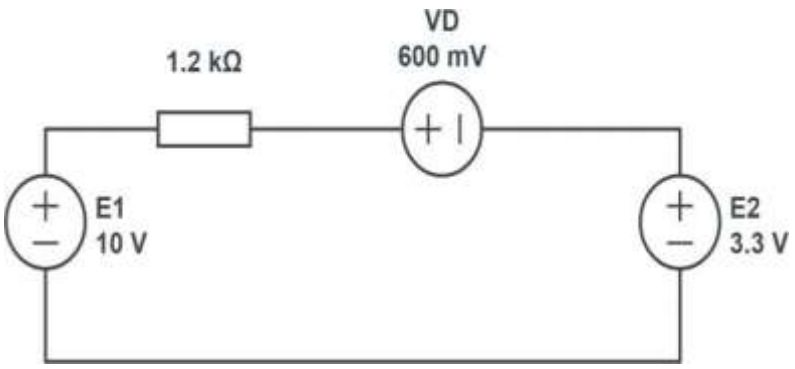


Then the diode is blocked. We replace the diode with an open circuit. Then the current through the resistor is zero.

3)The same applies to the third case:

$E_1 - U - E_2 = 0$

$U = E_1 - E_2 = 6.7V, \qquad U > V_d$



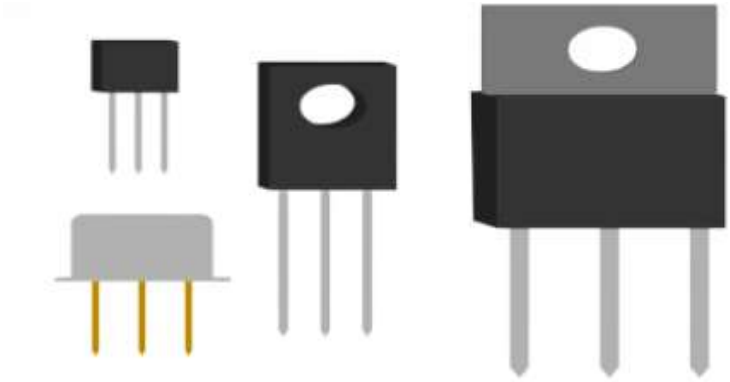
Then,the diode is conducting..

$E_1 - RI - V_d - E_2 = 0 \longrightarrow$ I =5.08 mA

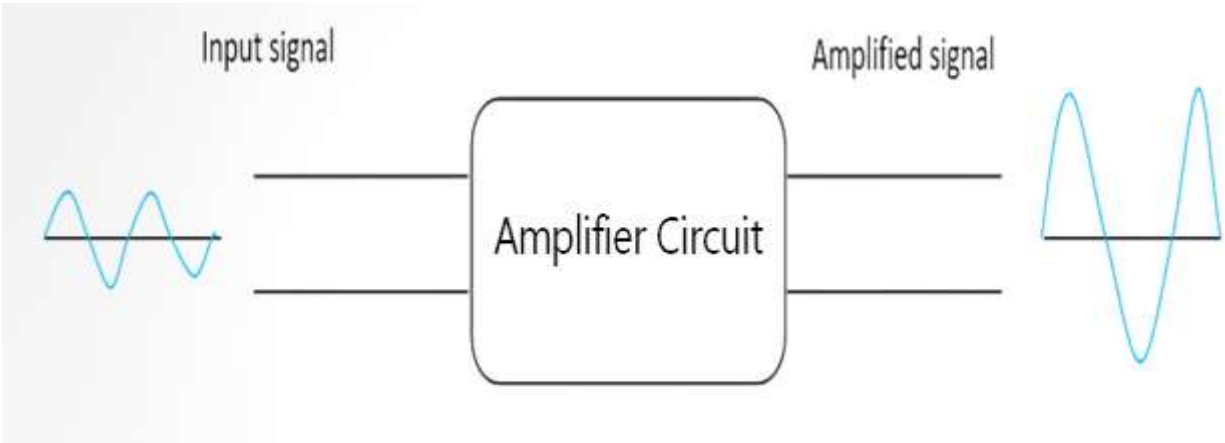
Chapter 3: bipolar transistors and field-effect transistors

The Transistors:

The transistor is an active component that belongs to the family of semi-conductors with three active electrodes, used to control a current (or voltage).

