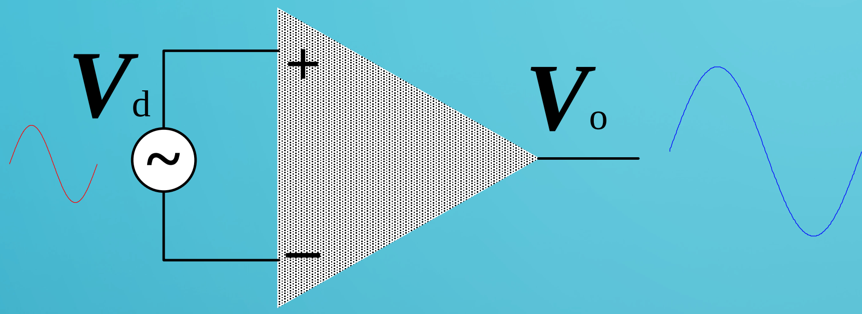
NETWORK THEORY

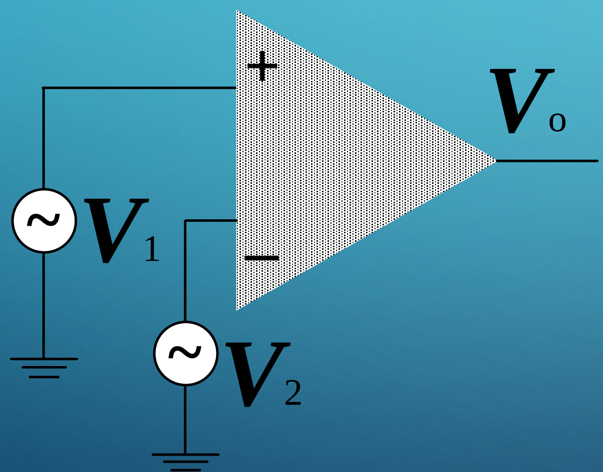
LECTURE 7

SECTION-D :NETWORK SYNTHESIS

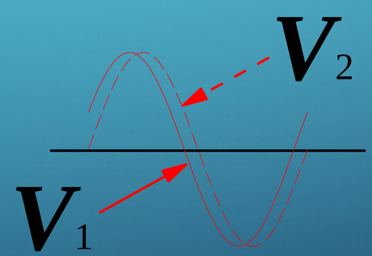
DOUBLE-ENDED INPUT



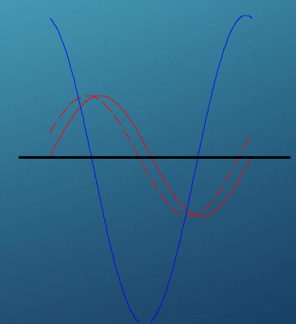
- Differential input
- $V_d = V_+ - V_-$
- 0^o phase shift change between V_o and V_d



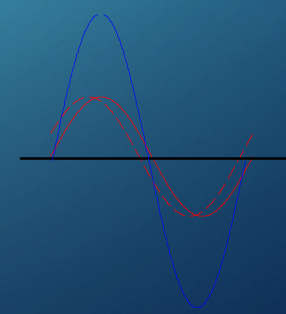
Qu: What V_o should be if,



Ans: (A or B) ?

