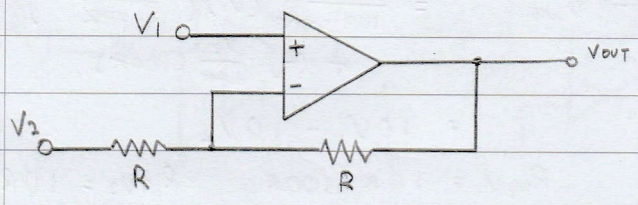
No.: Date:

Esmund Lim AE Tutorial 1

1a)



$V_{OUT} = V_{OUT}|_{V_1} + V_{OUT}|_{V_2}$

$= V_1\left(1+\frac{R}{R}\right) + (-)\frac{V_2}{R}(R)$

$= 2V_1 - V_2$

or

$V_1 + \left(\frac{V_1}{R}R\right) + (-)\frac{V_2}{R}R$

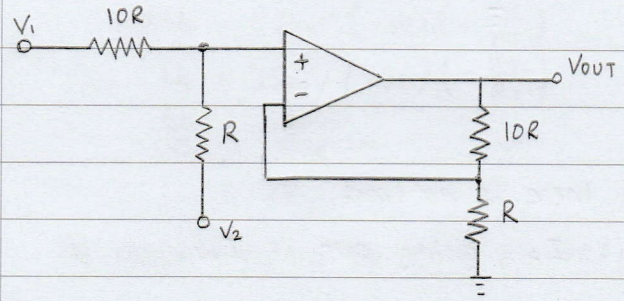
$= V_1\left(1+\frac{R}{R}\right) - V_2$

$= 2V_1 - V_2$

$R_{in}V_1 = \infty$

$R_{in}V_2 = R$

b)



$V_{OUT} = V_{OUT}|_{V_1} + V_{OUT}|_{V_2}$

$= \frac{R}{R+10R}(V_1)\left(\frac{R+10R}{R}\right) + \frac{10R}{R+10R}(V_2)\left(\frac{10R+R}{R}\right)$

$= V_1 + 10V_2$

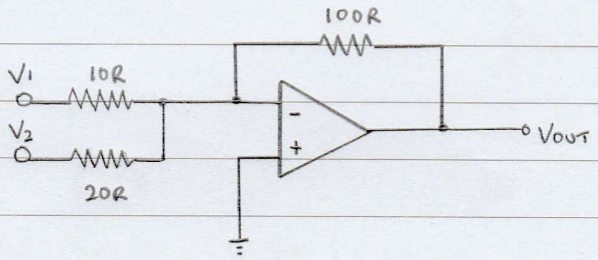
$R_{in}V_1 = 10R + R$

$= 11R$

$R_{in}V_2 = 10R + R$

$= 11R$

c)



$V_{OUT} = V_{OUT}|_{V_1} + V_{OUT}|_{V_2}$

$= -\left(\frac{V_1}{10R}\right)100R - \frac{V_2}{20R}\left(\frac{5}{100R}\right)$

$= -10V_1 - 5V_2$

$R_{in}V_1 = 10R$

$R_{in}V_2 = 20R$

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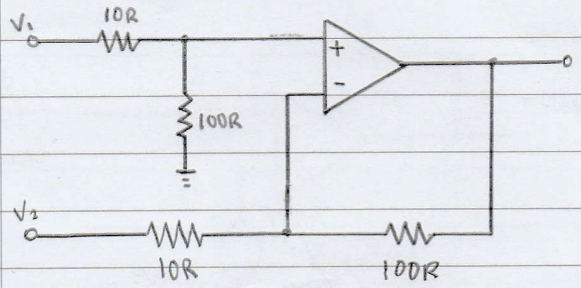
d)



$V_{OUT} = V_{OUT}|_{V_1} + V_{OUT}|_{V_2}$

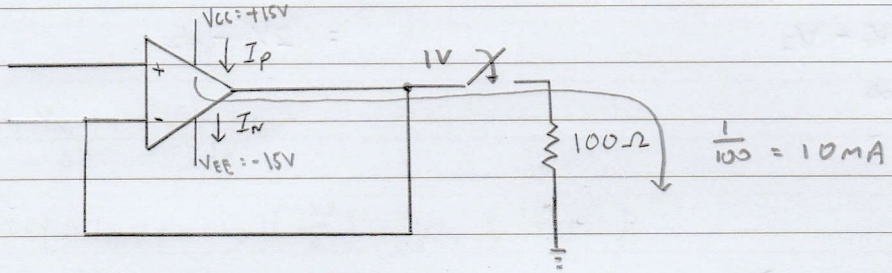
$= \frac{100R}{10R+100R}(V_1)\left(\frac{100R+10R}{10R}\right) + (-)\frac{V_2}{10R}(100R)$

$= 10V_1 - 10V_2$

$R_{in}V_1 = 10R + 100R$ $R_{in}V_2 = 10R$

$= 110R$

2a)



$\frac{1}{100} = 10mA$

b) $I_P = I_N$

1. No current going in the input
2. output not going out current because there is no load
3. only current going in op-amp is I_P, going out is I_N

