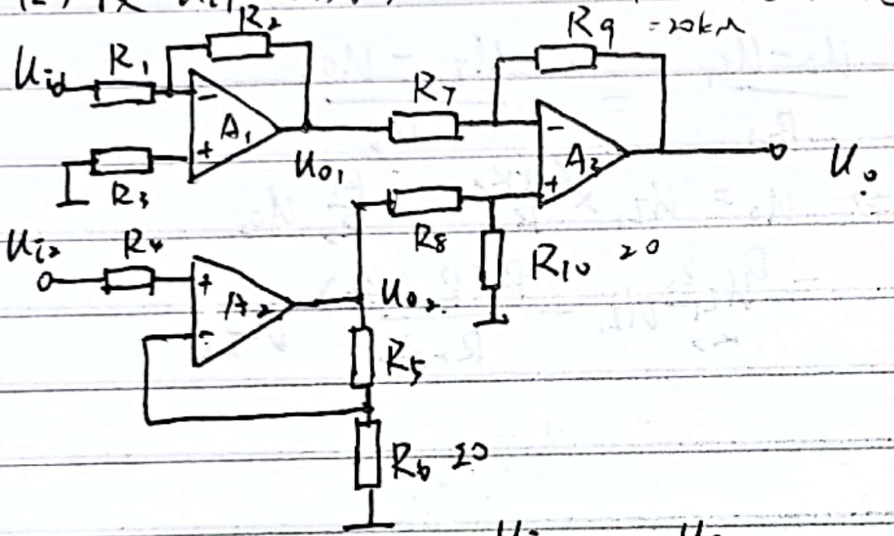
第一章作业

2.4 如图放大电路，已知 $R_1=R_2=R_5=R_7=R_8=10k\Omega$，$R_6=R_9=R_{10}=20k\Omega$

(1) 列出 u_o 和 u_{o1}、u_{o2} 的表达式

(2) 设 $u_{i1}=0.3V$， $u_{i2}=0.1V$，则求输出电压 u_o 的值.



$u_{1+}=u_{1-}=0$ $\frac{u_{i1}}{R_1}=\frac{-u_{o1}}{R_2} \Rightarrow u_{o1}=-\frac{R_2}{R_1}u_{i1}=-u_{i1}$

$$\begin{cases} \frac{u_{2-}}{R_6}+\frac{u_{2-}-u_{o2}}{R_5}+i_{2-}=0 \\ \frac{u_{i2}-u_{+}}{R_4}=i_{2+} \\ \frac{u_{o2}}{R_5+R_6}=\frac{u_{2-}}{R_6} \end{cases} \Rightarrow u_{o2}=\frac{3}{2}u_{i2}$$

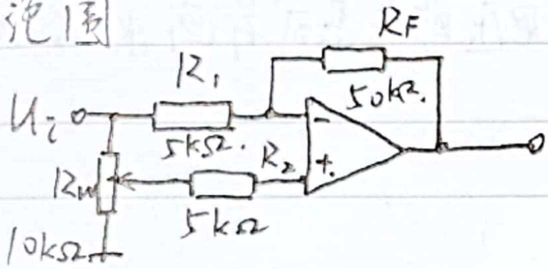
$$\begin{cases} \frac{u_{o2}-u_{3+}}{R_8}=\frac{u_{3+}}{R_{10}} \\ \frac{u_{o1}-u_{3-}}{R_7}=\frac{u_{3-}-u_o}{R_9} \end{cases} \Rightarrow u_o=2(u_{o2}-2u_{o1})$$

$$=2\left(\frac{3}{2}u_{i2}+u_{i1}\right)$$

$$=3u_{i2}+2u_{i1}$$

(2) $u_o=3\times0.1+2\times0.3=0.9V$.

2.5. 设电位器滑动臂到地的电阻为kR_w，$0\le k\le 1$。求电压增益的调节范围



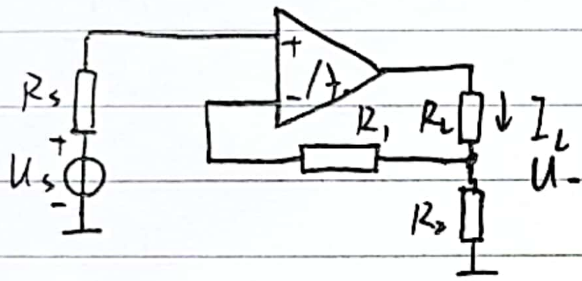
$$\frac{u_i'-u_i}{(1-k)R_w}+\frac{u_i'}{kR_w}+\cancel{\frac{u_i'-u_+}{R_2}}=0$$

$$\frac{u_i-u_-}{R_1}=\frac{u_--u_o}{R_F}\Rightarrow u_-=\frac{10}{11}u_i+\frac{1}{11}u_o$$

