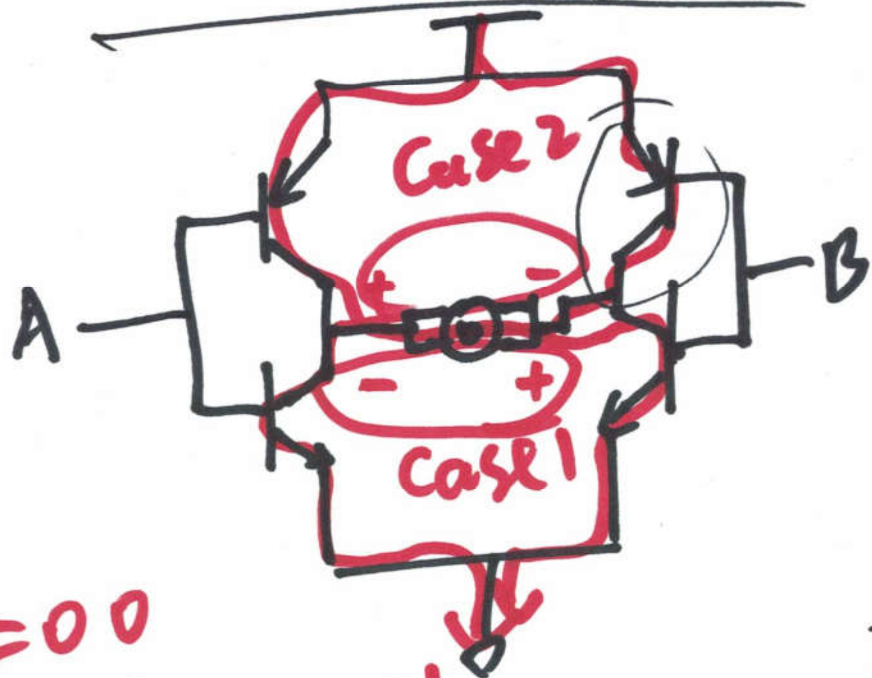
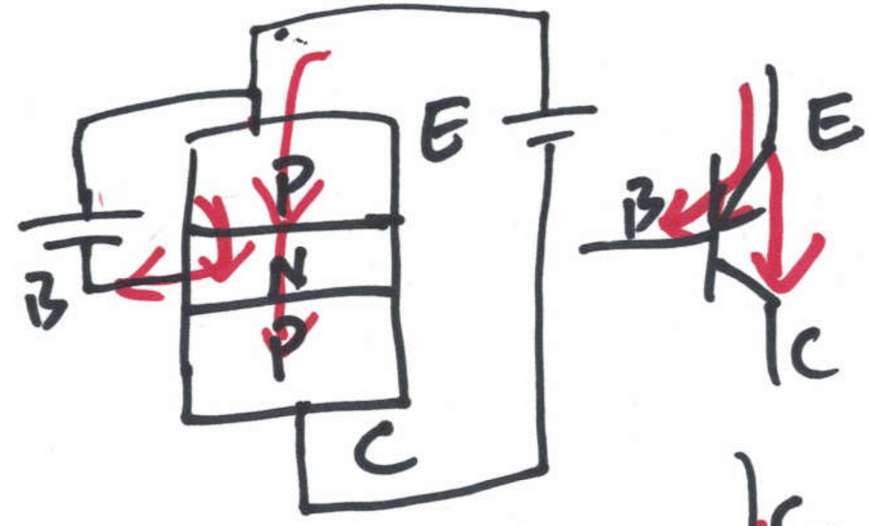
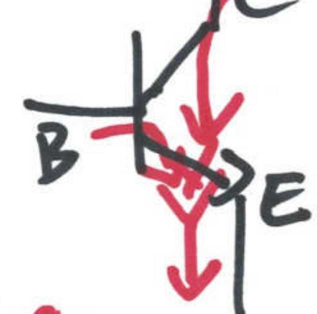
More BJTs

