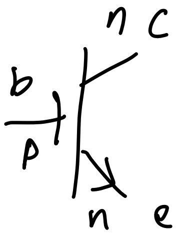
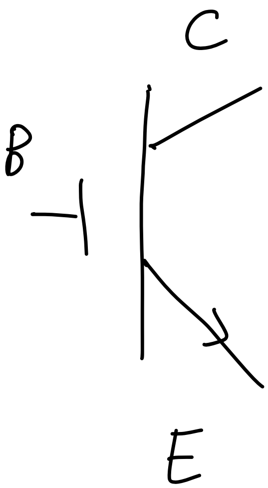


- $i_C = I_s e^{V_{BE}/V_T}$

- $i_E = i_B + i_C$ $\qquad$ $i_C = \beta i_B$



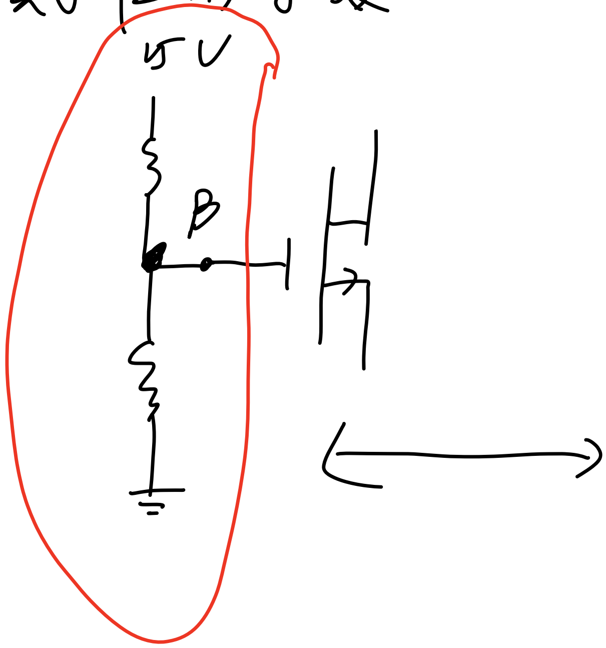
DC 分析：

① $V_{BE} = 0.7V$，若 $V_{BE} < 0.7V$
不工作
$i_B = i_C = i_E = 0$

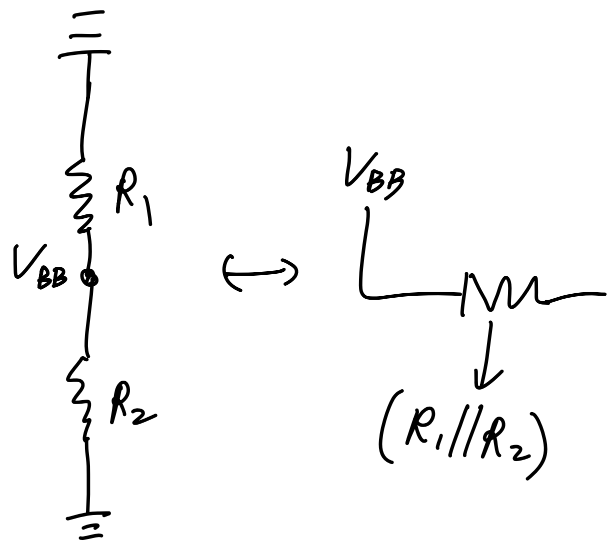
②
1° $V_C > V_B$
$i_C = \beta i_B$
2° $V_C < V_B$
$V_{CE} = 0.2V$

