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2-1

1. 晶体管工作在放大区时发射极结正向偏置，集电结反向偏置。
~~工作在饱和区时，发射结正向偏置，集电结反向偏置，正向偏置。~~

2. 工作在放大区的晶体管，当基极电流 I_B 从 20uA 增大至 40uA 时，集电极电流 I_C 从 1mA 变成 2mA，则该管的 β 约为 50　$I_C=\beta I_B$

3. 工作在放大状态的晶体管，流进发射结的主要是扩散电流，流进集电结的主要是漂移电流。

4. 环境温度升高时，晶体管的 β 增大，反向电流 I_{CEO} 增大，发射结压降减小。

5. 两个晶体管，其中A管的 $\beta=200$，$I_{CEO}=200\mu A$；B管的 $\beta=50$，$I_{CEO}=10\mu A$，其余参数基本相同。相比之下，B管的性能更好。

2-4　处于放大状态时，

解：NPN型晶体管 $U_C>U_B>U_E$，PNP型 $U_E>U_B>U_C$。

A管：$U_X>U_Y>U_Z$　则Y为基电极b

又由 $U_{YX}=0.3V$ 可知X为发射极e，则Z为集电极C。

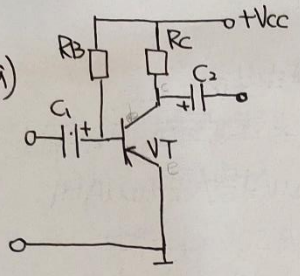
因此 $U_E>U_B>U_C$　故为PNP型。

B管：$U_Y>U_X>U_Z$　则X为基电极b

又由 $U_{YZ}=0.3V$ 可知Z为发射极e，则Y为集电极C。

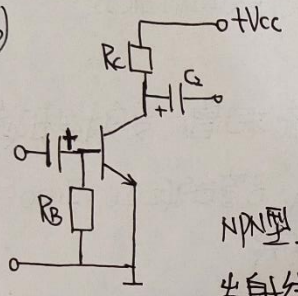
因此 $U_C>U_B>U_E$。故为NPN型。

2.7 解：(a)

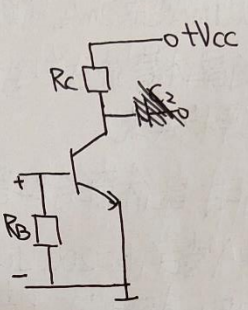


该晶体管为PNP型，若要处于放大状态，应满足 $U_e > U_b > U_c$，而此时 $U_b > U_e$，$U_b > U_c$，应将+Vcc改接为-Vcc，未写与电压大小无关

(b)



直流通路为

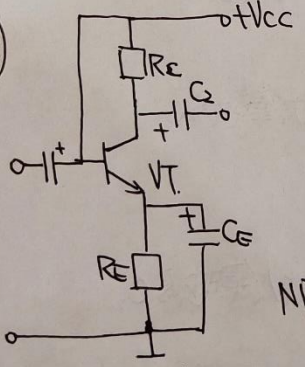


NPN型

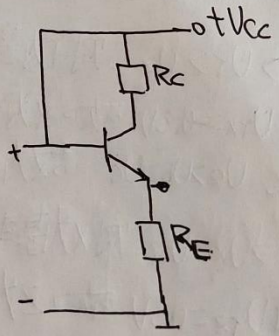
发射结零偏，不能工作在放大状态，

应将RB与+Vcc相接

(c)



直流通路为



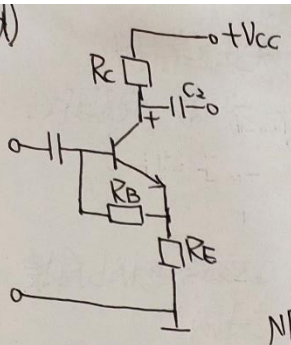
NPN型

发射极结和集电结均正向偏置，晶体管处于饱和状态，

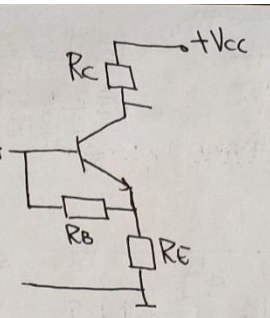
并且动态时，基极为交流接地，输入信号无法接入，

应将在基极b和电源+Vcc之间加电阻RB

(d)



