[5-10] $u_{o1}=u_{i1}$, $u_{o2}=u_{i2}$

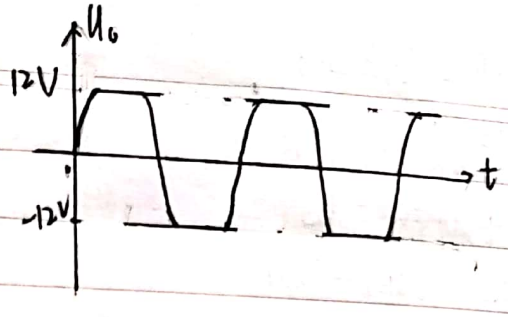
两个驱动电路(电压缓冲器)+差分放大电路

一个差分放大电路

$$u_o=\frac{20k+100k}{20k}\cdot\frac{100k}{20k+100k}u_{o2}-\frac{100k}{20k}u_{o1}$$

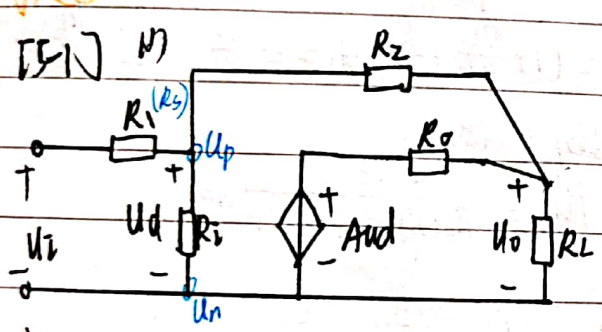
$$=5u_{o2}-5u_{o1}$$

$$=5(u_{i2}-u_{i1})$$



习题5

[5-1] (1)



(2)

$u_o=A_{ud}=10^5(u_p-u_n)=10^5\times2\times10^{-5}V=2V$

$u_o'=\frac{R_L}{R_L+R_o}A_{ud}=2V\times\frac{200}{200+50}=1.6V$

因为 $|A(u_p-u_n)|=20V>V_{cc}=12V$ 超出线性区

$\therefore u_o=-12V$

$u_o'=\frac{200}{200+50}\times(-12V)=-9.6V$

[5-2] $\frac{u_p-u_s}{R_s}+\frac{u_p-u_n}{R_2}=0$ (由5-1图)

又 $u_p-u_n=u_d$ $u_n=0$

$\therefore u_d=\frac{R_2}{R_i+R_s}u_s$

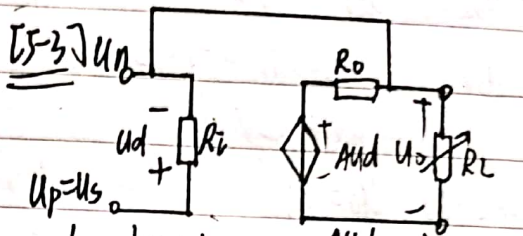
又 $u_o=A_{ud}$

$\therefore$ 工作在线性区时, $u_o=50\sin2\pi t\ V$

$|u_o|\le12V$ 即 $|u_s|\le0.24mV$

$$\therefore u_o=\begin{cases}12V, & u_s>0.24mV\\ 50\sin2\pi t\ V, & |u_s|\le0.24mV\\ -12V, & u_s<-0.24mV\end{cases}$$

[5-3] u_n



$(R_o+R_L+R_i)u_o-\frac{A_{ud}}{R_o}-R_iu_s=0$

$u_d=u_s-u_o$

$$\therefore\frac{u_o}{u_s}=\frac{R_i+\frac{A}{R_o}}{\frac{A}{R_o}+R_i+R_2+R_o}\approx1$$

[5-4] $\begin{cases}\frac{u_n-u_s}{10K}+\frac{u_n-u_o}{100K}+\frac{u_n-u_p}{100K}=0\\ \frac{u_o-A_{ud}}{100}+\frac{u_o-u_n}{100K}=0\end{cases}$

