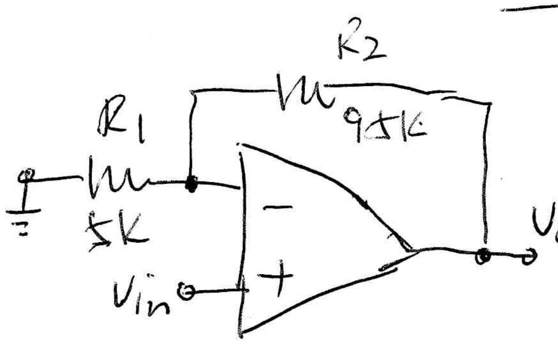
EE2002 Tutorial 3

1(a)

(i)



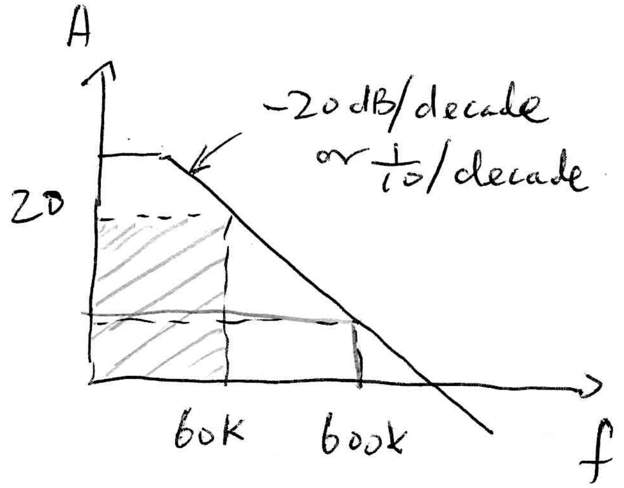
$$\beta = \frac{R_1}{R_1+R_2} = \frac{5}{5+95} = 0.05$$

$$A_{CL} = \frac{1}{\beta} = 20$$

$$A_{CL} \cdot BW_{CL} = 1 \cdot f_t$$

$$\therefore BW_{CL} = \frac{f_t}{A_{CL}} = \beta \cdot f_t = \underline{60\,kHz}$$

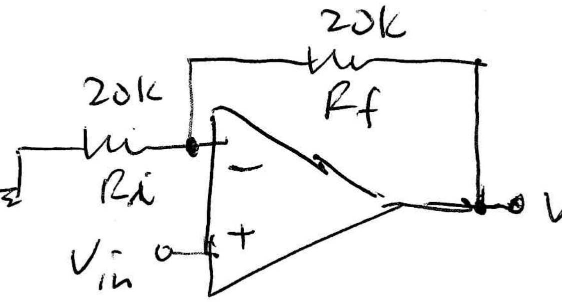
(ii)



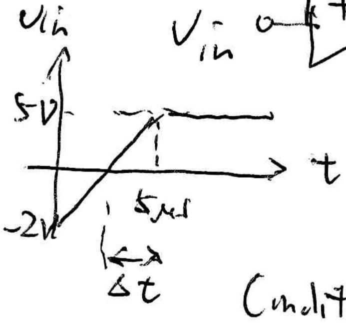
$$20 \times 60k = 600k \times A_{CL}(600k)$$

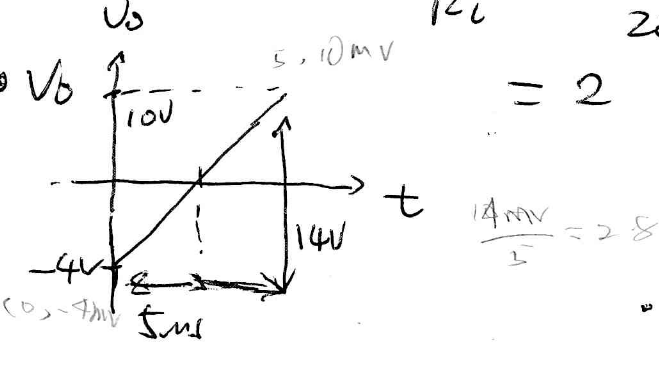
$$\therefore A_{CL}(600kHz) = \frac{1200\,kHz}{600\,kHz} = \underline{2\,V/V}$$

1(b)



$$A_{CL} = 1 + \frac{R_f}{R_i} = 1 + \frac{20k}{20k} = 2$$





Condition (i), Maximum Response Time with given SR

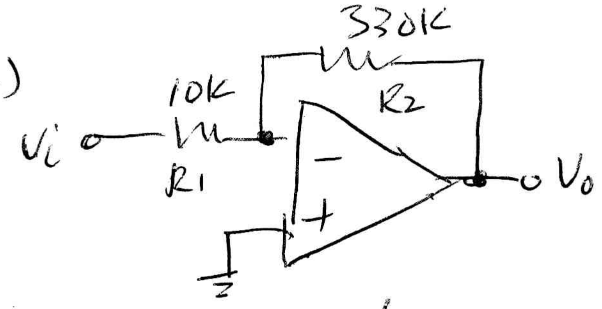
$$t_{max} = \frac{14V}{SR} = \frac{14V}{4V/\mu s} = 3.5\mu s < \Delta t = 5\mu s$$

Condition (ii), BW response time of Amplifier

$$t_r = 0.35/BW_{CL} = \frac{0.35}{\beta \cdot f_t} = \frac{0.35}{0.5 \times 2MHz} = 0.35\mu s \ll \Delta t\ (5\mu s)$$

Condition (i) & (ii) ⇒ no distortion.