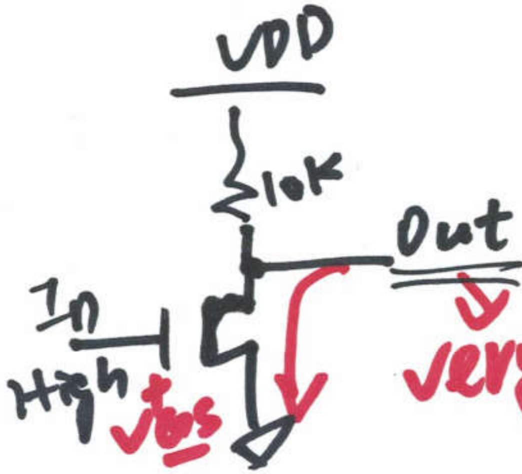
① The H-Bridge



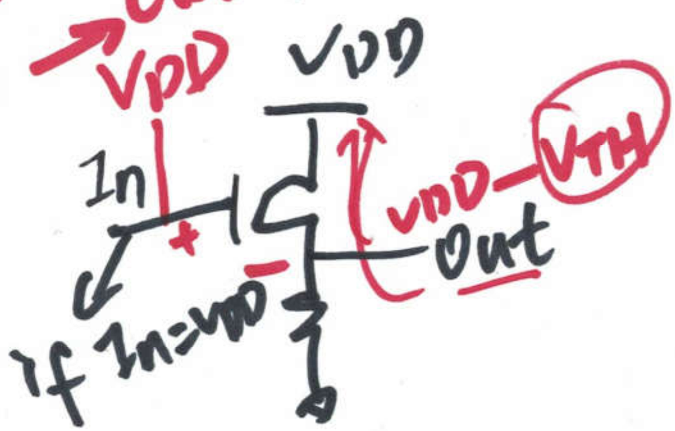




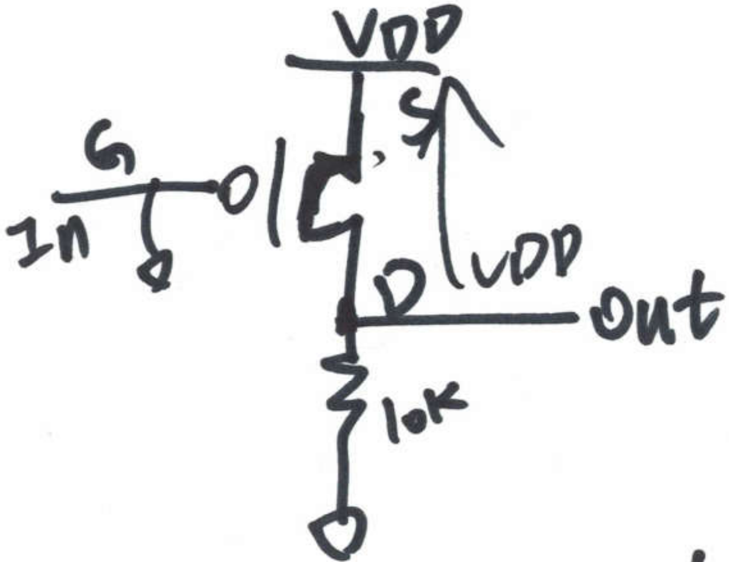
AB=00
AB=11
AB=10 → case 1
AB=01
↓
case 2

