AMBIA KHATUN ELA

2038520121

(1) what is an op-Amp? what are the characteristic of an ideal op-Amp?

Ans: An op amp is an active circuit element designed to perform mathmatical operations of addition, subtraction, multiplication, division, differentiation, and integration.

(1) The current into both input terminals are Zero:

$$i_1 = 0, \quad i_2 = 0$$

This is due to infinite input resistance. An infinite resistance between the input terminals implies that an open circuit exists there ~~are~~ and current cannot enter the op-amp.

(2) The voltage across the input terminals is negligibly small.

$$V_d = V_2 - V_1 \simeq 0$$

$$V_1 = V_2$$

Thus an ideal op-amp has zero current into its two input terminals and small voltage between two input terminals

3. Infinite open-loop gain.

4. Infinite common-mode Rejection Ratio.

5. Infinite Band width.

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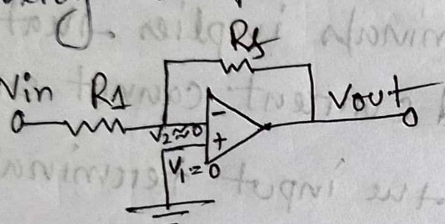
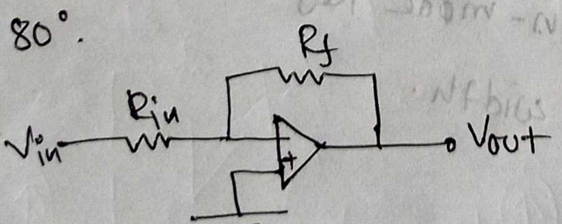
②. what do you mean by virtual ground of an op-amp?

Ans: In op-amps the term virtual ground means that the voltage at that particular node is almost equal to ground (0V)...... It is not physically connected to ground. This concept is very useful in analysis of op-amp circuits and it will make a lot of calculations very simple.

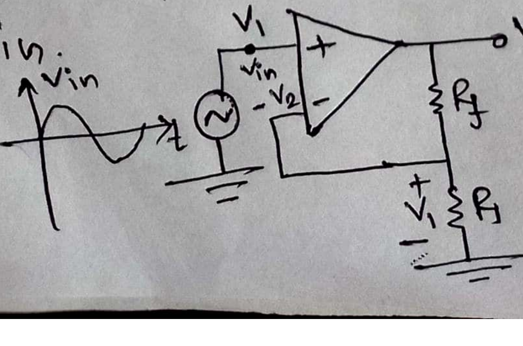


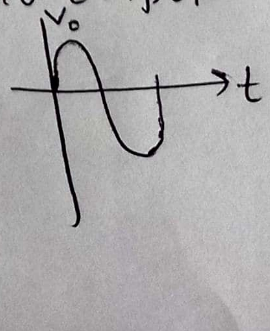
③ what is inverting and non-inverting Amplifier?

An inverting amplifier (also known as an inverting operational amplifier or an inverting op-amp) is a type of operational amplifier circuit which produces an output which produces an output which is out of phase with respect to its input by 180°.



A non-ideal operational amplifier's equivalent circuit has a finite input impendence, a non-zero output impedance, and a finite gain.





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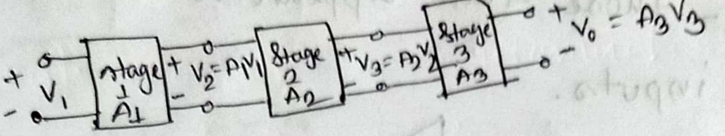
④ what is cascaded op-Amp?

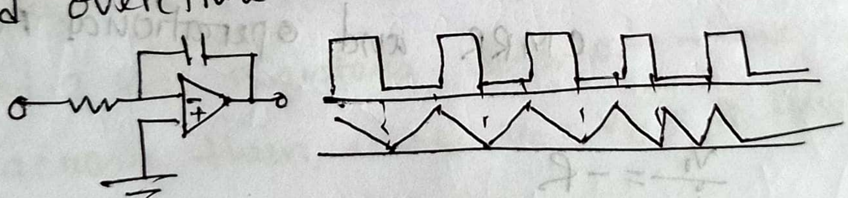
Ans: A cascaded connection is a head to-tail arrangment of two or more op-amp circuits such that the output of one is the input of the next.

