

Lab N 05 : Characteristics of a transistor and operating point

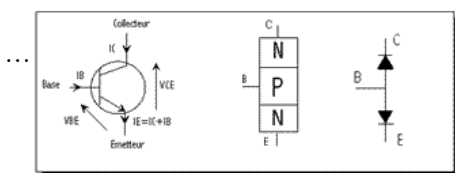
Aims of the practical work: Know the operating modes of a bipolar transistor by tracing its different characteristic curves.

A. Theoretical part

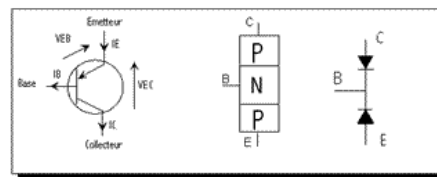
Transistor: it is a semiconductor device, which can amplify electrical currents.

The bipolar transistor is the basic technical operator of electronic functions such as amplification or switching. It is obtained by inserting a semiconductor bar between two of the opposite type. Thus, we obtain two possibilities:

Le transistor NPN :



Le transistor PNP :



The names of the 3 terminals thus constituted are: the base (B), the emitter (E) and the collector (C). The symbolic representations of transistors inform us about their type (PNP or NPN) as well as the direction of the currents.

Two junctions constitute the transistor, junctions which can be compared to 2 diodes (between B-C and B-E) whose direction depends on the type.

Working principle:

There are 2 operating modes of the transistor: linear and non-linear mode (blocked/saturated).

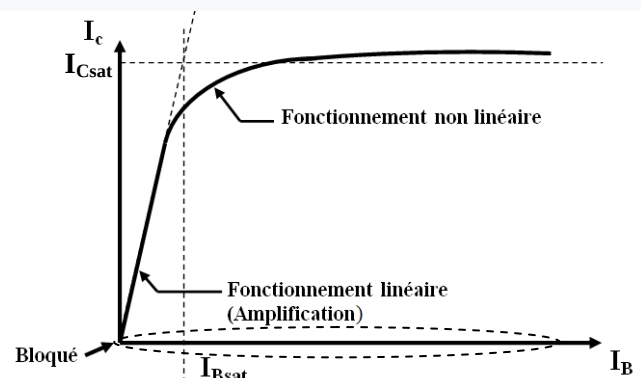
The curve representing the collector current (I_C) as a function of the base current (I_B) makes it possible to identify these 3 operating modes:

- Blocked: there is no current in the transistor.
- Linear: the current I_C is directly proportional to the current I_B , we then exploit the amplification properties of the transistor: $I_C = \beta I_B$.
- Saturated: from a certain current I_B , called saturation current I_{Bsat} , the current I_C reaches a maximum value, the transistor is said to be “saturated”.

Study of an NPN transistor:

observe and assimilate the following sentences

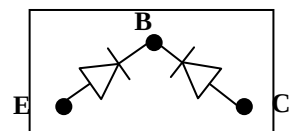
- 1- For $I_B = 0$, le Transistor is **blocked**.
- 2- For $V_{BE} < V_{BEsat}$, le Transistor is in linear mode
- 3- For $V_{CE} \approx V_{CC}$, le Transistor is **blocked**.
- 4- For $V_{CE} \approx 0$, le Transistor is **saturated**.
- 5- For $I_C < \beta I_B$, le Transistor is **saturated**.
- 6- For $I_C = \beta I_B$, le Transistor is in **linear mode**.



B. Practical part :

B.1 Transistor test :

Use the multimeter (diode test mode) to test your transistor



Check the following values
 $C \rightarrow E = O.L$ $E \rightarrow C = O.L$ $B \rightarrow C = O.L$ $C \rightarrow B = 0.666v$ $E \rightarrow B = 0.777v$ $B \rightarrow E = O.L.$
 Le transistor type is : ☐NPN or ☒PNP ?

B.2 Characteristics of the bipolar transistor.