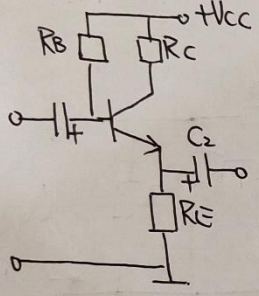
直流通路为



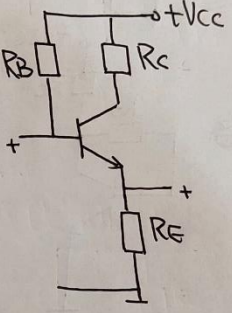
NPN型.

基极偏置电流为零，无法工作在放大状态，应将RB另接在基极和电源+Vcc之间

(e)



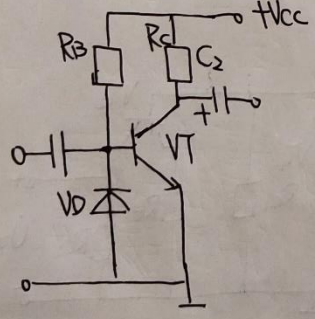
直流通路为



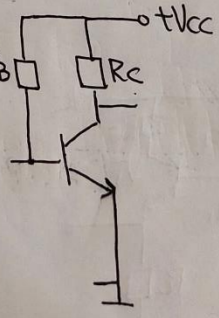
NPN型

电路可正常放大.

(f)

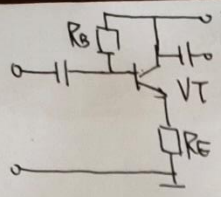


直流通路为



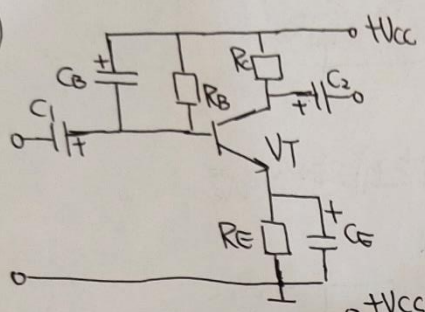
电路可正常放大，二极管起保护作用

(g)



输出端直接与+Vcc相连，无法正常放大。
应在集电极c和电源+Vcc之间接一电阻Rc.

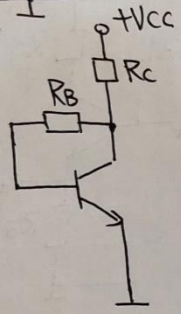
(h)



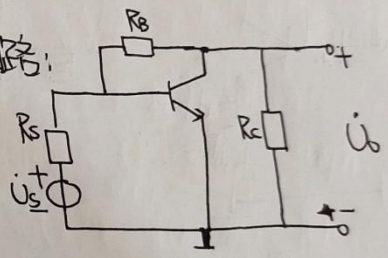
输入交流信号时，CB短路，基极b直接接地，输入信号无法接入。
应将 CB开路去.

28

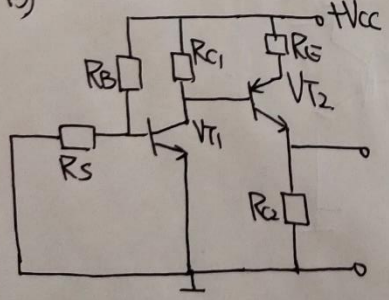
解：(a) 直流通路：



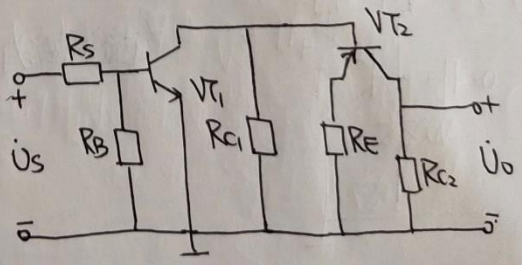
交流通路：



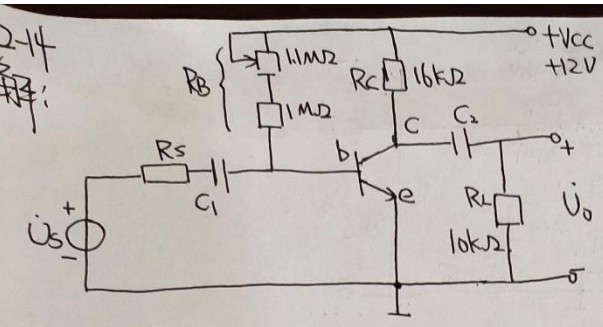
(b) 直流通路.