$$A = A_1 A_2 A_3$$

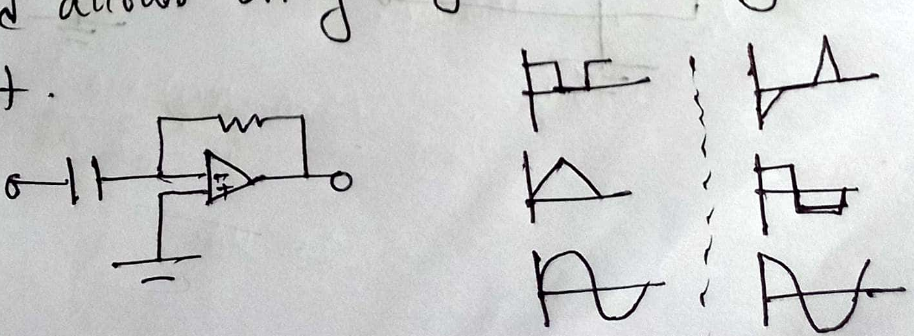


⑤ How an op-amp can be used as an integrator & differentiator?

Ans: The operational amplifier integrator is an electronic integration circuit. Based on the operational amplifier (op-amp), it perform the mathmatical operation of integration with respect to time; that is its output voltage is propotional to input voltage integrated overtime.

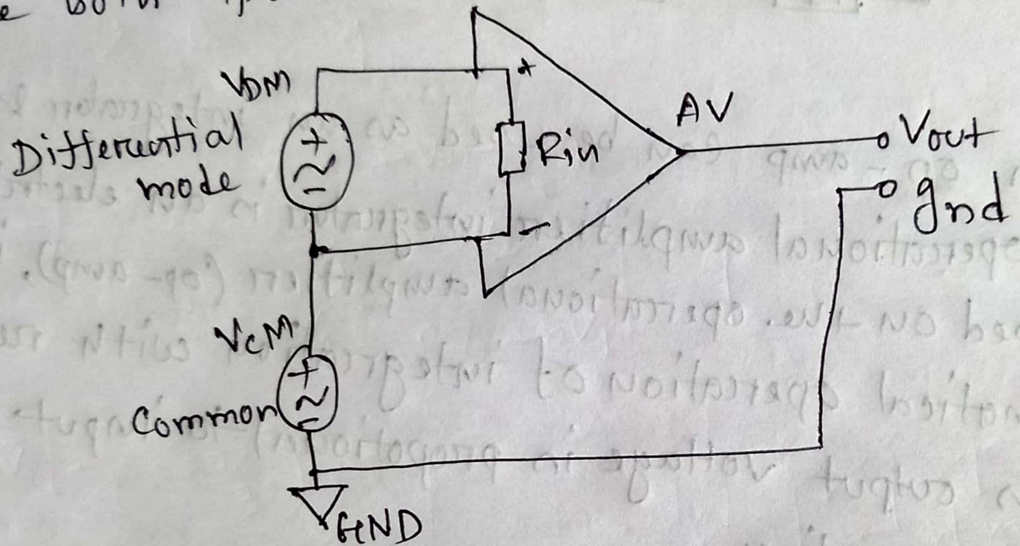


An op-amp differentiator is an inverting amplifier, which uses a capacitor in series with the input voltage----. Differentiators have frequency limitation while operating on sine wave inputs; the circuit all ~~a~~ low frequency signal components and allows only high frequency components at the output.



⑥ what is CMRR?

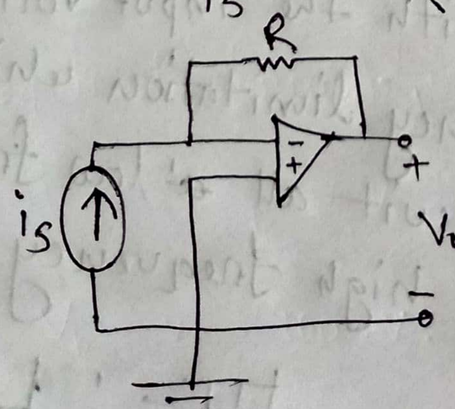
In electronics, the common mode rejection ratio of a differential amplifier is a metric used to quantify the ability of the device to reject common-mode signals, i.e- those that appear simultaneously and in-phase both inputs.