B.2.1 Transfer characteristic $I_c = f(I_b)$.

Carry out the following assembly:

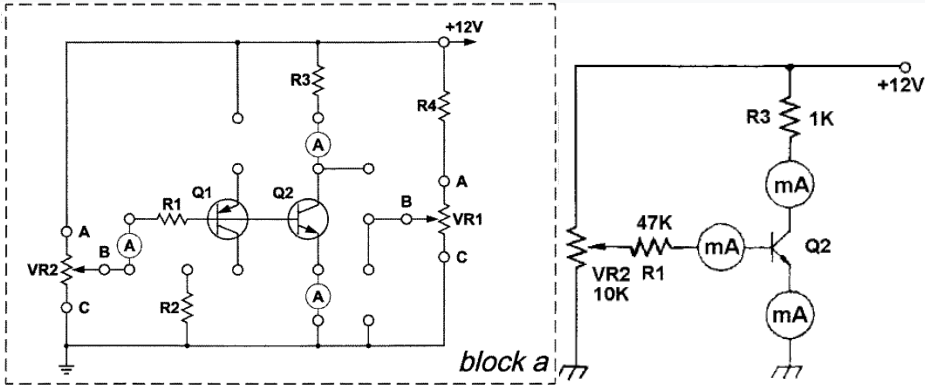


Fig. 1 : Montage pour le traçage de la caractéristique de transfert

- Connect ammeters to measure I_b and I_c
- Adjust VR2 (10K Ω) so that $I_b = 0, 10, \dots 150 \mu A$ and complete the following table:

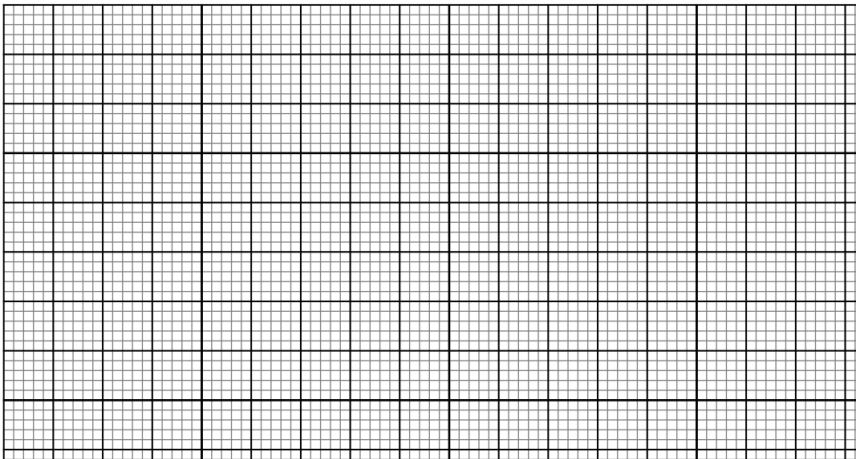
$I_B(\mu A)$	0	10	20	25	30	40	50	60	75	90	100	150
$I_C(mA)$												

Table 1

What is the value of I_{csat} (according to table 1).

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Trace the current transfer characteristic $I_c = f(I_B)$.



Specify on this curve the different operating zones of the bipolar transistor.

Read the value of I_{Bsat} from the curve.

