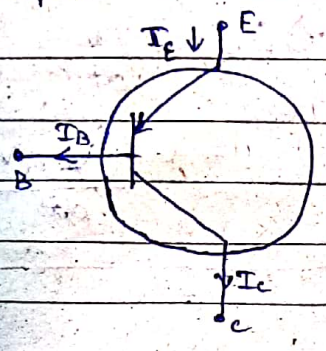
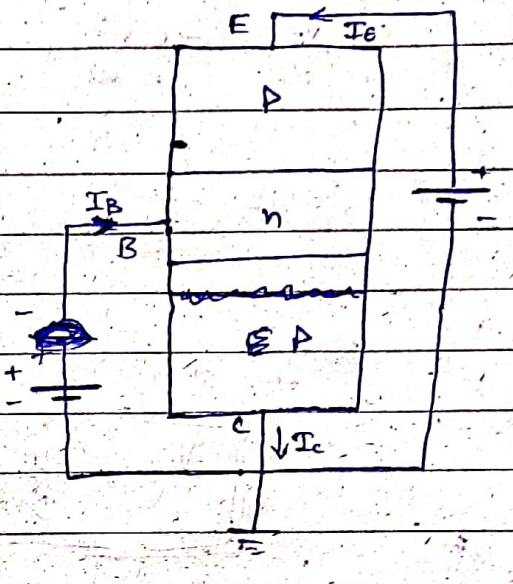
Transistors

Common-Collector Config. (CC config.):

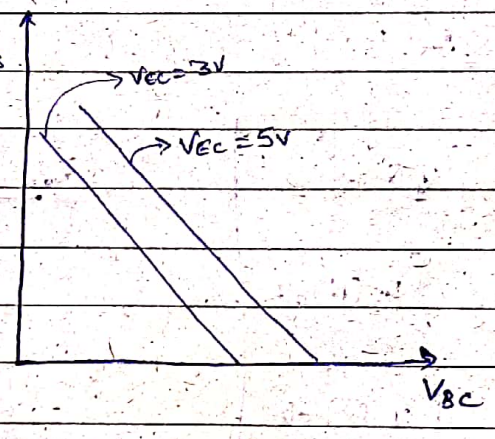
(*) Collector terminal will be common to both input and output.





output char of CC:

= o/p char of CE



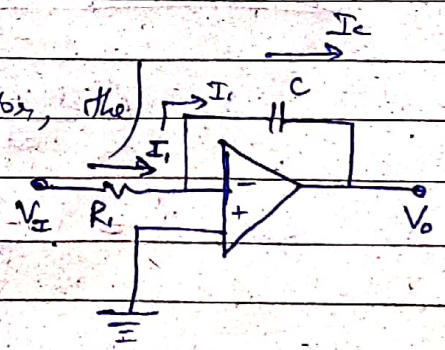
Integrator

$R_2 = R_1 x$

$R_4 = R_3 x$

$\frac{(1+x)R_1}{(1+x)R_3} = \frac{R_1}{R_3} = \frac{R_2}{R_1}$

(If feedback component is capacitor, the circuit is called Integrator.)



$$I_1 = \frac{V_I}{R_1}$$

(*) $I_C = C\frac{dv}{dt}$

ohm's law

Ohm's law for cap. curves

$\Rightarrow I_c = C\dfrac{dv}{dt}$

$= C\dfrac{d(V_1 - V_2)}{dt}$

$\Rightarrow I_c = C\dfrac{d(0 - V_o)}{dt} = -C\dfrac{dV_o}{dt}$

$\Rightarrow \dfrac{V_I}{R} = -C\dfrac{dV_o}{dt}$

$dV_o = -\dfrac{1}{RC} V_I \, dt$

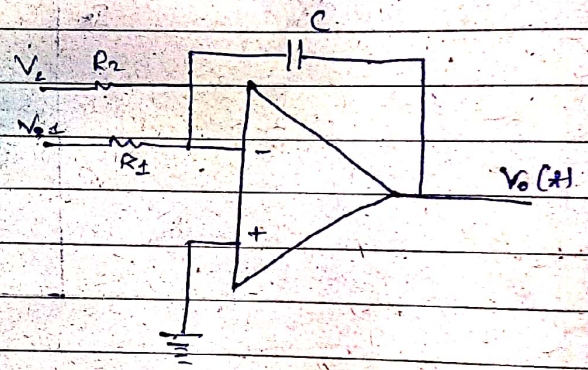
Integrating,

$$\boxed{V_o = \frac{-1}{RC}\int V_I(t)\,dt}$$

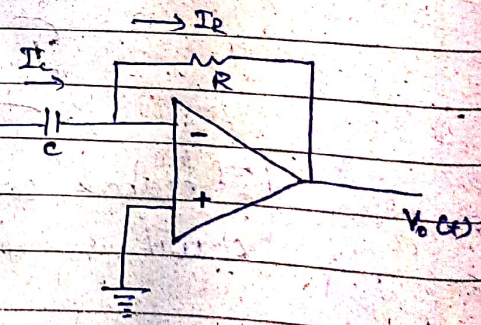
$X_c = \dfrac{1}{\omega C}$

Case :-

$$\boxed{\begin{aligned} V_o = &-\frac{1}{R_1 C}\int V_1(t)\,dt \\ &-\frac{1}{R_2 C}\int V_2(t)\,dt \\ &-\frac{1}{R_3 C}\int V_3(t)\,dt \end{aligned}}$$