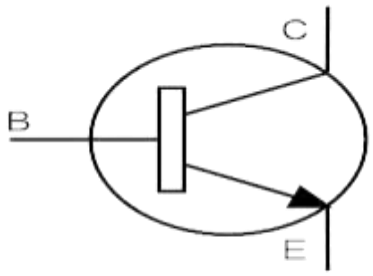


- Transistors are mainly used as **switches** or **amplifiers**.
- When used as an amplifier, a transistor transforms a small input current into a larger output current.

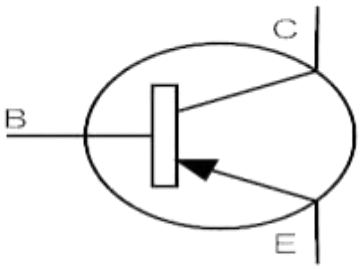


The bipolar transistor: It is a current-controlled device. This means that it uses the input current at its base terminal to control the output or collector current. There are two types of bipolar transistor:

- NPN bipolar transistor
- PNP bipolar transistor



n-p-n transistor



p-n-p transistor

➢ The bipolar transistor has three terminals:

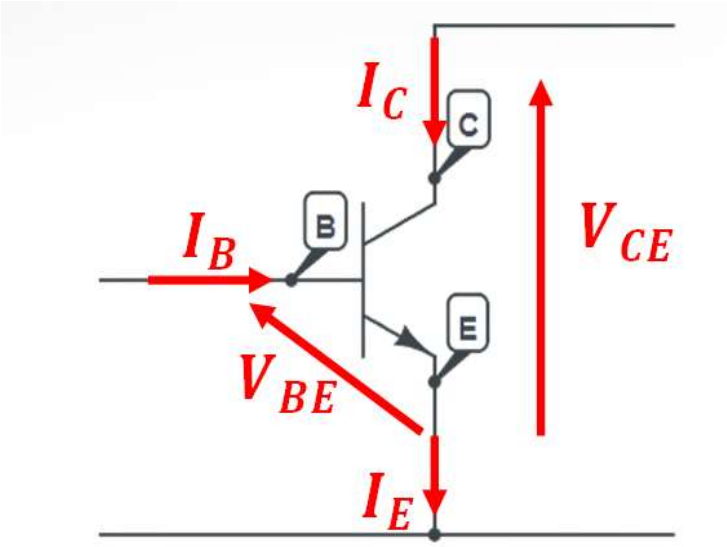
- **Base (B):** This is used to activate the transistor
- **Collector (C):** This is the transistor's positive wire.
- **Emitter (E):** This is the transistor's negative wire.



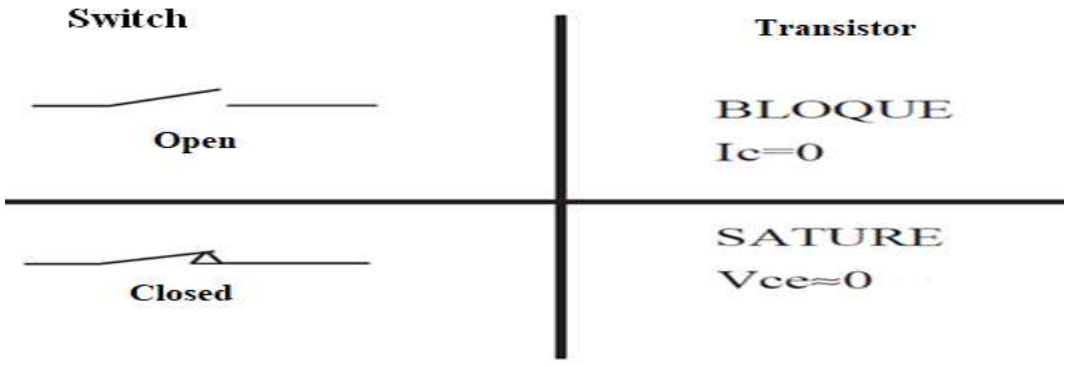
Circuit Study Based On the Bipolar Transistor

To completely understand how a transistor works, we need to determine six parameters:

- I_C
- I_B
- I_E
- V_{CE}
- V_{BE}



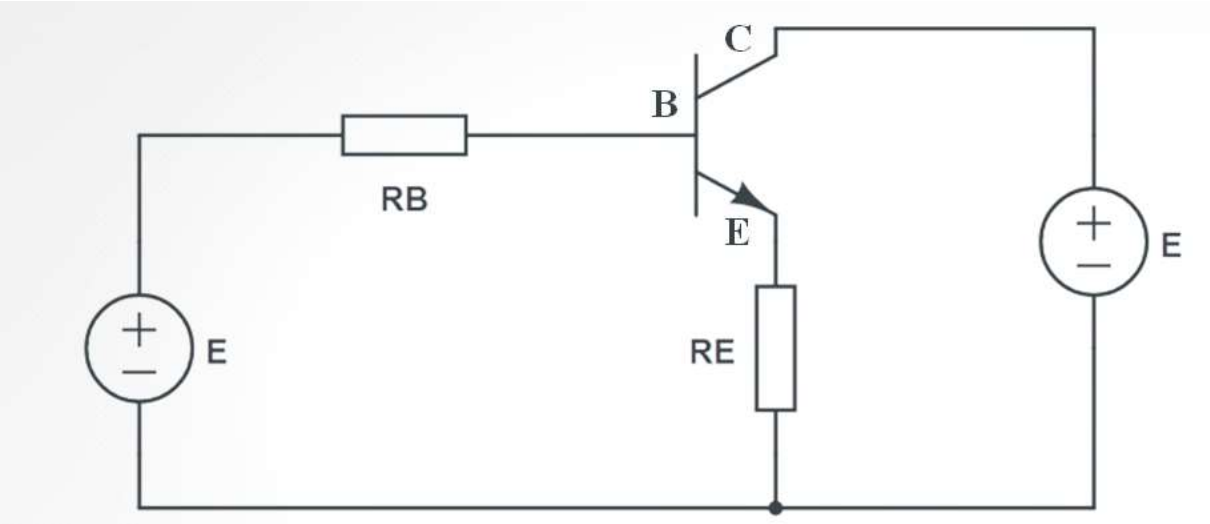
- Voltage V_{CE} and current I_C are generally referred to as the transistor's operating point.
- A transistor is used for commutation when its mode of operation is similar to a switch.
- A transistor is said to be blocked when its base current is zero.



Example: calculate the operating point of this transistor.

We give R_B= **110KΩ**, R_E = **500Ω**, E = **10V**, V_{BE} = **0. 6V**,

β = **130**



We calculate the base current I_B

$$E - R_B I_B - V_{BE} - R_E I_E = 0$$

$I_E = I_C + I_B$ with $I_C = \beta I_B$ Then: $I_E = (1 + \beta) I_B$

$$E - R_B I_B - V_{BE} - R_E(\beta + 1) I_B = 0$$

$$E - V_{BE} - (R_B + R_E(\beta + 1)) I_B = 0$$

$$I_B = \frac{E - V_{BE}}{R_B + R_E(\beta + 1)}$$

$$I_B = \frac{10 - 0.6}{110 * 10^3 + 500(130 + 1)}$$

$$I_B = 0.053mA$$

$$I_C = \beta I_B \Rightarrow I_C = 130 * 0.053 * 10^{-3} = 6.89mA$$

$I_E = I_C + I_B$

$\boldsymbol{I_E = 6.94mA}$

Finally, we calculate the voltage V_{CE}

$E - V_{CE} - R_E I_E = 0$

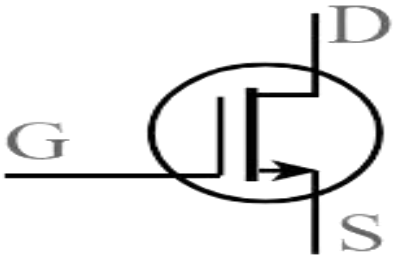
$V_{CE} = E - R_E I_E$

$V_{CE} = 10 - (500 * 6.94 * 10^{-3})$

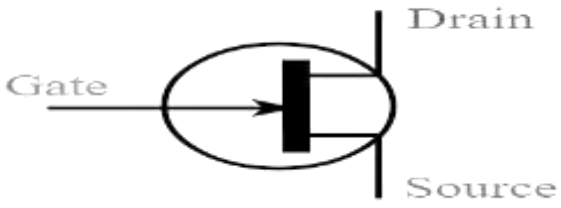
$\boldsymbol{V_{CE} = 6.53V}$

The Field Effect Transistors (FET)