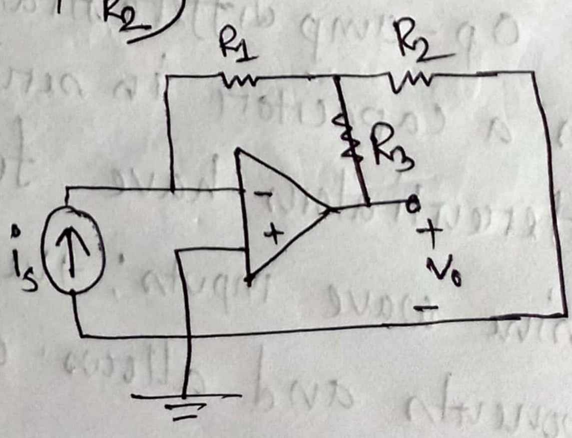


CMRR and operational Amplifier

(5.4). ⓐ $\frac{V_o}{i_s} = -R$

ⓑ $\frac{V_o}{i_s} = -R_1\left(1 + \frac{R_3}{R_1} + \frac{R_3}{R_2}\right)$





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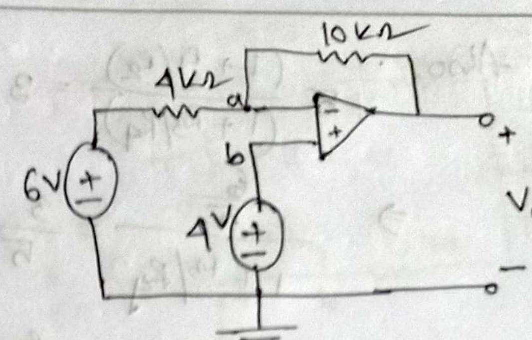
(5.5)

$$V_o = V_{o1} + V_{o2}$$



$$\frac{6 - V_a}{4} = \frac{V_a - V_o}{10}$$

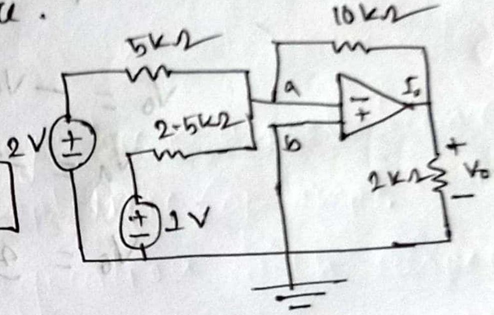
$V_a = V_b = 4$ and so

$$\frac{6-4}{4} = \frac{4 - V_o}{10}$$

$$\Rightarrow \quad 5 = 4 - V_o$$

$\therefore$ $V_o = -1V$ as before.

(5.6)



$$V_o = -\left[\frac{10}{5}\,2 + \frac{10}{2.5}(1)\right]$$

$$= -(4+4) = -8V$$

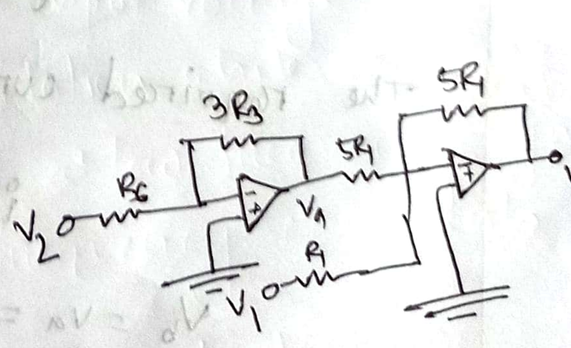
The current i_o is the sum of the currents through the 10kΩ and 2kΩ resistors. Both of these resistors have voltage $V_o = -8V$ across them, since $V_a = V_b = 0$. Hence

$$i_o = \frac{V_o - 0}{10} + \frac{V_o - 0}{2} \text{ mA}$$

$$= -0.8 - 0.4$$

$$= -1.2 \text{ mA}.$$

(5.7)



