[ص ٦٤ في الملف] Lec (7) (1) (P.56→63) 1

BJT Transistor Lec (13-16)

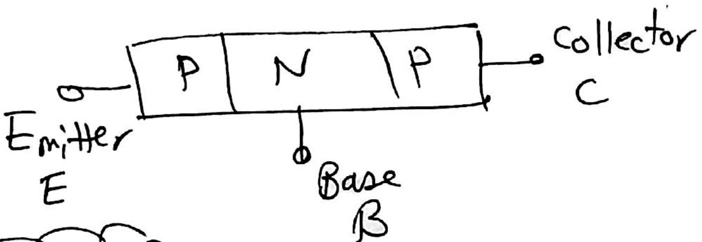
* Bjt → Bipolar junction transistor [2 PN junction Connected Back to Back] , It has 3 terminal device & has 3 set of Voltage-Current characterstics.

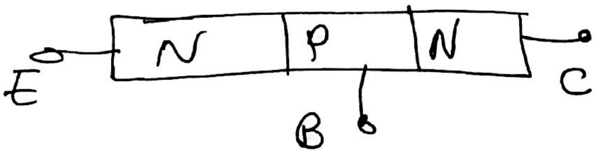
* Bjt → used to perform **amplifications** for → V, I, P

(holes, Electrons → 2 carriers, عشان فيه نوعين Bi)

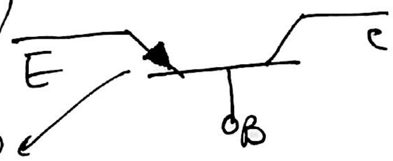
Operation

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



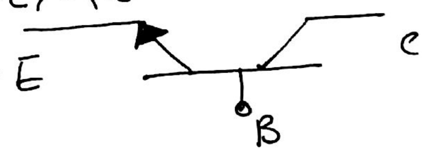


Symbol

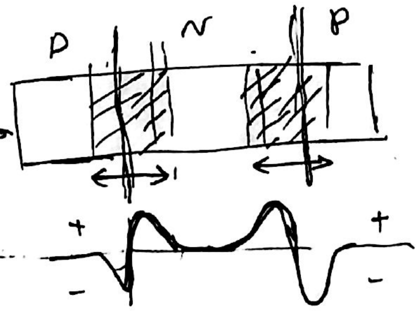


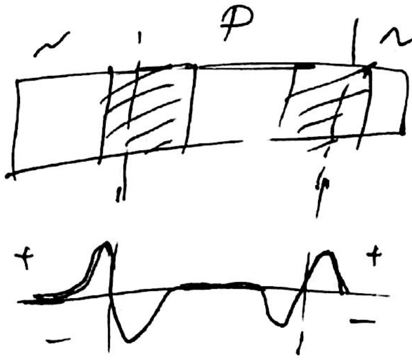
(سهم داخل) Conventional current

(سهم خارج (اتجاه))



Barrier Potential

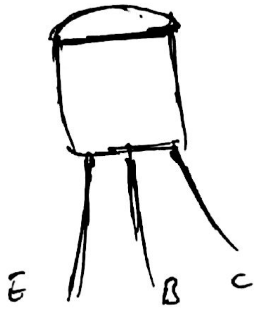




→ Barrier Potential is +ve on [n] side & -ve on [p] side

لازم تشغل ال Tr ك Switch

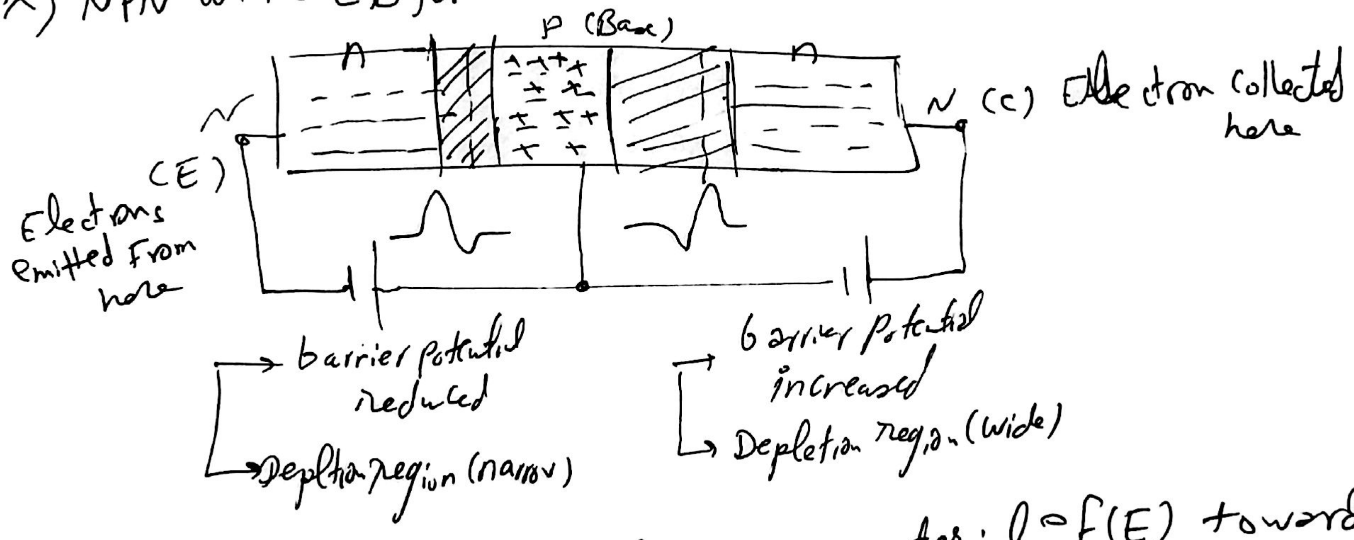
وممكن تشغله ك amplifier ال Basic operation