A field-effect transistor (FET) is a type of transistor that uses an electric field (voltage) to control the flow of current in a semiconductor



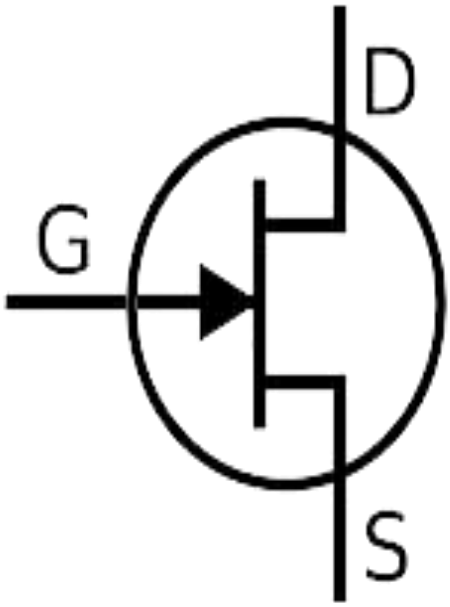
- **A field-effect transistor (FET) also has three terminals : source, drain, gate. which are analogous to the emitter, collector, base of the BJT, respectively.**

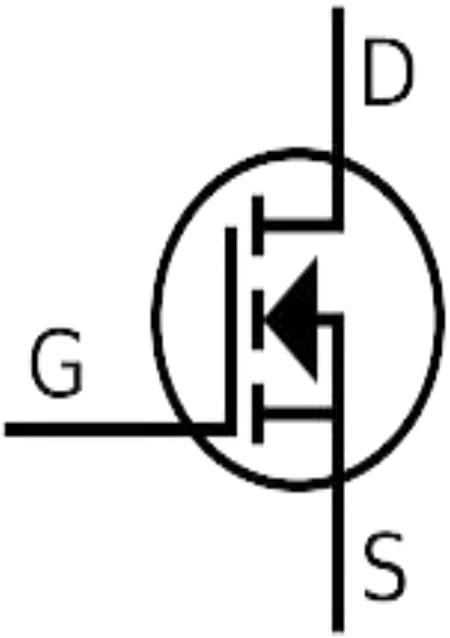


The most commonly used types of FET are

- MOSFET: Metal Oxide Semi Field Effect Transistorr
- JFET: Junction Field Effect Transistor

JFET





MOSFET

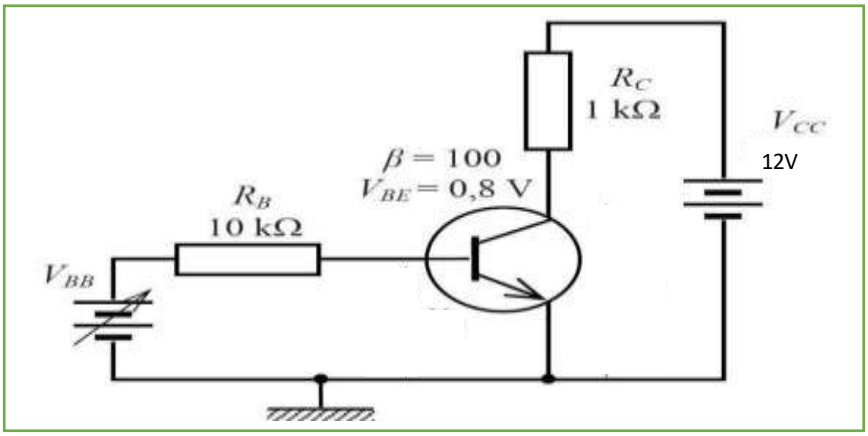
Exercises related to the third chaptre

Exercice 1 :

The voltage V_{BB} is successively given two values:0.5V;2V:

For each of these values, answer the following questions:

- determine the base current I_B?
- determine the collector current I_C?
- determine the collector voltage V_{CE}?
- What is the state of the transistor?