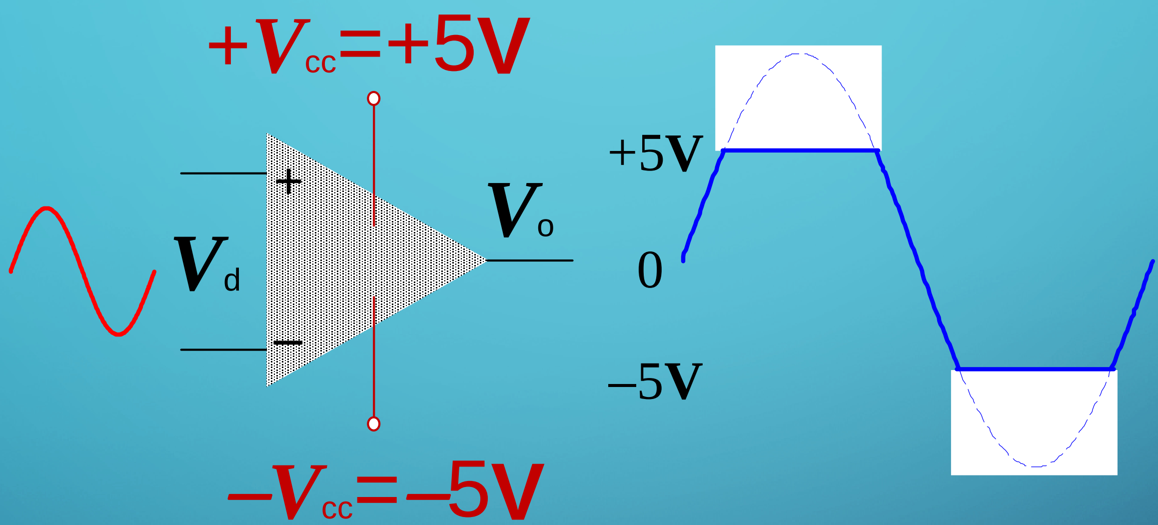


(A)



(B)

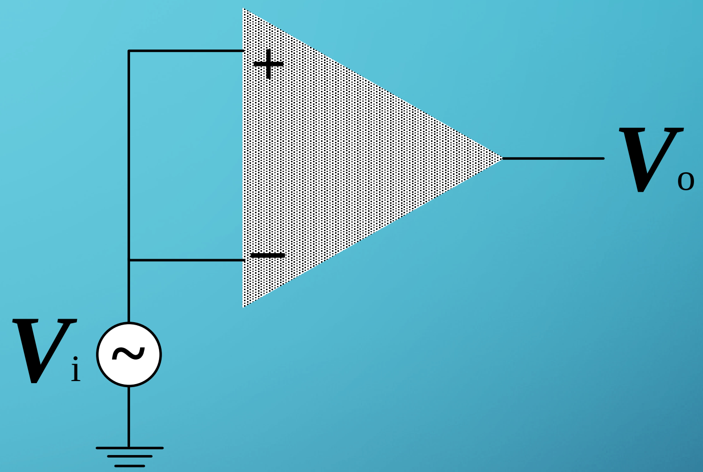
DISTORTION



The output voltage never excess the DC voltage supply of the Op-Amp

COMMON-MODE OPERATION

- Same voltage source is applied at both terminals
- Ideally, two input are equally amplified
- Output voltage is ideally zero due to differential voltage is zero
- Practically, a small output signal can still be measured



Note for differential circuits:
Opposite inputs : highly amplified
Common inputs : slightly amplified

$\Rightarrow$ Common-Mode Rejection

COMMON-MODE REJECTION RATIO (CMRR)

Differential voltage input :

$$V_d = V_+ - V_-$$

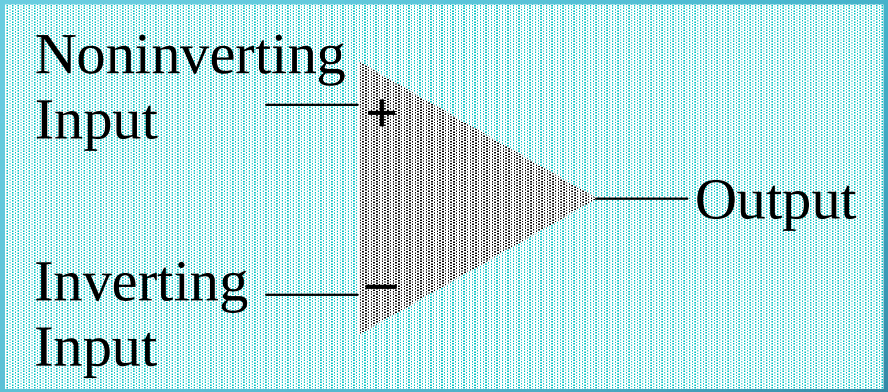
Common voltage input :

$$V_c = \frac{1}{2}(V_+ + V_-)$$

Output voltage :

$$V_o = G_d V_d + G_c V_c$$

G_d : Differential gain
G_c : Common mode gain



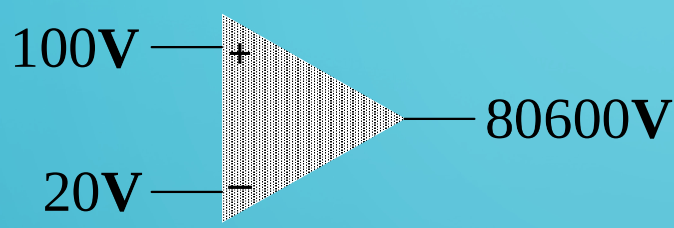
Common-mode rejection ratio:

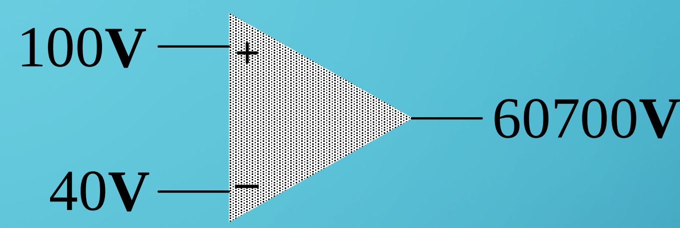
$$\text{CMRR} = \frac{G_d}{G_c} = 20\log_{10}\frac{G_d}{G_c}\ \text{(dB)}$$

Note:
When $G_d >> G_c$ or CMRR $\to\infty$
$\Rightarrow V_o = G_d V_d$

CMRR EXAMPLE

What is the CMRR?





Solution :

$$\left.\begin{aligned} V_{d1} &= 100 - 20 = 80\mathbf{V} \\ V_{c1} &= \frac{100+20}{2} = 60\mathbf{V} \end{aligned}\right\} (1) \qquad \left.\begin{aligned} V_{d2} &= 100 - 40 = 60\mathbf{V} \\ V_{c2} &= \frac{100+40}{2} = 70\mathbf{V} \end{aligned}\right\} (2)$$

From (1) $V_o = 80G_d + 60G_c = 80600\mathbf{V}$

From (2) $V_o = 60G_d + 70G_c = 60700\mathbf{V}$

$G_d = 1000$ **and** $G_c = 10$ $\Rightarrow \mathbf{CMRR} = 20\log(1000/10) = 40\mathbf{dB}$

NB: This method is Not work! Why?

OP-AMP PROPERTIES

(1) Infinite Open Loop gain

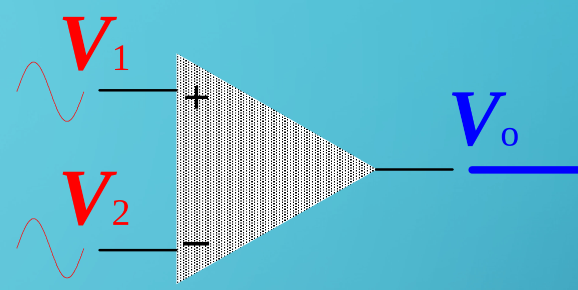
- The gain without feedback
- Equal to differential gain
- Zero common-mode gain
- Pratically, G_d = 20,000 to 200,000

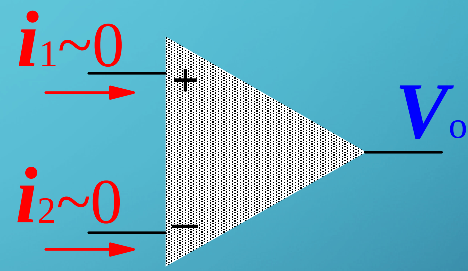
(2) Infinite Input impedance

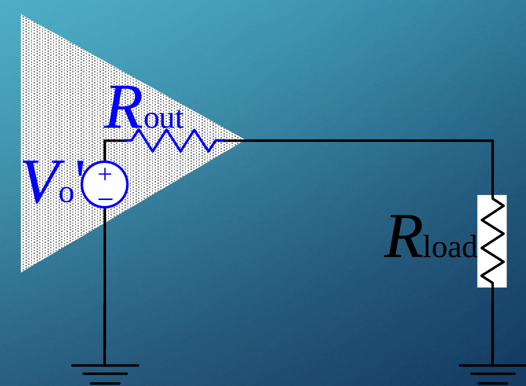
- Input current i_i ~0A
- T-Ω in high-grade op-amp
- m-A input current in low-grade op-amp

(3) Zero Output Impedance

- act as perfect internal voltage source
- No internal resistance
- Output impedance in series with load
- Reducing output voltage to the load
- Practically, R_{out} ~ 20-100 Ω







$$V_{load} = V_o' \frac{R_{load}}{R_{load} + R_{out}}$$