Differentiator :-



$I_c = C\dfrac{d(V_I - 0)}{dt}$

and $I_R = \dfrac{(0 - V_o)}{R}$

Since $I_c = I_R$

$\Rightarrow C\dfrac{d(V_I - 0)}{dt} = \dfrac{(0 - V_o)}{R}$

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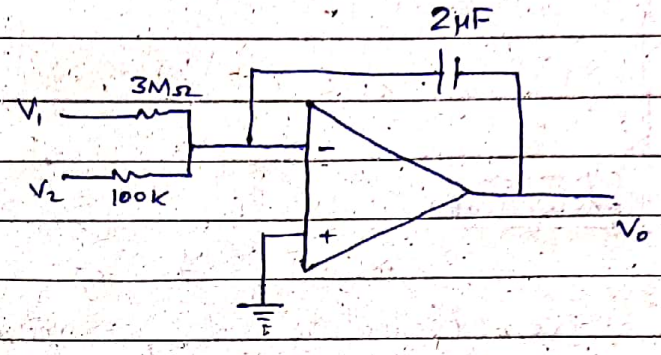
$$C\frac{dV_I}{dt} = \frac{-V_o}{R}$$

$$\Rightarrow \boxed{V_o = -RC\frac{dV_I}{dt}}$$

Q: $V_1 = 10\cos(2t)$ mV

and $V_2 = 0.5t$ mV

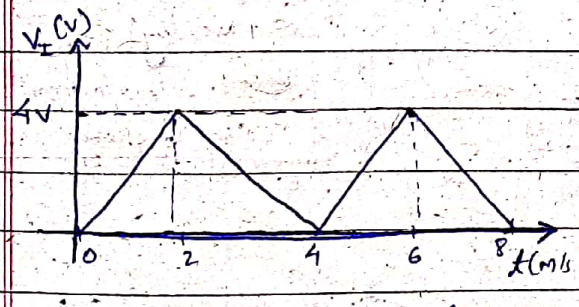
find V_o.

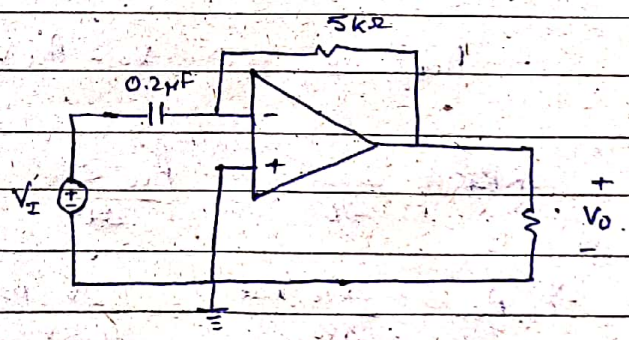


Sol

$V_o = -0.833\sin(2t) - 1.25t^2$ mV

Q:





Sketch the output waveform.

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Slew Rate :-

Max Rate at which amplifiers output can change in volts per microsecond. ($V/\mu s$)

$$\boxed{SR = \frac{\Delta V_o}{\Delta t} \cancel{\left(\frac{V}{\mu s}\right)}} \left(\frac{V}{\mu s}\right)$$

omit

Ex. For op-amp $SR = 2\ V/\mu s$, what is the max. closed loop voltage gain that can be used when Input signal varies by 0.5V in $10\mu s$.

(*) Change in V_I doesn't change V_o immediately, this ~~rate~~ is slew rate.

(*) When slew rate is ∞ (ideally), the V_o changes instantaneously with V_I change.

$$A_{cl} = \frac{V_o}{V_I} \Rightarrow V_o = A_{cl} V_I$$

$$SR = \frac{\Delta V_o}{\Delta t} = \frac{A_{cl}\ \Delta V_I}{\Delta t}$$

$$\Rightarrow A_{cl} = \frac{\Delta V_o / \Delta t}{\Delta V_I / \Delta t} = \frac{2V/\mu s}{(0.5V/10\mu s)} = 40 \text{ Ans}$$

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Common Mode Rejection Ratio : (CMRR)

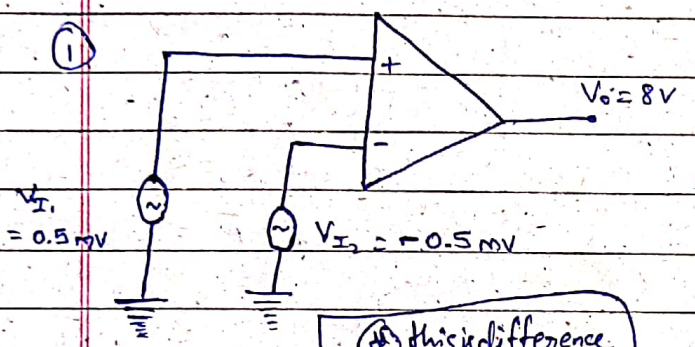
Amplify the difference signal while rejecting the common signal at two inputs.

