电路与电子学基础

(Fundamentals of Circuits and Electronics)

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第06章

基本放大电路

Ch6 思考题/课外作业(40h课程)：

01. P252 E6-2

02. P253 E6-6

03. P253 E6-9

04. P253 E6-11

05. P253 E6-12

06. P253 E6-13

第06章

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课外作业参考解答

1. P252 E6-2

解： (a) U_{BE}=0.3V>0，U_{BC}=-5.9V<0，放大(NPN锗管)；

(b) U_{BE}=-0.3V<0，U_{BC}=5.7V>0，放大(PNP锗管)；

(c) U_{BE}=-0.7V<0，U_{BC}=-3.3V<0，截止(NPN管) 。

2. P253 E6-6

解：当$U_{CC}=10V, U_{CE}=5V, I_C=2mA$时，有

$$R_C=\frac{U_{CC}-U_{CE}}{I_C}=\frac{10-5}{2}k\Omega=2.5k\Omega$$

$$I_B=\frac{I_C}{\beta}=\frac{2}{100}mA=0.02mA$$

$$R_B=\frac{U_{CC}-U_{BE}}{I_B}=\frac{10-0.7}{0.02}k\Omega=465k\Omega$$

3. P253 E6-9

解：(1)计算静态工作点

直流通道如图(a)所示

$$R_d = R_{B1} // R_{B2} = \frac{68\times 22}{68+22} = 16.6k\Omega$$

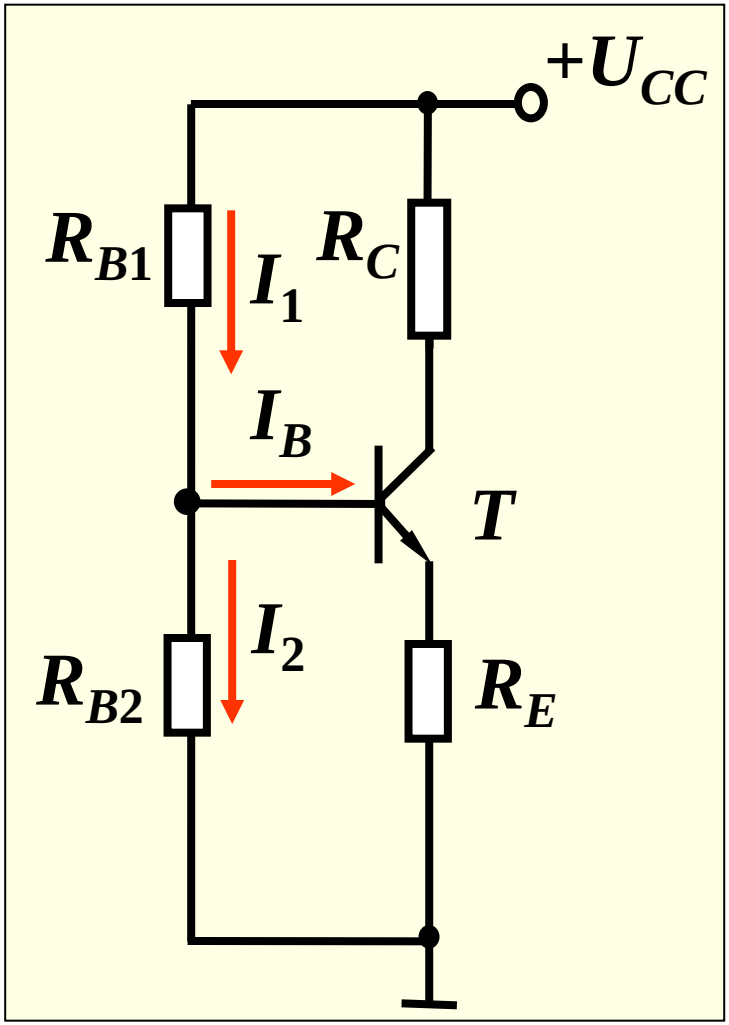
$$U_{SB} = \frac{R_{B2}}{R_{B1}+R_{B2}} U_{CC}$$

