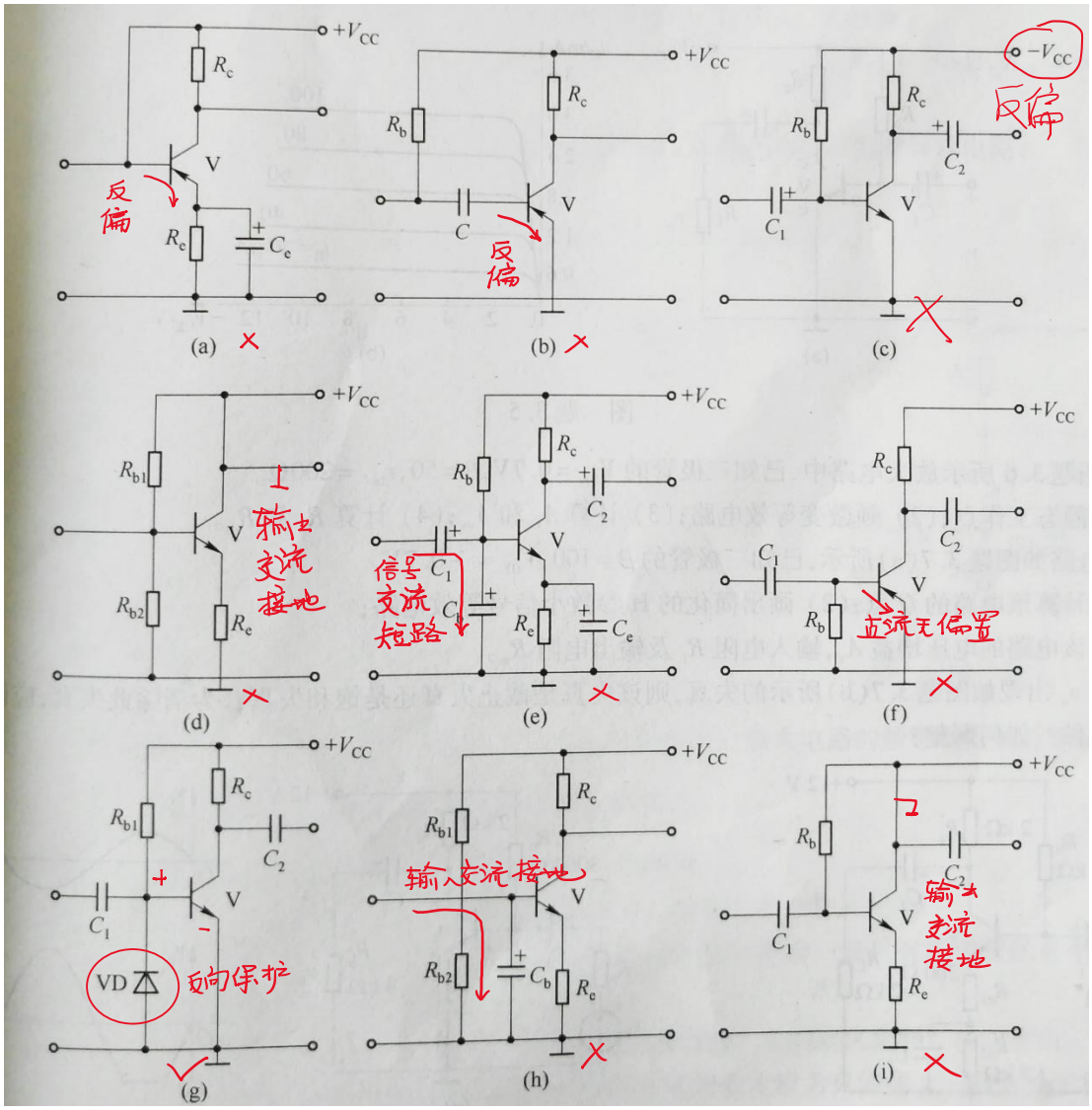
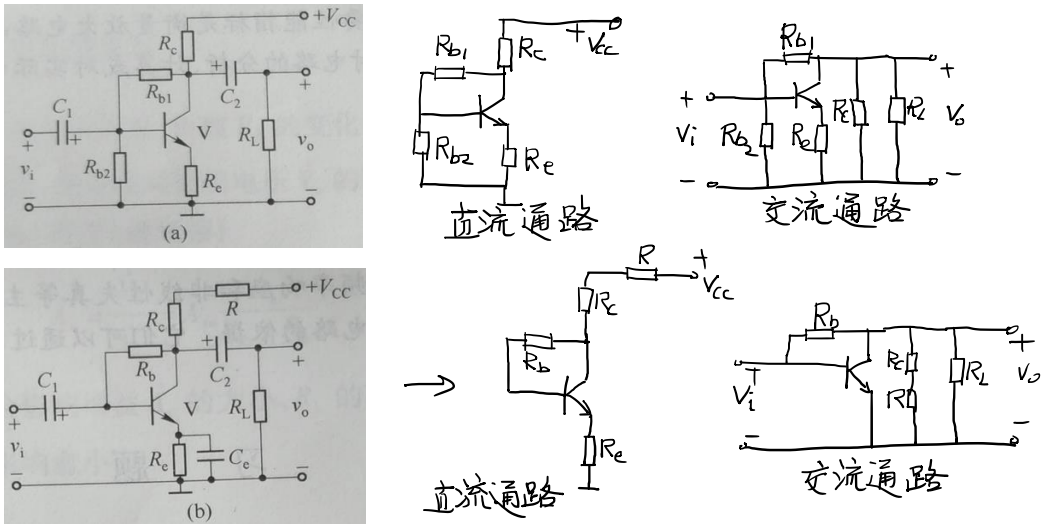
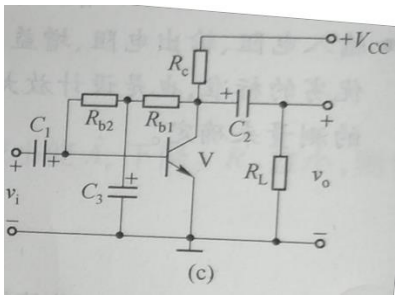
模拟与数字电路第三章作业

