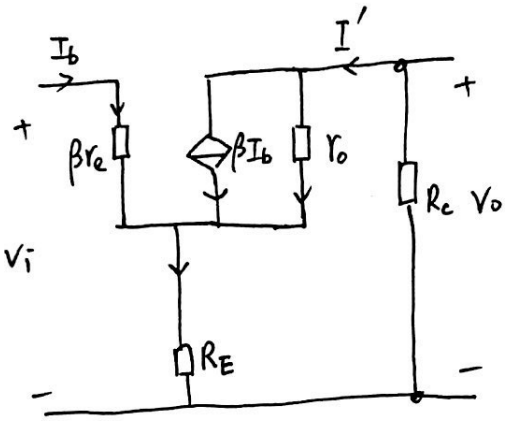
P227. Z_b



设流过 R_c 上的电流为 I' 则流过 R_E 上的电流为 $I'+I_b$

且考察 R_c 上两端电压有：

$$-I'\cdot R_c = (I'-\beta I_b)r_o + (I'+I_b)\cdot R_E$$

整理有 $$I' = \frac{\beta I_b \cdot r_o - I_b \cdot R_E}{R_c + R_E + r_o}$$

$$Z_b = \frac{V_i}{I_i} = \frac{V_i}{I_b} = \frac{I_b\cdot\beta r_e + (I'+I_b)\cdot R_E}{I_b}$$

$$= \beta r_e + \left(\frac{\beta I_b \cdot r_o - I_b R_E}{R_c + R_E + r_o} + I_b\right)\cdot\frac{R_E}{I_b}$$

$$= \beta r_e + \frac{\beta r_o + R_c + r_o}{R_c + R_E + r_o}\cdot R_E$$

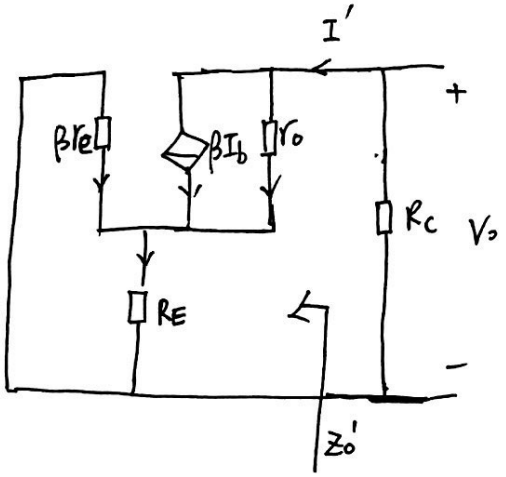
$$= \beta r_e + \frac{\beta + 1 + \frac{R_c}{r_o}}{1 + \frac{R_c + R_E}{r_o}} R_E$$

若 $r_o \geq 10(R_c + R_E)$ 有 $\frac{R_c + R_E}{r_o} \approx 0$

此时 $Z_b \simeq \beta r_e + (\beta+1)R_E$

$$\approx \beta(r_e + R_E)$$

P227. Z_o：



$Z_o = Z_o' // R_C$

其中 $Z_o' = \frac{V_o}{I'}$

考察 R_E 上面端的电压，有：$(I' + I_b) R_E = -I_b \cdot \beta r_e$

整理有：$I_b = \frac{-R_E}{R_E + \beta r_e} I'$

$$Z_o' = \frac{V_o}{I'} = \frac{(I' - \beta I_b) r_o + (I' + I_b) R_E}{I'}$$

$$= \frac{I' \cdot r_o + \beta \cdot \frac{R_E}{R_E + \beta r_e} I' \cdot r_o + \left[I' - \frac{R_E}{R_E + \beta r_e} I'\right] R_E}{I'}$$

$$= r_o + \frac{\beta R_E r_o}{R_E + \beta r_e} + \frac{\beta r_e \cdot R_E}{R_E + \beta r_e}$$