又 $u_d=u_p-u_n$, $u_p=0$, $u_n=u_s$

$\therefore u_d=-u_s$

$\frac{u_o}{u_s}\approx-10$

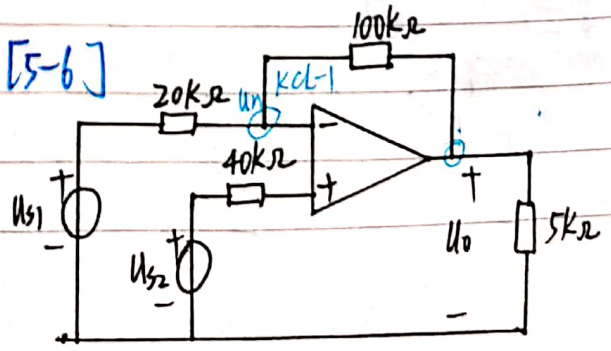
(2) $|-10u_s|\le12V$

[5-5] $\frac{u_o}{u_s}=-\frac{10k\Omega}{5k\Omega}=-2$

(1) $u_o=-6V$ (2) $u_o=10V$ (3) $-2u_s=4V>12V$ $<-12V$

$\therefore u_o=\pm12V$ (4) $u_o=12V$

[5-6]



工作在线性区时，

由KCL-1：$\frac{U_n-U_{S1}}{20K}+\frac{U_n-U_0}{100K}=0$

又 $U_n=U_p=U_{S2}$

$\therefore U_0=6U_{S2}-5U_{S1}$

(1) $U_{S1}=2V$, $U_{S2}=0$, $U_0=-10V$

(2) $U_{S1}=3V$, $U_{S2}=0$, $6U_{S2}-5U_{S1}=-15V<-12V$

$\therefore U_0=-12V$

(3) $U_{S1}=2V$, $U_{S2}=3V$, $U_0=8V$

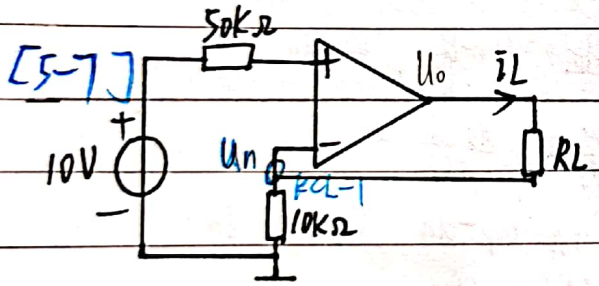
(4) $U_{S1}=1V$, $U_{S2}=4V$, $6U_{S2}-5U_{S1}=19V>12V$

$\therefore U_0=12V$

(5) $|30-5U_{S1}|\le 12V$

$\therefore 3.6V\le U_{S1}\le 8.4V$

[5-7]



$\frac{U_n}{10\times10^3}+\frac{U_n-U_0}{R_L}=0$

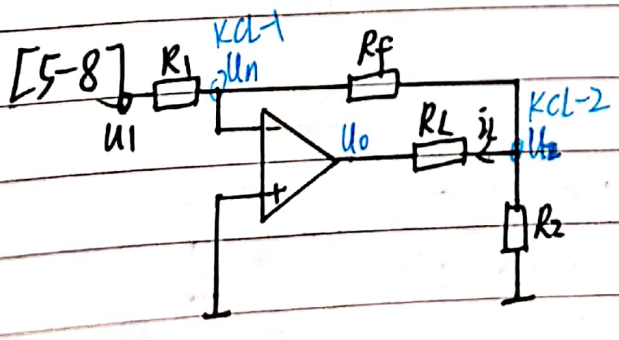
又 $U_n=U_p=10V$，$i_L=\frac{U_0-U_n}{R_L}$

$\therefore i_L=1mA$

2) 工作在线性区时，$U_0\le 12V$

$\therefore R_L=\frac{U_0-U_n}{i_L}<2k\Omega$

[5-8]



KCL-1：$\frac{U_n-U_1}{R_1}+\frac{U_n-U_2}{R_f}=0$ ①

KCL-2：$\frac{U_2-U_n}{R_f}+\frac{U_2-U_0}{R_L}+\frac{U_2}{R_2}=0$ ②

又 $U_n=U_p=0$　　$i_L=\frac{U_2-U_0}{R_L}$

由①得，$U_2=-\frac{R_f}{R_1}U_1$

代入②，$(\frac{1}{R_f}+\frac{1}{R_L}+\frac{1}{R_2})U_2=\frac{1}{R_L}U_0$

$\therefore (1+\frac{R_L}{R_f}+\frac{R_L}{R_2})U_2=U_0$

$\therefore i_L=\frac{U_2-U_0}{R_L}=(\frac{1}{R_f}+\frac{1}{R_2})\frac{R_f}{R_1}U_1$