$$= \frac{22}{22+68}\times 12V = 2.9V$$

$$I_B = \frac{U_{SB}-U_{BE}}{R_d+(1+\beta)R_E}$$ **(6-3-15)-P203**

$$= \frac{2.9-0.7}{16.6+61\times 2} mA$$

=0.0159mA



图(a) 直流通道

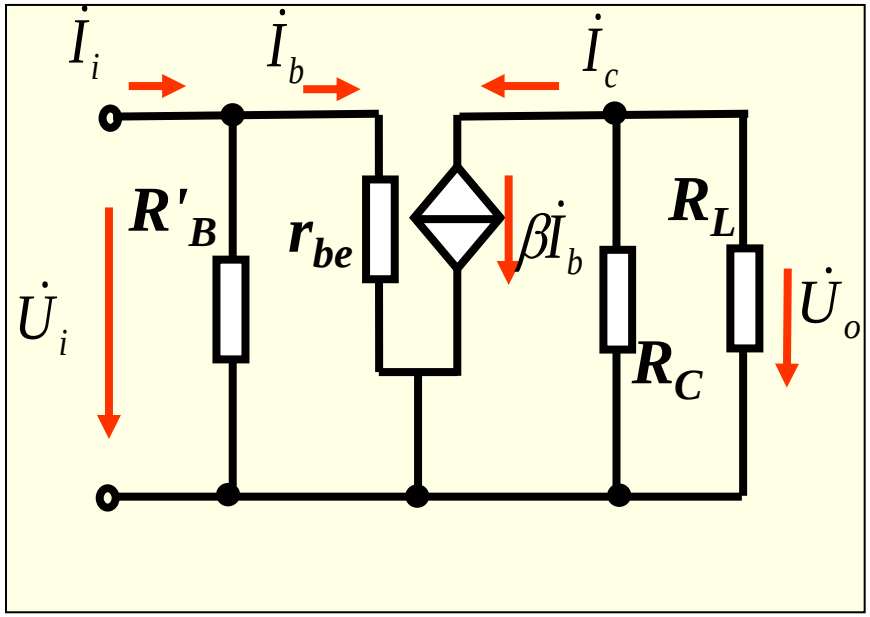
$$I_C = \beta I_B = 0.95mA,$$

$$I_E = (1+\beta) I_B = 0.97mA$$

$$U_{CE} = U_{CC} - I_C R_C - I_E R_E$$

$$= (12 - 0.95\times 3 - 0.97\times 2)V$$

$$= 7.21V$$



图(b)微变等效电路

(2)微变等效电路如图(b)所示

$$r_{be} \approx 1\sim 300(\Omega) + (1+\beta)\frac{U_T(mV)}{I_E(mA)} \{r_{bb'} = 1\sim 300(\Omega)\}$$

$$= 10 + 61\times \frac{26mV}{0.97mA} \approx 1.65k\Omega$$

$$r_i = R'_B \| r_{be} \approx r_{be} = 1.65k\Omega$$

$$r_o = R_C = 3k\Omega$$

$$A_u = -\beta \frac{R'_L}{r_{be}} = -60\times \frac{\frac{3\times 6}{3+6}}{1.65} = -73$$

$$R'_L = R_C \| R_L, R'_B = R_{B1} \| R_{B2}$$

4. P253 E6-11

解：电压放大倍数

$$A_u = \frac{\dot{U}_o}{\dot{U}_i} = -\beta \frac{R'_L}{r_{be}} = -60 \times \frac{\frac{3\times 6}{3+6}}{1.65} = -73$$

$$R'_L = R_C \parallel R_L$$

源电压放大倍数

$$A_{us} = \frac{\dot{U}_o}{\dot{U}_s} = \frac{r_i}{R_S + r_i} \bullet A_u = \frac{1.65}{1+1.65} \times (-73) = -45.45$$

