BJT Transistor

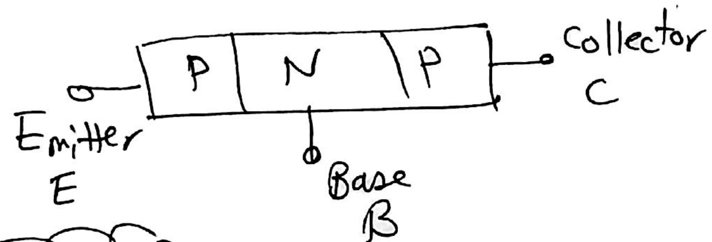
* Bjt → Bipolar junction transistor [2 PN junction Connected Back to Back], It has 3 terminal device & has 3 set of Voltage-Current characterstics.

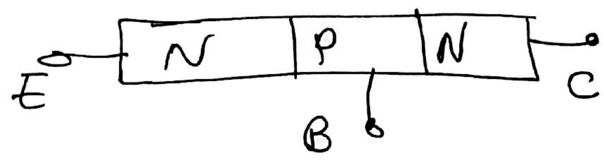
* Bjt → used to perform **amplifications** for → V, I, P

(holes / Electrons → 2carriers شغالين بـ عشان Bi)

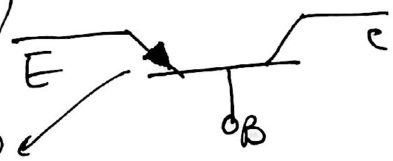
Operation

→ a semiconductor layer (N, or P) between two other type layers (N between 2P or P between 2N)



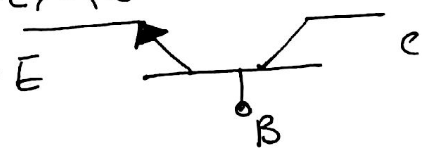


Symbol

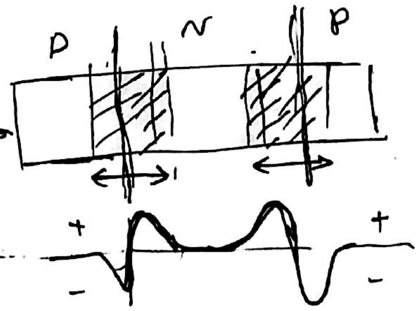


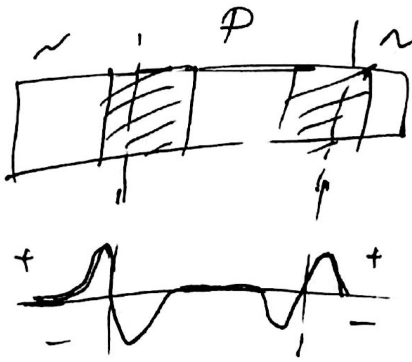
(اتجاه التيار) Conventional current

(سهم خارج (تيار))

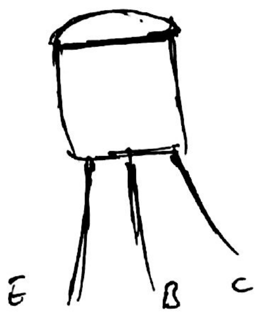


Barrier Potential





→ Barrier Potential is +ve on [n] side & -ve on [p] side

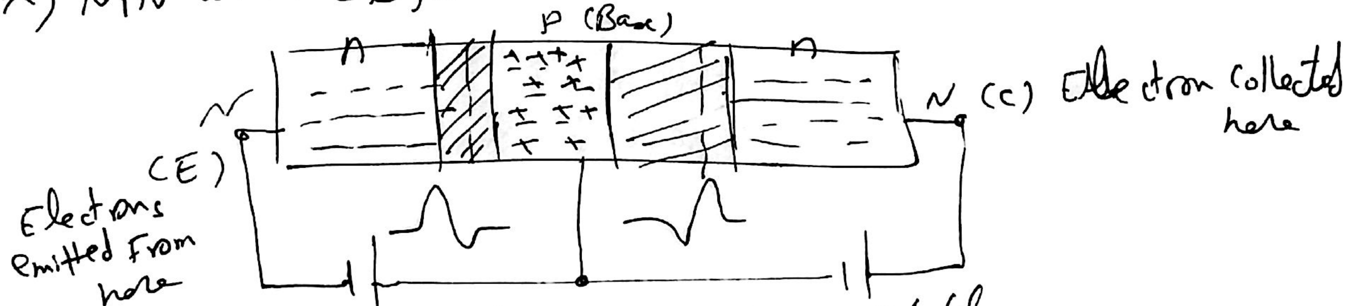


لازم نفهم عمله لل Tr. كـ Switch

وقبل ال Basic operation لازم نفهم ال amplifier operation (cont.)

