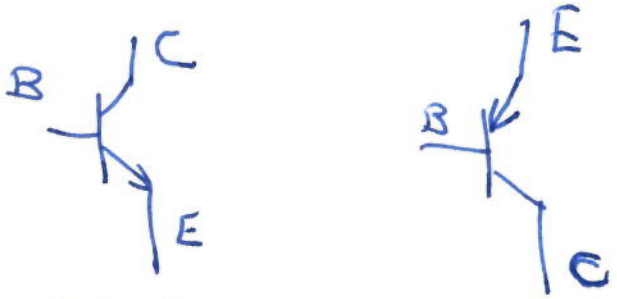
BJT symbols



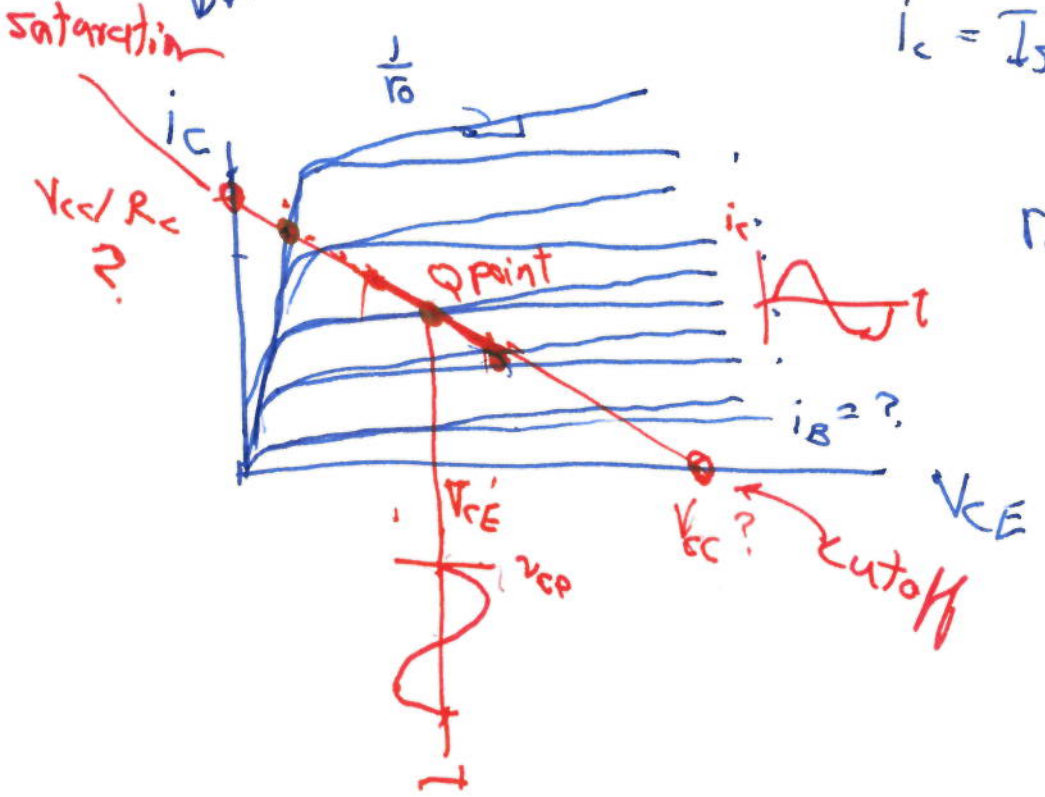
$i_C = \beta i_B$

$i_E = i_C + i_B$

$i_E = (\beta + 1) i_B$

$i_C = \alpha i_E \qquad \alpha = \frac{\beta}{\beta + 1}$

$i_C = I_S e^{V_{BE}/V_T}$

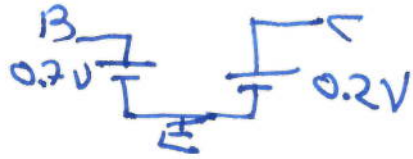


$r_o = \frac{V_A}{I_C}$ ← Early voltage ← DC "current Q point"