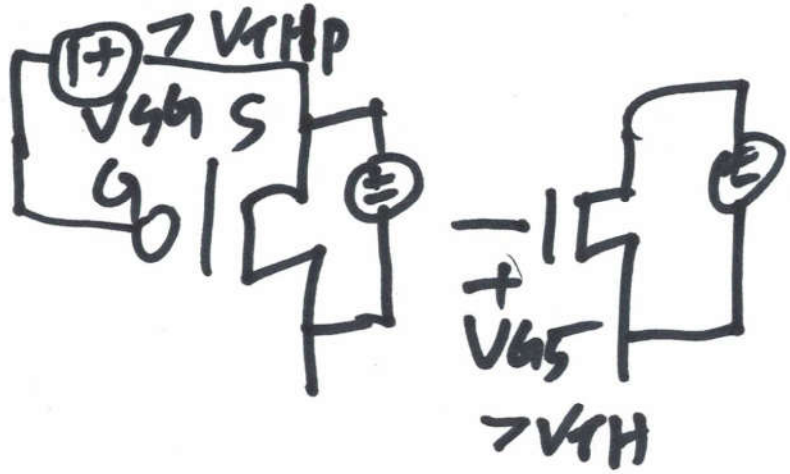


very close to GND

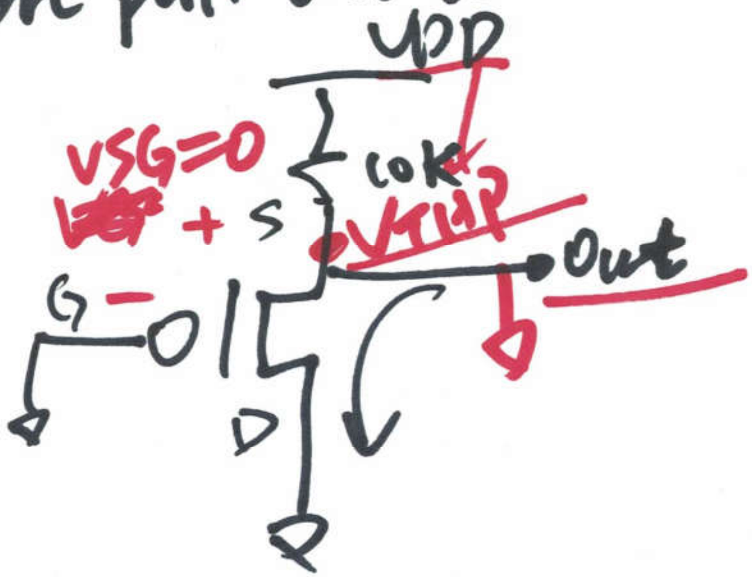


NMOSes are good at pulling to GND