$$\frac{R_2}{R_1} = 5$$

$$\Rightarrow R_2 = 5R_1$$

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Also,

$$5\,\frac{(1+R_1/R_2)}{(1+R_3/R_4)} = 3$$

$$\Rightarrow \frac{\frac{6}{5}}{1+R_3/R_4} = \frac{3}{5}$$

$$\Rightarrow 2 = 1 + \frac{R_3}{R_4}$$

$$\Rightarrow R_3 = R_4$$

$R_1 = 10k\Omega$

$R_3 = 20k\Omega$

$R_2 = 50k\Omega$

$R_4 = 20k\Omega$

$$V_o = -V_a - 5V_1$$

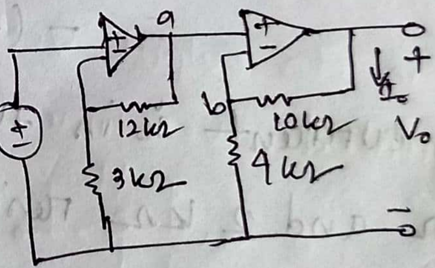
$$V_a = -3V_2$$

$$V_o = 3V_2 - 5V_1$$

5.9

$$V_o = \left(1+\frac{12}{3}\right) \times 20$$

$$= 100\,mV$$



At the output of the second op amp.

(Non inverting) $$V_o = \left(1+\frac{10}{4}\right) V_o$$

$$= (1+2.5) \times 100 = 350\,mV$$

The required current i_o in the current through the 10kΩ resistor

$$i_o = \frac{V_o - V_b}{10}\,mA$$

$$V_b = V_a = 100\,mV.$$

Hence, $$i_o = \frac{(350-100) \times 10^{-3}}{10 \times 10^3}$$

$$= 25\,\mu A.$$

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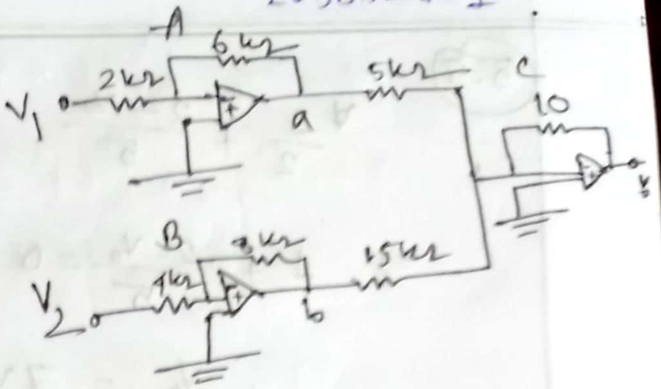
$$V_a = -\frac{R_f}{R_1} \times V_1$$

$$= \frac{-6}{2} \times (1)$$

$$= -3V$$



$$V_b = -\frac{8}{4} \times V_2$$

$$= -2 \times 2$$

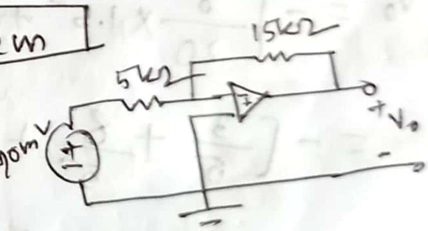
$$= -4V$$

$$V_0 = -\left(\frac{10}{5} V_a + \frac{10}{15} V_b\right)$$

$$= -\left[2(-3) + \frac{2}{3}(-4)\right] = 8.33V.$$

Practice Problem

5.3



$$V_0 = -\frac{\cancel{15}^{3}}{\cancel{5}} \times 40$$

$$= 120\ mV$$

$$R_f = \frac{0 - V_0}{15K} = \frac{120}{15} = 8\mu A \text{ (Ans)}$$

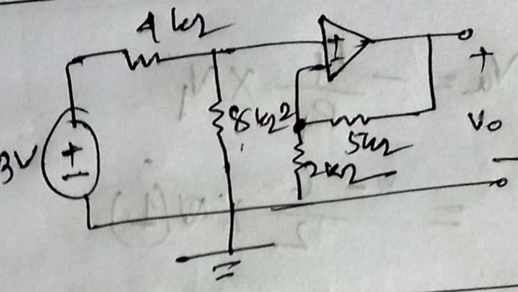
5.5

$$\frac{2}{2} + \frac{2-V_o}{5}$$

$$\Rightarrow 1 + \frac{2-V_o}{5} = 0$$

$$V_o = 7V$$

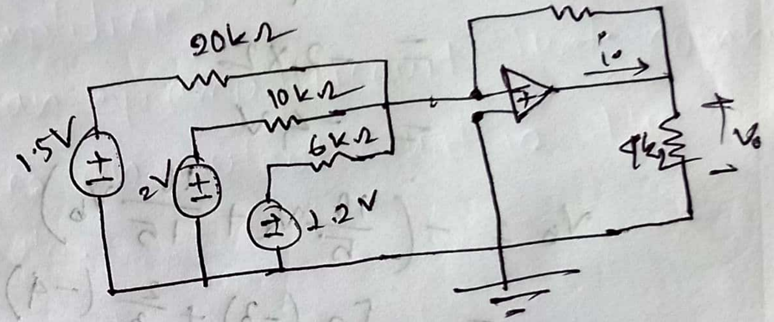
(Ans)



