

[5-10] $U_{01} = U_{i1}, U_{02} = U_{i2}$

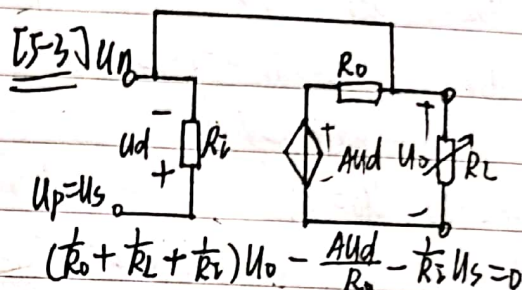
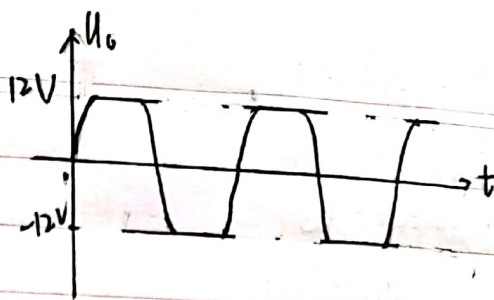
两个驱动电路 (电压缓冲器) 缓冲放大电路

一个差分放大电路

$$U_0 = \frac{20k+100k}{20k} \cdot \frac{100k}{20k+100k} U_{02} - \frac{100k}{20k} U_{01}$$

$$= 5U_{02} - 5U_{01}$$

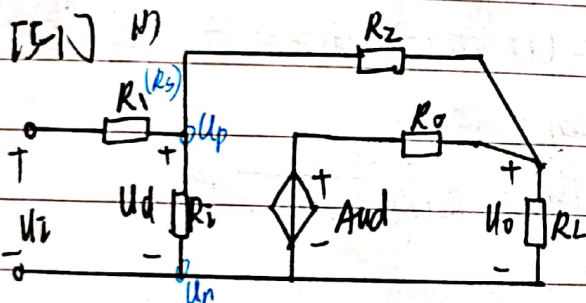
$$= 5(U_{i2} - U_{i1})$$



$$U_d = U_s - U_0$$

$$\therefore \frac{U_0}{U_s} = \frac{\frac{1}{R_i} + \frac{A}{R_0}}{\frac{A}{R_0} + \frac{1}{R_i} + \frac{1}{R_L} + \frac{1}{R_0}} \approx 1$$

题5



2)

$$U_0 = A_{ud} = 10^5 (U_p - U_n) = 10^5 \times 2 \times 10^{-5} V = 2V$$

$$U_0' = \frac{R_L}{R_L + R_0} A_{ud} = 2V \times \frac{200}{200 + 50} = 1.6V$$

3) $\because |A(U_p - U_n)| = 20V > U_{CC} = 12V$ 超出线性区

$$\therefore U_0 = -12V$$

$$U_0' = \frac{200}{200 + 50} \times (-12V) = -9.6V$$

[5-4] $\begin{cases} \frac{U_n - U_s}{10k} + \frac{U_n - U_0}{100k} + \frac{U_n - U_p}{100k} = 0 \\ \frac{U_0 - A_{ud}}{100} + \frac{U_0 - U_n}{100k} = 0 \end{cases}$

$$\text{又 } U_d = U_p - U_n, U_p = 0, U_n = U_s$$

$$\therefore U_d = -U_s$$

$$\frac{U_0}{U_s} \approx -10$$

$$12) |10U_s| \leq 12V$$

[5-5] $\frac{U_0}{U_s} = -\frac{10k\Omega}{5k\Omega} = -2$

$$\therefore 1) U_0 = -6V \quad 2) U_0 = 10V \quad 3) -2U_s \geq 4V \quad 4) -2U_s \leq -12V$$

$$\therefore U_0 \geq 2V \quad 14) U_0 = 12V$$

[5-2] $\frac{U_p - U_s}{R_1} + \frac{U_p - U_n}{R_2} = 0$ (由5-1图)