5. P253 E6-12

解：先求电路的静态工作点。

$$R_d = R_{B1} // R_{B2} = \frac{120\times 40}{120+40}k\Omega = 30k\Omega$$

$$U_{SB} = \frac{R_{B2}}{R_{B1}+R_{B2}}U_{CC}$$

$$= \frac{40}{120+40}\times 12V = 3V$$

$$I_B = \frac{U_{SB}-U_{BE}}{R_d+(1+\beta)(R_E+R_E^{'})}$$

$$= \frac{3-0.6}{30+101\times 2.1}mA$$

$$=0.01\text{mA}$$

$$I_C = \beta I_B = 1.0mA$$

$$I_E = (1+\beta)I_B$$

$$= 101\times 0.01mA$$

$$= 1.01mA$$

$$U_{CE} = U_{CC} - I_C R_C - I_E(R_E + R_E^{'})$$

$$= \{12 - 1.0\times 4 - 1.01\times(2+0.1)\}V$$

$$\approx 5.9V$$

微变等效电路如图(c)所示

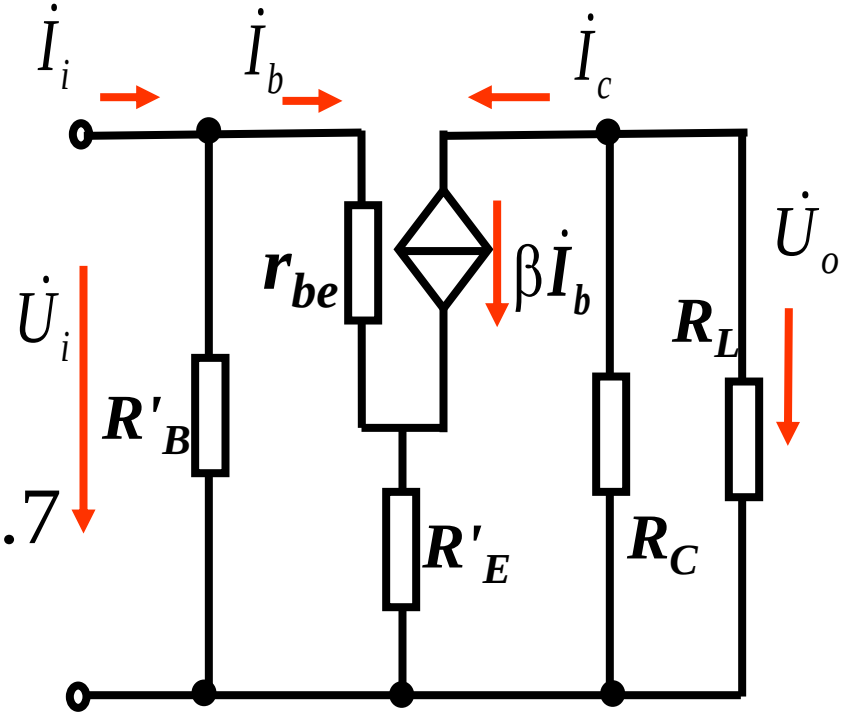
$$r_{be} \approx 1\sim 300(\Omega) + (1+\beta)\frac{U_T(mV)}{I_E(mA)} \{r_{bb'} = 1\sim 300(\Omega)\}$$