交流通路：



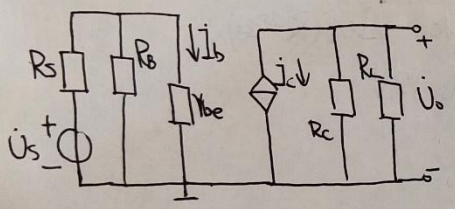
2-4 解：



1. $I_{BQ}=\frac{I_{CQ}}{\beta}=\frac{0.5mA}{50}=10\mu A$

$R_B=\frac{V_{CC}-V_{BEQ}}{I_{BQ}}=\frac{12-0.7V}{10\mu A}=1.13M\Omega$

2. 画出微变等效电路：



3. 输入电阻 $R_i=\frac{R_B\cdot R_{be}}{R_B+R_{be}}$

$=2.7k\Omega$

输出电阻 $R_o=R_c=16k\Omega$.

$r_{be}=r_{bb}'+(1+\beta)\cdot\frac{26mV}{I_{EQ}}$

$=100\Omega+\frac{26\times10^{-3}}{10\times10^{-6}}\Omega$

$=2700\Omega$.

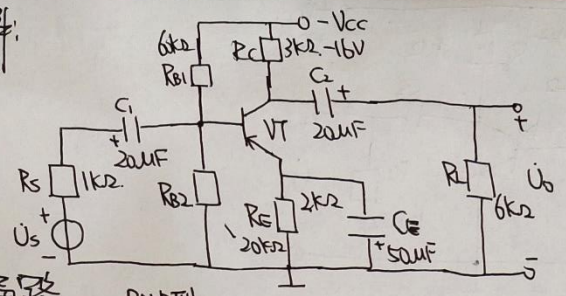
电压增益 $A_u=\frac{\dot U_o}{\dot U_i}=-\frac{\beta R_L'}{r_{be}}=-112$.

源电压增益 $A_{us}=\frac{\dot U_o}{\dot U_s}=\frac{R_i}{R_i+R_s}A_u$

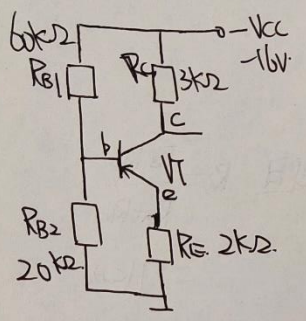
而 $R_i=\frac{R_B\cdot R_{be}}{R_B+R_{be}}=2.7k\Omega$.

则 $A_{us}=\frac{2.7}{2.7+1}\times|-112|=-83.5$

25解:



1)直流通路 PNP型



$U_B = \frac{R_{B2}}{R_{B1}+R_{B2}}(-V_{CC}) = \frac{20}{60+20} \times (-16V) = -4V$

$I_{CQ} \approx I_{EQ} = \frac{U_B - U_{BE}}{R_E} = \frac{-4V+0.3V}{2k\Omega} = -1.85mA$

$I_{BQ} \approx \frac{I_{CQ}}{\beta} \approx \frac{-1.85mA}{60} = -31\mu A$

$U_{CEQ} \approx V_{CC} - I_{CQ}(R_C+R_E)$

$= -6.75V$

2)由以知得 $U_{CEQ} = -V_{CC} - I_{CQ}(R_C+R_E)$

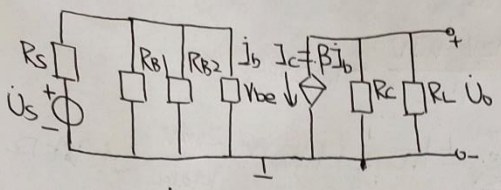
则 $I_{CQ} = \frac{-V_{CC}+U_{CEQ}}{R_C+R_E} = -2.4mA$

$U_B \approx I_{CQ} \cdot R_E + U_{BE} = -2.4mA \times 2k\Omega - 0.3V = -5.1V$

$U_B = \frac{R_{B2}}{R_{B1}+R_{B2}}(-V_{CC}) = -5.1V$

解得 $R_{B1} = 42.7k\Omega$.