$$\text{又 } U_p - U_n = U_d \quad U_n = 0$$

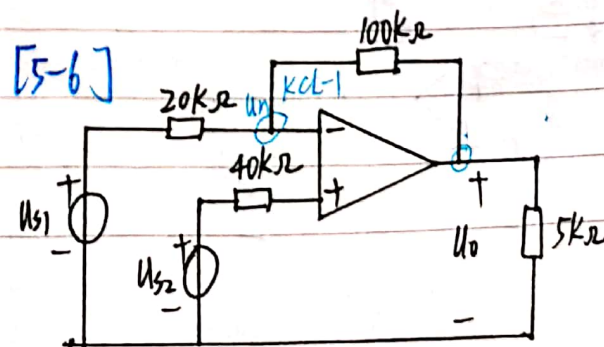
$$\therefore U_d = \frac{R_2}{R_1 + R_2} U_s$$

$$\text{又 } U_0 = A_{ud}$$

$$\therefore \text{工作在线性区时, } U_0 = 50 \sin 2\pi t V$$

$$|U_0| \leq 12V \quad R_1 |U_s| \leq 0.24mV$$

$$\therefore U_0 = \begin{cases} 12V, & U_s > 0.24mV \\ 50 \sin 2\pi t V, & |U_s| \leq 0.24mV \\ -12V, & U_s < -0.24mV \end{cases}$$



扫描全能王 创建

工作在线性区时,

$$\text{由KCL-1: } \frac{U_n - U_{s1}}{20K} + \frac{U_n - U_o}{100K} = 0$$

$$\text{又 } U_n = U_p = U_{s2}$$

$$\therefore U_o = 6U_{s2} - 5U_{s1}$$

$$1) U_{s1} = 2V, U_{s2} = 0, U_o = -10V$$

$$2) U_{s1} = 3V, U_{s2} = 0, 6U_{s2} - 5U_{s1} = -15V < -12V$$

$$\therefore U_o = -12V$$

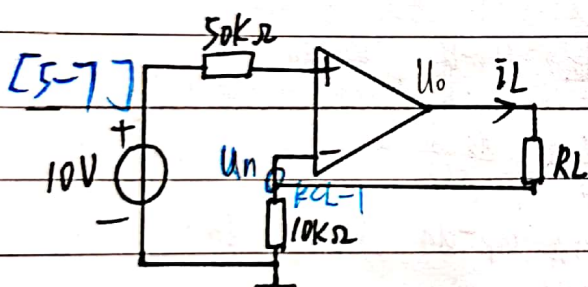
$$3) U_{s1} = 2V, U_{s2} = 3V, U_o = 8V$$

$$4) U_{s1} = 1V, U_{s2} = 4V, 6U_{s2} - 5U_{s1} = 19V > 12V$$

$$\therefore U_o = 12V$$

$$5) |30 - 5U_{s1}| \leq 12V$$

$$\therefore 3.6V \leq U_{s1} \leq 8.4V$$



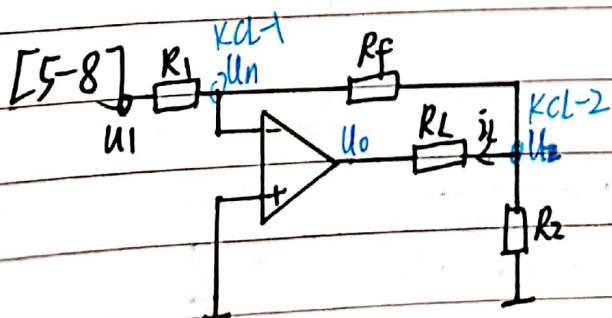
$$\frac{U_n}{10 \times 10^3} + \frac{U_n - U_o}{R_L} = 0$$

$$\text{又 } U_n = U_p = 10V, \quad i_L = \frac{U_o - U_n}{R_L}$$

$$\therefore i_L = 1mA$$

$$2) \text{工作在线性区时, } U_o \leq 12V$$

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



$$\text{KCL-1: } \frac{U_n - U_1}{R_1} + \frac{U_n - U_o}{R_F} = 0 \quad (1)$$

$$\text{KCL-2: } \frac{U_o - U_n}{R_F} + \frac{U_o - U_o}{R_L} + \frac{U_o}{R_2} = 0 \quad (2)$$

$$\text{又 } U_n = U_p = 0 \quad i_L = \frac{U_o - U_o}{R_L}$$

$$\text{由(1)得: } U_o = -\frac{R_F}{R_1} U_1$$

$$\text{代入(2): } (\frac{1}{R_F} + \frac{1}{R_L} + \frac{1}{R_2}) U_o = \frac{1}{R_L} U_o$$