operation (<u>cont.</u>)

- 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



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

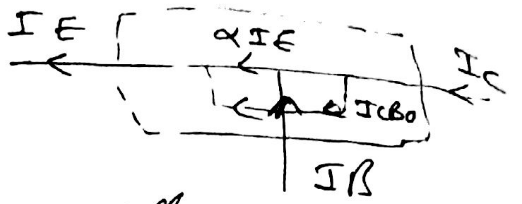
→ when arrive (PN junction (<u>BC</u>)), The electrons move forward rapidly Towards collector (Because of Positive Supply voltage [تنجذب ناحية البطارية بسرعة]:

وعندها كأنها بتقول 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 termi'l (X) مش 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 $= \left.\dfrac{\Delta I_C}{\Delta I_E}\right|_{V_{CB}\ \text{Const.}}$

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]
للعلم بعض مرات لو اتطلب تم اهماله

∴ after neglecting I_{CBo}

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

مهم جداً
وتُحفظ

مثال / 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/

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

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

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

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

$\therefore$ $I_C = 5.15\ mA$

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 $I_C = 10mA$

Sol/

ⓐ $I_C = \alpha I_E + I_{CBO}$

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

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

$\therefore$ $\alpha = 0.9909$

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

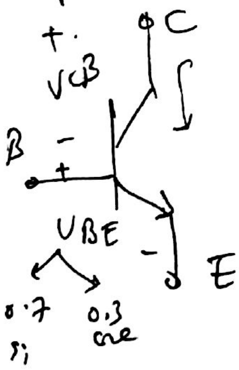
ⓑ $I_C = 10mA$

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

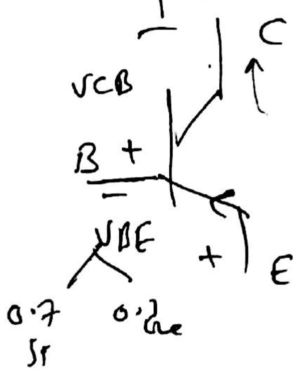
$\therefore I_B = 98\mu A$

* Transistor Voltage *

npn



pnp

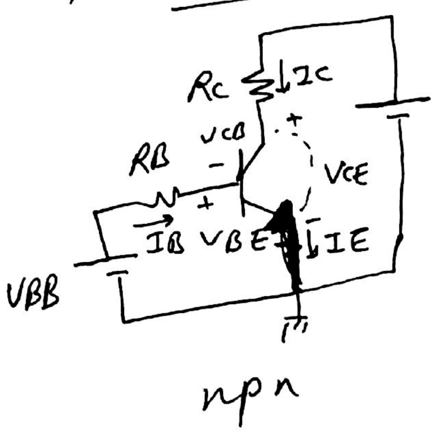


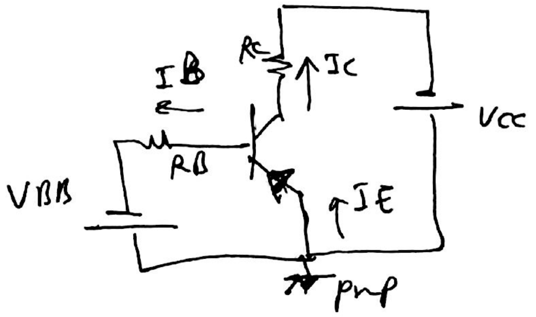
الجهد الكافي لتشغيل الترانزستور

لنا (Si) 0.7 = VBE
(Ge) 0.3

فيما بعد ازاي

Transistor characterstics and Parameters





* NBB Forward biased (Base emitter) Junction
Ncc Reverse " (Base collector) junction

* when (BE) forward → like Diode forward with voltage drop (0.7 V)

(1) ∴ $V_{BE} = 0.7$

(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} تعطى لك

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]