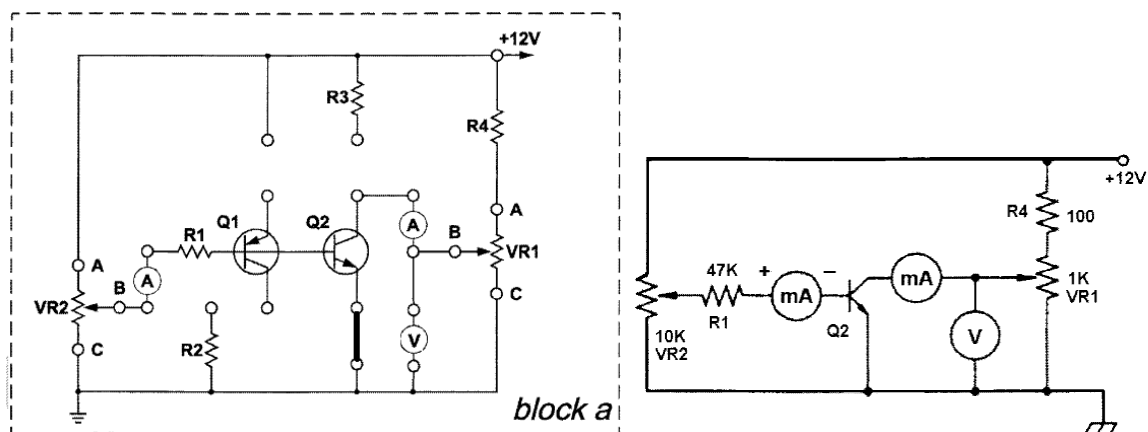
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The ratio $\beta = I_c/I_b$ in the linearity domain of the curve is called "current amplification coefficient".

Calculate the value of β

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B.2.2 Output characteristic $I_C = f(V_{CE})$ at constant I_B



- Insert the connection clip according to Fig2 (23002-block a)
- Connect ammeters and the voltmeter to measure I_B , I_C and V_{CE}
- Adjust VR2 (10k) to have different values of I_B , For each I_B , Adjust VR1 (1k) to have different values of V_{CE} according to the tables (2 to 4).

V_{CE} (V)	0.1	0.2	0.3	0.4	0.5	0.7	1.0	3.0	5.0	8.0
I_C (mA)										

Table 2 ($I_B = 0 \mu A$)

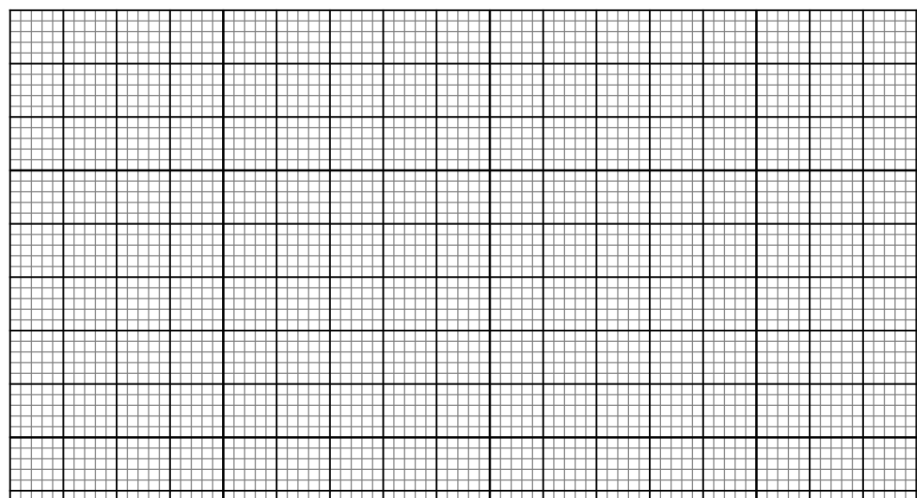
V_{CE} (V)	0.1	0.2	0.3	0.4	0.5	0.7	1.0	3.0	5.0	8.0
I_C (mA)										

Table 3 ($I_B = 20 \mu A$)

V_{CE} (V)	0.1	0.2	0.3	0.4	0.5	0.7	1.0	3.0	5.0	8.0
I_C (mA)										

Table 4 ($I_B = 60 \mu A$)

Tracer the curves $I_C = f(V_{CE})$ for different values of I_B .



Specify on the curve the operating zones of the transistor (1) blocked, (2) saturated and (3) linear.
Draw the static load line and calculate the coordinates of the rest point