$$\therefore (1 + \frac{R_L}{R_F} + \frac{R_L}{R_2}) U_o = U_o$$

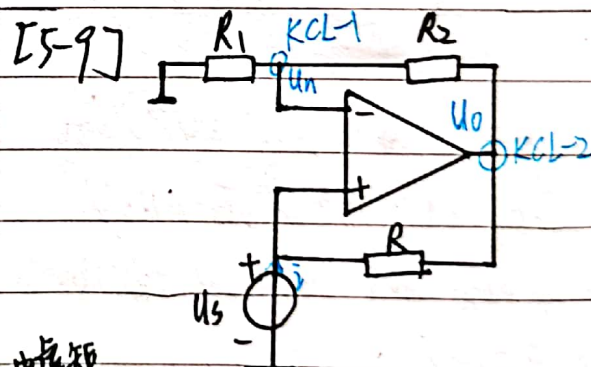
$$\therefore i_L = \frac{U_o - U_o}{R_L} = (\frac{1}{R_F} + \frac{1}{R_2}) \frac{R_F}{R_1} U_1$$

$$\text{即 } i_L = g U_1, \quad g = \frac{1}{R_1} (1 + \frac{R_F}{R_2})$$

$$12) U_o = (1 + \frac{R_L}{R_F} + \frac{R_L}{R_2}) U_o = -\frac{R_F}{R_1} (1 + \frac{R_L}{R_F} + \frac{R_L}{R_2}) U_1$$

$$|U_o| \leq U_{CC}$$

$$\therefore |U_1| \leq \frac{R_1 R_2}{R_L (R_F + R_2) + R_2 R_F} U_{CC}$$



由虚短

$$U_n = U_p = U_5$$

$$\text{KCL-1: } \frac{U_n}{R_1} + \frac{U_n - U_o}{R_2} = 0 \Rightarrow U_o = (1 + \frac{R_2}{R_1}) U_5$$

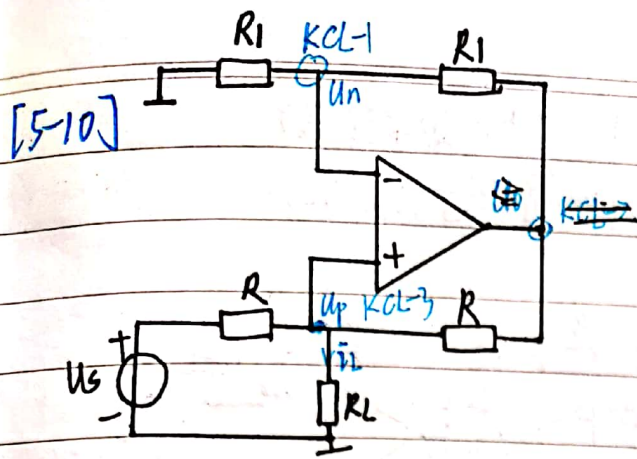
$$\text{KCL-2: } \frac{U_o - U_n}{R_2} + \frac{U_o - U_5}{R} = 0$$

$$i = \frac{U_5 - U_o}{R} \quad \therefore i = -\frac{R_2}{R_1 R} U_5$$

$$(b) \text{中, } i = \frac{U_5}{-\frac{R_1}{R_2} R} = -\frac{R_2}{R_1 R} U_5$$

即(a)等效为图(b)