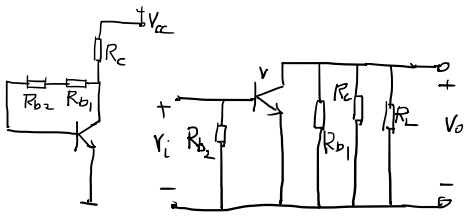
3.1 判断如下电路对正弦交流信号有无放大作用，并简述理由。



3.4 试画出下图所示的电路的直流通路和交流通路。

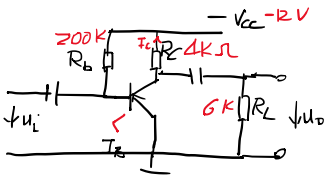


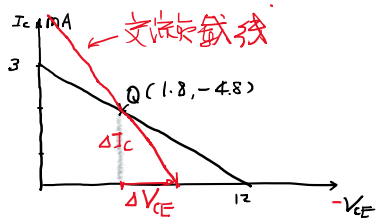




3.5 共发射极电路如图所示。三极管的$\beta = 30$，输出特性如图 b 所示。设$-V_{cc} = -12v$，$R_b = 200\Omega$，$R_c = 4k\Omega$，$R_L = 6k\Omega$。

1、试用图解法求出静态工作点，并判断该工作点选的是否合适；
2、若$\beta = 100$，电路能否正常工作？
3、画出交流负载线，求出该电路最大不失真输出电压V_{max}。有效值。





$\frac{\Delta I_C}{\Delta V_{CE}} = \frac{1}{R_L'}$

解

1、先估算基极电流$I_B = \frac{-v_{BE}-(-12)}{200} \approx \frac{12}{200} = 60\mu A$，$I_C = 30 \times 60 = 1.8mA$，