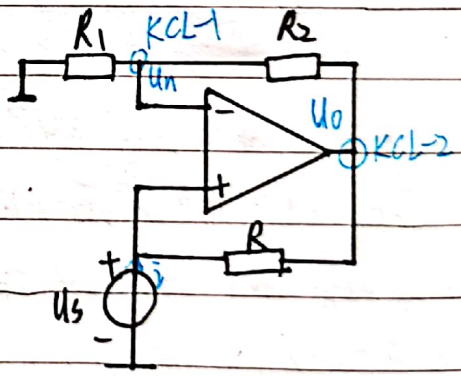
即 $i_L=gU_1$，$g=\frac{1}{R_1}(1+\frac{R_f}{R_2})$

(2) $U_0=(1+\frac{R_L}{R_f}+\frac{R_L}{R_2})U_2=-\frac{R_f}{R_1}(1+\frac{R_L}{R_f}+\frac{R_L}{R_2})U_1$

$|U_0|\le U_{CC}$

$\therefore |U_1|\le \frac{R_1R_2}{R_L(R_f+R_2)+R_2R_f}U_{CC}$

[5-9]



由虚短

$U_n=U_p=U_S$

KCL-1：$\frac{U_n}{R_1}+\frac{U_n-U_0}{R_2}=0$ $\Rightarrow U_0=(1+\frac{R_2}{R_1})U_S$

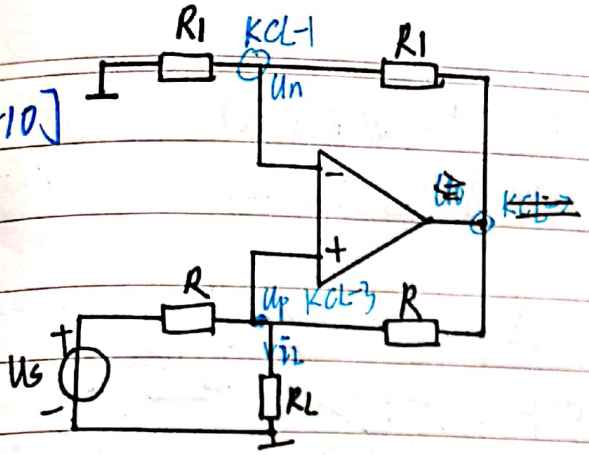
KCL-2：$\frac{U_0-U_n}{R_2}+\frac{U_0-U_S}{R}=0$

$i=\frac{U_S-U_0}{R}$　　$\therefore i=-\frac{R_2}{R_1\cdot R}U_S$

(b)中，$i=\frac{U_S}{-\frac{R_1}{R_2}R}=-\frac{R_2}{R_1\cdot R}U_S$

即(a)等效为图(b)

[5-10]



$U_n = U_p$

KCL-1: $\frac{U_n}{R_1} + \frac{U_n - U_o}{R_1} = 0$ ①

~~KCL-2: $\frac{U_o - U_n}{R_1} + \frac{U_o - U_p}{R} = 0$~~

KCL-3: $\frac{U_p - U_s}{R} + \frac{U_p}{R_L} + \frac{U_p - U_o}{R} = 0$ ③

$i_L = \frac{U_p}{R_L}$

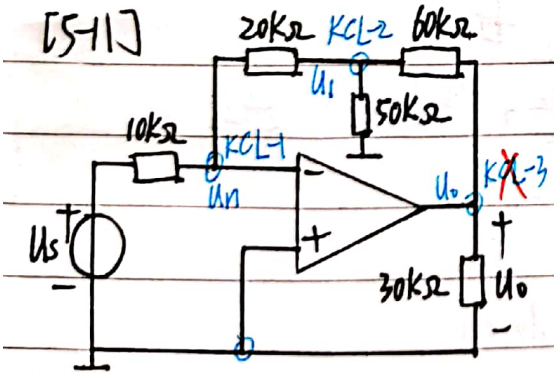
由①得: $U_o = 2U_n = 2U_p$ 代入③:

$\therefore \frac{U_p - U_s}{R} + \frac{U_p}{R_L} - \frac{U_p}{R} = 0$

$\therefore \frac{U_p}{R_L} = \frac{U_s}{R}$ 即 $i_L = \frac{U_s}{R}$

∴ (a) 等效为 (b)

[5-11]