$$= 10 + 101\times\frac{26mV}{1.01mA} \approx 2.61k\Omega$$

$$R'_L = R_C \| R_L, R'_B = R_{B1} \| R_{B2}$$

$$A_u = -\beta\frac{R'_L}{r_{be} + (1+\beta)R'_E}$$

$$= -100\times\frac{\frac{4\times 4}{4+4}}{2.61+101\times 0.1} \approx -15.7$$



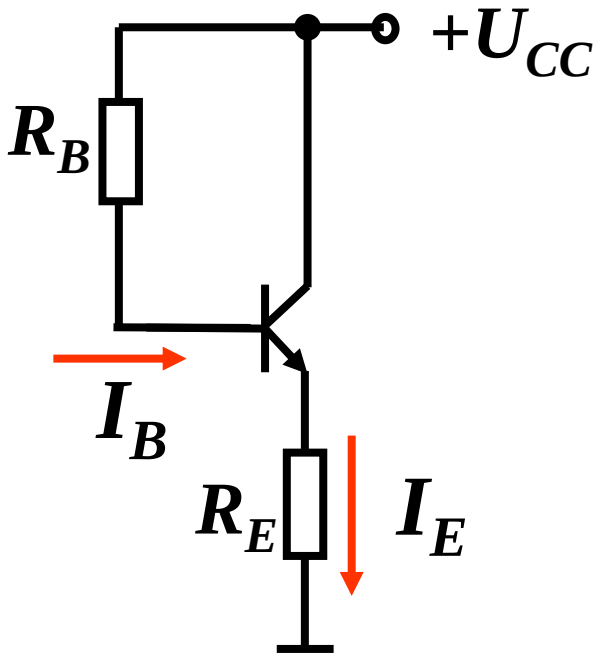
图(c)微变等效电路

$$r_i = R'_B \| [r_{be} + (1+\beta)R'_E]$$

$$= 30 \| 12.71(k\Omega) = 8.9k\Omega \quad r_o = R_C = 4k\Omega$$

6. P253 E6-13

解：(1)直流通道如图(*d*)所示。



图(*d*)直流通道

$$I_B = \frac{U_{CC} - U_{BE}}{R_B + (1+\beta)R_E}$$

$$\approx \frac{12 - 0.7}{100 + 101 \times 2} mA = 37\,\mu A$$

$$I_E = (1+\beta) I_B$$

$$= 101 \times 0.037 mA = 3.74 mA$$

$$I_C = \beta I_B = 3.7 mA$$

$$U_{CE} = U_{CC} - I_E R_E = (12 - 3.74 \times 2) V = 4.52 V$$

(2) 微变等效电路如图(e)所示

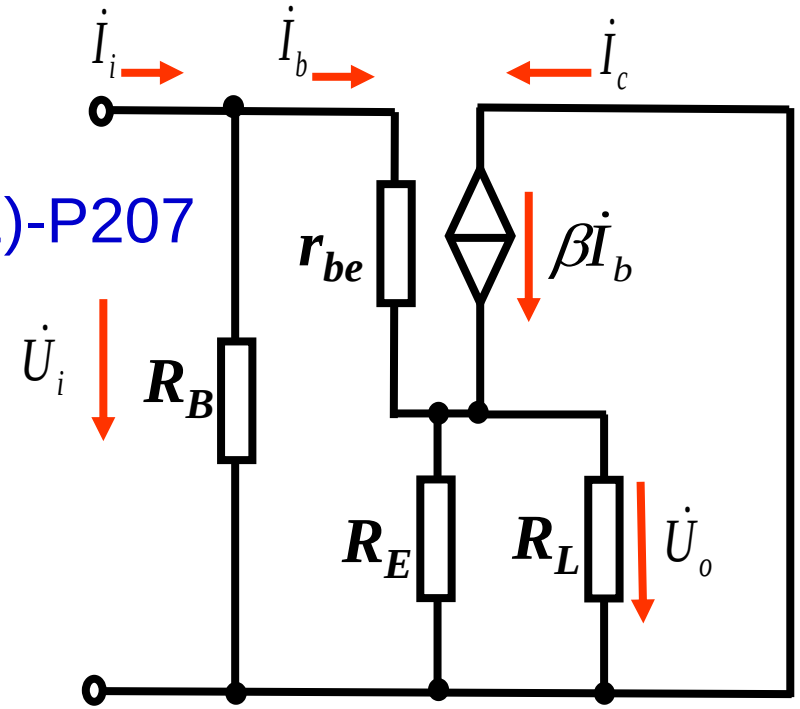
$$r_{be} \approx 200(\Omega) + (1+\beta)\frac{U_T(mV)}{I_E(mA)} \{设 r_{bb'} = 200(\Omega)\}$$

$$= 200 + 101 \times \frac{26mV}{3.74mA} \approx 902\Omega$$

$$R'_L = R_E \parallel R_L = \frac{2\times 4}{2+4} k\Omega = \frac{4}{3} k\Omega$$

$$A_u = \frac{(1+\beta)\ R'_L}{r_{be} + (1+\beta)R'_L} \quad \text{(6-3-21)-P207}$$

$$= \frac{101 \times \frac{4}{3}}{0.902 + 101 \times \frac{4}{3}} = 0.99$$



图(e)微变等效电路

$$r_i = \dot{U}_i / \dot{I}_i = R_B // \{r_{be} + (1+\beta)R'_L\}$$ (6-3-22)-P207

$$= 100 // 135.6(k\Omega) \approx 57.6k\Omega$$

$$R'_s = R_s // R_B = \frac{100 \times 10^5}{100 + 10^5} = 99.9\Omega$$

$$r_o = \frac{\dot{U}}{\dot{I}} = 1/(\frac{1+\beta}{r_{be} + R'_s} + \frac{1}{R_E}) = R_E // \frac{r_{be} + R'_s}{1+\beta}$$ **(6-3-23)-P208**

一般： $$R_E >> \frac{r_{be} + R'_s}{1+\beta}$$

所以： $$r_o \approx \frac{r_{be} + R'_s}{1+\beta} = \frac{902 + 99.9}{101}\Omega = 9.9\Omega$$