ITE – Homework 5

Problem 1 BJT V_t, α, β, V_{th}

(a) V_t = thermal voltage = constant =

$= \frac{kT}{e} = 26\,mV$ (at 300K)

$\alpha = I_C/I_E$ = Ratio of I_C to I_E =

= Fraction of I_E that reaches the C
(C = collector)

Typical values $\alpha \approx 0.95 \ldots 0.99$

$\beta = \frac{\alpha}{1-\alpha}$ = Ratio of I_C to I_B

β derives itself from α

Typical values $\beta \approx 40 \ldots 200$

V_{th} = BE diode threshold voltage

= 0.7V for Si BJTs

(b) α is best suited to understand BJT

α = Fraction of E current that reaches C

α is very close to 1.0

(c) β is relevant in practice

$$\beta = I_C / I_B \qquad \beta = \frac{\alpha}{1-\alpha}$$

β relates output (current I_C) to input (current I_B). This is of interest to us.

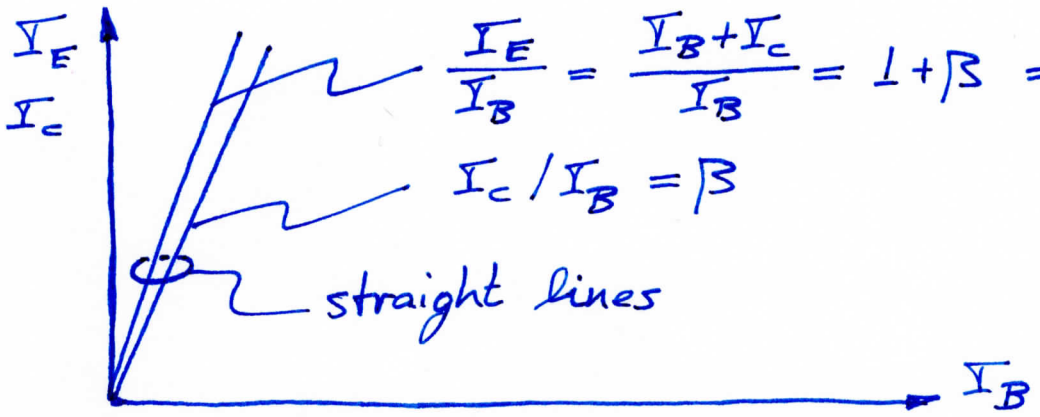
(d) α depends strongly on the base width W_B

$W_B \downarrow \Rightarrow \alpha \uparrow$

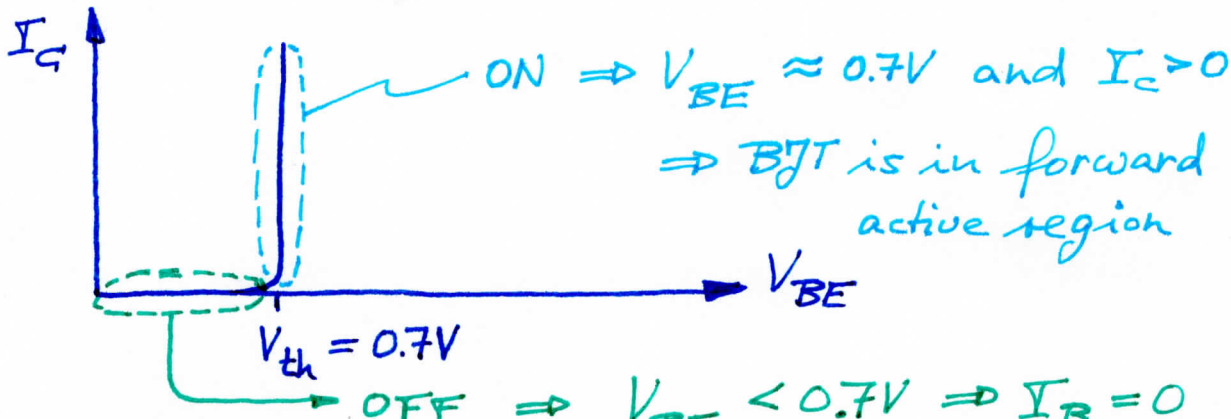
Note that β also depends on W_B because β depends on α.