Solve exercises related to the third chaptre

Exercise 1:

a) **1st case:** V_{BB}=0.5V

The first mesh is used to calculate the I_B current**:**

V_{BB}-R_BI_B-V_{BE}=0

I_B=−0.03mA=0A

I_C=βI_B=100∗0

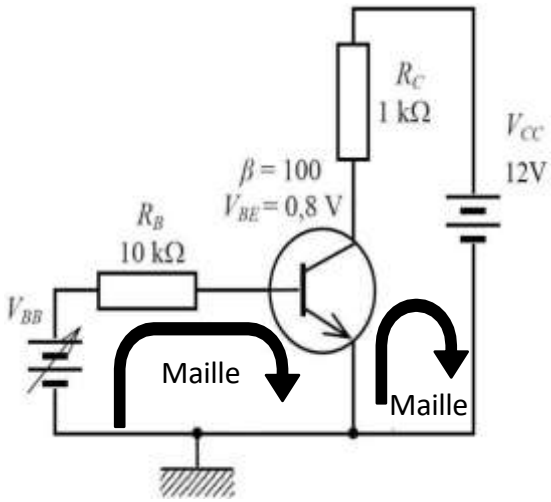
I_C=0A

The second mesh is used to calculate the I_B current:

V_{CC}−$RcIc$−V_{CE}=0

⇒V_{CC}=V_{CE}=12V

The transistor is blocked (I_B=0)



b) **2sd case:**V_{BB}=2V

I_B=0.12mA

I_C=12mA

V_{CE}= 0V

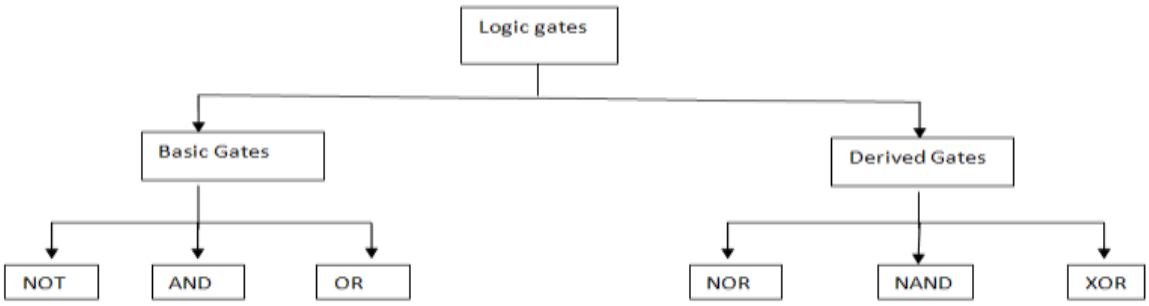
Transistor is saturated(switching)(IB>0 etVCE=0)

Chapter 4: Logic gate technologies

What are Logic Gates?

- Electronic circuits capable of making logical decisions;
- Basic building blocks of digital systems design;
- Can have one or more input signals and an output which is a logical combination of the inputs.

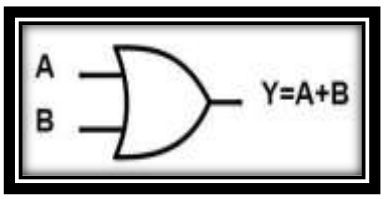
Gates are classified into two types:



➢ **1.Basic Gates:**

2.1. OR Gate

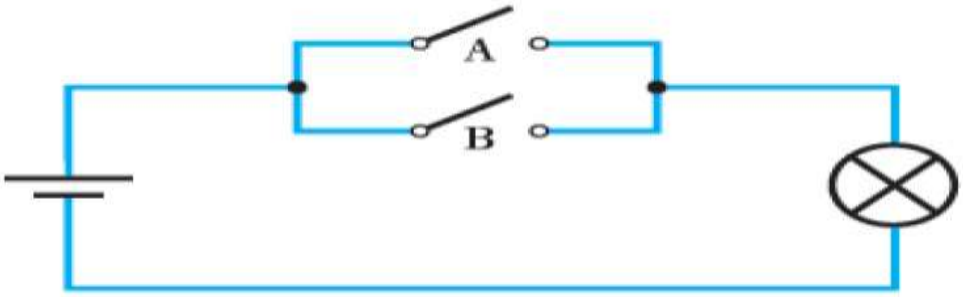
- The OR gate composed of two or more inputs (A,B)and single output (Y).
- The Boolean equation for this gate is Y=A+B
- Produces an output 1 when any or all of the inputs are 1.
- The OR operation is represented by a plus sign, +.
- The standard logic symbol for the OR gate is shown as



- The logical operation of a 2-input OR gate can be summarized in the truth table below

A	B	Y=A+B
0	0	0
0	1	1
1	0	1
1	1	1

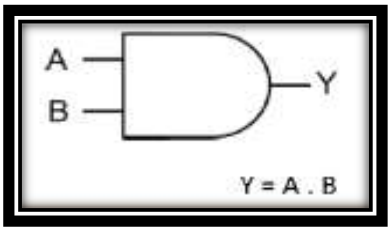
- A practical example of the OR gate is shown in the figure below



For the lamp to glow, either switch A or B or both are closed.

