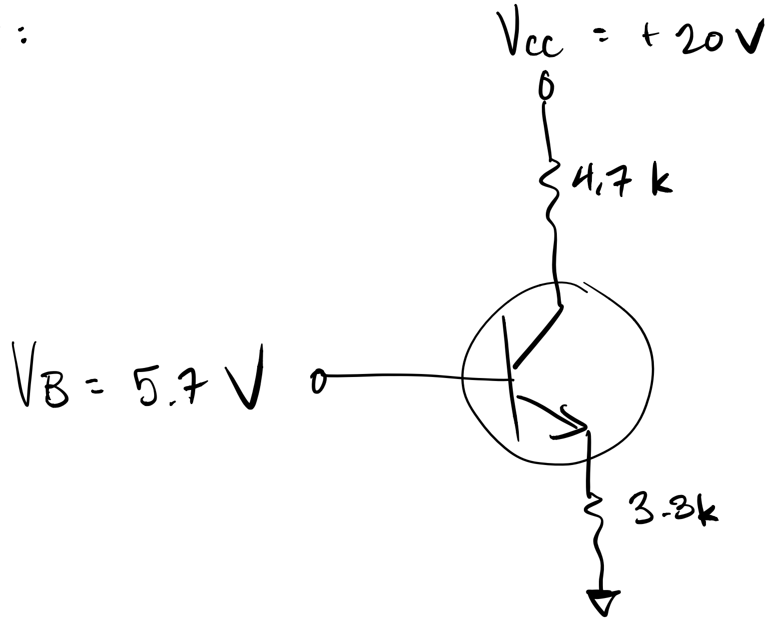
BJT Active Region Circuits

ex:



NPN

"never pointing in"

PNP: 

∴ determine V_E, I_E, I_B, I_C,
V_C, and V_{CE} if $\beta = 100$

∴ first, assume transistor is ON and operating in active region.

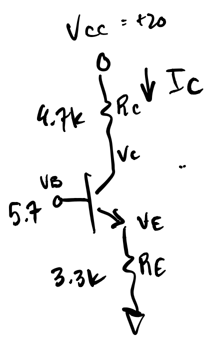
NPN : $V_{BE} \cong 0.7V$ (Si)

$$V_{BE} = V_B - V_E$$

$$\therefore V_E = V_B - V_{BE}$$

$$= 5.7V - 0.7 = 5V$$

known!



then $I_E = \dfrac{V_E}{R_E} = \dfrac{5V}{3.3k} = 1.515\text{ mA}$

$$I_E = I_B(1+\beta)$$

$$\longrightarrow I_B = \frac{I_E}{1+\beta} = \frac{1.515}{101} = 0.015\text{ mA}$$

or $15\ \mu A$

$$I_C = \beta I_B$$

$$= 100 \cdot .015 = 1.5\text{ mA}$$

$$V_C = V_{CC} - R_C I_C = 20 - 4.7\cancel{k} \cdot 1.5\cancel{m} = 12.95$$

- finally, $V_{CE} = V_C - V_E$

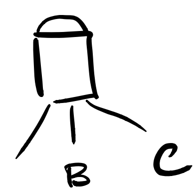
$= 12.95 - 5 \approx \underline{8V}$

- $\underline{\text{practical}}$ transistors have $\underline{\text{ratings}}$, just like diodes

$\underline{2N3904}$

- mid 1960s
- still made today!

- NPN Silicon small-signal transistor
  - usually in $\underline{\text{TO-92}}$ package



$V_{CE_0}(max) = \underline{40V} \leftarrow \ggg 8V$ (ok!)

at 0 current

$V_{EB_0}(max) = \underline{6V} \leftarrow$ implies $\underline{\text{reverse}}$ bias of base-to-emiter junction $< 6V$ (we're not reverse-biased!)

$\beta = 100$ (typical)

min. : 30 @ $I_C = 100$ mA

max. : 300

I_C (max) = $\underset{\sim}{200 \text{ mA}}$ ← 1.5 <<<< 200 (ok!)

$P_{diss\,(max)} = 625$ mW

.. better check!