Active $V_{BE} = 0.7\,V \qquad I_C = \beta I_B$

$V_{CE} \geq 0.2\,V$

Saturation $V_{BE} = 0.7\,V \qquad V_{CE} = 0.2\,V$



cutoff

$I_? = 0$ (2) $V_{CE} = V_{cc}$

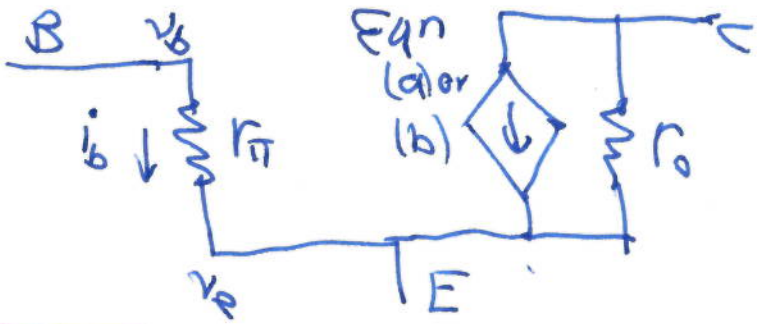
Small Signal Model

$V_T = 25\,mV$

(a) $i_c = \beta\, i_b$ or $g_m = \frac{I_C}{V_T}$ (b) $i_c = g_m V_{be}$

$r_\pi = \frac{\beta V_T}{I_C}$

$r_o = \frac{V_A}{I_C}$ or $\left(\frac{d i_c}{d V_{CE}}\right)^{-1}$



AC circuit

Small v_{in} or i_{in} → v_{out} or i_{out}

R_{in} R_{out}

$A_v = \frac{v_{out}}{v_{in}}$ $R_{out} = \frac{V_{out}(R_L \to \infty)}{i_{out}(R_L \to 0)}$