$u_{CE} = I_C R_C - V_{CC} = 1.8 \times 4 - 12 = -4.8V$。画出直流负载线如图，其中$I_{Cmax} = \frac{12}{4} = 3mA$。工作点合适。

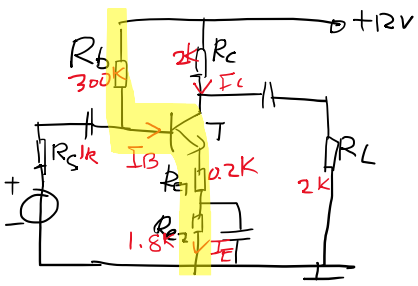
2、如果$\beta = 100$，则$I_C = \beta I_B = 100 \times 0.06 = 6mA > I_{Cmax}$，所以不能正常工作。

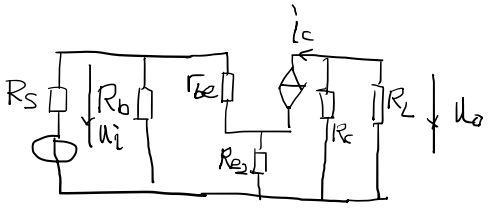
3、交流负载电阻是$R_L' = R_C \parallel R_L = \frac{4\times6}{4+6} = 2.4K\Omega$。交流负载线在横轴上的截距

$\Delta V_{ce} = R_L' \cdot I_{CQ} = 2.4 \times 1.8 = 4.32V$，$V_{0max} = min\{|V_{CEQ}|, \Delta V_{CE}\} = 4.32V$，有效值：$4.32 / \sqrt{2} = 3.05V$。

3.6 下图所示放大电路中，已知三极管的$V_{BE} = 0.7V$，$\beta = 50$，$r_{bb'} = 200\Omega$。求：

1、静态工作点；2、画微变等效电路；3、计算A_v，A_{vs}，4、计算R_i，R_0。





解 1、估算静态工作点。在基极直流通路，有：$R_bI_B+0.7+(1+\beta)I_BR_e=V_{CC}$，$I_B=\frac{V_{CC}-0.7}{R_b+(1+\beta)R_e}=\frac{12-0.7}{300+(50+1)\times2}=\frac{11.3}{400}=28\mu A$，$I_C=50\times28=1.4mA$，$U_{ce}=12-I_CR_C-I_eR_e\approx12-I_C(R_C+R_e)=12-1.4(2+2)=6.4V$。

2、微变等效电路如图所示。

3、计算放大倍数。$r_{be}=r_{bb'}+\frac{26m_v}{I_E}(1+\beta)=200+51\times\frac{26}{1.4}=1.15k\Omega$，

$$A_v=-\frac{\beta R_L'}{r_{be}+(1+\beta)R_e}=-\frac{50\times\frac{2\times2}{2+2}}{1.15+51\times0.2}=-\frac{50}{11.35}=-4.41$$

$A_{vs}=A_v\frac{r_i}{r_i+R_s}$，$r_i=\frac{R_b\cdot(r_{be}+(1+\beta)R_e)}{R_b+r_{be}+(1+\beta)R_e}=\frac{300(1.15+51\times0.2)}{300+1.15+51\times0.2}=\frac{3405}{311}=11k\Omega$

$A_{vs}=-4.41\frac{11}{11+1}=-4.04$；$r_0=R_c=2k\Omega$。$r_i=R_b\parallel(r_{be}+(1+\beta)R_e)=300\parallel(1.15+51\times0.2)=10.93k\Omega$