$$i_C \neq \beta i_B$$

戴维南等效



电源⟷接地



$$V_{BB} = \frac{R_2}{R_1+R_2} \cdot 15V$$

- 小信号模型

$$I_C + i_C = I_S e^{(V_{BE}+v_{be})/V_T}$$

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

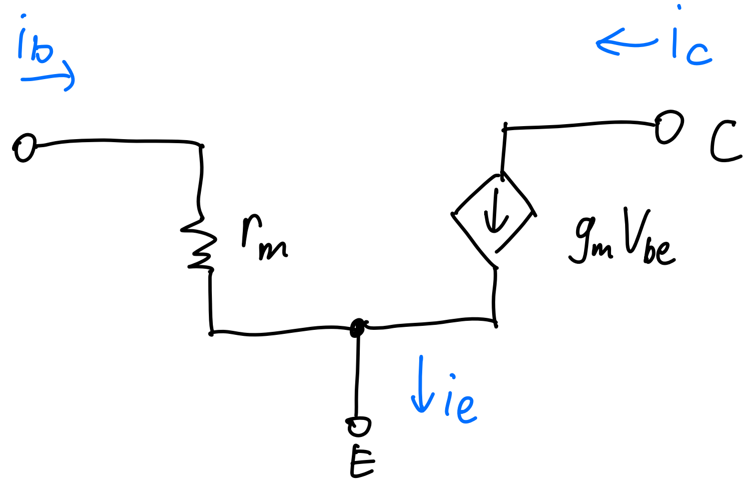
$$= I_C e^{v_{be}/V_T}$$

$$= I_C \left(1 + \frac{v_{be}}{V_T}\right)$$

$$\Rightarrow \quad i_c = \frac{I_c V_{be}}{V_T} = g_m V_{be}$$

- 混合π模型（E直接接地）

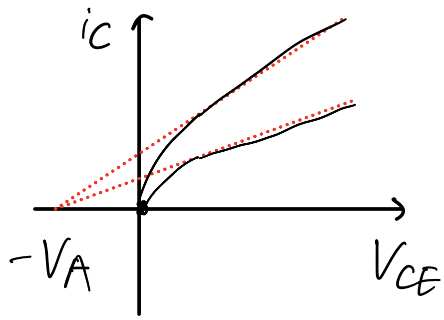
$V_T = 0.025$



$g_m = I_c / V_T$

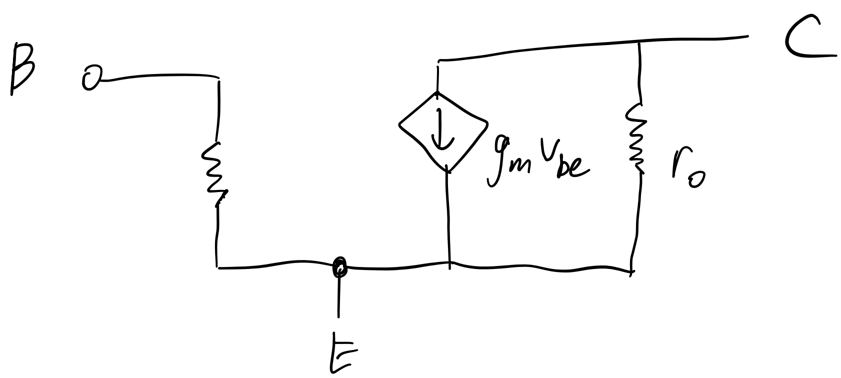
$r_\pi = \beta / g_m$

不理想：

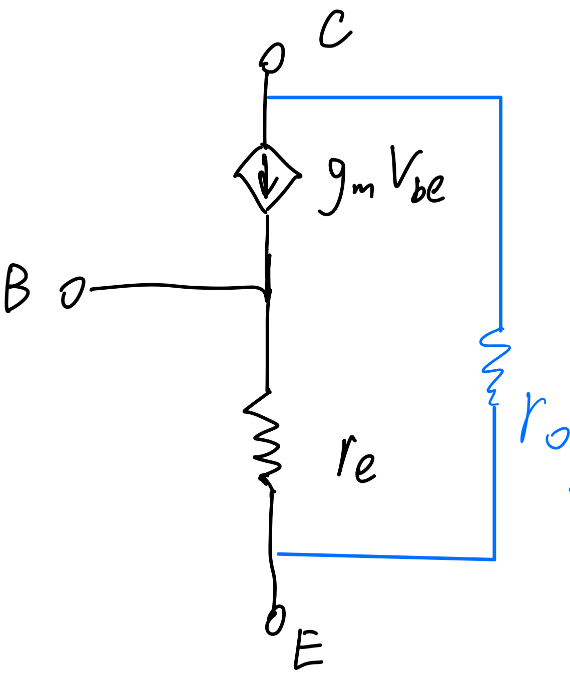


$$i_c = I_s e^{V_{BE}/V_T} \left(1 + \frac{V_{CE}}{V_A}\right)$$

$$r_o = \left(\frac{\partial i_c}{\partial V_{CE}}\right)^{-1} = \frac{V_A}{I_c}$$



T 模型 (E极接了电阻)