When R_L is connected

$I_P' = I_P + 10mA$

$I_N' = I_N$

c) Additional power drawn

$P = IV$

$= 15V(10mA)$

$= 150mW$

Output power

$P = 1V \times 10mA$

$= 10mW$

* efficiency poor

140 mW turns to heat energy

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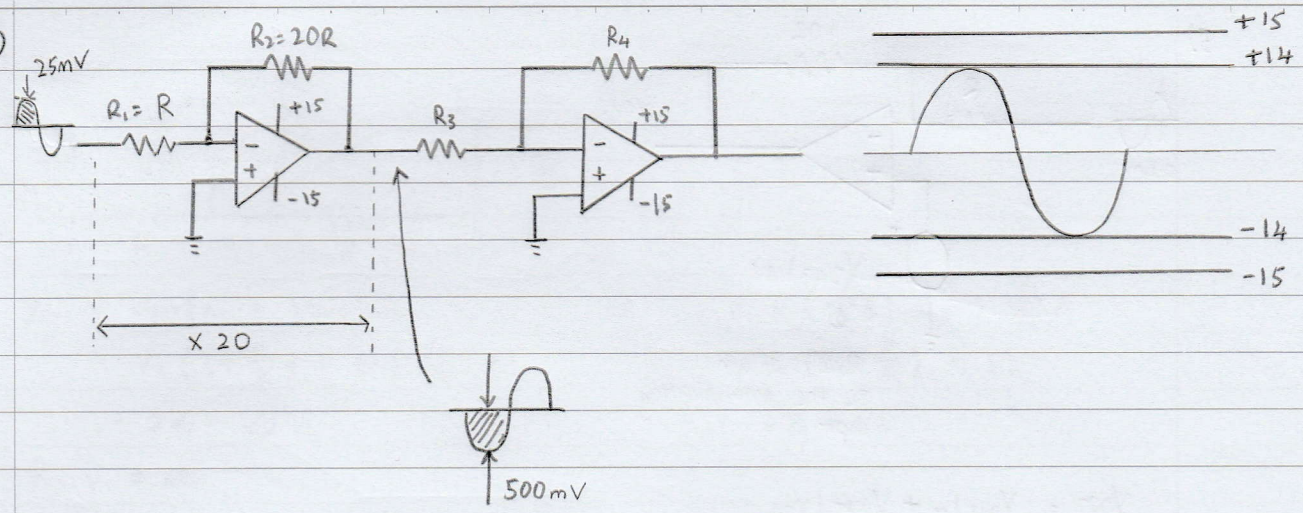
3)



$$V_{OUT} = V_{in}\left(-\frac{R_2}{R_1}\right)\left(-\frac{R_4}{R_3}\right)$$

$$\pm 14 = \pm 25mV\,(-20)\left(-\frac{R_4}{R_3}\right)$$

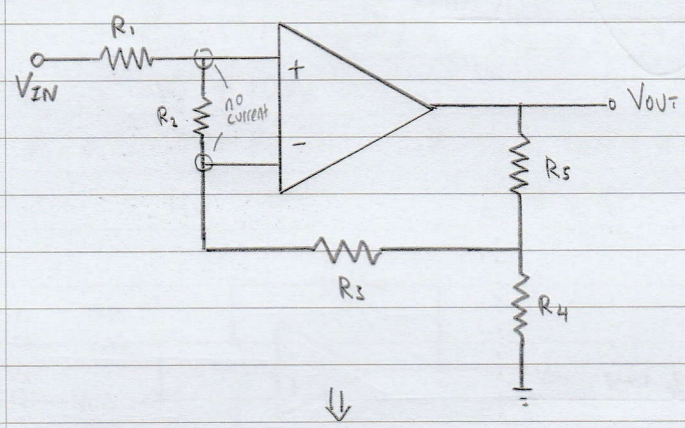
$$14 = 25mV\,(-20)\left(-\frac{R_4}{R_3}\right)$$

$$\frac{R_4}{R_3} = \frac{14}{25mV(20)}$$

$$= 28$$

The maximum permissible gain of the second stage is 28

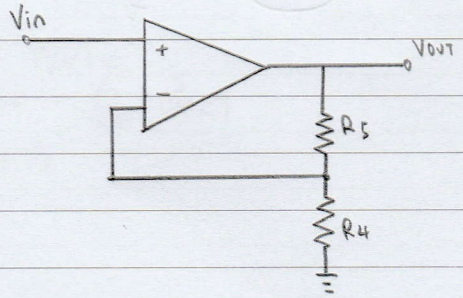
4)



$R_1 = 0$

$R_2 = \infty$

$R_3 = 0$



$$V_{OUT} = \frac{R_5 + R_4}{R_4}(V_{in})$$

$$\frac{V_{OUT}}{V_{in}} = \frac{R_5 + R_4}{R_4}$$

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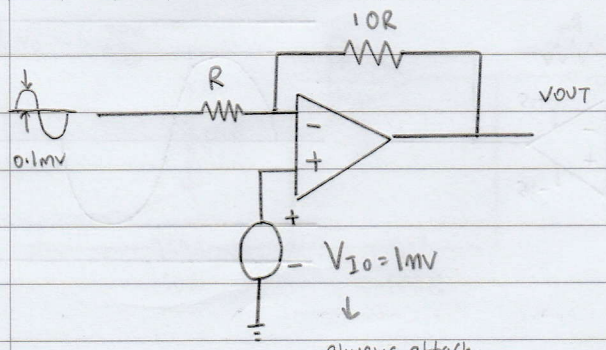
5)



always attach to the non-inverting input

$$V_{OUT} = \underset{ac}{V_{OUT}|_{V}} + \underset{dc}{V_{OUT}|_{V_{IO}}}$$

$$= -(0.1mV \sin \omega t)\left(\frac{10R}{R}\right) + V_{IO}\left(\frac{10R+R}{R}\right)$$

$$= -1mV \sin \omega t + 1mV\,(11)$$

$$= \underset{ac}{(-1 \sin \omega t} \underset{dc}{+ 11)}\,mV$$