3.9 三极管$\beta=50$，试求：

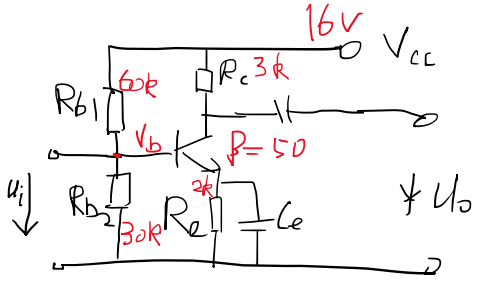
1、静态工作点。若$\beta=100$，电路能否正常工作？

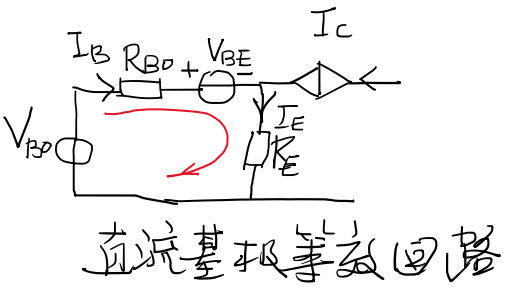
2、电压放大倍数；

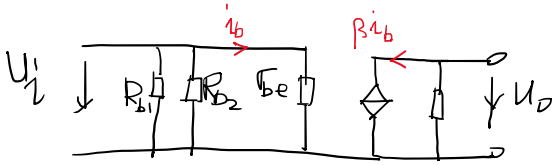
3、输入电阻，输出电阻；

4、电容虚焊时的电压放大倍数。

解：







1、 静态工作点：$V_{Bo}=\frac{R_{b2}Vcc}{R_{b2}+R_{b1}}=\frac{30\times16}{30+60}=\frac{16}{3}=5.3V$，等效电阻：$R_{B_0}=\frac{60\times30}{60+30}=20k\Omega$，在直流基极回路中，$I_B\cdot R_{B_0}+v_{BE}+(1+\beta)R_E\cdot I_B=V_{B0}$，$I_B=\frac{V_{Bo}-V_{BE}}{R_{B0}+(1+\beta)R_e}=\frac{5.3-0.7}{20+2(1+50)}\approx\frac{4.6}{20+102}\approx37.7\mu A$，$I_C=\beta I_B=50\times37.7=1.89mA$，$V_{ce}=V_{cc}-I_c(R_c+R_E)=16-1.89(3+2)=6.55V$。如果$\beta=100$，但$V_B$基本不变，$I_B$减小，$I_E\approx\frac{V_B-V_{BE}}{R_E}$基本保持不变，$V_{CE}$也基本不变，能正常工作。

2、 电压放大倍数。$A_u = -\frac{\beta R_C}{r_{be}}$，$r_{be} = 200 + (1+\beta)\frac{26}{I_E} = 200 + 51 \times \frac{26}{1.89} = 0.9k\Omega$

$A_u = -\frac{50\times3}{0.9} = -167$，$r_i = R_{b_1} \| R_{b_2} \| r_{be}$ $\frac{20\times0.9}{20+0.9} = 0.86k\Omega$，$r_0 = R_c = 3k\Omega$

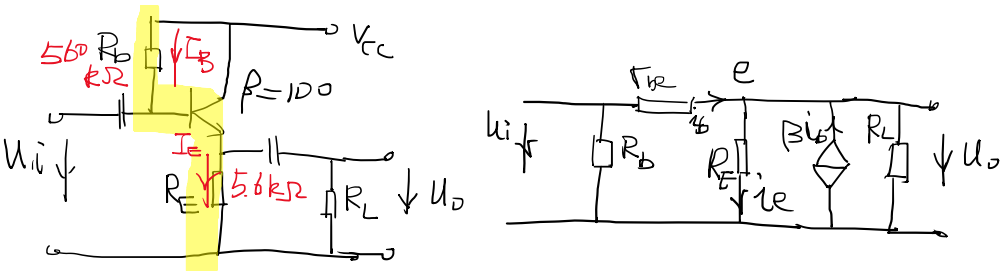
3、 如果C_e虚焊，则放大倍数：$A_u = -\frac{\beta R_C}{r_{be}+(1+\beta)R_e} = -\frac{50\times3}{0.9+51\times2} = -1.46$。