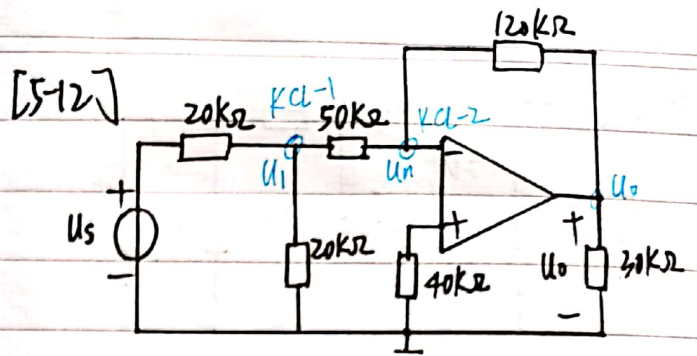




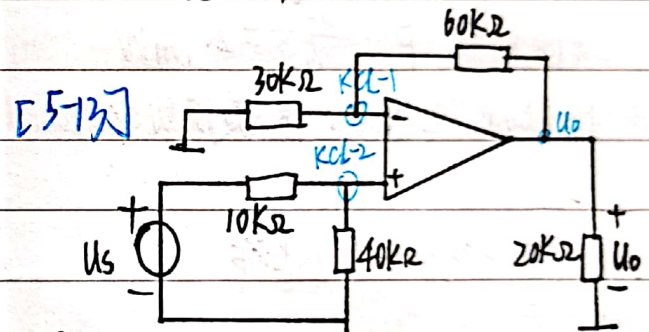
$$\begin{aligned} \text{KCL-1: } \frac{U_n}{R_1} + \frac{U_n - U_o}{R_1} &= 0 \quad (1) \\ \text{KCL-2: } \frac{U_o - U_n}{R} + \frac{U_n - U_s}{R} &= 0 \\ \text{KCL-3: } \frac{U_p - U_s}{R} + \frac{U_p}{R_L} + \frac{U_p - U_o}{R} &= 0 \quad (3) \\ i_L &= \frac{U_p}{R_L} \end{aligned}$$

由①得: $U_o = 2U_n = 2U_p$ 代入③:

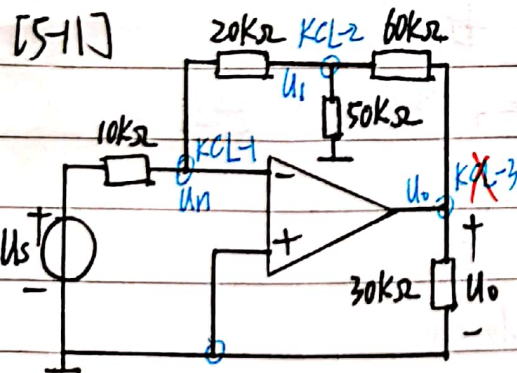
$$\begin{aligned} \therefore \frac{U_p - U_s}{R} + \frac{U_p}{R_L} - \frac{U_p}{R} &= 0 \\ \therefore \frac{U_p}{R_L} &= \frac{U_s}{R} \quad \text{即 } i_L = \frac{U_s}{R} \\ \therefore (a) \text{ 等效为 } (b) \end{aligned}$$



$$\begin{aligned} \text{KCL-1: } \frac{U_n - U_s}{20k} + \frac{U_n}{20k} + \frac{U_n - U_o}{50k} &= 0 \quad (1) \\ \text{KCL-2: } \frac{U_n - U_1}{50k} + \frac{U_n - U_o}{120k} &= 0 \quad (2) \quad \text{又 } U_n = U_p = 0 \\ \text{由①: } 12U_1 &= 5U_s \quad \text{由②: } 12U_1 = -5U_o \\ \therefore \frac{U_o}{U_s} &= -1 \end{aligned}$$



$$\begin{aligned} \text{KCL-1: } \frac{U_n}{30k} + \frac{U_n - U_o}{60k} &= 0 \Rightarrow U_o = 3U_n \\ \text{KCL-2: } \frac{U_p - U_s}{10k} + \frac{U_p}{40k} &= 0 \Rightarrow U_s = \frac{5}{4}U_p \\ \text{又 } U_n &= U_p \\ \therefore \frac{U_o}{U_s} &= \frac{12}{5} = 2.4 \\ (2) \quad |2.4U_s| &\leq 12 \quad \therefore |U_s| \leq 5V \end{aligned}$$



$$\begin{aligned} \text{KCL-1: } \frac{U_n - U_s}{10k} + \frac{U_n - U_1}{20k} &= 0 \quad (1) \\ \text{KCL-2: } \frac{U_1 - U_n}{20k} + \frac{U_1 - U_o}{60k} + \frac{U_1}{50k} &= 0 \quad (2) \\ \text{KCL-3: } \frac{U_o - U_1}{60k} + \frac{U_o}{30k} &= 0 \quad (3) \quad \text{这个电流不是0} \\ \text{又 } U_n &= U_p = 0 \end{aligned}$$

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

$$\therefore \frac{63}{26}U_n = 2U_s + \frac{5}{26}U_o \quad \text{又 } U_n = 0 \quad \therefore \frac{U_o}{U_s} = -10.4$$