$$V_a = \frac{\cancel{8}^{\,2}}{\cancel{8+4}_{\,\cancel{4}}} \times \cancel{3}$$

$$= 2V$$

5.6



$$\cancel{V_o = -\left[\frac{8}{20}\times 1.5 + \frac{8}{10}\times 2 +\right.}$$

$$V_o = -\left[\frac{8}{20}\times 1.5 + \frac{8}{10}\times 2 + \frac{8}{6}\times 1.2\right]$$

$$= -\left[\frac{3}{5} + \frac{8}{5} + \frac{8}{5}\right]$$

$$= -3.8V \text{ (Ans)}$$

$$i_o = \frac{V_o - 0}{8} + \frac{V_o - 0}{4} = \frac{-3.8}{8} + \frac{-3.8}{4} \;\; \cancel{= -1.425}$$

$$= \frac{V_o}{8} + \frac{V_o}{4}$$

$$= -1.425 \text{ mA (Ans)}$$

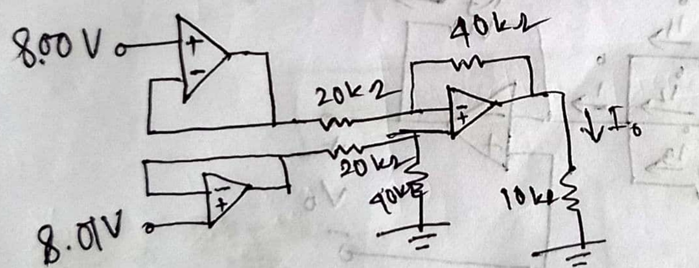
(5.7). If the gain is 4, then

$$\frac{R_2}{R_1} = 4 \rightarrow R_2 = 4R_1$$

$$\frac{R_2}{R_1} = \frac{R_4}{R_3} \rightarrow R_4 = 4R_3$$

So, $R_1 = R_3 = 10\,k\Omega$ the $R_2 = R_4 = 40\,k\Omega$ (Ans)

(5.8)



$$V_a = \frac{40}{40+20} \times 8.01$$

$$= \frac{40}{60} \times 8.01$$

$$= 5.34\,V$$

$$V_o = \left(\frac{R_2}{R_1}\left(1 + \frac{2R_3}{R_4}\right)\right)(V_2 - V_1)$$

$R_3 = 0$, $R_4 = \infty$, $R_2 = 40\,k\Omega$, $R_1 = 20\,k\Omega$

$$V_o = \frac{40}{20}(8.01 - 8) = 0.02$$

$$i_o = \frac{V_o}{10k} = \frac{0.02}{10 \times 10^3}$$

$$= 2\,\mu A \text{ (Ans)}$$

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(6.3) $v = \frac{1}{c}\int_0^1 i\,dt + v(0)$

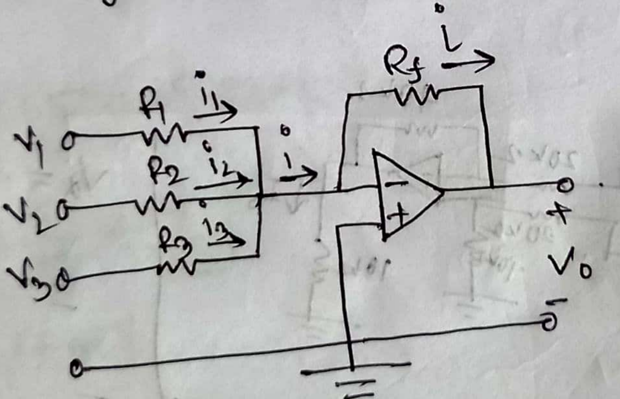
$v = \frac{1}{2\times10^{-6}}\int_0^1 6\,e^{3000t}\,dt \cdot 10^{-3}$

$= \frac{3\times10^{3}}{-3000}\,e^{-3000t}$

$= (1 - e^{-3000t})\ V$

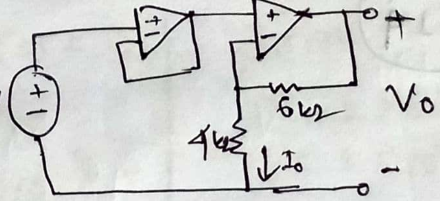
① what is Summing Amplifier?