$P_{diss} = I_C \cdot V_{CE}$

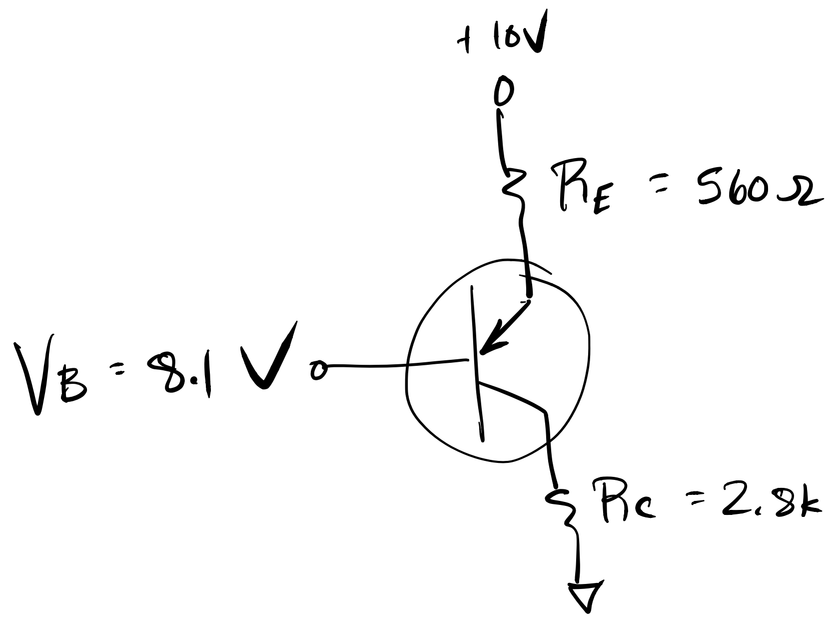
$= 1.5 \cdot 8 = \underset{\sim}{12 \text{ mW}}$

(ok !!!)

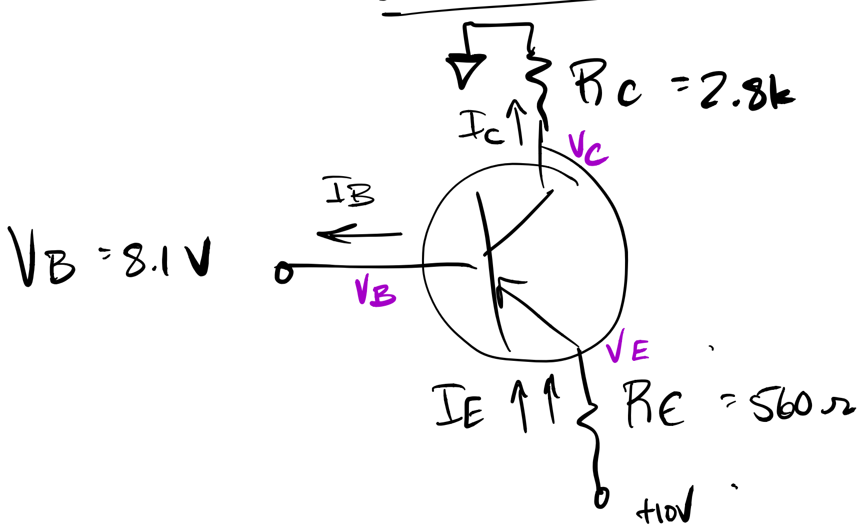
(side note : V_{CC} power supply voltage)

collector !!!

∴ let's do a PNP example (book!)



∴ Joe Tritschler recommends drawing PNP circuits with collector on top and emitter on bottom!



$\because$ for PNP Si transistor, $V_{BE} = -0.7V$

$$V_E = V_B - V_{BE}$$

$$= 8.1 - (-0.7) = 8.8V$$

$$I_E = \frac{10 - V_E}{R_E} = \frac{10 - 8.8}{560}$$

$$I_E = 2.14 \text{ mA}$$

$$I_E = I_B(1+\beta)$$

$$\longrightarrow I_B = \frac{I_E}{1+\beta} = \frac{2.14}{101}$$

$$I_B = 0.0212 \text{ mA} \quad (\text{or } 21.2 \,\mu A)$$

$$I_C = \beta I_B = 100 \cdot .0212 = 2.12 \text{ mA}$$

- watch current direction !!!!!

$$V_C - I_C R_C = 0$$

$$\longrightarrow V_C = I_C R_C$$

$$= 2.8k \cdot 2.12\,mA$$

$$= 5.94\ V$$

then $V_{CE} = V_C - V_E$

$$= 5.94 - 8.8$$

$$V_{CE} = -2.86\ V$$

yes! Negative voltage!

- practical PNP small-signal transistor:

2N3906 - compliment to 2N3904
- same ratings!