$u_+=ku_i$　　$u_o=11ku_i-10u_i$

$-10u_i\le u_o\le u_i$

2.7. 证R_L中流过的电流I_L与电阻R_L的大小无关

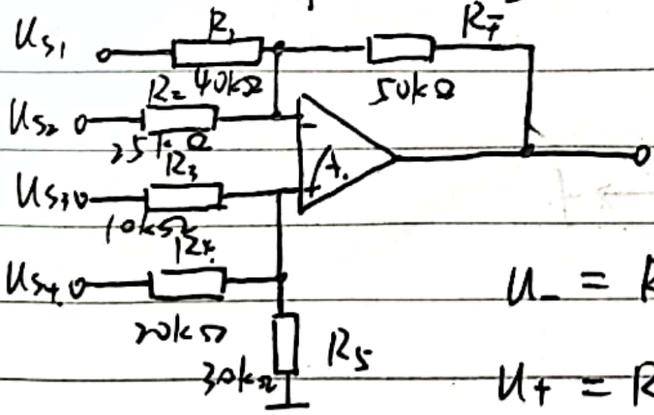


$u_+=u_-=u_s$

$I_L=\frac{u_-}{R_2}=\frac{u_s}{R_2}$

与R_L大小无关

2.10. 加减运算电路如图，求电压u_o表达式



$$\begin{cases}\frac{u_--u_{s1}}{R_1}+\frac{u_--u_{s2}}{R_2}+\frac{u_--u_o}{R_F}=0\\ \frac{u_+-u_{s3}}{R_3}+\frac{u_+-u_{s4}}{R_4}+\frac{u_+}{R_5}=0\end{cases}$$

$$\left.\begin{array}{l}u_-=R_p\left(\frac{u_{s1}}{R_1}+\frac{u_{s2}}{R_2}+\frac{u_o}{R_F}\right)\\ u_+=R_p'\left(\frac{u_{s3}}{R_3}+\frac{u_{s4}}{R_4}\right)\end{array}\right]\Rightarrow u_-=u_+$$

$R_p=R_1//R_2//R_F=\frac{200}{17}k\Omega$　　$R_p'=R_3//R_4//R_5=\frac{60}{11}k\Omega$

$$\Rightarrow u_o=\frac{R_FR_p'}{R_p}\left(\frac{u_{s3}}{R_3}+\frac{u_{s4}}{R_4}\right)-\left(\frac{R_F}{R_1}u_{s1}+\frac{R_F}{R_2}u_{s2}\right)$$

正相的比例放大计算错误

2.11. 设输入信号 u_{i1} 为1kHz、幅度为1V的正弦波，u_{i2} 为1kHz、幅度为1V的方波，求输出电压和输入电压的关系式并画出输出电压的波形

$$\begin{cases} \dfrac{u_{i1}}{R_1}+\dfrac{u_{o1}}{R_2}+\dfrac{u_{2-}}{R_3}=0 \\ u_{2-}=u_{2+}=\dfrac{R_6}{R_5+R_6}u_{i2}=\dfrac{1}{2}u_{i2} \\ \dfrac{u_{o1}-u_{2-}}{R_4}+\dfrac{0-u_{2-}}{R_3}+\dfrac{u_o-u_{2-}}{R_7}=0 \end{cases}$$