A summing amplifier is an op amp circuit that combines several inputs and produces an output that is the weighted sum of the inputs.



$$V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$$

5.9 Due to the voltage follower,

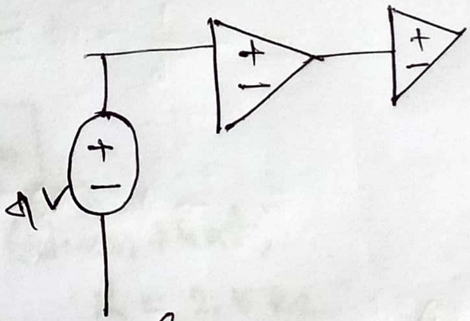


$$V_a = 4V$$

For the non-inverting amplifier,

$$V_o = \left(1 + \frac{6}{4}\right) V_a$$
$$= (1 + 1.5) \times 4 = 10\,V$$

$$i_o = \frac{V_b}{4} = \frac{10}{4}$$



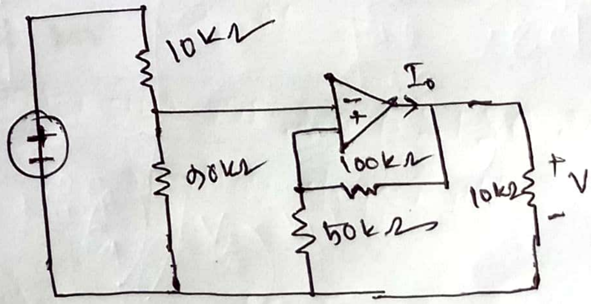
$$V_b = V_a = 4$$

So, $V_b = V_a = 4$

$$i_o = \frac{4}{4} = 1\,mA$$

Exercise

5.13



$$\frac{100}{50} + \frac{100 - V_o}{100} = 0$$

$$\Rightarrow 2 + \frac{100 - V_o}{100} = 0$$

$$\Rightarrow 200 + 100 - V_o = 100$$

$$\Rightarrow V_o = 200\,V$$

$$i_o = \frac{V_o}{10k} = \frac{200}{10 \times 10^3}$$
$$= 0.02\,mA \text{ (Ans)}$$

chapter-6

(6.63)

$$V = \frac{1}{C}\int_0^t i\,dt + V(0) \text{ and } V(0) = 0$$

$$= \frac{1}{\cancel{2}\times 10^{-6}}\int_0^1 \cancel{6}e^{-3000t}\,dt \times 10^{-3}$$

$$= \left[\frac{3\times 10^{3}}{-3000}\,\frac{e^{-3000t}}{-3000}\right]_0^1$$

$$= (1 - e^{-3000t})\ V \quad \underline{\text{Ans}}$$

Given that,

$V = 2\mu F$

$= 2\times 10^{-6}$

$i = 6e^{-3000t}\ mA$

$= 6e^{-3000} \times 10^{-3}$

Practice problem

(6.13)

$$RC = 25\times 10^{3} \times 10 \times 10^{-6}$$

$$= 0.25$$

$$V_0 = -\frac{1}{RC}\int_0^t V_i(t) + V_0(0)$$

$$= -\frac{1}{0.25}\int_0^t 10t\,dt\ mV$$

$$= -\frac{1}{0.25}[10t]_0^t$$

$$= 40\,mV \quad \underline{\text{(Ans)}}$$

Given that,

$R = 25k\Omega$

$C = 10\mu F$

$V = 10\,\cancel{mV}t = 10t\ mV$

$t = 0$

(6.14)

$$RC = 10\times 10^{3} \times 2 \times 10^{-6}$$

$$= 2\times 10^{-2}$$

$$V_0 = -RC\frac{dV_i}{dt}$$

$$= -RC \times \frac{d3t}{dt}$$

$$= -2\times 10^{-2} \times 3.1$$

$$= -60\ mV \quad \underline{\text{(Ans)}}$$

Given that,

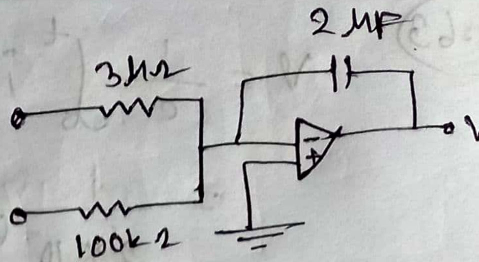
$R = 10k\Omega$

$C = 2\mu F$

$V_i = 3t$

Example

(6.13)