[5-14] (1) $U_1 = \frac{R_V}{R_V + 19k\Omega} \times 5mV = 0.25mV$
(2) $U_2 = 5mV$

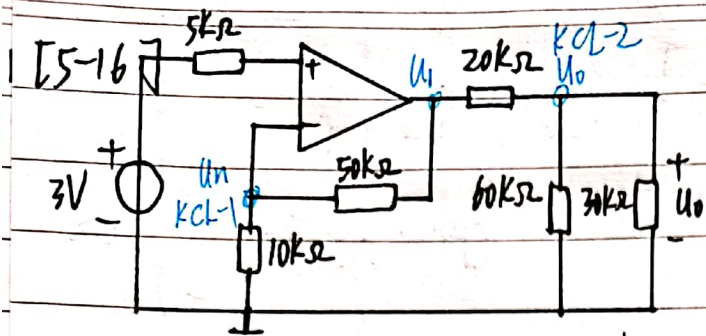
[5-15] (1) $U_o = \frac{100}{100 + 300} \times 5V = 1.25V$

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

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

(2) $U_o' = 5V$
 $P_i' = \frac{U_o'^2}{R_o} = 0.25W$
信号源提供功率为0





[5-20] (课本前面给了公式)

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

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

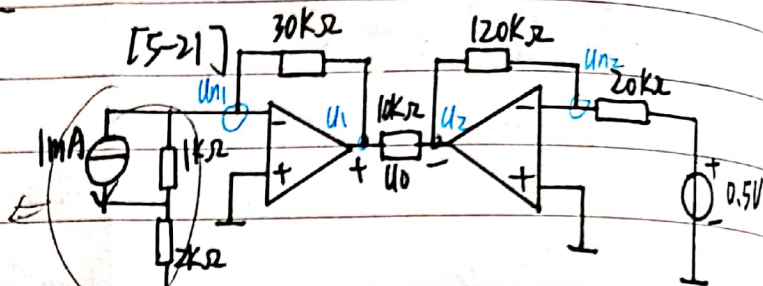
又 $U_n = U_p = 3V \therefore U_1 = 18V$

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

$\therefore U_o = \frac{1}{2}U_1 = 9V$

$\therefore 30k\Omega$ 电阻功率 $P = \frac{U_o^2}{30k\Omega} = 2.7mW$

由虚断特性知理想电压源提供功率为0



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 $U_{n1} = U_{p1} = 0, U_{n2} = U_{p2} = 0$

$\therefore U_o = 13V$

[5-17] 如图为同相求和放大电路

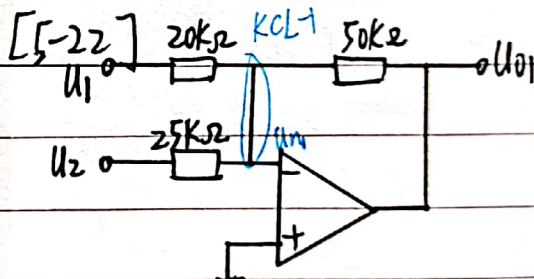
$$U_o = \frac{1 + \frac{40k}{10k}}{\frac{1}{10k} + \frac{1}{20k} + \frac{1}{60k}} (\frac{U_{s1}}{10k} + \frac{U_{s2}}{20k} + \frac{U_{s3}}{60k})$$

$= 3U_{s1} + 1.5U_{s2} + 0.5U_{s3}$

[5-18] 如图为反相求和放大电路

$$U_o = -(\frac{100k}{40k}U_{s1} + \frac{100k}{30k}U_{s2} + \frac{100k}{10k}U_{s3})$$

$= -2.5U_{s1} - 3.3U_{s2} - 10U_{s3}$



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

又 $U_n = U_p = 0$

$\therefore U_{o1} = -2.5U_1 - 2U_2$

同理 又 $U_o = -2(U_{o1} + U_3)$

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

$\therefore U_o = 5U_1 + 4U_2 - 2U_3$

($\frac{U_{n2} - U_{o1}}{25k} + \frac{U_{n2} - U_3}{25k} + \frac{U_{n2} - U_o}{50k} = 0$)
 $U_{n2} = U_{p2} = 0$