$A_i = \frac{i_{out}}{i_{in}}$

$R_{in} = \frac{v_{in}}{i_{in}}$

Typical circuits

Common Emitter $|A_V| > 1$ $|A_i| > 1$

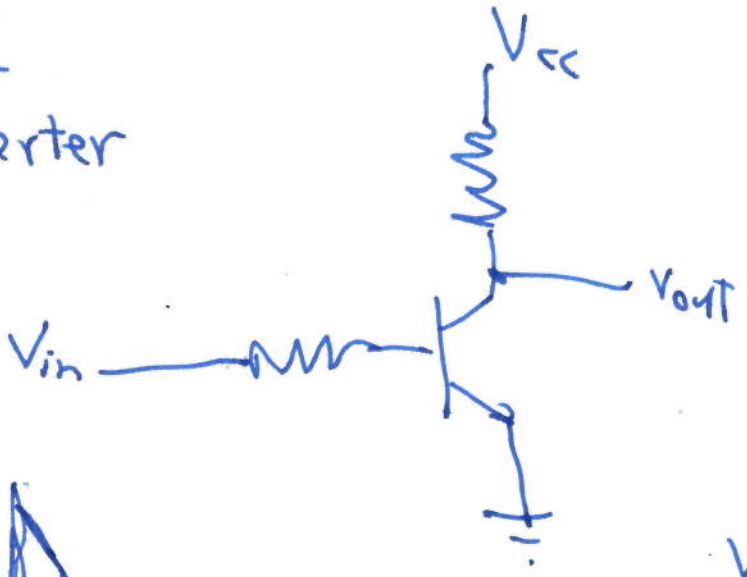
Common Base $A_i \approx 1$

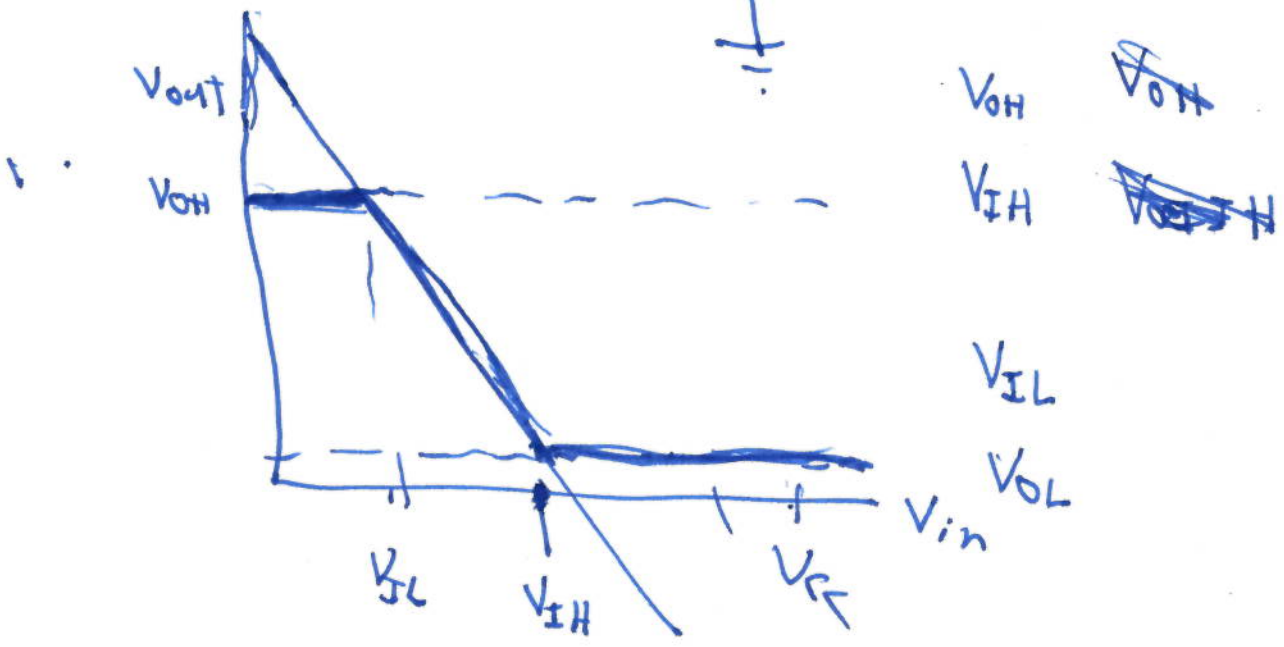
Common Collector $A_V \approx 1$

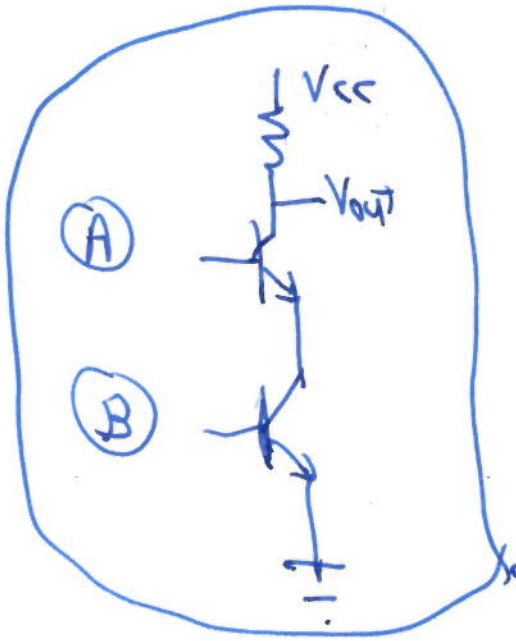
4 - Resistor Model.

Logic

Inverter







IN		OUT	
A	B		
L	L	H	H
L	H	H	L
H	L	H	L
H	H	L	L

NAND NOR