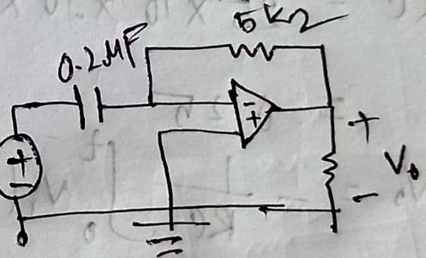
$$V_o = -\frac{1}{R_1C}\int V_1\,dt - \frac{1}{R_2C}\int V_2\,dt$$

$$= -\frac{1}{3\times10^{6}\times2\times10^{-6}}\int_0^t 10\cos 2t - \frac{1}{100\times10^{3}\times2\times10^{-6}}\int_0^t 0.5t\,dt$$

$$= -\frac{1}{6}\times10^{5}\,\frac{\sin 2t}{2} - \frac{1}{0.2}\times\frac{0.5t^{2}}{2}$$

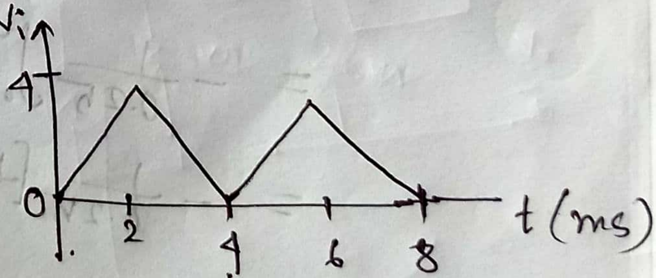
$$= -0.833\sin 2t - 1.25t^{2}\text{ mV} \quad \text{(Ans)}$$

(6.14) This is differentiator with,



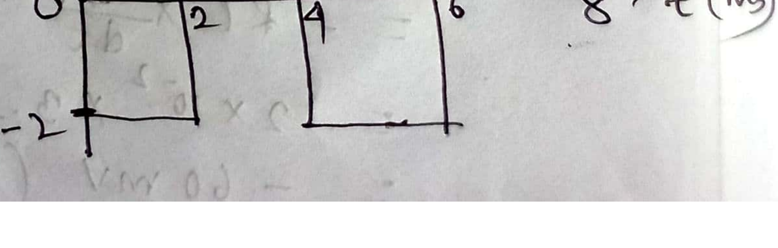
$$RC = 5\times10^{3}\times0.2\times10^{-6}$$
$$= 10^{-3}\text{ s}$$

For, $0<t<4$ ms, we can express the input voltage

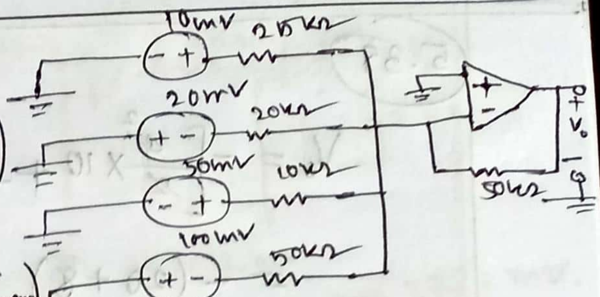


$$V_i = \begin{cases} 2t & 0<t<2 \text{ ms} \\ 8-2t & 2<t<4 \text{ ms} \end{cases}$$

$$V_o = -RC\frac{dV_i}{dt} = \begin{cases} -2\text{ mV} & 0<t<2\text{ ms} \\ 2 & 2<t<4\text{ ms} \end{cases}$$



(5.31)