2. 2. AND Gate

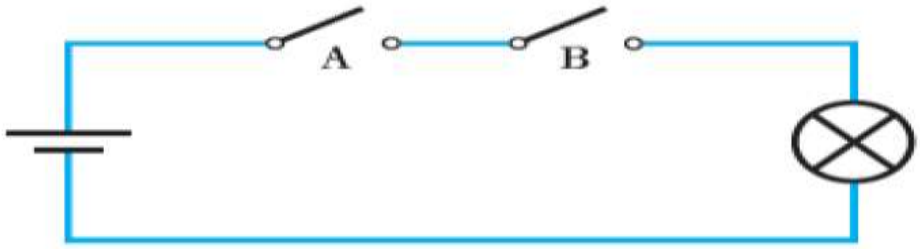
- Produces an output of 1 only when all inputs are 1
- It composed of two or more inputs and single output.
- The Boolean equation for this gate is Y=A.B
- The standard logic symbol for the AND gate is shown as



- The logical operation of a 2-input AND gate can be summarized in the truth table below

A	B	Y=A.B
0	0	0
0	1	0
1	0	0
1	1	1

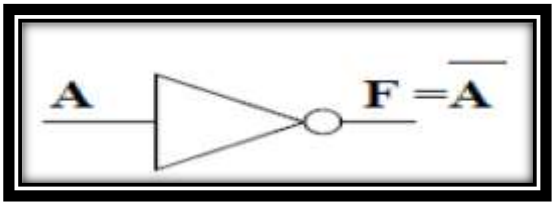
- A practical example of the AND gate is shown in the figure below:



The lamp will be ON only when both switches A and B are closed.

2. 3. NOT Gate

- It has a single input and one output.
- It called also an inverter
- The purpose of the NOT gate is to change one logic level to the opposite level.In term of bits, it change '1' at its input to logic '0' at the output , and a '0' to a logic '1'.
- The NOT operation is represented by a bar.
- The standard logic symbol for the NOT gate is shown as



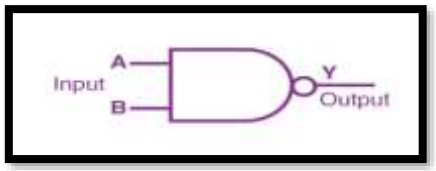
- The truth table for a NOT gate is shown below:

A	$\overline{A}$
0	1
1	0

➢ **2.Derived Gates:**

2. 1. NAND Gate

- It is actually a NOT-AND gate.
- Gives an output of 1 if both inputs are not 1.
- The standard logic symbol for the NAND gate is shown as

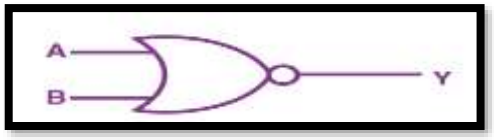


- The Boolean expression of the NAND gate is $Y = \overline{A.B}$
- The Truth table for a 2-input NAND gate is given as

A	B	$Y = \overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

2. 2. NOR Gate

- This gate is the combination of OR and NOT gates.
- Produces an output 1 when all inputs are 0.
- The standard logic symbol for the NOR gate is shown as

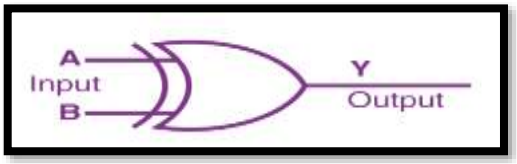


- The Boolean expression of the NOR gate is $Y=\overline{A+B}$
- The truth table for a 2-input NOR gate is as follows

A	B	$Y=\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

2.3. XOR Gate

- The output is 1 only if both inputs are different.
- The XOR of two variables is written by $\oplus$.
- The standard logic symbol for the XOR gate is shown as