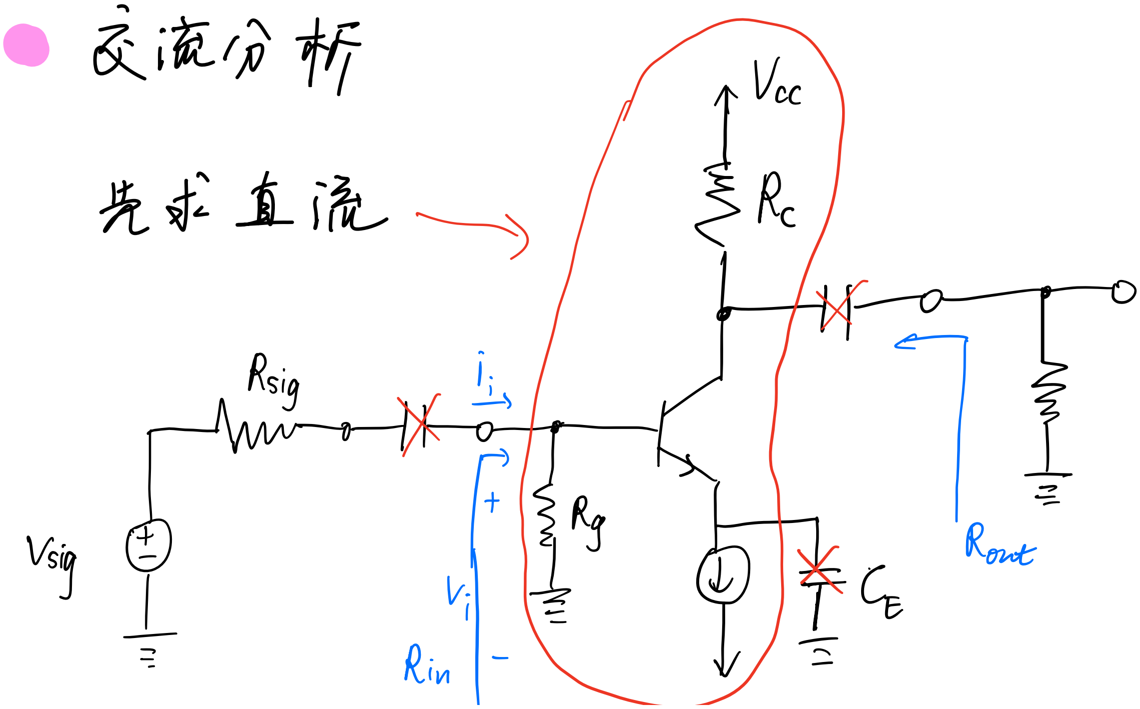
修正部分

$$g_m = I_c / V_T$$

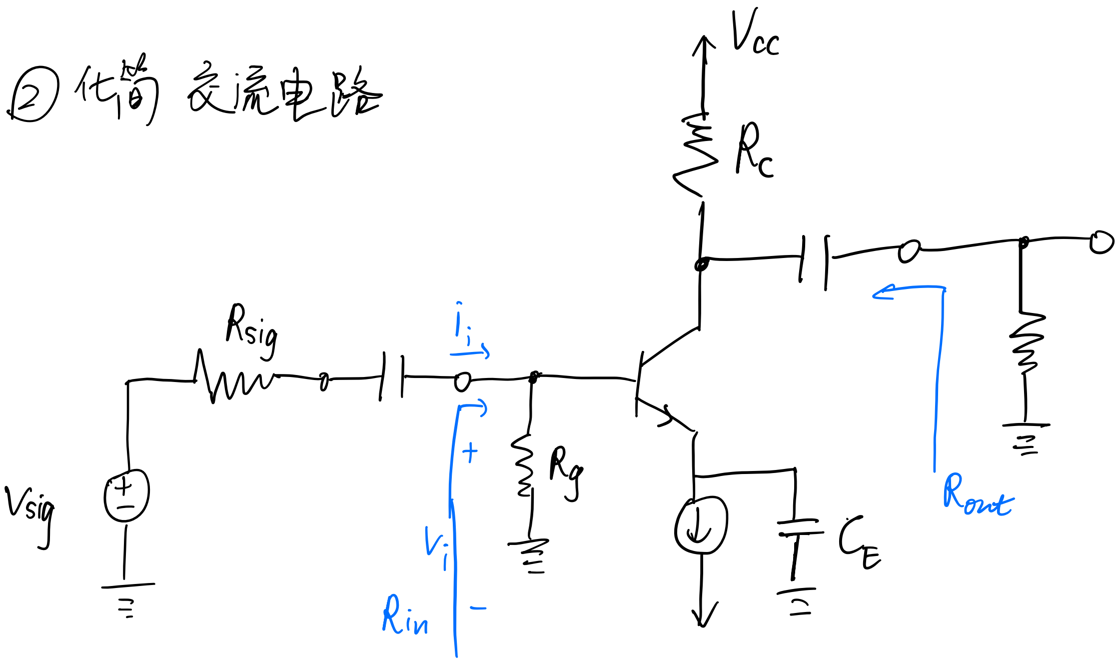
$$r_e = \frac{V_T}{I_E} = \frac{\alpha}{g_m} = \frac{\frac{\beta}{1+\beta}}{g_m} \approx \frac{1}{g_m}$$

