[专题二] BJT管及放大电路

知识点1: 极性判断 略，善用假设.

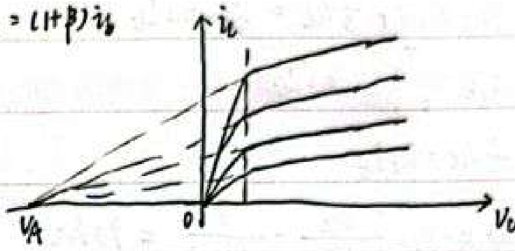
知识点2: BJT 相关概念题 / 静态工作点计算 (认识一下条件)

· 三极管工作:

1. 放大模式下，$i_c = I_s e^{\frac{V_{BE}}{V_T}}$，$i_c = \beta i_b$，$i_e = (1+\beta) i_b$

2. 考虑厄利现象(图右):

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



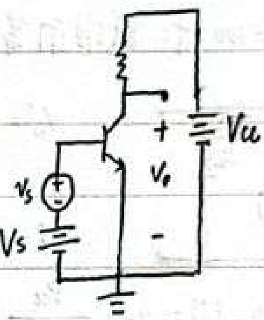
输出电阻 $r_o = \frac{\Delta V_{CE}}{\Delta i_c} = \frac{V_A}{I_c}$

3. 小信号中频等效电路

$v_I = V_s + v_s$

$$i_c = I_s e^{\frac{V_{BE}}{V_T}} = I_s e^{\frac{V_s + v_s}{V_T}} = I_c \cdot e^{\frac{v_s}{V_T}}$$ (I_c是静态工作下，集电极电流)

若 $v_s \ll V_T$，则 $i_c = I_c + \frac{I_c}{V_T} \cdot v_s$ (交流)



∴ 定义跨导 $g_m = \frac{I_c}{V_T}$　$i_c = g_m v_s = g_m v_{be}$，$i_c = \beta i_b$

△ $g_m = \frac{\beta}{r_{be}}$

4. 几种放大电路的优劣势 / 性质:

① 直接耦合电路 → 零漂，器件受温度影响

② 共射放大电路: 电压放大倍数为负，具有一定电压放大能力

③ 共集放大电路: 射极跟随器，放大倍数正近似为1
输入电阻一般较大，输出电阻一般较小

④ 共基放大电路: 电压放大倍数正，不具电流放大能力
宽频带，中高频特性好.

A 5、一个电压放大器的输入电阻越小，对信号源的影响则 ______；输出电阻越小，带负载的能力则越 ______。

$\frac{V_o}{V_I}$

A. 越大，越强 B. 越小，越强 C. 越大，越弱 D. 越小，越弱

A。电压电压放大器要求输入电阻大，输出电阻小，目的是使放大器的输入从信号源获得大的电阻分压，负载从放大器的输出获得大的电阻分压。

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·三极管静态工作点计算

<方法> 基本准大…

[P2 - Ex2] 解:

(a) β非常大, 则 $I_E \approx I_C$

$V_{BQ} = 0.7 + \frac{1}{3}V_{cc} = R_2 \cdot 0.2 I_E$

$V_{cc} = (R_1 + R_2) \cdot 0.2 I_E$

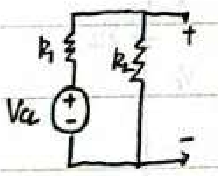
$\frac{1}{3}V_{cc} = R_E I_E$

$\Rightarrow R_1 + R_2 = \frac{V_{cc}}{\frac{1}{5}I_E} = \frac{9}{0.1mA} = 90k\Omega$

$\frac{R_2}{R_1+R_2} \cdot V_{cc} = \frac{1}{3}V_{cc} + 0.7 \Rightarrow$

$(\frac{R_2}{R_1+R_2} - \frac{1}{3}) \cdot V_{cc} = 0.7 \Rightarrow \frac{R_2}{R_1+R_2} - \frac{1}{3} = \frac{7}{90} \Rightarrow \underline{R_2 = 37k\Omega \ \therefore R_1 = 53k\Omega}$