$$u_{o1}=-u_{i1}-u_{2-}=-u_{i1}-\frac{1}{2}u_{i2}$$

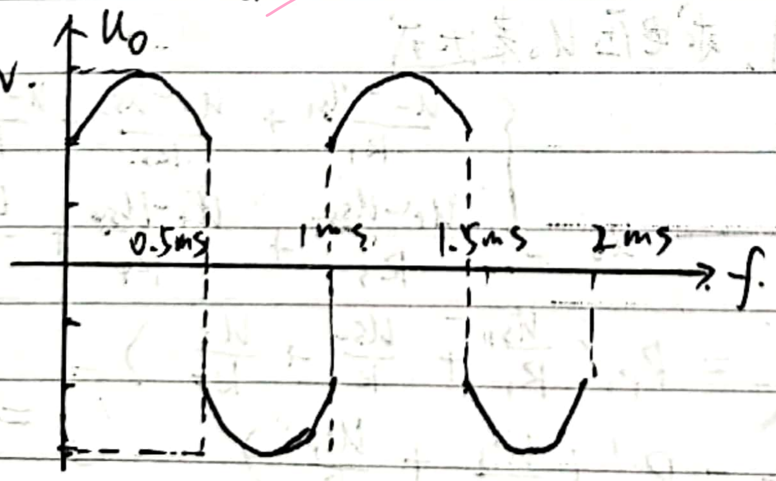
$$u_{o1}-u_{2-}-u_{2-}+u_o-u_{2-}=0$$

$$u_o=3u_{2-}-u_{o1}$$

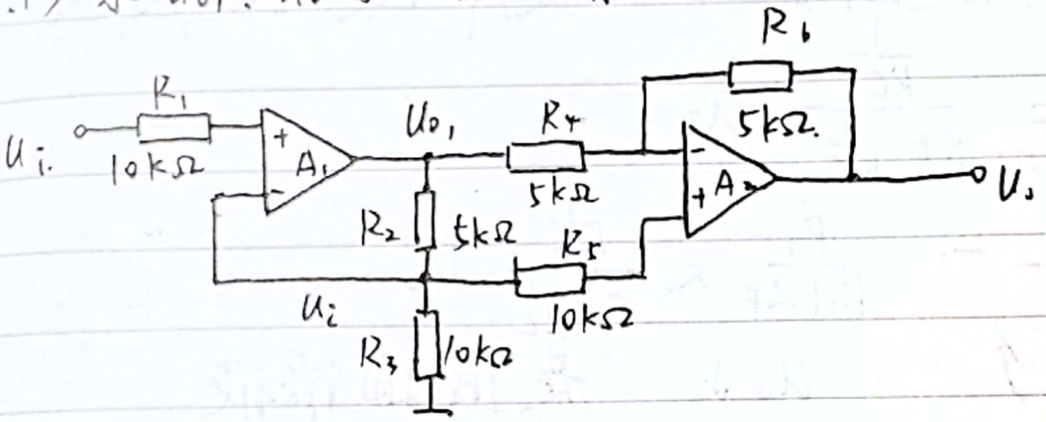
$$=\frac{3}{2}u_{i2}-\left(-u_{i1}-\frac{1}{2}u_{i2}\right)$$

$$=u_{i1}+2u_{i2}$$

$\Rightarrow$



2.13 求 u_{o1}、u_o 与 u_i 的关系式



$$u_i = \frac{R_3}{R_2+R_3}u_{o1} \Rightarrow u_{o1} = \left(1+\frac{R_2}{R_3}\right)u_i = \frac{3}{2}u_i$$

$$u_{2-} = u_i$$

$$\frac{u_{o1}-u_{2-}}{R_4} = \frac{u_{2-}-u_o}{R_6} \Rightarrow u_o = 2u_{2-} - u_{o1}$$

$$u_o = 2u_i - \frac{3}{2}u_i = \frac{1}{2}u_i$$

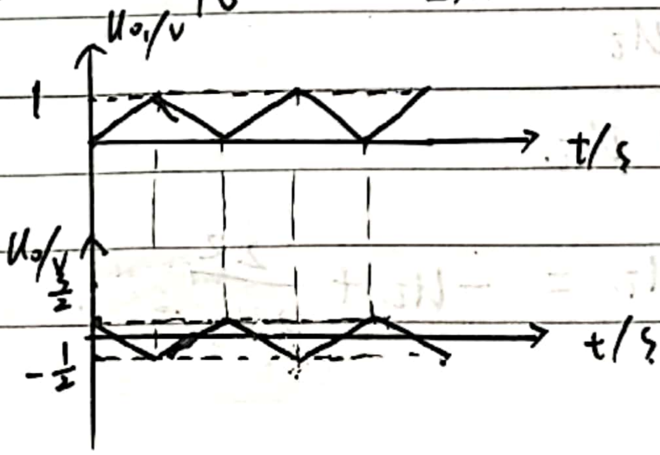
2.17 u_i 为矩形波 $t=0$ $u_C=0$ 画出 u_{o1} 和 u_o 的波形.

$$\frac{u_i}{10^6} = -C\frac{du_{o1}}{dt} \Rightarrow u_{o1} = -\frac{1}{10^6\times10\times10^{-6}}\int_0^t u_i\,dt$$

$$= -\frac{1}{10}\int_0^t u_i\,dt$$

$$\frac{u_o}{10^4} + \frac{u_{o1}}{10^4} = \frac{1}{2\times10^4} \Rightarrow u_o = \frac{1}{2} - u_{o1}$$

$$= \frac{1}{2} + \frac{1}{10}\int_0^t u_i\,dt$$



2.20 写出各电路的传递函数，说明是什么类型的滤波器

注意虚断的条件

a）

$$u_+ = \frac{\frac{1}{sC}}{R+\frac{1}{sC}} u_i = \frac{\frac{1}{RC}}{s+\frac{1}{RC}} u_i$$

$$u_o = \frac{R_1}{R_1+R_F} u_- = \frac{R_1}{R_1+R_F} \times \frac{\frac{1}{RC}}{s+\frac{1}{RC}} \cancel{u_i}$$