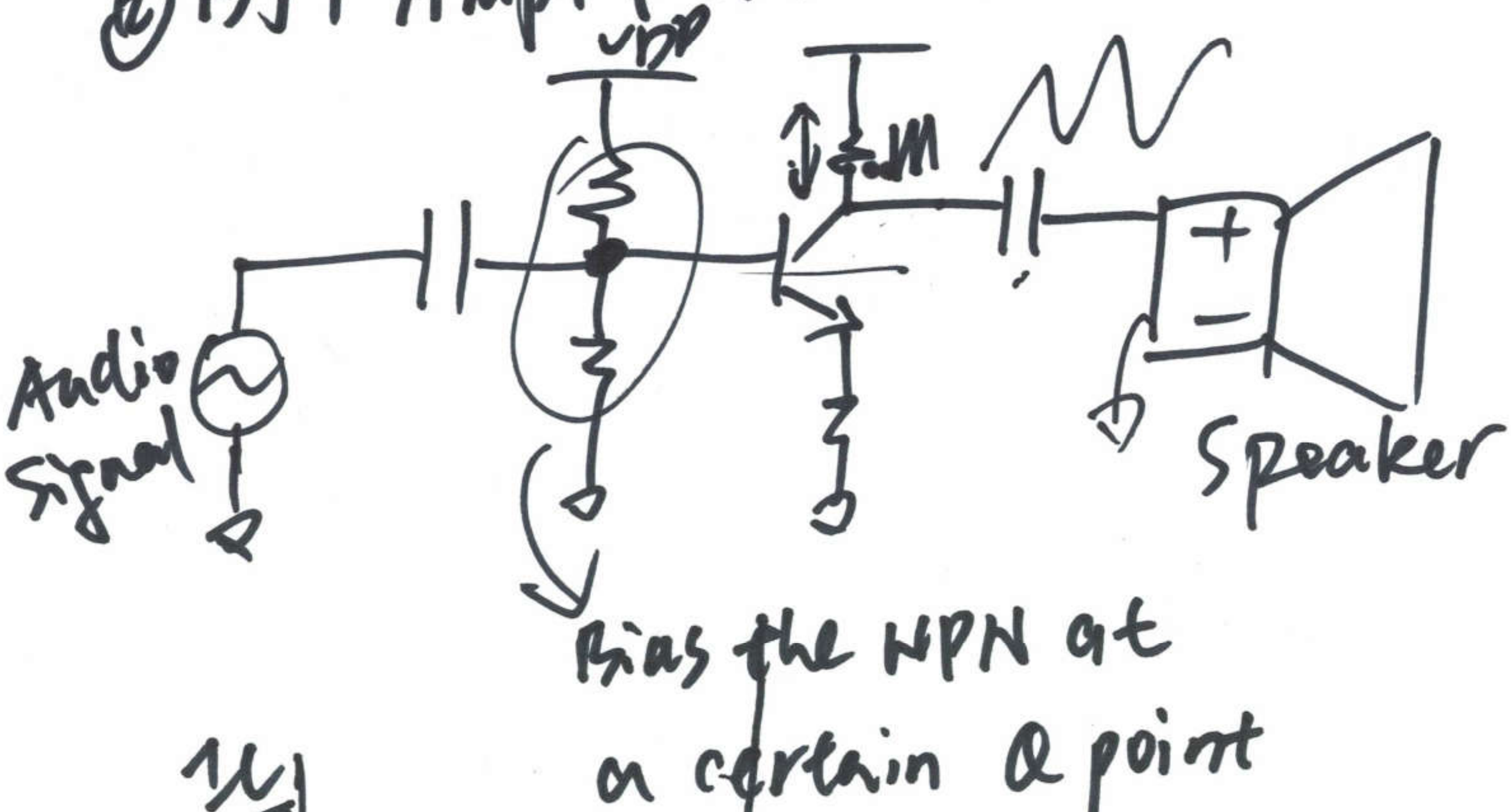




PMOSes are good at pull out to VDD



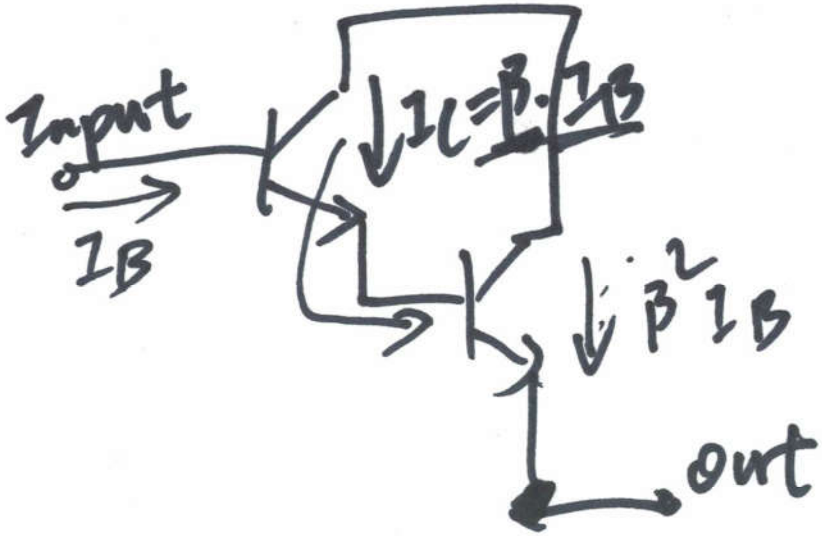
② BJT Amplifier:



③

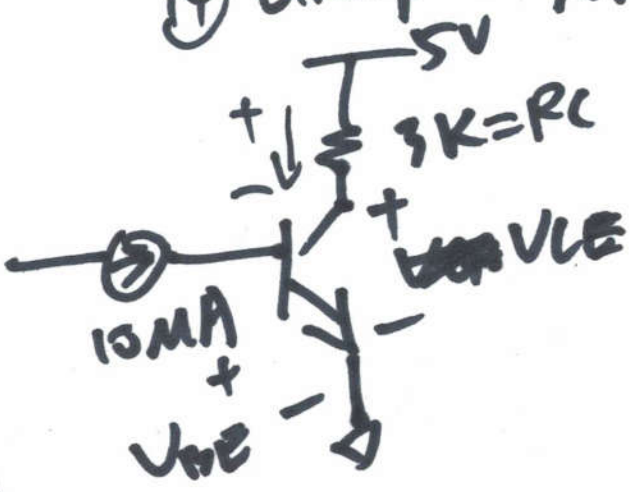
③ Multi-stage Amplifiers

△ Darlington Amplifier



$$I_C = I_S \cdot e^{V_{BE}/V_T}$$

④ Example: NPN BJT, $I_S = 10^{-15}$ A, $\beta = 100$, ① what is V_{BE} and V_{CE}?



① $\begin{cases} V_{CE} = 5V - I_C \cdot R_C \\ I_C = \beta \cdot I_B = 100 \cdot 10\mu A \end{cases}$

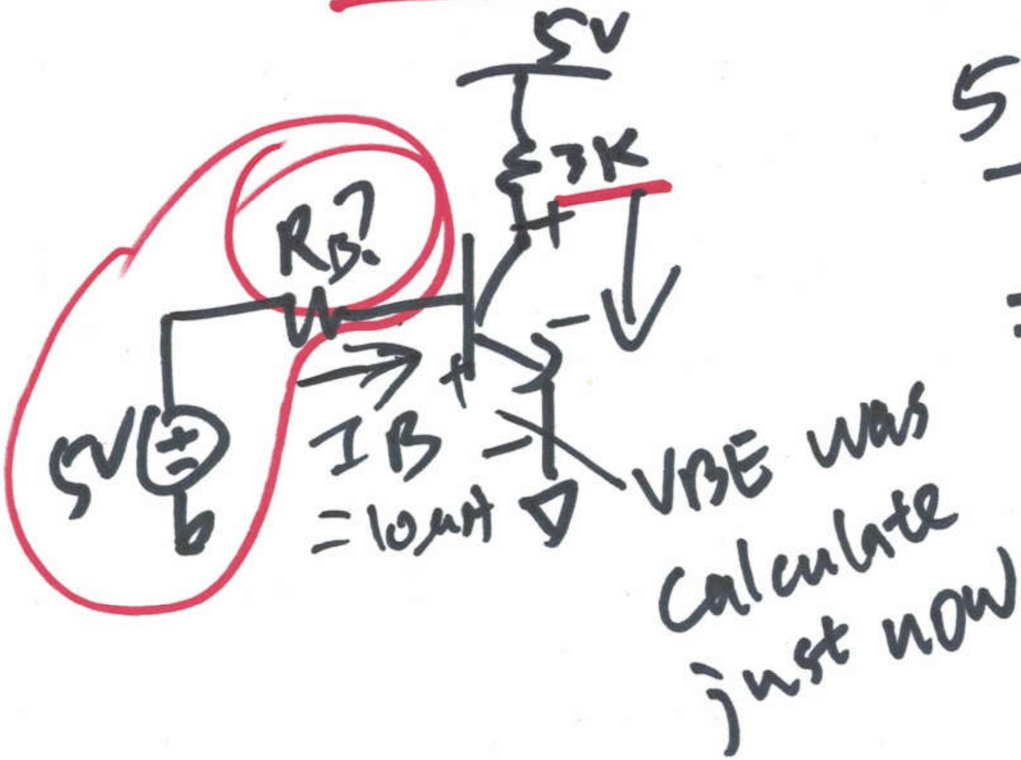
25mV

$I_C = I_S \cdot e^{V_{BE}/V_T} \Rightarrow e^{V_{BE}/V_T} = \frac{I_C}{I_S}$

$\frac{V_{BE}}{V_T} = \ln \frac{I_C}{I_S} \Rightarrow V_{BE} = V_T \cdot \ln \frac{I_C}{I_S}$

② Replace the 10μA current source with a resistor and a 5V voltage source. what resistance is required to result in the same operation?