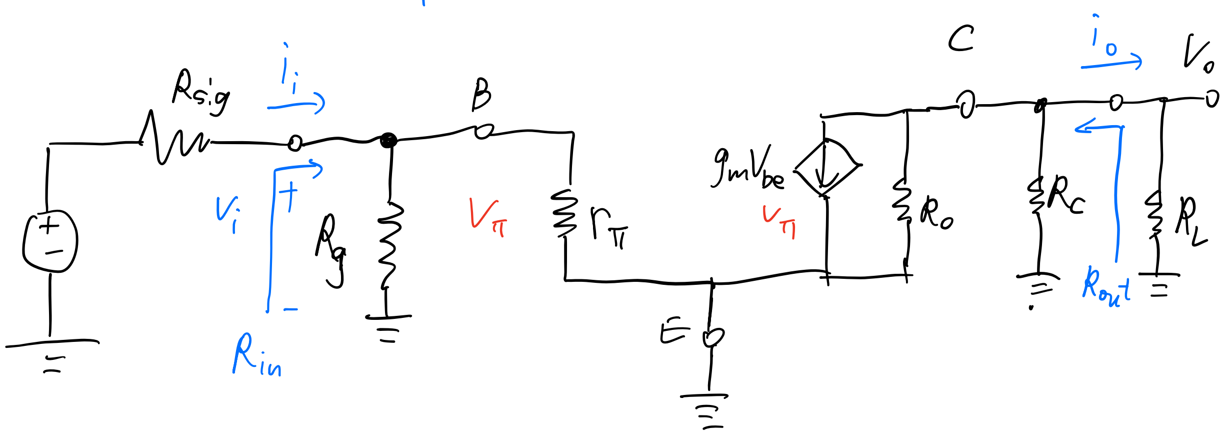
交流分析

先求直流



② 化简 交流电路





$$R_{in} = \frac{V_i}{i_i} = (R_g // r_\pi)$$

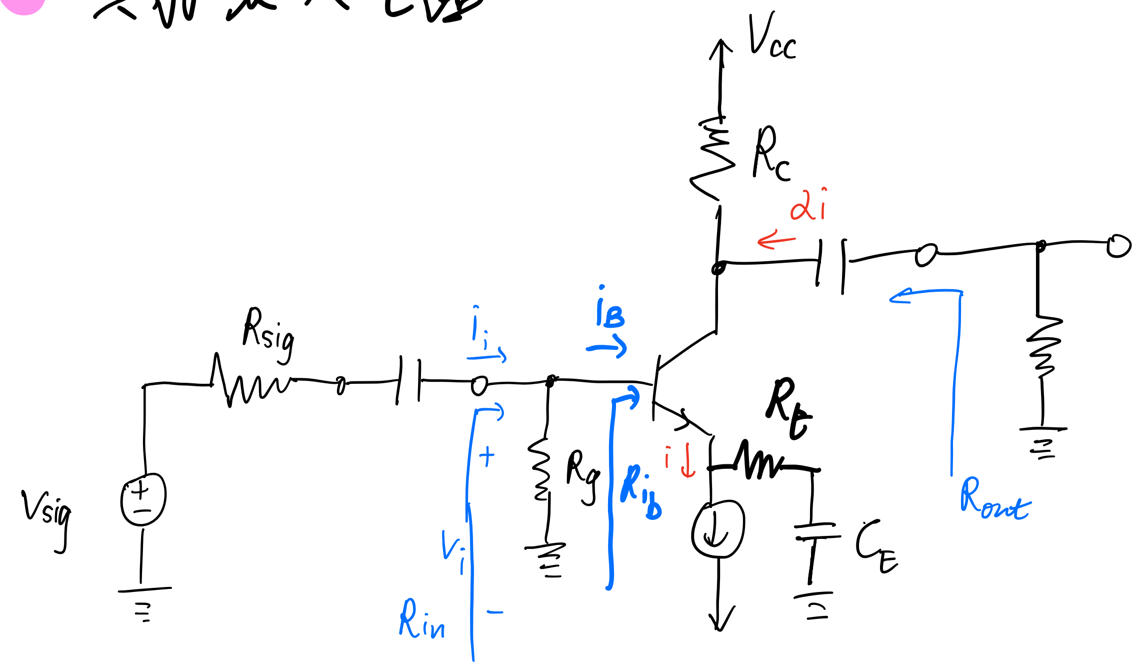
$$A_v = \frac{V_o}{V_i} = \frac{-g_m V_\pi (R_o // R_C // R_L)}{V_\pi}$$ （负号因方向）

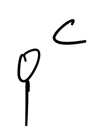
$$R_{out} = (R_o // R_C) \approx R_C$$

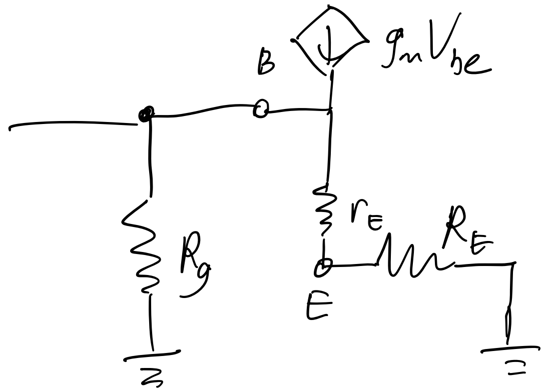
$$G_V = \frac{V_o}{V_{sig}} = A_v \cdot \frac{R_{in}}{R_{in}+R_{sig}}$$

