Lecture 18

<u>Transistor analysis</u> (recap)

Two parts

① Large signal (Q-pt)

⇒ non-linear element transistor

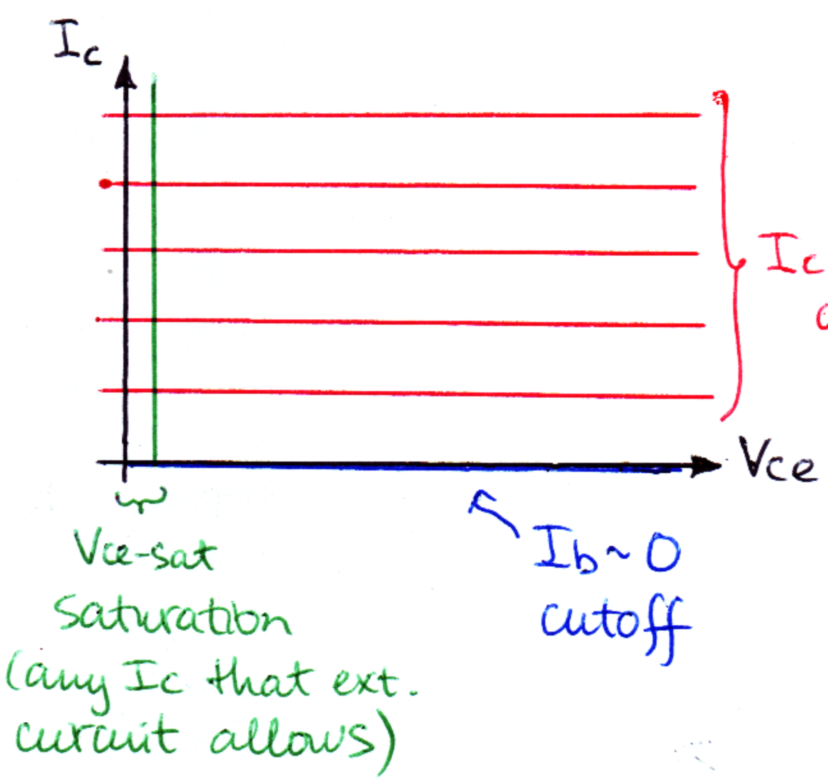
approx. of the actual transfer characteristics:

i) $V_{be} < 0.6V$, $I_b \sim 0$, $I_c \sim 0$, $I_e \sim 0$ → cutoff

ii) $V_{be} \sim 0.6V$, $V_{cb} > 0$, $I_b \sim$ small, $I_c = \beta I_b$, $I_e \approx I_c$ → active

iii) $V_{be} \sim 0.6V$, $V_{cb} \sim -0.4V$ → saturation

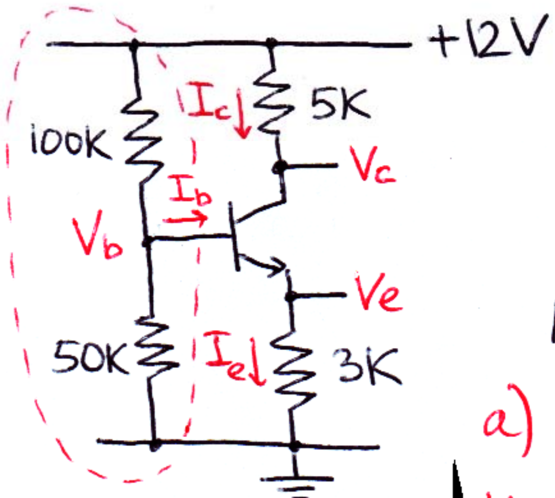
$$\beta_{sat} = \frac{I_c}{I_b} < \beta \; ; \quad V_{ce} = V_{ce\text{-}sat} \sim 0.2V$$



② Small-signal analysis

- makes sense if transistor is in active
- replace DC values → 0's ; $i_c = \beta \cdot i_b$, $r_e = \frac{V_T^*}{(I_c)_Q}$
- linear behaviour

Example: large signal analysis (Q-pt determination)



Find I_b, I_c, I_e
V_b, V_c, V_e

Assume $\beta = 100$, $V_{be} \sim 0.6V$
$V_{ce\text{-}sat} \sim 0.2V$

Method 1)

a) ( ) → Thev. equivalent

$V_{Th} = +12V \frac{50}{100+50} = +4V$

$R_{Th} = 100K \parallel 50K = 33.3K$

b) assume Q = active (if not true, change your mind)

$I_b = \frac{V_{Th} - V_b}{R_{Th}}$, $I_e = I_b(\beta+1) = \frac{V_e}{R_e} = \frac{V_b - 0.6V}{R_e}$; Solve for V_b, I_b

⇒ $V_b = 3.66V$, $I_b = 0.010\,mA$
$V_e = 3.06V$, $I_e = 1.031\,mA$, $I_c = 1.021\,mA$

Method 2) (method 1 is "too exact" : β is known @ 10-20% level at best)

$I_b \sim$ small , ⇒ $V_b \sim 4V$, $V_e \sim 3.4V$, $I_e \sim 1.1mA \simeq I_c$
$I_b = \frac{I_c}{\beta} \sim 0.011\,mA$

$V_{b,new} = V_{Th} - I_b R_{Th} \sim 3.6V$ (off by 0.4V) ⇒ $V_{e,new} = 3V$

overall error due to $I_b \to 0$ is 10% (good enough)