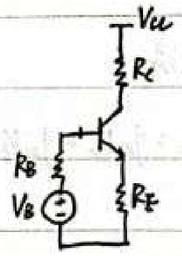
(b) β=100时: 戴维南等效:



$V_B' = \frac{R_2}{R_1+R_2} \cdot V_{cc} = 3.7V$

$R_B = R_1 // R_2 = 21.79k\Omega$

$\Rightarrow$



$\therefore V_B' = I_B R_B + 0.7 + (1+\beta) R_E I_B$

$\Rightarrow I_B = \frac{V_B' - 0.7}{R_B + (1+\beta)R_E} = 4.79 \times 10^{-3} mA$

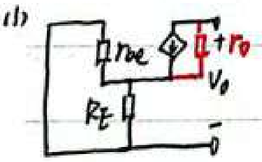
上一问: $R_E = \frac{V_{cc}}{3I_E} = \frac{9}{3 \times 0.5 \times 10^{-3}} = 6k\Omega$

$\therefore I_E = (1+\beta) I_B = \underline{0.483mA}$

知识点3: 相关交流模型计算

[P2 - Ex.2]

(1)



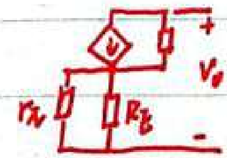
$R_0 = \frac{V_0}{i_0} = \frac{i_b r_{be} + (1+\beta) i_b R_E}{\beta i_b} = \frac{r_{be} + (1+\beta) R_E}{\beta}$ ✗.

(V_i … ✗)

怎么还有 r_0 <小王>..

$R_0 = \frac{V_0}{i_0} = \frac{\beta i_b r_0 + i_b \cdot (1+\beta)(R_E // r_{be})}{\beta i_b}$

↓



<这题好怪啊, 不做了…>

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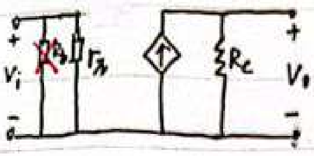
[P3-Ex.1]

小信号模型：



$A_v = \frac{V_o}{V_i} = \frac{-\beta R_c}{~~(R_b // r_\pi)~~ r_\pi}$　这里的R_b相当于电流源V_i内阻就无效了。

β未知，得由静态~~模~~解：

~~静态中 $V_{cc} = V_{CE} + I_C R_C = 7 + 1 \times 2\ V = 9V$~~　求是错的了… 这题正确解法应该是

~~$I_b = \frac{V_{cc} - 0.7}{R_b} = \frac{6.3V}{470k\Omega} \approx 0.0134\ mA$~~　$g_m = \frac{I_c}{V_T} = \frac{\beta}{r_{be}}$　$\therefore \beta = r_{be} \cdot g_m$

~~$\therefore \beta = \frac{I_c}{I_b} = 74.60$~~　~~$R_b // r_\pi = \frac{470 \times 10^3 \times 1.6 \times 10^3}{470 \times 10^3 + 1.6 \times 10^3} = 1.595\ k\Omega$~~　$A_v = -\frac{\beta R_c}{r_{be}} = -g_m R_c = -76.92$

$\therefore A_v = -74.6 \times \frac{2}{~~1.595~~\ 1.6} = ~~-93.54~~$

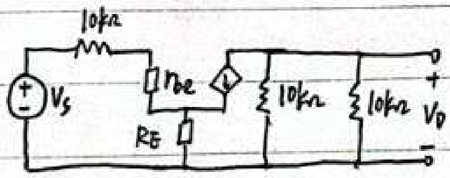
~~<注：题中没算R_b，我觉得有误>~~

[P3-Ex.3]

(1) 解：先算静态：$I_C = \frac{\beta I_E}{1+\beta} = \frac{50}{51} \times 0.2mA$

$\therefore g_m = \frac{I_c}{V_T} = \frac{\beta}{r_{be}}$，$r_{be} = \frac{\beta}{g_m} = \frac{\beta V_T}{I_c} = 50 \times \frac{26}{\frac{50}{51} \times 0.2} = 6.63k\Omega$