- There are 2 PN junction in BJT
  (Collector-Base junction (CB) , Emitter Base junction (EB))
- to operate as amplifier (EB must be forward & BC Reverse)
- The middle layer (Base) → very thin (narrow) than the Two layers (more lightly doped)
- Because of lightly doped layer ∴ Conductivity of Base (decreased) and so, The resistance (increased), The distance bet^n CB & EB is minimized & free electrons
- The Barrier Potential are +ve in n-type & -ve in P-type

EX) NPN with EB forward & CB reverse



→ barrier potential reduced
→ Depletion region (narrow)

→ barrier potential increased
→ Depletion region (wide)

→ electrons emitted from (E) and leave n-material of (E) towards P material (Base) & move easily Because depletion Region is narrow between E & B & potential Barrier is Reduced.

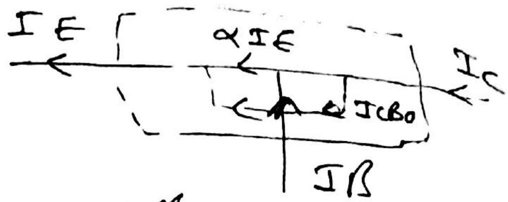
→ when arrive (PN juction (BC)), the electrons move forward rapidly Towards collector (Because of Positive Supply voltage [تنجذب الإلكترونات بسرعة]:

وعشان كدة بنقول بتتجمع الالكترونات عند collector

Transistor current

- ∴ BE junction is Forward Bias → depletion region is reduced due to reduction of Potential Barrier, BC is reverse
- ⇒ large no. of majority carriers (Electrons) diffuse across BE junction (Forward) → These electrons Enter the (Base region) and will have 2 choices.
  - → Exit to the Voltage Source Through Base terminal (X)
    مش صفر zero لأنه قليل جدا
  - → Continue flowing to the Collector across (wide depletion region (Because the positive voltage across collector layer > Voltage of Base]
- Since the Base region is lightly doped (high resistance) & " " " " is Thin, The Electrons need to travel less distance to be attracted to the high positive potential of collector ~~potential~~ terminal,
- But (Small amount of Electrons leave Base through the source connection, while the Big (major) amount of current flow into Collector.

- The current is result from (minority carrier in P (E)) + Electrons emitted from Emitter & reaches P (Base)



[1] ∴ $I_C = \alpha I_E + I_{CBo}$

αI_E → Portion of emitter Current

I_{CBo} → Reverse Current

α → Common Base Current gain $= \dfrac{\Delta I_C}{\Delta I_E}\Big|_{V_{CB}\ \text{const.}}$

I_{CBo} → Leakage Current due to Reverse Bias between (B & C)

[2] $I_E = I_C + I_B$

Solve [1] & [2] $\quad I_B = I_E - I_C = \dfrac{I_C - I_{CBo}}{\alpha} - I_C = \left(\dfrac{1-\alpha}{\alpha}\right) I_C - \dfrac{I_{CBo}}{\alpha}$

[3] β = current gain $= \left(\dfrac{\Delta i_C}{\Delta i_B}\right) = \dfrac{\alpha}{1-\alpha}$

[4] ∴ $I_B = \dfrac{I_C}{\beta} - \dfrac{I_{CBo}}{\alpha}$

Note I_{CBo} very small value [can be neglected]
لو لم يعطى قيمته أو نطلب يتم إهماله

∴ after neglecting I_{CBo}

① $I_C \cong \alpha I_E$
② $I_E = I_C + I_B$
③ $I_C = \beta I_B$
④ $\beta = \dfrac{\alpha}{1-\alpha}$

مهم جداً
وتحفظ

ex) $\alpha = 0.9 \rightarrow 0.998$

$\beta = 20 \longrightarrow 800$

EX(1)

Calculate the Value of Collector Current & Emitter Current for transistor with $\alpha_{dc} = 0.98$ & $I_{CBO} = 5\mu A$ & $I_B = 100\mu A$

Sol/

$I_C = \alpha I_E + I_{CBO}$

$I_E = \alpha [I_C + I_B] + I_{CBO}$

$\therefore I_C = 0.98 I_C + 0.98 \times 100 \times 10^{-6} + 5 \times 10^{-6}$

$0.02 I_C = 103 \times 10^{-6}$

$\therefore$ $I_C = 5.15\ mA$

EX(2)

the Collector & Base Currents of transistor are measured as $I_C = 5.202\ mA$, $I_B = 50\mu A$, $I_{CBO} = 2\mu A$, calculate (a) α_{dc}, β_{dc}, I_E (b) The new I_B Value that make $I_C = 10 mA$