3.10 对下图电路，$\beta = 100$，求：

1、静态工作点；

2、微变等效电路；

3、负载分别是$R_L = 1.2k\Omega$和开路时的电压放大倍数，输入输出电阻。



解：1、静态工作点。基极回路，$I_B \cdot R_B + U_{BE} + (1+\beta)R_e \cdot I_B = V_{CC}$，$I_B = \frac{V_{CC}-V_{BE}}{R_B+(1+\beta)R_e} = \frac{12-0.7}{560+101\times5.6} = \frac{11.3}{1112} = 10\mu A$，$I_C = 1mA$，$V_{ce} = 12 - 5.6 = 6.4v$。

2、微变等效电路如上。

3、开路电压放大倍数：$A_{u0} = \frac{(1+\beta)R_e \cdot i_b}{(r_{be}+(1+\beta)R_e)i_b} \approx \frac{(1+\beta)R_e}{r_{be}+(1+\beta)R_e} \approx 1$，$r_{be} = 200 + (1+\beta)\cdot\frac{26}{I_E} = 200 + (1+\beta)\frac{26}{1} \approx 2.8k\Omega$，$R_L \| R_e = \frac{1.2\times5.6}{1.2+5.6} = 0.99k\Omega$。

$\frac{560\times102.79}{560+102.79}$

负载电压放大倍数：$A_u = \frac{101\times0.99}{2.8+101\times0.99} = 0.97$

输入电阻，输出开路：$r_i = R_b||(r_{be} + (1+\beta)R_e) = 560||(2.8 + 101\times5.6) = 280k\Omega$，

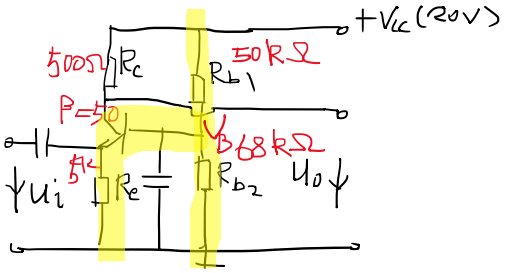
带负载时：$r_i = R_b||(r_{be} + (1+\beta)R'_e) = 560 \| (2.8 + 101\times0.99) = 86.8k\Omega$

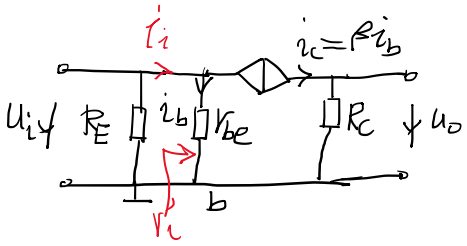
输出电阻：$r_0 = \frac{r_{be}}{1+\beta} = \frac{2.8}{101} \approx 28\Omega$

3.12 如图所示电路，求：

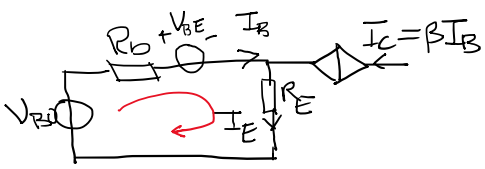
1、电路所属组态及其静态工作点；

2、放大倍数和输入输出电阻。





解：微变等效电路如图所示。为共基极放大电路。



$R_b = R_{b1} \| R_{b2}$

$V_{B0} \approx \frac{R_{b2}}{R_{b1}+R_{b2}} \cdot V_{CC}$

$R_B = \frac{50\times68}{50+68} = 28.8k\Omega, V_{B0} = \frac{68\times20}{50+68} = 11.5V$。$V_{B0} - V_{BE} = I_B \cdot R_b + (1+\beta) I_B \cdot R_E$

$I_B = \frac{v_{B_0} - v_{BE}}{R_b + (1+\beta)R_E} = \frac{11.5-0.7}{28{,}8+51\times5} = \frac{10.8}{283.8} = 38\mu A$（或按$\frac{V_{B0}}{\beta R_E} = \frac{11.5}{50\times5} = 46\mu A$估算。）