[5-19] (a) 中, $U_o = U_1 - U_2$

$U_1 = \frac{30}{30+10}U_s = \frac{3}{4}U_s, U_2 = \frac{60}{60+40}U_s$

$\therefore U_o = \frac{3}{20}U_s$

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

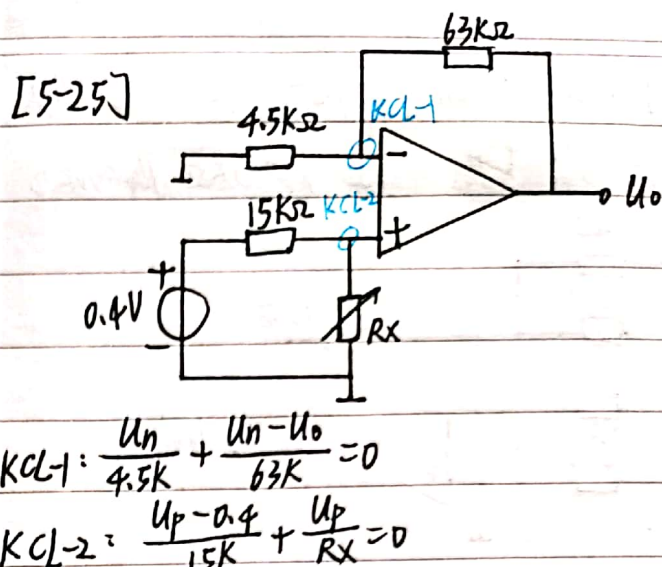
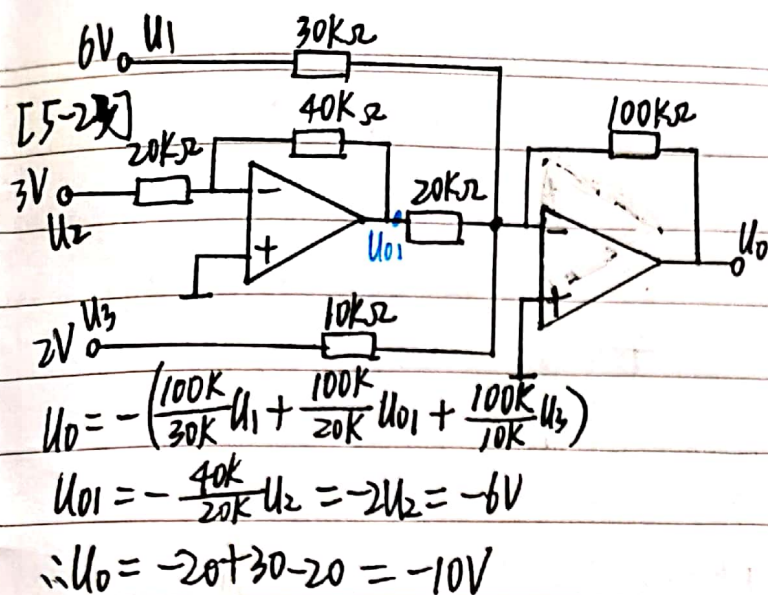
$\frac{U_p}{80k} + \frac{U_p - U_2}{20k} = 0$

又 $U_n = U_p \therefore U_o = 4(U_2 - U_1)$

$\therefore U_o = -\frac{3}{5}U_s$

[5-23] 同上





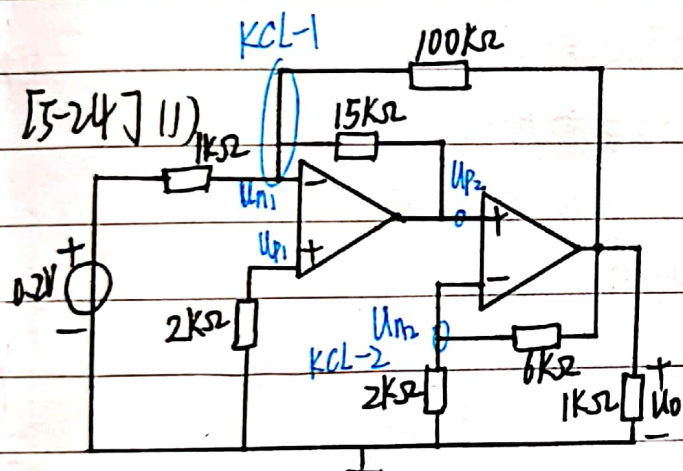
又 $U_n = U_p$

$$\therefore U_0 = \frac{6R_x}{R_x + 15K}$$

1) $\therefore R_x = 60K\Omega$ 时, $U_0 = 4.8V$

2) $|U_0| = \left|\frac{6R_x}{R_x + 15K}\right| \leq 5V$

$$\therefore R_x \leq 75K\Omega$$



$$KCL-1: \frac{U_{n1} - 0.2}{1K} + \frac{U_{n1} - U_{p2}}{15K} + \frac{U_{n1} - U_0}{100K} = 0$$