$$\boxed{CMRR = \frac{A_d}{A_c}}$$ → differential gain

$$\boxed{CMRR = 20 \log_{10}\left(\frac{A_d}{A_c}\right) \cdot (dB)}$$ → decibel

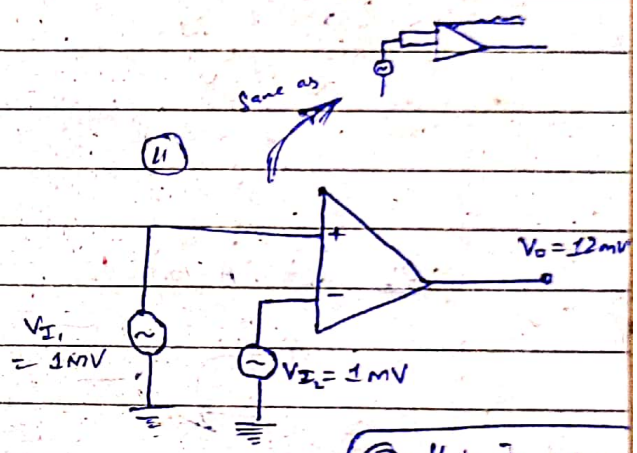
Eg. Calculate CMRR.

(i)



this is difference

(ii)



this is common

Sol. $V_d = V_{I_1} - V_{I_2} = 1mV$ (difference)

as phase of both term

$V_c = \frac{V_{I_1} + V_{I_2}}{2} = 1mV$ (common)

$A_c = \frac{V_o}{V_c} = \frac{12mV}{1mV} = 12$

$A_d = \frac{V_o}{V_d} = \frac{8}{1 \times 10^{-3}} = 8000$

$\Rightarrow CMRR = \frac{A_d}{A_c} = \frac{8000}{12} = \boxed{666.7}$

or

in decibel,

$CMRR = 20 \log_{10}\left(\frac{A_d}{A_c}\right) = \boxed{56.48\ dB}$

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UNIT - 5

Boolean Algebra

NOT (A', $\bar{A}$)

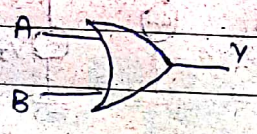
X	Y
0	1
1	0

AND ($A \cdot B$)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

$A \cdot A = A$
$A \cdot 1 = 0$
$A \cdot 0 = 0$
$A \cdot \bar{A} = 0$

OR ($Y = A + B$)



A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

$A + A = A$
$A + 1 = 1$
$A + 0 = A$
$A + \bar{A} = 1$

Q. ~~Ans~~ $AB + A\bar{B}$

$= A(\underbrace{B + \bar{B}}_{1})$

$= A(1)$

Ans $= A$

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Q. $AB + A\bar{B}C + A\bar{B}\bar{C}$

$= AB + A\bar{B}\underbrace{(C+\bar{C})}_{1}$

$= \cancel{A\bar{B}}\ AB + AB'$

$= A(B+\bar{B})$

Ans $= A$

Q. $A\bar{B} + AB\bar{C} + A\bar{B}\bar{C}D$

Q. $(A+B)(A+C)$ minimize the expression.

Q. $AB + \bar{A}\bar{B} + A\bar{B}$

$\Rightarrow A(B+\bar{B}) + \bar{A}\bar{B}$

$\Rightarrow A + \bar{A}\bar{B}$

$= \underbrace{(A+\bar{A})}_{1}(A+\bar{B}) = \underbrace{AA}_{A} + 0 + \bar{B}A + \bar{A}\bar{B}$

$= (A+\bar{B})$

Property

$A + \bar{A}B$

$= (A+\bar{A})(A+B)$

$= 1\ (A+B)$

$= (A+B)$

Q. $AB + \bar{A}B + A\bar{B}$

$= B(A+\bar{A}) + A\bar{B}$

$= B + A\bar{B}$

$= \underbrace{(B+\bar{B})}_{1}(B+A)$

Ans. $\Rightarrow B+A$

Eg. $AB + \bar{A}B + BC$

$= AB + \bar{A}C + BC(A+\bar{A})$

$= AB + \bar{A}C + ABC + \bar{A}BC$

$= AB(1+C) + \bar{A}C(B+1)$

$= AB + \bar{A}C$

comparing we get that BC is of no use in question

Hence BC $\Rightarrow$ redundant term.

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Demorgan's Theorem

$\overline{A \cdot B \cdot C} = \bar{A} + \bar{B} + \bar{C}$

$\overline{A + B + C} = \bar{A} \cdot \bar{B} \cdot \bar{C}$

Minimization

- SOP (Sum of Product) — generally used
  - eg. $ABC + ABD + AC$
- POS (Product of Sum)
  - Eg. $(A+B+C)(A+C)(C+D)$

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