小信号：



$R_{in} = r_{be} + (1+\beta) R_E$
$= 6630 + 51 \times 125\Omega = 13.005k\Omega$

$\frac{V_o}{V_i} = \frac{-\beta i_b \cdot 5k\Omega}{i_b \cdot r_{be} + (1+\beta) i_b \cdot R_E} = \frac{-50 \times 5k\Omega}{13.005k\Omega} = -19.223$

$\frac{V_i}{V_S} = \frac{R_{in}}{R_{in} + R_S} = \frac{13.005}{13.005 + 10}$

$\therefore \frac{V_o}{V_S} = -10.867$

(2) 解：　$V_{be} \le 5mV \Rightarrow V_i = \frac{r_{be} + (1+\beta) R_E}{r_{be}} \cdot V_{be} \le 9.808mV$

$\Rightarrow V_S \le ~~5.544mV~~$ 17.35mV　　$|V_o| \le 188.539mV$

乘反了。

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[P3-Ex.8] 解： <共集放大电路>

先解直流： 静态：

$$g_m = \frac{I_c}{V_T} = \frac{\beta}{r_{be}}$$

$$V_{cc} = I_e R_e + 0.7 + I_b R_s$$

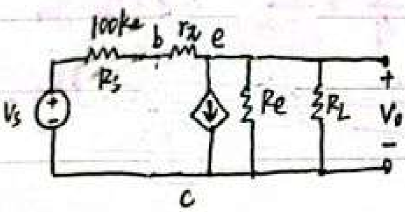
$$\therefore I_b = \frac{V_{cc} - 0.7}{R_s + (1+\beta)R_e} = \frac{5-0.7}{100+121\times3.3} = 8.612\times10^{-3}\,mA$$

$\therefore I_c = 1.033\,mA$

$\underline{I_E = 1.042\,mA}$

$$\therefore r_{be} = \frac{\beta V_T}{I_c} = \frac{120\times25\,mV}{1.033\,mA} = 2.904\,k\Omega = \underline{2.9\,k\Omega}$$

∴小信号模型：



$$R_i = (1+\beta)(R_e // R_L) + \cancel{R_s} + r_\pi = 95.76\,k\Omega$$

$$R_o = \cancel{R_e // R_L + \frac{R_s + r_\pi}{1+\beta}}$$

$$R_e // \left(\frac{R_s + r_\pi}{1+\beta}\right) = 3.3\,k\Omega // 0.85\,k\Omega = 0.676\,k\Omega$$

$$\therefore \frac{V_o}{V_s} = \frac{V_o}{V_i}\cdot\frac{V_i}{V_s} = \frac{R_i}{R_i+R_s}\cdot\frac{(1+\beta)i_b(R_E//R_L)}{(1+\beta)i_b(R_E//R_L) + i_b\cdot r_\pi}$$

$$= \frac{95.76}{95.76+100}\cdot\frac{121\times\frac{3.3\times1}{3.3+1}}{121\times\frac{3.3\times1}{3.3+1} + 2.9} = 0.474$$

[P3-Ex.9] 解：

$\beta = 100,\ I_c = 1\,mA,\ R_C = 5\,k\Omega \qquad g_m = \frac{I_c}{V_T}$

$$A_V = -\frac{\beta I_b R_c}{I_b R_{be}} = -g_m R_c = -\frac{1}{25}\times5\times10^3 = \underline{-200}$$

（红笔修改：R_c → $R_c//R_L$；5 → 2.5；-200 → -100）

[P3-Ex.10] 解：

$$V_B' = \frac{39}{120+39}\times12\,V = 2.943\,V$$

$$R_B = R_{B_1} // R_{B_2} = 29.43\,k\Omega$$

∴静态： $V_B' = I_B R_B + 0.7 + I_E R_E$

$$\therefore I_{BQ} = \frac{V_B' - 0.7}{R_B + (1+\beta)R_E} = \underline{0.016\,mA}$$

$I_{CQ} = \beta I_{BQ} = \underline{0.821\,mA} \qquad V_{CEQ} = V_{cc} - I_{CQ}\cdot R_c - I_{EQ}\cdot R_E = \underline{7.038\,V}$

$I_{EQ} = 0.838\,mA$ <答案有问题，这里β=50，I_{CQ}、I_{EQ}差别太小了>

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