KCL-1: $\frac{U_n - U_s}{10K} + \frac{U_n - U_1}{20K} = 0$ ①

KCL-2: $\frac{U_1 - U_n}{20K} + \frac{U_1 - U_o}{60K} + \frac{U_1}{50K} = 0$ ②

~~KCL-3: $\frac{U_o - U_1}{60K} + \frac{U_o}{30K} = 0$ ③ 出口电流不是0~~

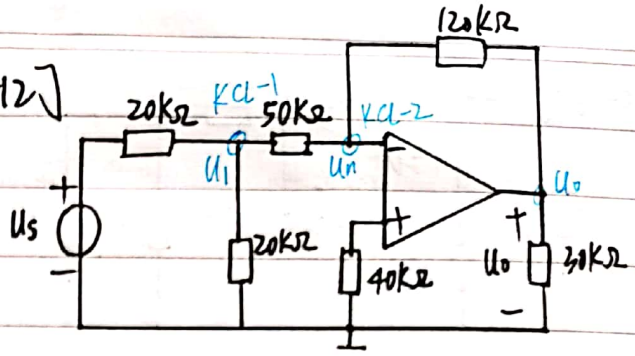
又 $U_n = U_p = 0$

由①得 $3U_n = 2U_s + U_1$ ④

由②得 $26U_1 - 15U_n - 5U_o = 0$ ⑤代入④消 U_1

$\therefore \frac{62}{26}U_n = 2U_s + \frac{5}{26}U_o$ 又 $U_n = 0$ $\therefore \frac{U_o}{U_s} = -10.4$

[5-12]



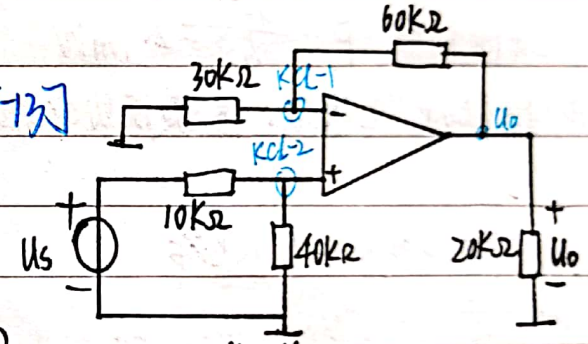
KCL-1: $\frac{U_n - U_s}{20K} + \frac{U_1}{20K} + \frac{U_1 - U_n}{50K} = 0$ ①

KCL-2: $\frac{U_n - U_1}{50K} + \frac{U_n - U_o}{120K} = 0$ ② 又 $U_n = U_p = 0$

由①: $12U_1 = 5U_s$ 由②: $12U_1 = -5U_o$

$\therefore \frac{U_o}{U_s} = -1$

[5-13]



(1)

KCL-1: $\frac{U_n}{30K} + \frac{U_n - U_o}{60K} = 0 \Rightarrow U_o = 3U_n$

KCL-2: $\frac{U_p - U_s}{10K} + \frac{U_p}{40K} = 0 \Rightarrow U_s = \frac{5}{4}U_p$

又 $U_n = U_p$

$\therefore \frac{U_o}{U_s} = \frac{12}{5} = 2.4$

(2) $|2.4U_s| \le 12$ $\therefore |U_s| \le 5V$

[5-14] (1) $U_1 = \frac{R_V}{R_V + 19K\Omega} \times 5mV = 0.25mV$

(2) $U_2 = 5mV$

[5-15] (1) $U_o = \frac{100}{100+300} \times 5V = 1.25V$

负载吸收功率 $P_1 = \frac{U_o^2}{R_o} = 1.5625 \times 10^{-2} W$

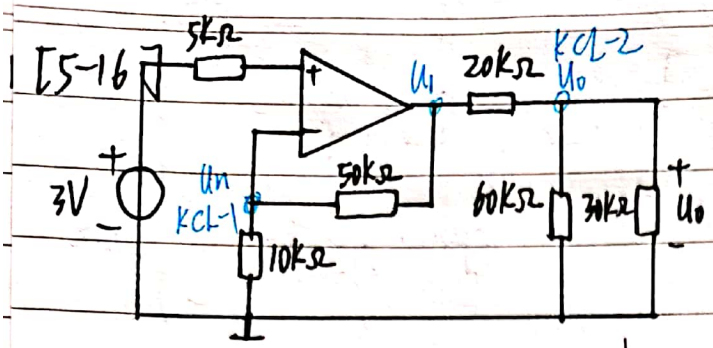
信号源提供功率 $P_2 = \frac{5^2}{300+100} = 1.5625 \times 10^{-2} W$