B)微变等效电路.



rbb'取200Ω

则 $r_{be}=(1+\beta)\frac{26mA}{I_{EQ}}\approx(1+60)\times\frac{26mV}{1.85mA}\approx 857\Omega$

$R_i=R_{B1}\|R_{B2}\|r_{be}\approx 811\Omega$.

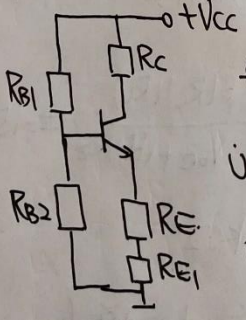
$A_{us}=\frac{U_o}{U_s}=-\frac{R_i}{R_i+R_s}\cdot\frac{\beta(R_c\|R_L)}{r_{be}}\approx 62$

$R_o=R_c=3k\Omega$.

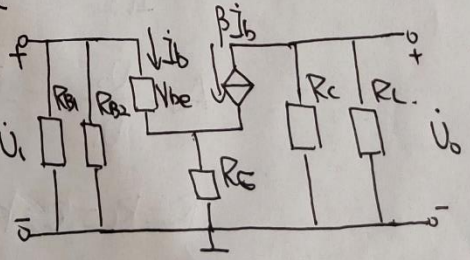
2)6 解:1)晶体管的β增大,电压增益增大,输入电阻增大.

2)集极电阻R_c增大,电压增益减小,输入电阻增大.

21 解: 直流通路.



~~交流通路~~ 微变等效电路



NPN型.

1) $R_E=0$ 时. $U_B=\frac{R_{B2}}{R_{B1}+R_{B2}}V_{CC}=\frac{10}{85}\times 18V=2.12V$

$I_{EQ}=\frac{U_B-U_{BE}}{R_E+R_{E1}}=\frac{2.12V-0.7V}{1k\Omega}=1.42mA$

$r_{be}=r_{bb'}+(1+\beta)\frac{26mV}{I_{EQ}}=100\Omega+(1+100)\times\frac{26mV}{1.42mA}=1.95k\Omega$

$R_i=\frac{\dot{U}_i}{\dot{I}_i}=R_{B1}//R_{B2}//[r_{be}+(1+\beta)R_E]$

$=1.6k\Omega$

$A_U=\frac{\dot{U}_o}{\dot{U}_i}=-\frac{\beta(R_C//R_L)}{r_{be}+(1+\beta)R_E}=-18$

$R_o=R_C=8.2k\Omega$

2) $R_E=200\Omega$ 时. $I_{EQ}=\frac{U_B-U_{BE}}{R_E+R_{E1}}=\frac{2.12-0.7}{1.2k\Omega}V=1.18mA$

$r_{be}=r_{bb'}+(1+\beta)\frac{26mV}{I_{EQ}}=100\Omega+(1+100)\times\frac{26mV}{1.18mA}=2.3k\Omega$

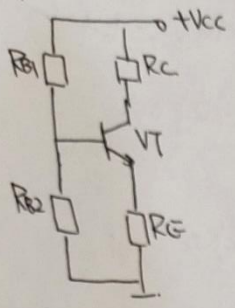
$R_i=\frac{\dot{U}_i}{\dot{I}_i}=R_{B1}//R_{B2}//[r_{be}+(1+\beta)R_E]=0.3k\Omega$

$A_U=\frac{\dot{U}_o}{\dot{U}_i}=-\frac{\beta(R_C//R_L)}{r_{be}+(1+\beta)R_E}=-15.7$

$R_o=R_C=6.2k\Omega$

R_E 增大, 电压增益减小, 输出电阻增大.