$$= r_o + \frac{\beta R_E r_o + \beta r_e R_E}{R_E + \beta r_e}$$ ← 分母同除以 R_E

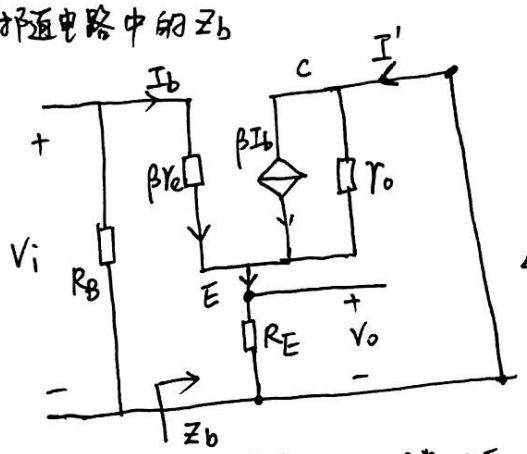
$$= r_o + \frac{\beta (r_o + r_e)}{1 + \frac{\beta r_e}{R_E}}$$

忽略 r_e $= r_o + r_o \frac{\beta}{1 + \frac{\beta r_e}{R_E}} = r_o \left[1 + \frac{\beta}{1 + \frac{\beta r_e}{R_E}}\right]$

$\therefore Z_o = R_C // Z_o'$

一般有 $\frac{r_e}{r_E} << 1$ $\left[1 + \frac{\beta}{1 + \frac{\beta r_e}{R_E}}\right]$ 通常较大 $\therefore Z_o \simeq R_C$

P234. 射随电路中的 Z_b



注意 C 是交流地电位

定义 I' 如上图. 考察 r_o 两端电压与 R_E 上两端有 $U_{r_o} + U_{R_E} = 0$

$$Z_b = \frac{V_i}{I_b}$$

利用 $U_{r_o} + U_{R_E} = 0$ 可得: $(I' - \beta I_b) r_o + (I' + I_b) R_E = 0$

整理有: $$I' = \frac{\beta r_o - R_E}{r_o + R_E} I_b$$

$$Z_b = \frac{V_i}{I_b} = \frac{I_b \cdot \beta r_e + (I' + I_b) R_E}{I_b}$$

$$= \beta r_e + \left(\frac{\beta r_o - R_E}{r_o + R_E} + 1\right) R_E$$

$$= \beta r_e + \frac{(\beta+1) r_o R_E}{r_o + R_E}$$

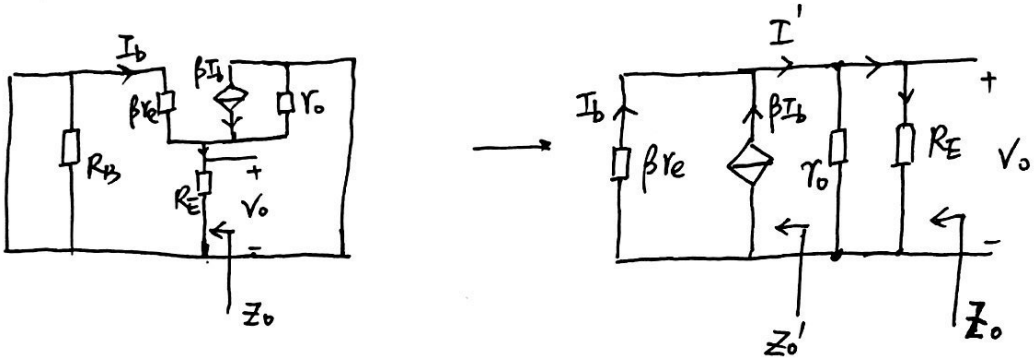
$$= \beta r_e + \frac{(\beta+1) R_E}{1 + \frac{R_E}{r_o}}$$

若 $r_o \geq 10 R_E$ 上式 $= \beta r_e + (\beta+1) R_E$

$$\approx \beta (r_e + R_E)$$

P234. 射极通电路中的 Z_o

r_e 等效电路为



$$Z_o = R_E \parallel r_o \parallel Z_o'$$

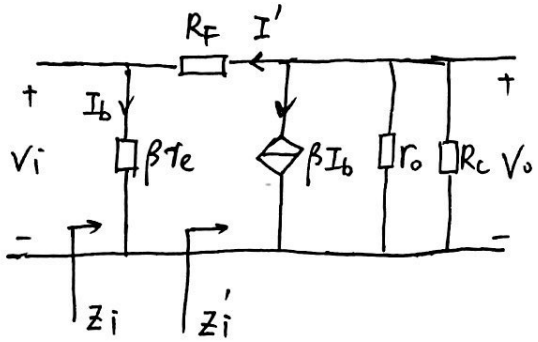
其中 $Z_o' = \frac{-V_o}{I'} = \frac{-\beta r_e \cdot I_b}{-(1+\beta) I_b} = \frac{\beta r_e}{1+\beta}$