(2) $U_o' = 5V$

$P_1' = \frac{U_o'^2}{R_o} = 0.25W$

信号源提供功率为0

[5-16]



KCL-1: $\frac{U_n}{10K}+\frac{U_n-U_1}{50K}=0$

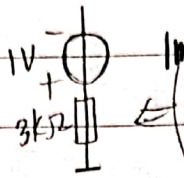
又 $U_n=U_p=3V$ ∴ $U_1=18V$

KCL-2: $(\frac{1}{60K}+\frac{1}{30K}+\frac{1}{20K})U_o-\frac{1}{20K}U_1=0$

∴ $U_o=\frac{1}{2}U_1=9V$

∴30KΩ电阻功率 $P=\frac{U_o^2}{30\times10^3}=2.7mW$

由虚断特性知 理想电压源提供功率为0



[5-17] 如图为同相求和放大电路

$U_o=\frac{1+\frac{40K}{10K}}{\frac{1}{10K}+\frac{1}{20K}+\frac{1}{60K}}(\frac{U_{S1}}{10K}+\frac{U_{S2}}{20K}+\frac{U_{S3}}{60K})$

$=3U_{S1}+1.5U_{S2}+0.5U_{S3}$

[5-18] 如图为反相求和放大电路

$U_o=-(\frac{100K}{40K}U_{S1}+\frac{100K}{20K}U_{S2}+\frac{100K}{10K}U_{S3})$

$=-2.5U_{S1}-3.3U_{S2}-10U_{S3}$

[5-19] (a)中, $U_o=U_1-U_2$

$U_1=\frac{30}{30+10}U_S=\frac{3}{4}U_S$, $U_2=\frac{60}{60+40}U_S$ ∴ $U_o=\frac{3}{20}U_S$

(b)中: $\frac{U_n-U_1}{20K}+\frac{U_n-U_o}{80K}=0$

$\frac{U_p}{80K}+\frac{U_p-U_2}{20K}=0$

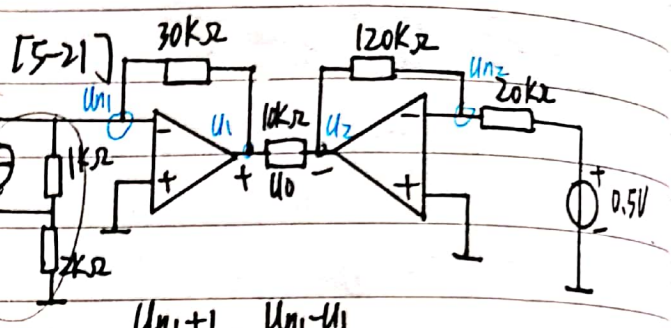
又 $U_n=U_p$ ∴ $U_o=4(U_2-U_1)$

∴ $U_o=-\frac{3}{5}U_S$

[5-20] (课本前面给3公式)

$U_o=(1+\frac{R_2}{R_1}+\frac{2R_2}{R_6})(U_1-U_2)$

[5-21]



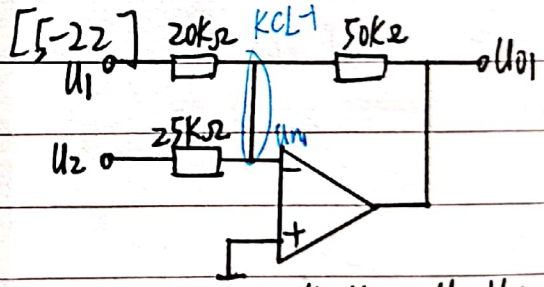
KCL-1: $\frac{U_{n1}+1}{3K}+\frac{U_{n1}-U_1}{30K}=0$

KCL-2: $\frac{U_{n2}-0.5}{20K}+\frac{U_{n2}-U_2}{120K}=0$

$U_o=U_1-U_2$ 又 $U_{n1}=U_{p1}=0$, $U_{n2}=U_{p2}=0$

∴ $U_o=13V$

[5-22]