2.18 解：直流通路。 1) $U_B = \frac{R_{B2}}{R_{B1}+R_{B2}} \cdot V_{CC} = \frac{15}{35} \times 10V = 4.3V$



$I_{CQ} \approx I_{EQ} = \frac{U_B - U_{BE}}{R_E} = \frac{4.3V - 0.7V}{2k\Omega} = 1.8mA$

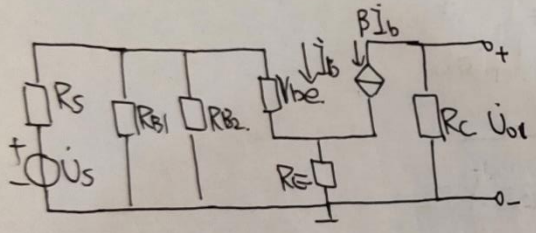
$U_{CEQ} \approx V_{CC} - I_{CQ}(R_C + R_E)$

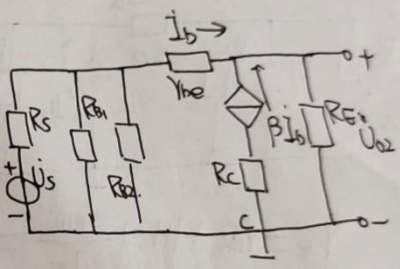
$= 10V - 1.8 \times 10^{-3}A \times 4 \times 10^3\Omega$

$= 2.8V$

NPN型。

b) 微变等效电路。





$V_{be} = V_{bb} + (1+\beta)\frac{26mV}{I_{EQ}} = 300 + (1+60)\times\frac{26}{1.8}\Omega = 1.2k\Omega$

$R_i = \frac{\dot{U}_i}{\dot{I}_i} = R_{B1} // R_{B2} // [V_{be} + (1+\beta)R_E] = 8k\Omega$

$A_{U1} = \frac{\dot{U}_{o1}}{\dot{U}_s} = \frac{-\beta R_C}{V_{be} + (1+\beta)R_E} \cdot \frac{R_i}{R_i + R_s} = -0.78$

$A_{U2} = \frac{\dot{U}_{o2}}{\dot{U}_s} = \frac{-(1+\beta)R_E}{V_{be} + (1+\beta)R_E} \cdot \frac{R_i}{R_i + R_s} = 0.79$

3) 输出电阻

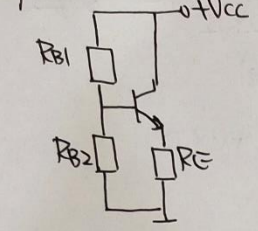
$R_{o1} = R_C = 2k\Omega$

$R_{o2} = R_E // \frac{V_{be} + R_s // R_{B1} // R_{B2}}{1+\beta}$

$= 26\Omega$

2-9

解：(1) 直流通路.



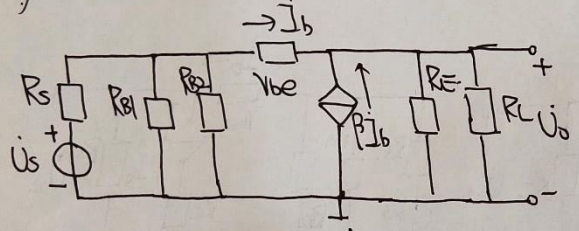
NPN型.

$$U_B = \frac{R_{B2}}{R_{B1}+R_{B2}} \cdot V_{CC} = \frac{47}{68+47} \times 12V = 4.9V$$

$$I_{CQ} \approx I_{EQ} = \frac{U_B - U_{BE}}{R_E} = 2.1\,mA$$

$$U_{CEQ} = V_{CC} - I_{EQ} \cdot R_E$$
$$= 12V - 2.1mA \times 2K\Omega$$
$$= 7.8V$$

(2) 微变等效电路.



$$V_{be} = V_{bb'} + (1+\beta)\frac{26mV}{I_{EQ}} = 1.35\,K\Omega$$

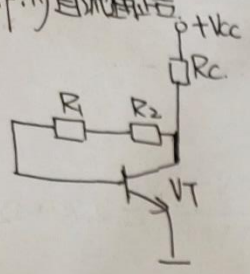
$$A_U = \frac{\dot{U}_o}{\dot{U}_i} = \frac{\dot{I}_e R_L'}{\dot{I}_b V_{be} + \dot{I}_e R_L'} = \frac{(1+\beta)R_L'}{V_{be} + (1+\beta)R_L'} = 0.99$$