所以 $$Z_o = R_E \parallel r_o \parallel \frac{\beta r_e}{1+\beta}$$

$$\approx R_E \parallel r_o \parallel r_e$$

若 $r_o >> r_e$ $Z_o \approx R_E \parallel r_e$

P240 Z_i (考虑 r_o)



$Z_i = \beta r_e \parallel Z_i'$

其中 $Z_i' = \dfrac{-V_i}{I'}$

求解 I'，考察 R_F 上压降 $I' \cdot R_F = V_o - V_i$

有 ~~$I' \cdot R_F = I' \cdot R_F$~~

$$R_F \cdot I' = -(I' + \beta I_b)(r_o \parallel R_C) - I_b \cdot \beta r_e$$

$$R_F \cdot I' = -I'(r_o \parallel R_C) - [r_o \parallel R_C + r_e] \cdot \beta I_b$$

$$\therefore I'(R_F + r_o \parallel R_C) = -\left[1 + \frac{r_o \parallel R_C}{r_e}\right] \cdot r_e \cdot \beta \cdot I_b \quad \text{其中 } r_e \cdot \beta I_b = V_i$$

$$\therefore \frac{-V'}{I'} = (R_F + r_o \parallel R_C) \cdot \frac{1}{1 + \dfrac{r_o \parallel R_C}{r_e}}$$

$$Z_i = \beta r_e \parallel Z_i' = \beta r_e \parallel \left[(R_F + r_o \parallel R_C) \cdot \frac{1}{1 + \dfrac{r_o \parallel R_C}{r_e}}\right]$$

$$= \frac{\beta r_e \cdot \dfrac{R_F + r_o \parallel R_C}{1 + \dfrac{r_o \parallel R_C}{r_e}}}{\beta r_e + \dfrac{R_F + r_o \parallel R_C}{1 + \dfrac{r_o \parallel R_C}{r_e}}}$$

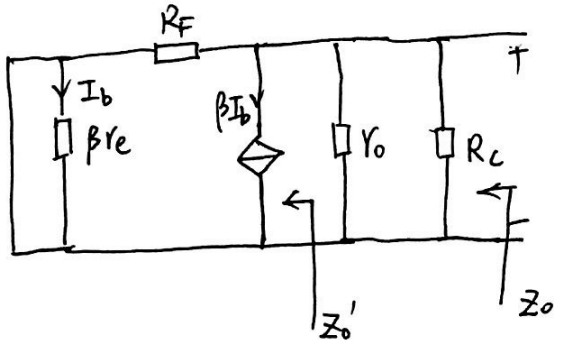
分子分母同乘以 $1 + \dfrac{r_o \parallel R_C}{r_e}$

$$= \frac{\beta r_e [R_F + r_o \parallel R_C]}{\beta r_e + \beta \cdot (r_o \parallel R_C) + R_F + r_o \parallel R_C} = \frac{\beta r_e [R_F + r_o \parallel R_C]}{\beta r_e + R_F + (\beta + 1)(r_o \parallel R_C)}$$

分子分母同除以 $\beta r_e \cdot R_F$

$$= \frac{1 + \dfrac{r_o \parallel R_C}{R_F}}{\dfrac{1}{R_F} + \dfrac{1}{\beta r_e} + \dfrac{r_o \parallel R_C}{r_e R_F}}$$

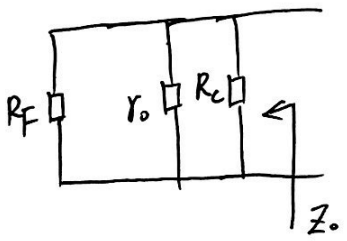
P244. Z_o



$Z_o = R_C \parallel r_o \parallel Z_o'$

对于 Z_o'：由于输入 V_i 短路，有 $I_b = 0$. 则 βI_b 断开.

上图可等效为



$\therefore Z_o = R_C \parallel r_o \parallel R_F$