⇓ same I_C, I_B, V_{CE}, V_{BE}



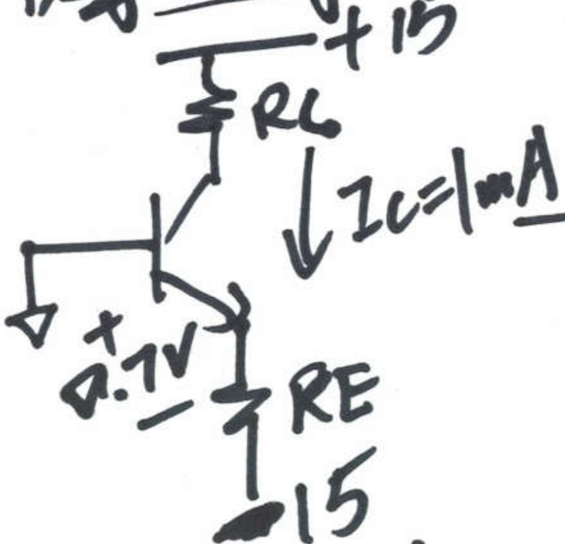
$$\frac{5V - V_{BE}}{R_B} = 10\mu A$$

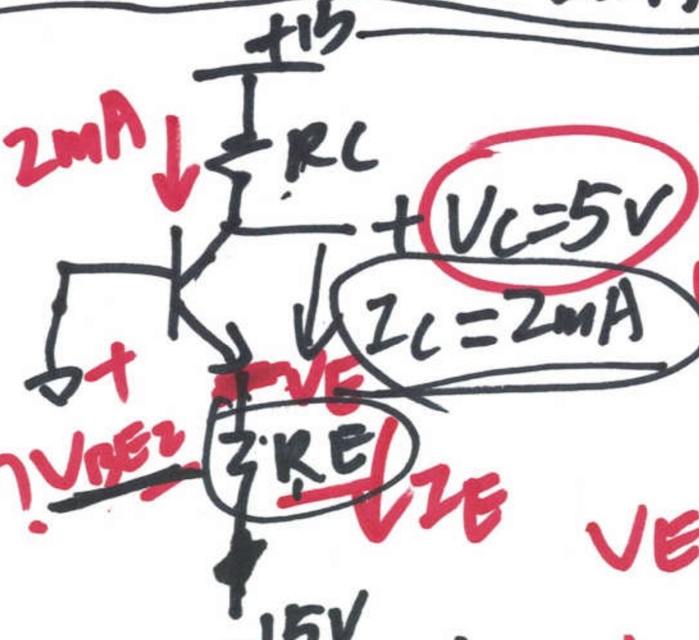
$\Rightarrow R_B$ can be calculated

Example:

$\beta = 100$, $V_{BE} = 0.7V$ at $I_C = 1mA$.

Design the circuit so that $I_C = 2mA$, $V_C = 5V$.





$V_{RC} = 15 - 5 = 10V$

$R_C = \frac{V_{RC}}{I_C} = \frac{10V}{2mA} = \square$

$V_E = -V_{BE2}$

$V_{RE} = V_E - (-15)$

$R_E = \frac{V_{RE}}{I_E}$

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

$$\begin{cases} \overset{1mA}{I_{C1}} = I_S e^{\overset{0.7}{V_{BE1}}/V_T} \\ \overset{2mA}{I_{C2}} = I_S e^{V_{BE2}/V_T} \end{cases}$$

$$\frac{I_{C1}}{I_{C2}} = \frac{I_S e^{V_{BE1}/V_T}}{I_S e^{V_{BE2}/V_T}}$$

$$\frac{1mA}{2mA} = e^{(\overset{0.7}{V_{BE1}} - V_{BE2})/V_T}$$

$V_{BE2} = \ldots$

(b)

$$I_C = \beta I_B$$

$$\alpha I_E = I_C$$

$$\alpha = \frac{\beta}{1+\beta}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

$$I_C + I_B = I_E$$

$$\alpha = \frac{\beta}{1+\beta} = \frac{100}{101}$$

$$I_E = \frac{1}{\alpha} I_C = \frac{1}{\alpha} \cdot 2\,\text{mA}$$