$$R_i = R_{B1} // R_{B2} // [V_{be} + (1+\beta)R_L']$$
$$= 21.8\,k\Omega.$$

$$R_o = R_E // \frac{V_{be} + R_S // R_{B1} // R_{B2}}{1+\beta}$$
$$= 23\Omega$$

2-24

解：1) 直流通路



$I_{CQ} = \beta I_{BQ}$

而 $I_{RC} = I_{BQ} + I_{CQ}$

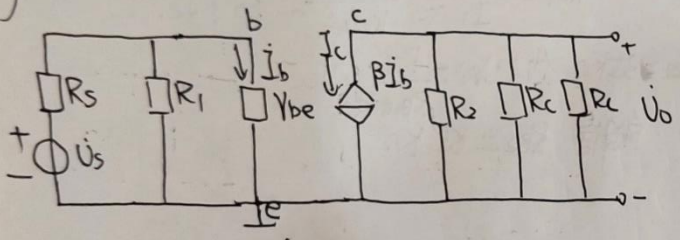
$$\frac{V_{CC} - U_{CEQ}}{R_C} = I_{BQ} + \beta I_{BQ}$$

$$I_{BQ} = \frac{V_{CC} - U_{CEQ}}{R_C \cdot (1+\beta)} = \frac{15 - 4\ V}{82k\Omega \times 3} = 26\mu A$$

$$I_{BQ} = \frac{U_{CEQ} - U_{BEQ}}{2R_1}$$

$R_1 = R_2 = 63k\Omega$.

2) 微变等效电路.



$$Y_{be} = Y_{bb'} + (1+\beta)\frac{26mA}{I_{EQ}} = 1.3k\Omega$$

$$A_U = \frac{\dot{U}_o}{\dot{U}_i} = -\frac{\beta(R_C \| R_L \| R_2)}{Y_{be}} = -149$$

$R_i = Y_{be} \| R_1 \approx 1.3k\Omega$

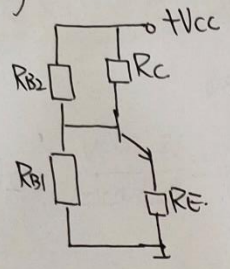
$$A_{US} = \frac{\dot{U}_o}{\dot{U}_s} = \frac{R_i}{R_i + R_S} A_U = -83$$

3) 输入电阻 $R_i = 1.3k\Omega$.

输出电阻 $R_o = R_C \| R_2 = 7.3k\Omega$

2-25

解：1) 直流通路.



$U_{BQ}=\frac{R_{B1}}{R_{B1}+R_{B2}}\cdot V_{CC}$

$I_{EQ}=\frac{U_{BQ}-U_{BEQ}}{R_E}$

对 $R_E=\frac{U_{BQ}-U_{BEQ}}{I_{EQ}}\approx\frac{3.5V-0.7V}{1mA}=2.8\,k\Omega$.

$R_C=\frac{V_{CC}-(U_{BQ}-U_{BEQ})-U_{CEQ}}{I_{CQ}}=5.2k\Omega$.

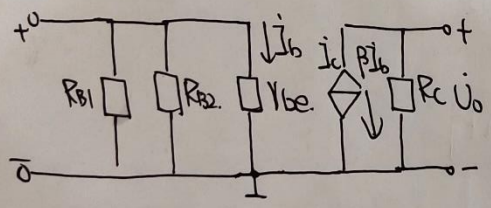
$I_{BQ}=\frac{I_{CQ}}{\beta}=10\mu A$

$R_{B1}=\frac{U_{BQ}}{I_1}=\frac{3.5V}{100\mu A}=35\,k\Omega$.

将 $R_{B1}=35k\Omega$ 代入 $U_{BQ}=\frac{R_{B1}}{R_{B1}+R_{B2}}\cdot V_{CC}$

解得 $R_{B2}=85\,k\Omega$.

b) 微变数电路.



$A_U=\frac{-\beta R_C}{r_{be}}=-\frac{100\times5.2k\Omega}{2.7k\Omega}=-193$

$R_i=R_{B1}\|R_{B2}\|r_{be}=2.4\,k\Omega$.

$R_o=R_C=5.2k\Omega$