$I_C = 50I_B = 50\times38 = 1.9mA$，$V_{CE} \approx v_{cc} - (R_c + R_E)I_c = 20 - 5.5\times1.9 = 9.5V$

$r_{be} = 200 + (1+\beta)\frac{26}{I_E} = 200 + \frac{26}{I_B} = 0.2 + \frac{26}{38} = 0.88k\Omega$

$u_0 = \beta i_b \cdot R_c = \beta \cdot \frac{u_i}{r_{be}} \cdot R_c$，$A_u = \frac{u_0}{u_i} = \frac{\beta R_C}{r_{be}} = \frac{50\times0.5}{0.88} = 28.4$

$i_i = \frac{u_i}{r_{be}} + \beta \cdot \frac{u_i}{r_{be}} = \frac{(1+\beta)u_i}{r_{be}}$，$r_i' = \frac{r_{be}}{1+\beta} = \frac{0.88}{51} = 17.2\Omega, r_i = R_E \| r_i^1 = \frac{5\times0.017}{5+0.017} = 17\Omega$

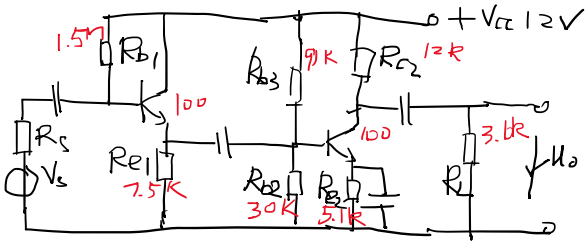
$r_0 = R_c = 0.5k\Omega$

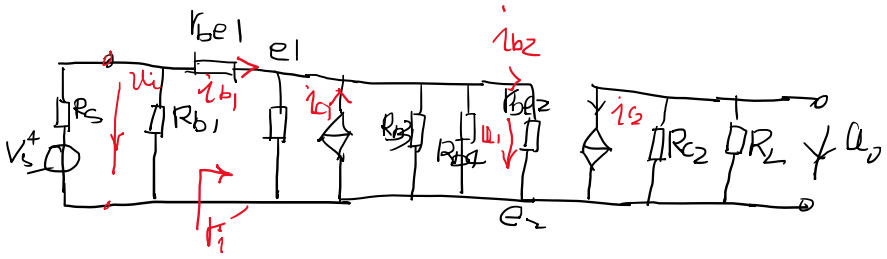
3.21 如图两级放大电路，β值均为 100，$r_{be_1} = 5.3k\Omega$，$r_{be_2} = 6k\Omega$。求：

1、小信号等效电路；

2、输入输出电阻；

3、开路和负载电压放大倍数。





输入电阻：$i_{b_1}\cdot r_{be_1}+(1+\beta)i_{bi}R'_e=u_i$，$r'_i=r_{be_1}+(1+\beta)R'_e$，$R'_e=Re_1||R_{b_3}||R_{b4}||r_{be2}=2.9k\Omega$，$r'_i=5.3+101\times 2.9=298.2k\Omega$，$r_i=R_{b1}\parallel r'_i=248.6k\Omega$，

输出电阻：$r_0=Rc_2=12k\Omega$

电压放大倍数：$A_u=\frac{u_0}{u_i}=\frac{u_1}{u_i}\cdot\frac{u_o}{u_1}$，$A_{u_1}=\frac{(1+\beta)\cdot R'_e}{r_{be_1}+(1+\beta)R'_e}=\frac{101\times 2.9}{5.3+101\times 2.9}=0.98$; $A_{u_2}=-\frac{\beta R'_L}{r_{be_2}}=-16.7R'_L$，$A_u=-0.98\times 16.7R'_L=-16.4R'_L$，$A_{u0}=-16.4\times 12=-196.8$，$A_{u_L}=-16.4\times\frac{3.6\times 12}{3.6+12}=-45.4$