Problem 2 BJT characteristics

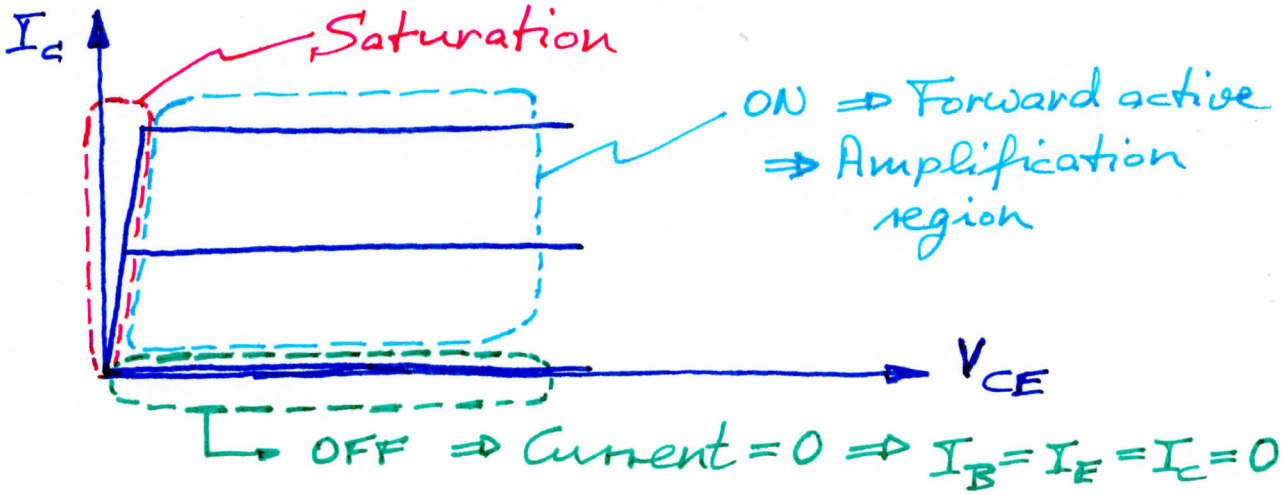
(a) I_E-versus-I_B and I_C-versus-I_B



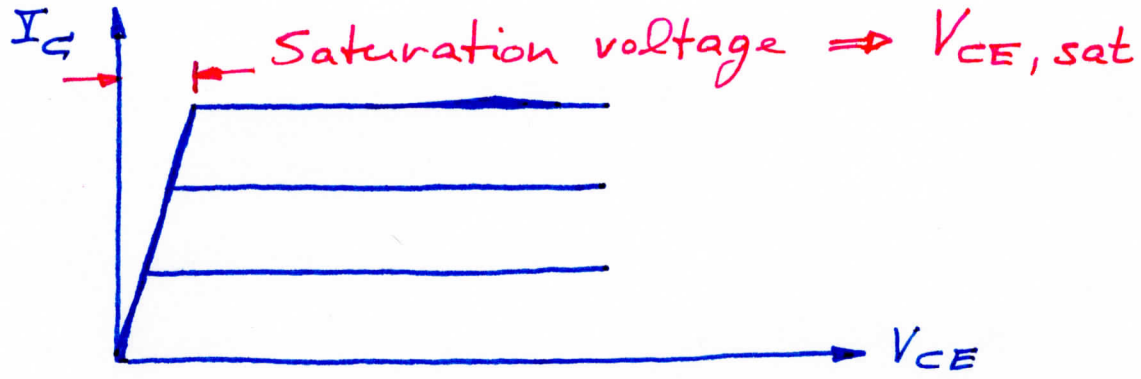
(b) I_C-versus-V_{BE}



(c) I_C-versus-V_{CE}



(d) Saturation voltage



KVL $\quad V_{CE} = V_{BE} + V_{CB}$

$V_{BE} \rightarrow 0.7V$

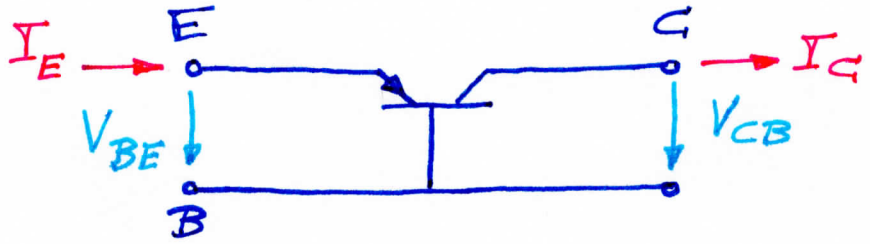
If $V_{CE} = 0 \Rightarrow V_{CB} = 0.7V \Rightarrow$ CB in forward direction ⇒ This must not happen.

If CB diode is forward biased, then collector injects carriers (rather than collecting carriers.

Typical value for $V_{CE,sat} \approx 0.2V$

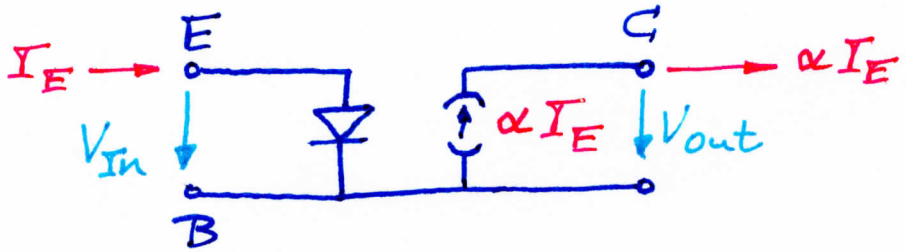
Problem 3 BJT circuit

(a) Common-B BJT amplifier



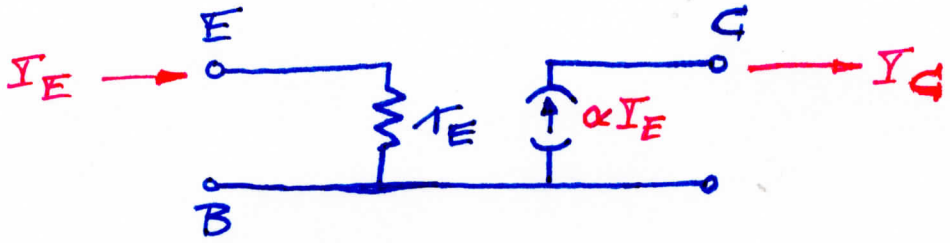
(b) Large-signal equivalent circuit

⇒ BE diode is a diode



(c) Small-signal equivalent circuit

⇒ BE diode is linearized ⇒ Becomes resistor



$$r_E = \frac{V_t}{I_E} \Rightarrow r_E \text{ is small because BE diode is forward biased}$$

(d) We prefer a large input resistance (so as to not overload the signal source). The common-B amplifier for this reason is rarely used.