- The Boolean expression of the XOR gate is $Y=A\oplus B$
- The truth table for a 2-input XOR gate is

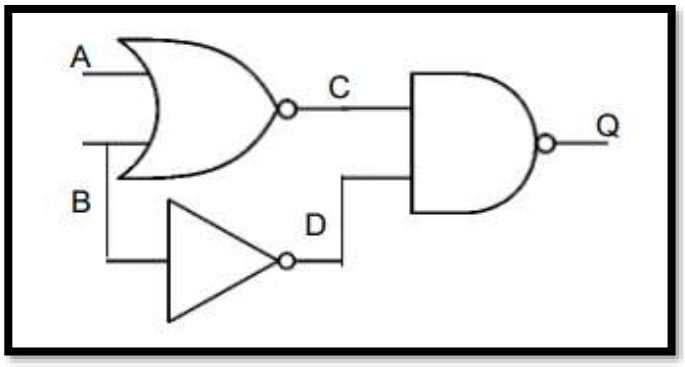
A	B	$Y=A\oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

Exercises related to the fourth chaptre

Exercice

The figure below shows a logic circuit and its incomplete truth table.

Complete the below truth table.



A	B	C	D	Q
	0			
	1			
	0			
	1			

Solve exercises related to the fourth chaptre

A	B	C	D	Q
0	0	1	1	0
0	1	0	0	1
1	0	0	1	1
1	1	0	0	1

.

Exam Topics with Solutions

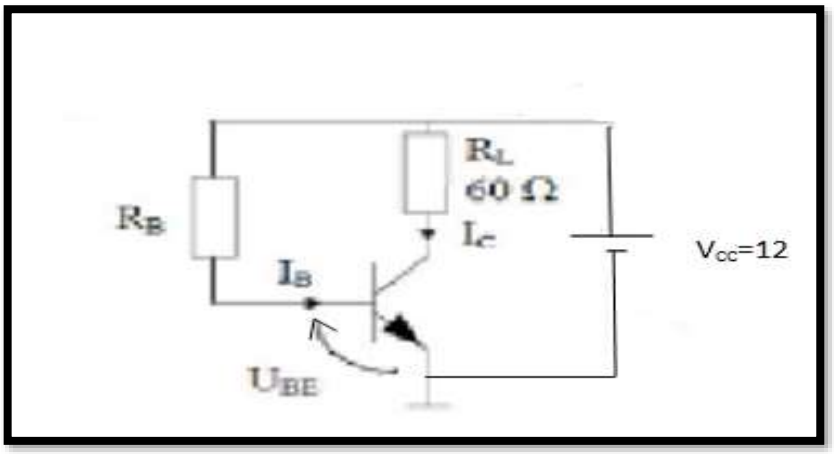
Exercise 1:

The following setup is assumed with a static current gain transistor β=100 and the voltage between the base and the transmitter is 0.7V.

1-If you want to have a current of 100 mA in the R_L load, what R_B resistance value should you choose?

2-If R_B is varied, then I_B varies and therefore I_C also varies. What is the maximum value that can be obtained for I_C (saturated transistor)?

3-What is the minimum value of R_B to saturate the transistor?



1)Law of Mesh

$V_{BE} + R_B I_B = V_{CC}$

$I_C = \beta I_B \longrightarrow I_B = 1mA$

So:R=11300Ω

2)The transistor is saturated so $V_{CE}=0$

Law of mesh

$V_{CC} - R_L I_C = 0 \longrightarrow I_C = 0.2A$

3)$I_B sat = \frac{0.2}{100} = 0.002A$ $I_B sat = I_C sat$

So: $R_B = 5650\Omega$

Exercise 2:
Check the appropriate answer(s):

1. In the active electronic components we find:
a. Capacitors
b. Diodes
c. Transistors
d. Resistances

2. **Kirchhoff's laws are defined by:**
a. $\Sigma\Delta I = 0$ and $\Sigma V = 0$
b. $\Sigma I = 0$ and $\Sigma V = 0$
c. $\Sigma\Delta I = 0$ and $\Sigma\Delta V = 0$
d. $\Sigma I = 0$ and $\Sigma\Delta V = 0$

3. **Transistors are mainly used as:**
a. Switches
b. Resistor
c. Transformer
d. Amplifiers

4.**The derivvative gate is**
a. NAND gate
b. OR gate
c. AND gate
d. None of the above

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