KCL-1: $\frac{U_n-U_2}{25K}+\frac{U_n-U_1}{20K}+\frac{U_n-U_{o1}}{50K}=0$

又 $U_{n1}=U_{p1}=0$

∴ $U_{o1}=-2.5U_1-2U_2$

同理 又 $U_o=-2(U_{o1}+U_3)$

$=-2(-2.5U_1-2U_2)-2U_3$

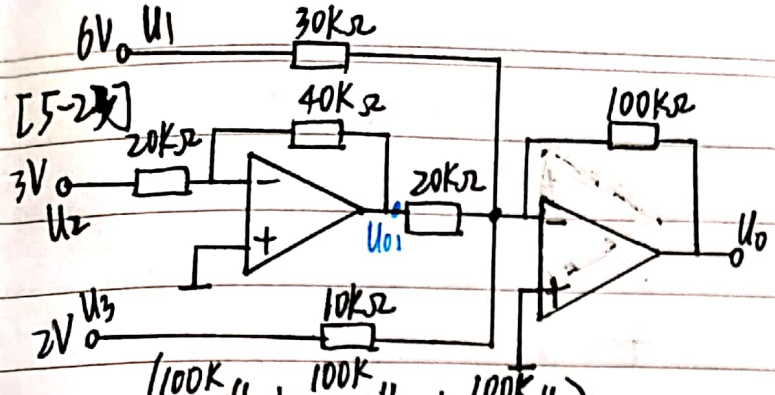
∴ $U_o=5U_1+4U_2-2U_3$

$(\frac{U_{n2}-U_{o1}}{25K}+\frac{U_{n2}-U_3}{25K}+\frac{U_{n2}-U_o}{50K}=0$

$U_{n2}=U_{p2}=0)$

[5-23] 同上

[5-23]

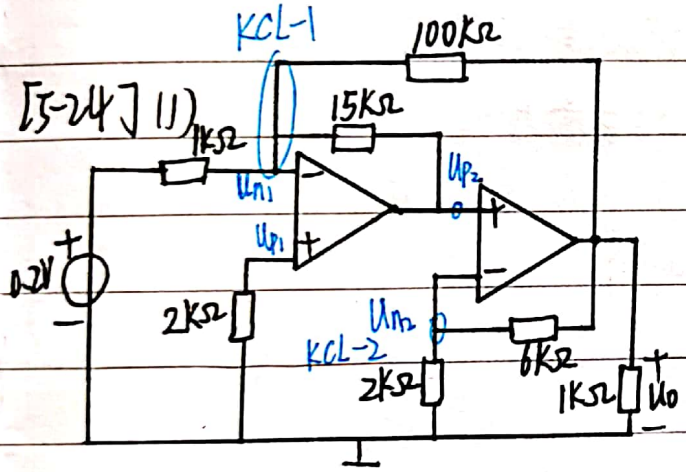


$$U_o=-\left(\frac{100K}{30K}U_1+\frac{100K}{20K}U_{01}+\frac{100K}{10K}U_3\right)$$

$$U_{01}=-\frac{40K}{20K}U_2=-2U_2=-6V$$

$$\therefore U_o=-20+30-20=-10V$$

[5-24] 1)



$$KCL\text{-}1:\ \frac{U_{n1}-0.2}{1K}+\frac{U_{n1}-U_{p2}}{15k}+\frac{U_{n1}-U_o}{100K}=0$$

$$KCL\text{-}2:\ \frac{U_{n2}}{2k}+\frac{U_{n2}-U_o}{6K}=0$$

$$\because U_{n1}=U_{p1}=0,\quad U_{p2}=U_{n2}$$

$$\therefore U_o=-7.5V$$

2) 去掉100KΩ电阻

$$KCL\text{-}1:\ \frac{U_{n1}-0.2}{1K}+\frac{U_{n1}-U_{p2}}{15}=0$$

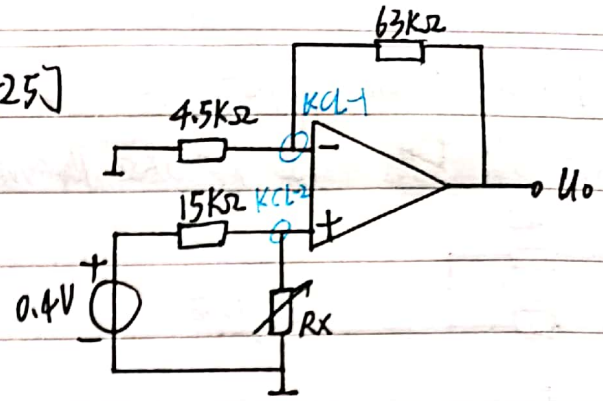
$$U_{n1}=U_{p1}=0\quad\therefore U_{p2}=-3V$$