2(a)



SR = 0.5 V/μs

$A_{CL} = \frac{-R_2}{R_1} = \frac{-330K}{10K} = -33 V/V$

$V_o = V_p A_{CL} \sin \omega t$

$\frac{dV_o}{dt} = V_p A_{CL} \omega \cos \omega t \leq SR$

$\omega_{max} = SR / V_p \cdot A_{CL}$

Input Signal	ω (rad/s)	Vp (V)	ωmax (rad/s)	ω < ωmax	
V1	10^6	0.01	1.515×10^6	Yes	
V2	350×10^3	0.05	303.03×10^3	No	→ SR distortion
V3	200×10^3	0.1	151.5×10^3	No	→ SR distortion
V4	50×10^3	0.2	75.75×10^3	Yes	

2(b) For fixed V_p, two remedies

(i) Find an op-amp with greater SR

(ii) Reduce the A_{CL} of op-amp.

Consider case (i)

For V2: $\frac{SR}{0.05 \times 33} \geq 350 \times 10^3 \Rightarrow SR \geq 577.5 \times 10^3 V/\mu s$

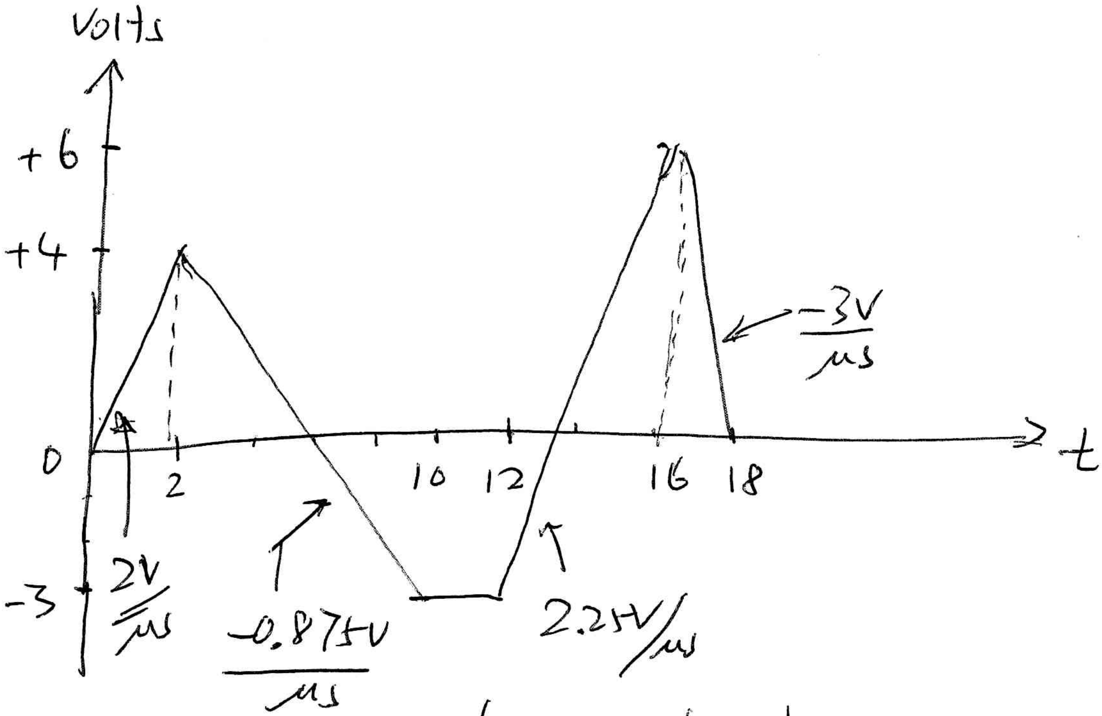
For V3: $\frac{SR}{0.1 \times 33} \geq 200 \times 10^3 \Rightarrow SR \geq 660 \times 10^3 V/\mu s$

Consider case (ii)

For V2: $\frac{0.5 \times 10^6}{0.05 \times A_{CL}} \geq 350 \times 10^3 \Rightarrow A_{CL} \leq$

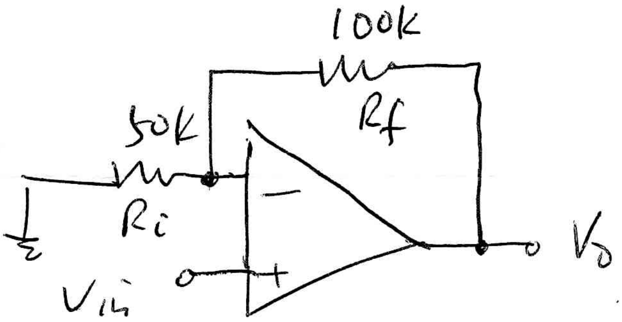
For V3: $\frac{0.5 \times 10^6}{0.1 \times A_{CL}} \geq 200 \times 10^3 \Rightarrow A_{CL} \leq$