$$KCL-2: \frac{U_{n2}}{2K} + \frac{U_{n2} - U_0}{6K} = 0$$

又 $U_{n1} = U_{p1} = 0, U_{p2} = U_{n2}$

$$\therefore U_0 = -7.5V$$

2) 去掉 $100K\Omega$ 电阻

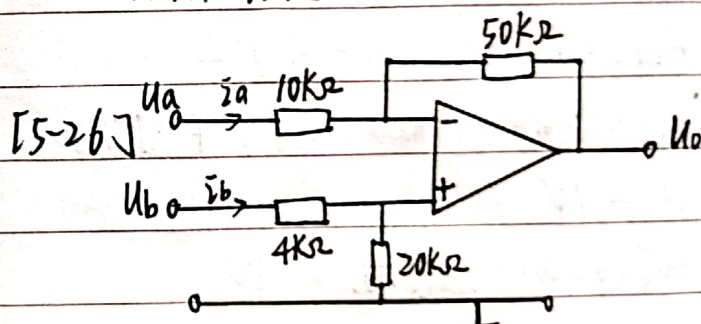
$$KCL-1: \frac{U_{n1} - 0.2}{1K} + \frac{U_{n1} - U_{p2}}{15K} = 0$$

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

$$KCL-2: \frac{U_{n2}}{2K} + \frac{U_{n2} - U_0}{6K} = 0$$

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

$$\therefore U_0 = -12V$$



$$U_0 = \frac{10K + 50K}{10K} \cdot \frac{20K}{20K + 4K} U_b - \frac{50K}{10K} U_a$$

1) $= 5U_b - 5U_a$

$|U_0| = 5|U_b - U_a| \leq 15V \therefore 1V \leq U_a \leq 7V$

2) 信号源 U_b 看进去的电阻: $24K\Omega$

$U_a \dots \dots 10K\Omega$

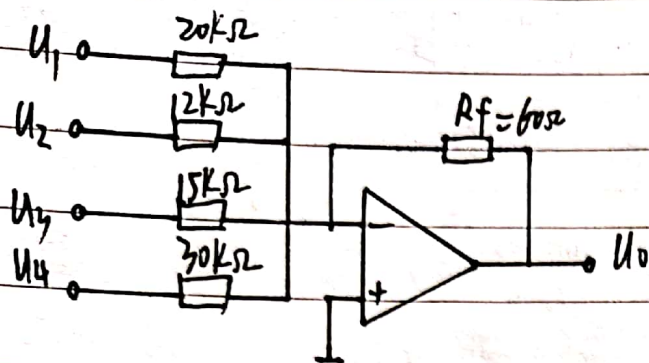
[5-27] 1) $2.5V \times 4 = 10V$

\therefore 工作电源最低 $\pm 10V$



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

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



$$[5-29] 1) U_0 = \frac{1 + \frac{R_f}{20K}}{\frac{1}{R_a} + \frac{1}{R_b} + \frac{1}{R_c}} \left(\frac{1}{R_a}U_a + \frac{1}{R_b}U_b + \frac{1}{R_c}U_c \right)$$

$$= \frac{1 + \frac{R_f}{20K}}{R_b R_c + R_a R_c + R_a R_b} (R_b R_c U_a + R_a R_c U_b + R_a R_b U_c)$$

$$\therefore R_b R_c = R_a R_c = R_a R_b = 4:1:2$$

$$\therefore R_b = 4K\Omega, R_c = 2K\Omega, R_f = 120K\Omega$$

$$12) U_0 = 7V$$

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

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

$$i_b = \frac{U_b - U_p}{R_b} = 0.1mA$$

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

$$13) \text{加倍后 } U_0 = 14V$$