Sol/

(a) $I_C = \alpha I_E + I_{CBO}$

$5.202 \times 10^{-3} = \alpha [I_C + I_B] + 2 \times 10^{-6}$

$5.202 \times 10^{-3} = \alpha [5.202 \times 10^{-3} + 50 \times 10^{-6}] + 2 \times 10^{-6}$

$\therefore$ $\alpha = 0.9909$

$\beta = \frac{\alpha}{1-\alpha} = \frac{0.9909}{1-0.9909} \cong 109$

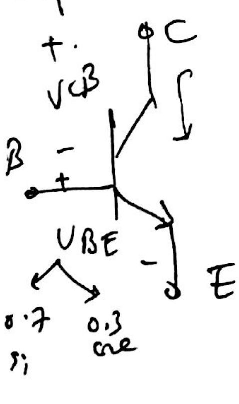
(b) $I_C = 10 mA$

$10 \times 10^{-3} = 0.99 [10 \times 10^{-3} + I_B] + 2 \times 10^{-6}$

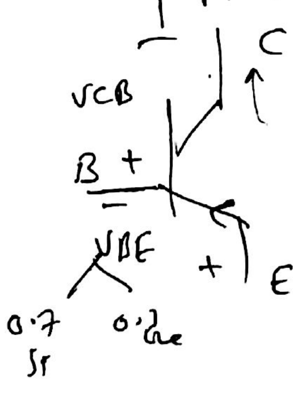
$\therefore I_B = 98\mu A$

* Transistor Voltage *

npn



pnp

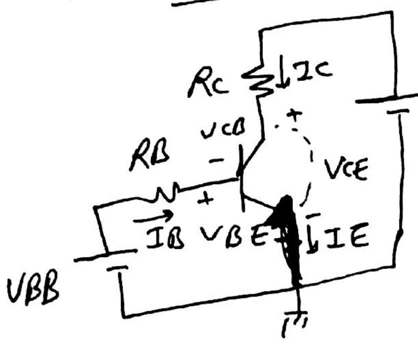


لنا [illegible] (Si) 0.7 = V_{BE} (Ge) 0.3

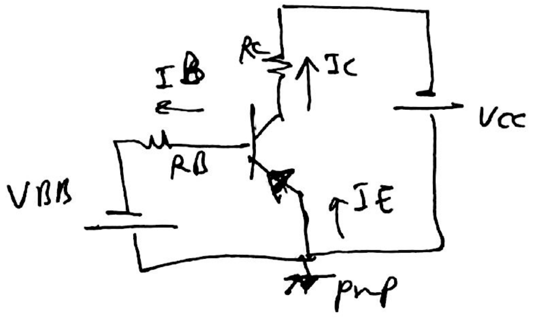
الجهد الكافي لتشغيل الترانزستور

فيما [illegible]

Transistor characterstics and parameters



npn



* V_{BB} Forward biased (Base emitter) Junction
  V_{CC} Reverse 〃 (Base collector) junction
* when (BE) forward → like Diode forward with voltage drop (0.7 V)

(1) [illegible] $V_{BE} = 0.7$

(2) * $I_B = \frac{V_{BB} - V_{BE}}{R_B}$

(3) $V_{CE} = V_{CC} - I_C R_C$

(4) $V_{CB} = V_{CE} - V_{BE}$

> there are 6 parameters
> I_C, I_B, I_E
> V_{BE}, V_{CE}, V_{CB}
> I_{CBO} (β, V_{BB}, V_{CC} [illegible])

EX(3) if $R_C = 100\,\Omega$, $R_B = 10\,k\Omega$, $V_{CC} = 10\,V$, $V_{BB} = 5\,V$, $\beta = 150$
find I_B, I_C, I_E, V_{BE}, V_{CE} and V_{CB}

Sol //
(1) $V_{BE} = 0.7$

(2) $I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{5 - 0.7}{10K} = 430\,\mu A$

(3) $I_C = \beta I_B = 150 \times 430\,\mu A = 64.5\,mA$

(4) $I_E = I_C + I_B = 64.5\,mA + 430\,\mu A = 64.93\,mA$

(5) $V_{CE} = V_{CC} - I_C R_C = 10 - (64.5 \times 10^{-3} \times 100) = 3.55\,V$

(6) $V_{CB} = V_{CE} - V_{BE} = 3.55 - 0.7 = 2.85\,V$

Solve yourself:- $R_B = 22K$, $R_C = 220\,\Omega$, $V_{BB} = 6\,V$, $V_{CC} = 9\,V$, $\beta = 90$
Find I_B, I_C, I_E, V_{CE}, V_{CB} Ans. [0.241 mA / 21.68 mA / 21.92 mA / 4.23 V / 3.53 V]