3(a)



Worst case $SR = |SR_{max}| = \left|\frac{\Delta V}{\Delta t}\right| = 3V/\mu s$

3(b)

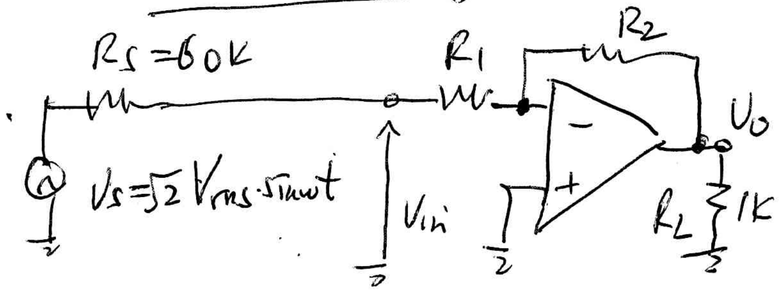


$A_{CL} = 1 + \frac{R_f}{R_i} = 1 + \frac{100k}{50k} = 3 V/V$

∵ input slope $= 3V/\mu s$,

∴ output slope $= 3 \times 3V/\mu s = 9V/\mu s$

4 (i) Using Inverting Configuration



Choose $R_1 = 47K$

$V_{in} = V_s \times \frac{R_1}{R_1 + R_s} = 1 \times \frac{47K}{47K + 60K}$

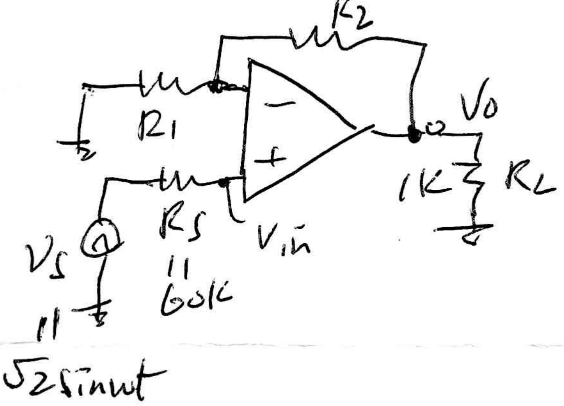
$= 0.44 V_{rms}$

For $V_o = 2.5 V_{rms}$, $A_{CL} = \frac{V_o}{V_{in}} = \frac{2.5 V_{rms}}{0.44 V_{rms}} = 5.68 V/V$

$\therefore R_2 = A_{CL} \cdot R_1 = 5.68 \times 47K = 267K$.

Use $R_2 = 270K$.

(ii) Using Non-Inverting Configuration



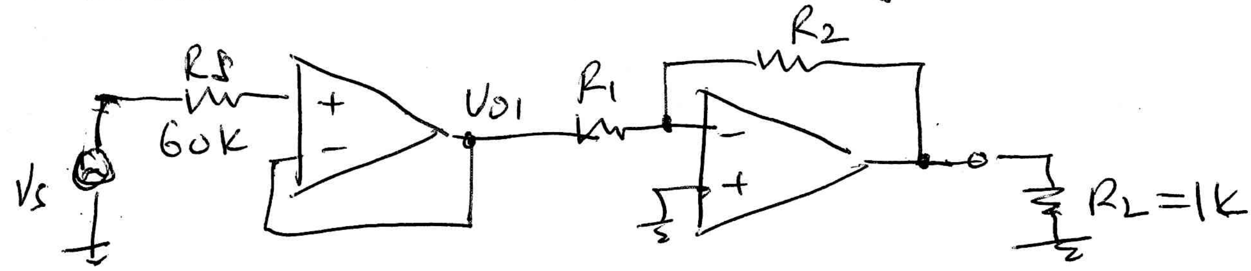
$A_{CL} = \frac{V_o}{V_{in}} = \frac{V_o}{V_s} = \frac{2.5V}{1V} = 2.5 V/V$

$1 + \frac{R_2}{R_1} = 2.5 \Rightarrow \frac{R_2}{R_1} = 1.5$

Choose $R_2 = 150K$

& $R_1 = \frac{150K}{1.5} = 100K$

(iii) Using a Voltage Follower plus Inverting Amplifier



$V_s = \sqrt{2} \sin \omega t$

$\frac{V_o}{V_{O1}} = \frac{V_o}{V_S} = \frac{-2.5V}{1V} = -2.5 V/V$

$\therefore \frac{R_2}{R_1} = 2.5 \Rightarrow R_2 = 2.5 R_1$

Choose $R_1 = 47k$; $R_2 = 117.5k\Omega$

Use $R_2 = 120k\Omega$