$$KCL\text{-}2:\ \frac{U_{n2}}{2k}+\frac{U_{n2}-U_o}{6K}=0$$

$$U_{n2}=U_{p2}=-3V$$

$$\therefore U_o=-12V$$

[5-25]



$$KCL\text{-}1:\ \frac{U_n}{4.5K}+\frac{U_n-U_o}{63K}=0$$

$$KCL\text{-}2:\ \frac{U_p-0.4}{15K}+\frac{U_p}{R_x}=0$$

$$\because U_n=U_p$$

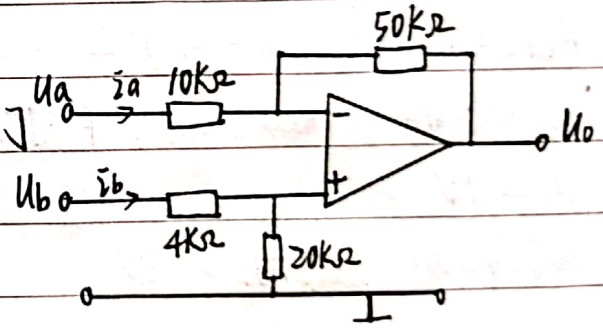
$$\therefore U_o=\frac{6R_x}{R_x+15k}$$

1) $\therefore R_x=60k\Omega$ 时，$U_o=4.8V$

2) $|U_o|=\left|\frac{6R_x}{R_x+15k}\right|\le 5V$

$$\therefore R_x\le 75K\Omega$$

[5-26]



$$U_o=\frac{10K+50K}{10K}\cdot\frac{20K}{20K+4K}U_b-\frac{50K}{10K}U_a$$

$$=5U_b-5U_a$$

1) $|U_o|=5|U_b-U_a|\le 15V\quad\therefore 1V\le U_a\le 7V$

2) 信号源U_b看进去的电阻：24KΩ

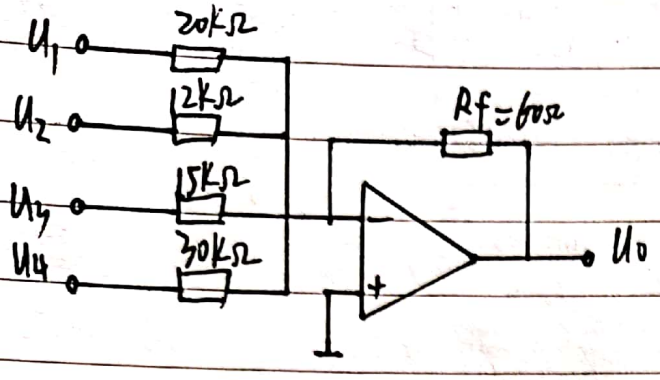
- U_a - - - - 10KΩ

[5-27] 12) $2.5V\times 4=10V$

∴工作电源最低±10V

[5-28] $U_0 = -\left(\frac{60K}{R_1}U_1 + \frac{60K}{R_2}U_2 + \frac{60K}{R_3}U_3 + \frac{60K}{R_4}U_4\right)$

$\therefore R_1 = 20K\Omega$, $R_2 = 12K\Omega$, $R_3 = 15K\Omega$, $R_4 = 30K\Omega$



[5-29] (1) $U_0 = \frac{1+\frac{Rf}{20K}}{\frac{1}{Ra}+\frac{1}{Rb}+\frac{1}{Rc}}\left(\frac{1}{Ra}U_a + \frac{1}{Rb}U_b + \frac{1}{Rc}U_c\right)$

$= \frac{1+\frac{Rf}{20K}}{RbRc+RaRc+RaRb}\left(RbRc\,U_a + RaRc\,U_b + RaRb\,U_c\right)$

$\therefore RbRc : RaRc : RaRb = 4:1:2$

$\therefore Rb = 4K\Omega$, $Rc = 2K\Omega$, $Rf = 120K\Omega$

(2) $U_0 = 7V$

此时 $U_p = U_n = \frac{20K}{20K+120K}U_0 = 1V$

$i_a = \frac{U_a - U_p}{Ra} = -0.25mA$

$i_b = \frac{U_b - U_p}{Rb} = 0$

$i_c = \frac{U_c - U_p}{Rc} = 0.25mA$

(3) 加倍后 $U_0 = 14V$