$s=j\omega$ $\omega\uparrow$ $u_o\downarrow$ 是低通滤波

b）

$$\frac{u_i}{R_1} + \frac{u_o}{R_F} + \frac{u_o}{\frac{1}{sC}} = 0$$

$$u_o = \frac{-\frac{1}{R_1}}{\frac{1}{R_F}+\frac{1}{sC}} \cancel{u_i}$$

$\omega\uparrow$ $s\uparrow$ $\frac{1}{sC}\downarrow$ $u_o\uparrow$

是高通滤波

(c)

$$\frac{u_i}{\frac{1}{sC}+R} + \frac{u_o}{R} = 0 \Rightarrow u_o = -R \times \frac{1}{\frac{1}{sC}+R} u_i$$

$$= -\cancel{\frac{R}{\frac{1}{sC}+R}}$$

$\omega\uparrow$ $s\uparrow$ $u_o\uparrow$ 是高通滤波

2.23. 写出电路增益和相移表达式，画出相应曲线

$$u_+ = \frac{R}{R+\frac{1}{sC}} u_i \qquad \frac{u_i-u_-}{R} + \frac{u_o-u_-}{R} = 0$$

$$u_- = \frac{1}{2}(u_i+u_o) = \frac{R}{R+\frac{1}{sC}} u_i$$

$$u_o = \left(\frac{2R}{R+\frac{1}{sC}} - 1\right) u_i$$

$$= \frac{R-\frac{1}{sC}}{R+\frac{1}{sC}} u_i = -u_i + \frac{2R}{R+\frac{1}{sC}} u_i$$

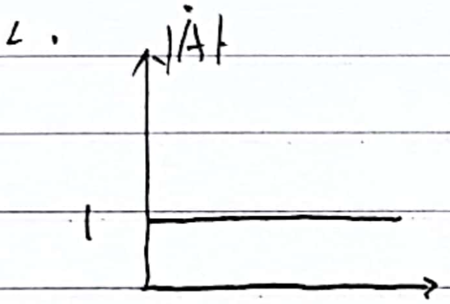
$$\Rightarrow\ R^2-\frac{1}{\omega_0^2C^2}=\frac{2R}{\omega_0 C}\ \Rightarrow\ \omega_0=\frac{1+\sqrt{2}}{RC}$$

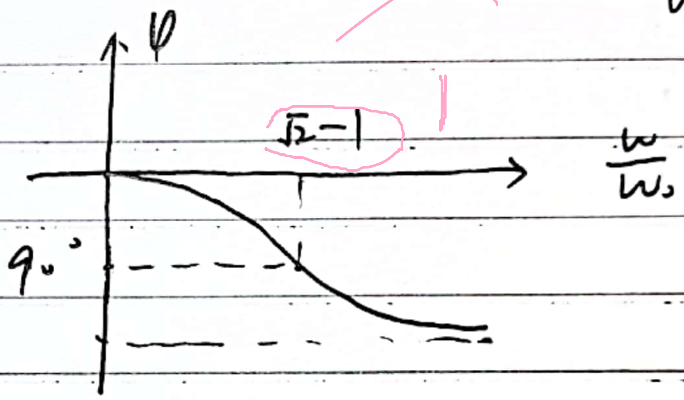
$$\frac{U_o}{U_i}=\frac{R-\frac{1}{sC}}{R+\frac{1}{sC}}=\frac{1-\frac{1}{s}\times\frac{\omega_0}{1+\sqrt{2}}}{1+\frac{1}{s}\times\frac{\omega_0}{1+\sqrt{2}}}=\frac{(1+\sqrt{2})-\frac{\omega_0}{j\omega}}{(1+\sqrt{2})+\frac{\omega_0}{j\omega}}$$

$$=\frac{(1+\sqrt{2})+\frac{\omega_0}{\omega}j}{(1+\sqrt{2})-\frac{\omega_0}{\omega}j}\ \Rightarrow\ |A(s)|=1$$

$$\varphi=\arctan\frac{2RC\omega}{R^2C^2\omega^2-1}=\arctan\frac{2(1+\sqrt{2})\frac{\omega}{\omega_0}}{(1+\sqrt{2})^2\frac{\omega^2}{\omega_0^2}-1}.$$

2.





还要注意w=0时，Au=-1，实际应该从180°开始变化。