$$\frac{V_o}{V_i} \cdot \frac{V_i}{V_{sig}}.$$

共射放大电路







$$R_{in} = \frac{V_i}{i_i} = R_B // R_{i_b}$$

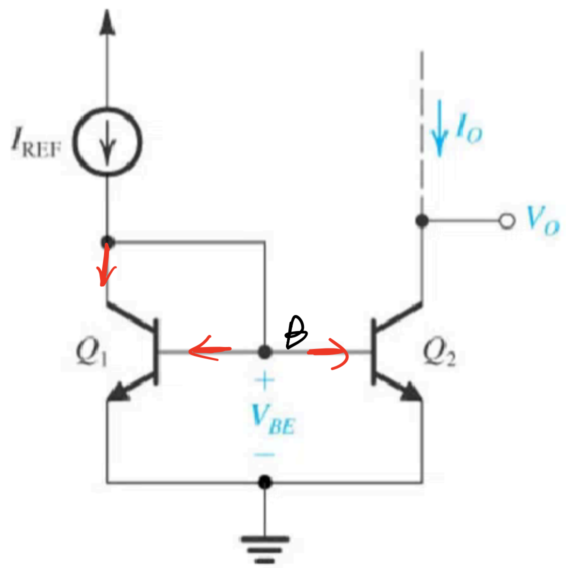
$$R_{i_b} = \frac{V_i}{i_b} = \underline{(1+\beta)(r_E + R_E)}$$

因流过的电流为 $i_E = (1+\beta) i_B$

$$A_v = \frac{V_o}{V_i} = \frac{-\alpha i (R_c // R_L)}{i\,(r_E + R_E)} = -\alpha \frac{R_c // R_L}{r_E + R_E}$$

集成电路

The Basic BJT Current Mirror



$$I_o = \frac{\beta}{\beta+1} I_E$$

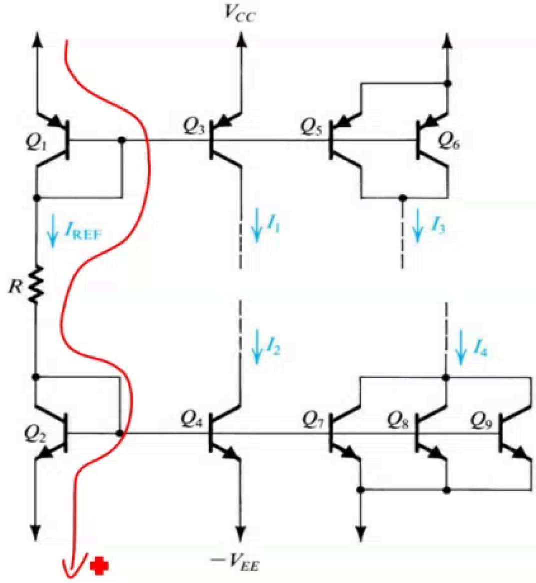
$$I_{REF} = \frac{\beta+2}{\beta+1} I_E$$

$$\frac{I_o}{I_{REF}} = \frac{\beta}{\beta+2} = \frac{1}{1+\frac{2}{\beta}}$$

$$I_{REF} = I_{C1} + I_{B1} + I_{B2}.$$

Q_1, Q_2 完全相同 $\Rightarrow I_{B1} = I_{B2} = I_B,\ I_{C1} = I_{C2} = \beta I_B$

$$I_o \approx I_{REF}$$



$$I_{REF} = \frac{V_{CC} + V_{EE} - V_{EB1} - V_{BE2}}{R}$$

$$I_1 = I_{REF}$$

$$I_2 = I_{REF}$$

$$I_3 = 2I_{REF}$$

$$I_4 = 3I_{REF}$$

 $\times m \Rightarrow I_m = m I_{REF}$