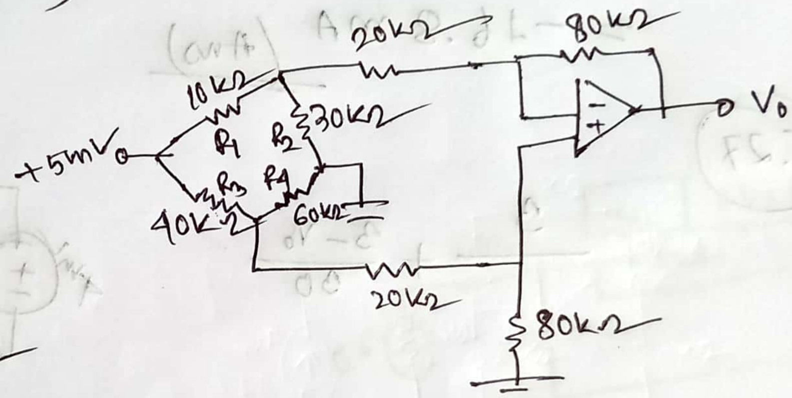
$$V_0 = \left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3 + \frac{R_f}{R_4}V_4\right)$$

$$= \left(\frac{\cancel{50}^{\,2}}{\cancel{25}} \times 10 + \frac{50}{\cancel{20}} \times \cancel{20} + \frac{\cancel{50}^{\,5}}{\cancel{10}} \times 50 + \frac{\cancel{50}}{\cancel{50}} \times 100\right)$$

$$= (20 + 50 + 250 + 100)$$

$$= 420\ V \text{ (Ans)}$$

(5.38)



$$R' = (R_1 + R_3)$$

$$= 10 + 40 = 50\ k\Omega$$

$$R'' = (R_2 + R_4) = 90\ k\Omega$$

$$V_1 = \frac{R_1}{R_1 + R_3} \times V$$

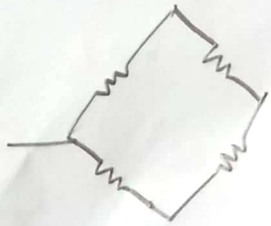
$$= \frac{10}{50} \times 5$$

$$= 1\ V$$

$$V_2 = \frac{R_2}{R_2 + R_4} \times V$$

$$= \frac{30}{90} \times 5$$

$$= 1.67\ V$$



$$V_0 = \frac{R_2}{R_1}(V_2 - V_1)$$

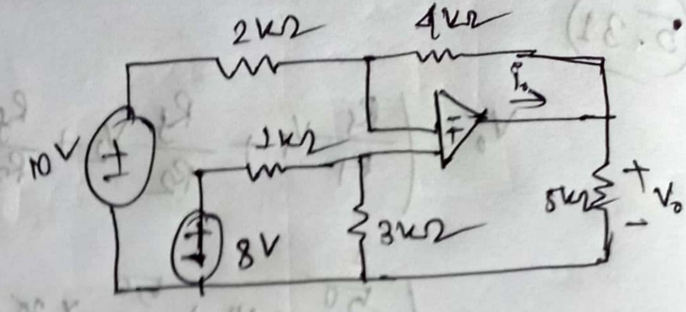
$$= \frac{80}{20}(1.67 - 1)$$

$$= 4 \times 0.67$$

$$= 2.68\ V \text{ (Ans)}$$

5.37

$$V_o = -\left[\frac{\cancel{4}^{2}}{\cancel{2}} \times 10 + \frac{\cancel{4}}{\cancel{4}} \times 8\right]$$



$= -(20+8)$ V

$= -28$ V

$i_o = \dfrac{V_o - 0}{10} + \dfrac{V_o - 0}{2}$

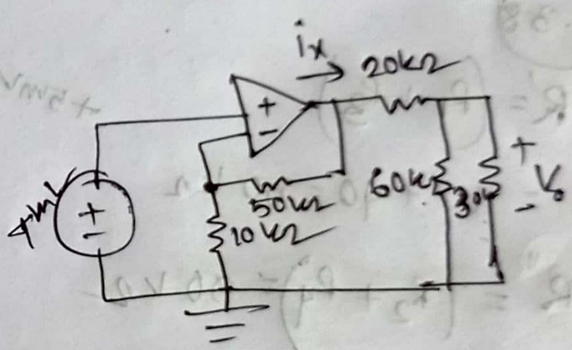
$= \dfrac{-28}{10} + \dfrac{\cancel{-28}^{14}}{\cancel{2}}$

$= -16.8$ mA (Ans)

5.27

$V_o = ?$
$i_x = ?$

$\dfrac{3}{\quad} + \dfrac{3 - V_o}{30}$



$V_a = \dfrac{60}{60+20} \times 4$

$= 3$ V